Driving Decarbonization: Retrofitting's Role in Europe's Inland Waterway Transportation

Applied Research Project Report

Anja von Matt
Jacqueline Alemayehu
Ela Gokcigdem

May 2025

Partner Organization: United Waterways
Faculty Lead: Sandeep Sengupta

Abstract

With increasing regulatory pressure to decarbonize inland waterway transport across Europe, the sector faces urgent demands to make its fleet more sustainable. Given the limited time frame until 2050, these central questions arise: Where are the river shipyards suitable for retrofitting, and how many such yards currently exist across Europe? And are they sufficient to meet the decarbonization targets by 2050? To address this, a mixed-method approach was applied, combining stakeholder interviews, survey results, a field trip, and a shipyard capacity analysis. Findings indicate a high concentration of shipyards in the estuarine regions of the Rhine/Waal, Scheldt, and Meuse rivers, particularly in the Netherlands and Belgium. The capacity assessment reveals that between 36 and 54 mid-sized shipyards would be needed year-round, operating exclusively on retrofitting and new builds. However, key data such as the growth rate of new build demand and current workload levels remain unavailable, suggesting that actual capacity needs are likely higher. A total of 57 shipyards were identified within the geographical scope of this research, but their varying sizes and capacities imply that they may not be sufficient to meet future demand. Key enablers to close this gap include new shipyard facilities, standardized retrofitting packages to reduce turnaround times, clear EU-level regulatory frameworks, and targeted subsidies to incentivize early adoption. Without coordinated support, the sector risks falling short of meeting its 2050 decarbonization goals.

Acknowledgements

We, the Applied Research Project team - Ela Gokcigdem, Anja von Matt, and Jacqueline Alemayehu - extend our heartfelt thanks to our partner organization, United Waterways. Special thanks to Tamas Csillag for being our dedicated contact and always supporting us, and to Axel Ryll for your technical expertise and guidance. We are also grateful to Sascha Gill for trusting the Geneva Graduate Institute and our team with this research.

A big thank you to our supervisor, Sandeep Sengupta, for your support throughout the project, and to Claudia Seymour for your valuable inputs.

Our appreciation goes to all participating shipyards that contributed to this research by completing the survey, answering our interview questions, and enabling us to conduct field visits. We also thank our interview partners from the European Commission for sharing their regulatory perspectives.

Abbreviations

CCNR	Central Commission for the Navigation of the Rhine
CEF	Connecting Europe Facility
ETS	Emission Trading System
EU	European Union
GHG	Greenhouse gases
HVAC	Heating Ventilation and Air Conditioning
HVO	Hydrotreated Vegetable Oil
INE	Inland Navigation Europe
IWT	Inland Waterway Transportation
SSMS	Sustainable and Smart Mobility Strategy
TCO	Total Costs of Ownership
UN	United Nations
ZE	Zero-Emissions

Table of Contents

List of Figures

List of Tables

1. Introduction

Inland waterway transportation (IWT) plays a vital role in Europe's transport system, offering a cost-effective and energy-efficient alternative to road and rail transport (European Council, n.d.). However, despite its environmental advantages compared to aviation or road transport, the sector remains heavily reliant on fossil fuels (Chircop et al., 2018). In the face of the European Union's (EU) climate targets by 2050 (European Council, n.d.), IWT must undergo a substantial transformation to reduce greenhouse gas (GHG) emissions.

Driven by frameworks such as the *European Green Deal* and the *Sustainable and Smart Mobility Strategy* (SSMS), the EU aims to achieve a 90% GHG emissions reduction compared to 1990 levels in the transport sector by 2050 and a 55% reduction by 2030 as an intermediary goal (European Council, n.d.-a; European Commission, 2019). This requires a rapid transition to low- and zero-emission (ZE) vessels. However, studies state that this goal cannot be met through ship new building alone (Inland Navigation Europe [INE] et al., 2025). Retrofitting the existing fleet has emerged as a critical pathway toward decarbonization. In the context of this study, *retrofitting* is defined as *"[...] the installation on-board ships of modern or innovative components or systems in order to meet new regulatory energy and emissions standards or to meet a ship owner's interest in upgrading the ship for higher operational standards."* (Chirica et al., 2019, p. 2). While in the short and medium term, retrofitting with various technologies offers a promising route to reduce GHG emissions, significant additional investments, policy, and required technological advances present notable challenges. Furthermore, the capacity of European shipyards to meet the prospected rising demand for retrofitting remains largely unknown. Initial studies suggest that the sector's infrastructure may not be sufficient to manage the expected volume of retrofits (Chandrasekar & Godjevac, 2023). This capacity gap could significantly delay the transition to ZE operations and undermine the EU's climate targets. However, no Europe-wide studies have yet analyzed and mapped the entire European inland navigation retrofit capacity.

This applied research project was conducted in collaboration with *United Waterways*, Europe's largest provider of modular white-label ship management services[1] across all waterways (*United Waterways*, n.d.).

About Our Partner: United Waterways

Based in Basel, Switzerland, United Waterways, as a white-label operator[1], manages ship operations under the brand identity of its clients across all waterways. Its services include ship management, hospitality, infrastructure support, and consultancy. The company manages over 100 vessels and has over 4,000 employees, facilitating over 2.5 million overnight stays and accommodating more than 2.1 million day guests on its vessels each year (*United Waterways*, n.d.).

In this research project, United Waterways served as a sector partner by helping define the research goals, providing technical input, facilitating access to relevant contacts within the IWT sector, and supporting the project throughout its development.

The project's goal is to assess whether existing shipyards along the rivers in Europe possess the technical capacity and infrastructure to support large-scale retrofitting for the decarbonization of IWT vessels. Through this assessment, the research aims to inform about retrofitting capacities at inland shipyards across rivers in Europe. The findings provide insights for shipowners, shipyard operators, and policymakers by identifying key capacity gaps, regional disparities, and potential bottlenecks in retrofitting towards decarbonization.

The methodology of this study follows a structured approach combining desk research, surveys, expert interviews, a field visit to two shipyards in the Netherlands, a capacity calculation, and written contact with other stakeholders in the IWT sector. The focus is on identifying shipyards along key European rivers and assessing their technical capabilities and capacities. By gathering insights directly from shipyards and industry experts, the study aims to provide a clear understanding of retrofitting potential and challenges across the inland waterway network. Limitations, such as limited sample size and potential biases, are acknowledged.

Following the introduction in Chapter 1, Chapter 2 presents the literature review. The first part focuses on the regulatory framework surrounding the decarbonization of IWT. Subsequently, technological approaches to retrofitting are discussed. In addition, the current state of knowledge regarding retrofitting capacities is outlined, and the retrofitting strategy of United Waterways is contextualized. Chapter 3 introduces the research questions based on the agreement with United Waterways. Chapter 4 then describes the methodology of the study. This includes an explanation of the research design, the geographical and technical scope of the

---

[1] White-label ship management involves a third-party company, like United Waterways, managing the technical, crew, and regulatory aspects of vessels, while the ships operate under the client company's brand.

study, a discussion of the qualitative and quantitative aspects of the research, and an outline of the limitations of the chosen methods and data collection processes. In Chapter 5, the findings and analysis of the collected data are presented. Finally, Chapter 6 provides the conclusion, summarizing the major findings of the study, and situating them within the broader context of the research questions.

2. Literature Review

2.1. Global Climate and the Role of the Shipping Industry

Climate change, driven by human-caused GHG emissions, leads to rising temperatures, increase in sea level, and more frequent extreme weather (Masson-Delmotte et al., 2021). The shipping industry is a significant contributor to global GHG emissions, responsible for 2.89% of annual CO_2 emissions in 2018 (International Maritime Organization [IMO], 2020). The combustion of fossil fuels on the vessels emits considerable amounts of CO_2, nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM), thereby exacerbating global warming and adversely affecting air quality and public health (Masson-Delmotte et al., 2021).

2.2. Policy Overview

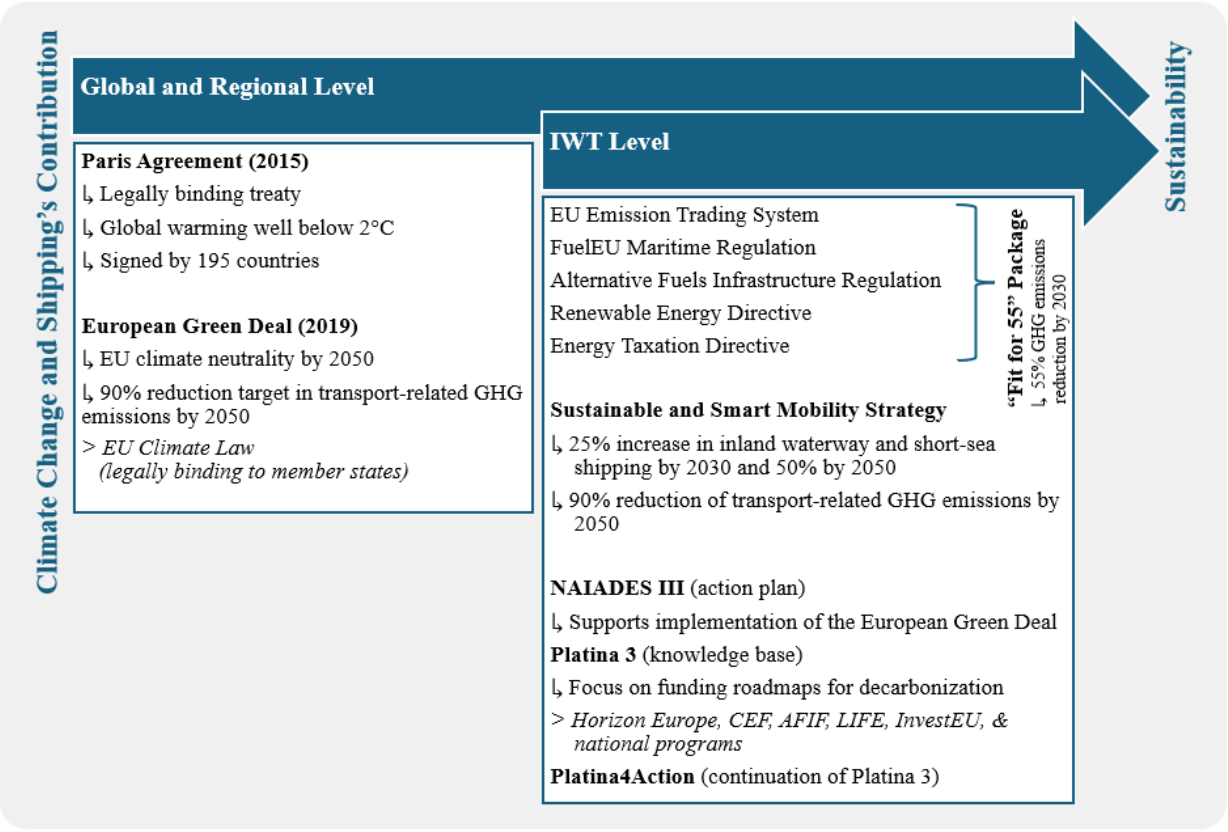


Figure 1: Policy Overview, created by the authors

Responding to the urgent climate crisis, the United Nations (UN) adopted the *Paris Agreement* on 12 December 2015 (UN, 2016), a legally binding agreement signed by 195 countries aiming to limit global warming well below 2°C, ideally to 1.5°C above pre-industrial levels (Article 2.1(a)) (United Nations Framework Convention on Climate Change [UNFCCC], 2016), addressing sectors like energy, industry, and transportation. In support of the *Paris Agreement*, the EU launched the *European Green Deal* in 2019, which is a policy package aiming for EU climate neutrality by 2050 (European Council, n.d.). The *Green Deal* emphasizes that all transport modes, including shipping, must contribute to this goal, setting a 90% GHG emission reduction target for the transport sector by 2050 (European Commission, 2019). As a key initiative of the *European Green Deal,* the *European Climate Law* provides its legal framework, setting legally binding climate targets for all EU members (European Commission, n.d.-a). It commits the EU to net-zero GHG emissions by 2050 (Article 1), with an interim target of at least 55% emission reduction by 2030 compared to 1990 levels (Article 4.1) (Regulation (EU) 2021/1119, 2021). The regulation requires member states to develop and implement national adaptation strategies to enhance climate change resilience and mitigate vulnerability (European Commission, n.d.-a).

The "*Fit for 55" package*, introduced by the European Commission in 2021, comprises a set of legislative proposals designed to implement the *EU Climate Law's* target of reducing greenhouse gas emissions by at least 55% by 2030 (European Commission, n.d.-b). It translates this objective into concrete measures to guide member states in cutting their emissions. Several of its proposals are particularly relevant for IWT:

The *EU Emissions Trading System* (EU ETS) was developed as a tool to reach the goals of the *European Green Deal*. Vessel owners of ships over 5,000kg gross tonnage must participate in the EU ETS with a phased implementation starting in 2025 (Dmitry, 2024; European Maritime Safety Agency, n.d.). Furthermore, the *FuelEU Maritime Regulation*, focused on reducing GHG emissions from sea-going vessels, may indirectly encourage similar decarbonization in IWT (Det Norske Veritas group [DNV], n.d.). The *Alternative Fuels Infrastructure Regulation* (AFIR) is crucial for IWT, facilitating the infrastructure for alternative fuels like onshore power supply and bunkering facilities (European Commission, n.d.-c). The *Renewable Energy Directive* (RED) indirectly supports IWT's decarbonization by promoting renewable energy use in transport, including biofuels and renewable electricity (Jacobs, 2022). The *Energy Taxation Directive* (ETD) aims to impose higher taxes on more polluting fuels to encourage the transition toward a cleaner energy sector and industry. This would also apply to the diesel currently used in the combustion engines of IWT vessels. However, its implementation remains pending due to ongoing negotiations (European Commission, n.d.-d).

The 2020 *SSMS* outlines the EU's roadmap for a 90% transport emission reduction by 2050 to meet *European Green Deal* objectives, recognizing inland navigation's crucial role in sustainable transport and its necessary decarbonization, primarily through replacing vessels with low-emission and ZE alternatives. The report highlights the challenges of decarbonizing the shipping sector, citing delayed ZE technology readiness, long vessel development and life cycles, high capital requirements, and intense international competition. Despite this, the strategy targets growth in the sector, anticipating a 25% increase in inland waterway and short-sea shipping by 2030 and 50% by 2050 (European Commission, 2020).

Introduced in June 2021, *NAIADES III* (Navigation and Inland Waterways Action and Development in Europe) is an EU action plan supporting the *Green Deal* and the *SSMS*. Its two main objectives are to promote a modal shift of freight transport to inland waterways and to accelerate the decarbonization of the sector in recognition of its CO_2 efficiency and its strategic importance for achieving the EU's climate targets. The plan includes measures to improve navigation, promote digitalization, update legal frameworks, and outlines 35 action steps from 2021 to 2027 (European Commission, 2021).

The EU-funded *PLATINA3* platform supports *NAIADES III* and the *European Green Deal* in IWT, focusing on funding roadmaps for the transition to ZE shipping (*PLATINA3* IWT Policy Platform, n.d.). Its report highlights a significant financial gap in decarbonizing IWT due to higher capital expenditure (CAPEX) and operational expenditure (OPEX) for greener shipping, emphasizing the need for appropriate funding and investment instruments (Roux et al., n.d.). Recognizing the crucial role of shipyards in fleet modernization, *PLATINA3* identifies key EU programs like *Horizon Europe, Connecting Europe Facility* (CEF), *Alternative Fuels Infrastructure Facility* (AFIF), *LIFE Clean Inland Shipping*, and *InvestEU* as crucial funding sources, alongside national programs (European Parliament, n.d.; Roux et al., n.d.). *PLATINA3* is continued by *PLATINA4Action* (2024-2027) to further implement *NAIADES III* and promote policies for non-polluting IWT (Platina4Action, n.d.).

2.3. Retrofitting of Inland Waterway Transportation Vessels

The following sections present a systematic introduction to the process of retrofitting vessels in Europe. Section 2.3.1. provides an initial overview of the subject matter and defines retrofitting in the context of this research. Building on this, Section 2.3.2. explores the role of retrofitting in meeting the EU's emission targets for inland navigation by 2050 and provides an overview of the current status in the EU. Section 2.3.3. describes retrofitting strategies and presents potential technological retrofitting variants. Section 2.3.4. presents the current status of United Waterways' retrofitting strategy. Finally, Section 2.3.5. gives an overview of the funding and subsidy schemes applicable for IWT.

2.3.1. Terminology

This section introduces the concept of retrofitting to establish a clear foundation for the discussion in the following subsections.

In the context of this study, ***retrofitting*** is defined as *"[...] the installation on-board ships of modern or innovative components or systems in order to meet new regulatory energy and emissions standards or to meet a ship owner's interest in upgrading the ship for higher operational standards."* (Chirica et al., 2019, p. 2). Within the scope of this study, such measures to enhance energy efficiency and reduce the environmental impact of IWT vessels are central to achieving the overarching net-ZE goal of the *European Green Deal* by 2050.

2.3.2. Status of Decarbonization and Importance of Retrofitting for the Inland Waterways Transportation

IWT occupies a unique position within the transport sector as it is regarded as one of the most CO_2-efficient freight transport modes, offering significantly lower energy consumption per ton-kilometer compared to road transport and comparable efficiency to rail (Tianlin et al., 2024). However, it still has notable environmental drawbacks (European Environment Agency [EEA], 2023). In Europe, where major rivers like the Rhine and Danube experience heavy traffic, IWT contributes significantly to regional emissions. While CO_2 output is relatively low, IWT vessels release substantial quantities of natrium oxide and particulate matter, raising concerns about air quality and public health (EEA, 2023). In contrast, road transport has progressed more rapidly in adopting electrification and reducing emissions, highlighting the slower pace of change in the IWT sector, which remains heavily reliant on fossil fuels (Van Lier & Macharis, 2024). This underscores the urgency of transforming IWT as part of the broader decarbonization of global shipping.

The decarbonization of IWT vessels in Europe remains at its early stages. As of 2023, approximately 15,727 IWT vessels operated in Europe, encompassing various cargo and river cruise vessel types (Central Commission for the Navigation of the Rhine [CCNR], 2024). Only about 0.2% of these were classified as "innovative", producing fewer emissions than conventional diesel-powered vessels (CCNR, 2024). Vessels meeting the 2050 net-zero goals are mostly pilot projects, as technologies remain commercially unviable. The commissioning of new builds in both the cruise and cargo sectors is influenced by geopolitical events and incidents like the COVID-19 pandemic (CCNR, 2024). Since the pandemic, new building activity has slowed. However, activity is expected to increase in 2024 and 2025.

2.3.3. Retrofitting in the Inland Waterways Sector

This section explores the potential retrofitting strategies for decarbonizing the IWT sector, as well as the technological possibilities.

2.3.3.1. Retrofitting Strategies

The transition to ZE vessels can be achieved through two main approaches: building new vessels or retrofitting existing ones (CCNR, 2022). According to a newly published statement by the IWT and ports sector on the Sustainable Transport Investment Plan (STIP[2]), it is anticipated that between 2020 and 2050 around two-thirds of the cargo and cruise fleet will undergo retrofitting, and only one-third will be replaced by new builds (INE et al., 2025). A recent analysis by Chandrasekar & Godjevac (2023), which examined the feasibility of retrofitting existing vessels versus constructing new ones in the Netherlands, based on the assumption that hydrogen will become the new fuel standard, reveals significant differences between the two approaches. The study found that constructing new ZE vessels would take roughly twice as long as retrofitting existing ones.

The road map of the CCNR (2022) outlines two pathways for emission reductions: a conservative approach utilizing mature, cost-effective technologies and an innovative pathway relying on emerging technologies like battery- or hydrogen-powered vessels. The *Statement by the IWT and Ports* has also adapted these two approaches in their analysis and estimated the needed amount of different fuel types by 2050 for both approaches (INE et al., 2025). The conservative pathway leverages existing infrastructure, such as using biofuels like Hydrotreated Vegetable Oil (HVO) with minimal adjustments to propulsion systems. In contrast, the innovative pathway focuses on ZE technologies, which could completely eliminate GHG

---

[2] The STIP is a joint statement from INE, the European Barge Union, the European Federation of Inland Ports, Waterborne, the European IWT Platform, the European Skippers Organisation, the ECIB, and the Platina4Action Platform. It calls on the European Commission to incorporate IWT in the upcoming European Maritime/Waterborne Industrial Strategy, European Port Strategy, and Sustainable Transport Investment Plan.

emissions during operation. However, challenges remain, including higher total cost of ownership (TCO) and the limited commercial readiness of these technologies. Studies show (that, while the conservative transition pathway leads to approximately 8% higher TCO compared to the business-as-usual scenario, the innovative pathway increases TCO by about 23%. This implies that the cost gap for the innovative pathway is roughly 1.6 to 2.9 times higher than for the conservative pathway, depending on fuel and technology assumptions (Karaarslan & Quispel, 2021).

The river cruise sector, a smaller segment of European IWT with approximately 408[3] vessels compared to approximately 15,319 cargo vessels (CCNR, 2024), is expected to align with sustainability and retrofitting standards set by the cargo sector. As the cargo sector leads in adopting ZE technologies, it will establish a framework for other sectors, including river cruises, to follow, driving industry-wide standardization.

INE et al. (2025) argue that besides the changes on the vessel itself, shipyards also need to optimize their infrastructure for clean energy re-fueling. Energy storage solutions such as for methanol and hydrogen are challenging, and further adaptations need to be done to make them commercially available.

2.3.3.2. Technological Possibilities

The following section introduces technological possibilities for greening the IWT sector, based primarily from the insights provided in the Status Report conducted by the Cruise Lines International Association (CLIA) and the European River Cruise Association (IGRC) (2024). The analysis focuses on six key areas: alternative energy carriers, power converter and energy storage technologies, propulsion efficiency enhancements, hotel load optimization, vessel energy efficiency technologies and measures, and digitalization technologies. While all six options are introduced in this section, the research mainly focuses on alternative Energy Carriers (1) and Power Converter & Energy Storage technologies (2).

---

[3] Only river cruise vessels with a minimum of 40 beds are considered in this number (Hader, 2024, cited in CCNR, 2024).

Table 1: Overview of the Possibilities of Retrofitting in the Inland Waterways Vessels, Source: own design, based on CLIA & IGRC, 2024

Alternative Energy Carriers	Adapt fuel systems for biodiesel (HVO - drop-in), methane (new engine or dual-fuel engine), methanol, and hydrogen (require tank/system changes)
Power Converter & Energy Storage	Advanced power converters, fuel cells, batteries (propulsion, hybrid systems, load leveling)
Propulsion Efficiency	High-efficiency propellers, pre/post-swirl stators, podded propulsion units
Hotel Load Efficiency	Smart HVAC[4], advanced insulation, waste heat recovery, LED lighting, IoT monitoring
Energy Efficiency Technologies and Measures	Monitoring fuel/speed/power, optimizing speed profiles, adjusting trim/ballast
Digitalization	AI-powered systems, big data analytics, digital twins for optimization

1) Key Energy Carriers

Retrofitting inland waterway vessels for alternative fuels like biodiesel, methanol, methane, and hydrogen requires adaptations to existing fuel systems. HVO (biodiesel) serves as drop-in fuel with minimal engine and port infrastructure modifications, maintaining compatibility with traditional diesel engines while reducing life cycle GHG emissions. Methane, methanol, and hydrogen require major adjustments in fuel tanks, storage, and delivery systems to manage their lower volumetric energy densities and unique safety characteristics, such as flammability for hydrogen and methane and corrosiveness for methanol. Limited availability of advanced biofuels and synthetic fuels remains a critical constraint, as supply chains are currently unable to support projected demand across multiple transport sectors, including aviation, heavy-duty road transport, and inland shipping (CLIA & IGRC, 2024; INE et al., 2025).

HVO is considered the most immediately viable option due to its drop-in compatibility and relatively low retrofit costs. However, it does not meet ZE standards without the addition of after-treatment technologies such as carbon capture or particulate filters (INE et al., 2025). On the cost side, due to the implementation of the EU ETS, the cost of emitting greenhouse gases is projected to rise steadily from €72 per tonne CO_2 in 2025 to €200 by 2050, narrowing the

---

[4] Heating, Ventilation, and Air Conditioning

gap between conventional diesel and biofuel prices (CLIA & IGRC, 2025). As a result, marine biodiesel, such as HVO derived from used cooking oil, is expected to become increasingly competitive. This shift is driven by the inclusion of conventional diesel in the ETS, which will lead to a price increase, while HVO benefits from significantly lower CO_2 emissions. Consequently, the prices of the two fuels are likely to converge (CLIA & IGRC, 2025).

2) Power Converter and Energy Storage Technologies

Retrofitting propulsion systems with advanced power converters, such as variable-frequency drives for electric motors, significantly enhances efficiency under variable load conditions. Batteries, integrated into hybrid systems, enable load leveling and reduce emissions by handling peak power demands. State-of-the-art lithium-ion batteries with high energy densities and improved thermal management are suited for inland vessels with predictable routes and access to charging stations. Hydrogen fuel cells, using proton exchange membrane technology, provide a ZE alternative but require pressurized or cryogenic storage for hydrogen onboard and specialized refueling infrastructure at key ports.

3) Propulsion Assistance Efficiency Technologies

Enhancing propulsion efficiency involves retrofitting systems like high-efficiency contra-rotating propellers, which optimize hydrodynamic thrust by mitigating energy losses from cavitation. Pre-swirl and post-swirl stators are increasingly adopted to reduce rotational losses in the propeller wake. Podded propulsion units, which integrate motors directly into the propeller housing, offer precise maneuverability and reduced transmission losses, making them particularly effective for narrow inland waterways. Computational fluid dynamics tools are often used to model and tailor these systems for specific hull geometries and operational profiles.

4) Hotel Load Efficiency Technologies

Reducing hotel load energy consumption, which accounts for 20-25% of vessel energy use, involves integrating smart HVAC systems with real-time climate control sensors to minimize redundant energy use. Hotel load refers to the energy required to power non-propulsion systems on a vessel, such as lighting, HVAC, galley equipment, and accommodations: essentially everything needed to maintain onboard comfort and operations when the ship is docked or cruising. Advanced insulation materials can reduce heating and cooling demands, while waste heat recovery systems convert thermal energy from engines into usable heating for water or space. Transitioning to LED lighting throughout the vessel will significantly reduce energy consumption. These retrofits often include IoT-enabled monitoring systems to continuously optimize energy use based on occupancy and ambient conditions.

5) Vessel Energy Efficiency Technologies and Measures

Vessel performance optimization involves inputs such as monitoring fuel consumption, speed, and propulsion power to enable data-driven decisions that enhance operational efficiency and identify areas for improvement. By implementing measures such as optimizing speed profiles, as well as adjusting trim and ballast conditions, operators can achieve substantial reductions in energy consumption and fuel usage. Coupled with speed optimization algorithms, these tools ensure the vessel operates within its most efficient engine load range, avoiding excessive energy consumption. Real-time data exchange with port and traffic management systems further enhances operational precision.

6) Digitalization Technologies

Advanced data platforms consolidate inputs from navigation, propulsion, and hotel systems to generate actionable insights for operators, improving operational efficiency. Digitalization technologies contribute to the decarbonization of IWT by enabling various efficiency improvements and optimizing the performance of vessels, especially after retrofitting. These technologies can be integrated into retrofitting packages, including measures to reduce overall energy consumption. For example, AI-powered systems and big data analytics can be used for monitoring fuel consumption, speed, and propulsion power, allowing for data-driven decisions that enhance operational efficiency. Optimizing speed profiles and adjusting trim and ballast conditions, guided by these digital tools, can lead to substantial reductions in energy consumption and fuel usage. Real-time data exchange with port and traffic management systems further enhances operational precision. Digital twins, as simulated models of vessels, are particularly useful for simulating operational scenarios and optimizing fuel and energy management strategies. These technologies support the shift towards more energy-efficient operations and help maximize the benefits of other retrofitting measures aimed at reducing environmental impact.

2.3.4. Current Status of United Waterways' Retrofitting Strategy

United Waterways is pursuing a two-phase retrofitting strategy to reduce GHG emissions and reach net zero in alignment with European decarbonization goals[5]. The first phase focuses on reducing GHG emissions through the use of alternative fuels, emphasizing HVO as the preferred fuel. The second phase aims to achieve net-ZE by switching to net zero technologies, once proven commercially efficient. The two-phase approach is based on the smaller size of the cruise sector compared to the cargo sector. Strategically, it is reasonable to wait and observe the technology decisions made by major cargo companies, as these will dictate the supporting infrastructure. The cruise sector, being a smaller fraction, will align with the adaptations chosen by the cargo sector. Central to this strategy is the use of dual-fuel engines, which offers flexibility in fuel options as they enable vessels to operate on both conventional fuels and cleaner alternatives like HVO or bio-methanol. In addition, battery packs play a crucial role in the overall retrofitting concept as they provide energy support during peak demand, reducing the need for generators burning diesel to operate at full capacity. Beyond battery packs, alternative fuel, and fuel systems, the company is focusing on other energy-saving measures, including improving hull insulation and enhancing onboard energy management systems. For the 100-150 passenger ships, additional strategies such as more energy-efficient propellers, digital energy management systems, and lowering cruising speeds are also discussed to achieve a reduction in fuel consumption. Such steps aim to reduce overall energy consumption as well as support the utilization of energy from carbon-neutral sources.

2.3.5. Funding and Subsidies

In light of the increasing regulatory pressure to decarbonize and the related additional financial burdens for ship operators outlined in the previous sections, there is a growing demand for financial support. Within the EU, there are several approaches to receive funding for various stakeholders within the IWT sector. In addition to the funding instruments mentioned in *Platina3* (Section 2.2.), the Innovation Fund 2024 offers direct financial support for deploying innovative low-carbon technologies, including for the IWT sector. IWT projects focusing on hydrogen propulsion, electrification, and net-zero solutions are eligible for funding, with dedicated budgets ranging from €1 billion to €2.4 billion (Esposito, 2024). The Innovation Fund is financed by the revenue of the ETS (*Innovation Fund - European Commission*, 2025).

---

[5] This information is based on the weekly meetings the team conducted with United Waterways.

Furthermore, some EU member countries like the Netherlands, Germany, Austria, and the Czech Republic offer subsidies.

The Sustainable Inland Vessels Subsidy Scheme in the Netherlands supports inland vessel owners investing in cleaner technologies. Eligible investments include Stage V EU-certified engines, catalytic converters, electric propulsion systems, and noise-reducing measures. Subsidy amounts vary based on company size:

- Large companies: up to 40% of investment costs
- Medium-sized companies: up to 50%
- Small companies: up to 60%

The maximum subsidy per vessel is €400,000. Applicants must own an inland vessel with a valid EU or Swiss shipping certificate and have operated on Dutch waterways for at least 60 days in the preceding 12 months. The application deadline is 31 October 2025, or until the budget is exhausted (RVO, n.d.).

In Germany, the Federal Ministry for Digital and Transport offers a subsidy program to support the sustainable modernization of inland vessels. Owners or operators of inland vessels can apply for funding to implement environmentally friendly upgrades, such as exhaust after-treatment systems, fuel-water emulsion systems, and other measures that enhance environmental performance. The program provides funding of up to €4.5 million per project. However, due to budget constraints, funding for multi-year or high-expenditure projects, such as extensive structural modifications or the installation of fuel cell systems, is currently limited. This program is available from January 1, 2024 to December 31, 2026 (BMV, 2024).

The Austrian Climate and Environmentally Friendly Shipping Support Program, managed by viadonau, offers up to 40% co-financing (maximum €4.5 million per project) for sustainable upgrades to inland vessels. Eligible applicants include freight and passenger vessel owners or operators in Austria investing in emission-reduction technologies or energy-efficient measures that exceed EU standards. The program runs until December 31, 2026 (viadonau, 2025).

Lastly, in the Czech Republic, the Czech state aid scheme offers grants to small and medium sized enterprises for modernizing inland vessels with eco-friendly, multimodal, and safety upgrades. Co-financing is up to 85% for small enterprises and 75% for medium ones, with a total budget of CZK 420 million. Maximum costs must not exceed 30% of a new vessel's price (EIBIP, 2019).

3. Research Questions

Building on the literature review, the following section outlines the research questions. Driven by the *European Green Deal*, the urgent need to decarbonize all modes of transportation, including IWT, calls for a reduction in fossil fuel use and greater adoption of low- and ZE technologies. The success of retrofitting the existing IWT fleet depends on the capacity of European waterway shipyards. However, a comprehensive overview of the existing shipyards, as well as an EU-wide assessment of their capacities to decarbonize the fleet, is currently missing.

The following research questions guide the analysis:

1. Where are the river shipyards suitable for retrofitting, and how many such yards currently exist across Europe?
2. Are the existing European river shipyards sufficient to meet the decarbonization targets by 2050, or is there a need for additional investment in building new retrofitting facilities?

4. Methodology

4.1. Research Design

Initially, a quantitative approach was planned, with desk research to identify relevant shipyards and an online survey to assess their retrofitting capacities. Due to low survey response rates, the methodology shifted to a more qualitative approach, with six semi-structured interviews conducted with shipyard representatives, two EU experts, and an engineering expert. A field visit to the Netherlands provided additional insights into shipyard operations. Contact with the Danube Commission, CCNR, and SeaEurope was established to gather perspectives on decarbonization and retrofitting feasibility. Furthermore, a capacity calculation completes the methodological approach. This methodological triangulation integrated both operational-level and policy-level insights.

4.2. Scope

The following sections define the geographical scope of this study and describe the fleet analyzed for the retrofitting capacity assessment.

4.2.1. Geographical Scope

The objectives and requirements of the *European Green Deal* are directed towards the geographical scope of the EU (European Council, n.d.-a). This study, however, is focused exclusively on inland waterways, excluding maritime shipping. Consequently, this research examines the retrofitting capacities of shipyards located along Europe’s inland waterways, a network that spans approximately 41’000 kilometers, linking 25 EU member states (Jacobs, 2022). The focus of this research project lies on major European rivers that have the capacity to transport at least 3 billion tonne-kilometers. Coastal shipyards near these rivers will also be considered if they have potential for retrofitting river vessels. Table 2 shows the list of all included rivers. This study will assess the shipyards along these rivers for their retrofitting capabilities.

Table 2: Key European inland waterways analyzed in this research

Region	Rivers
Western Europe	Rhine Seine Meuse Scheldt
Central Europe	Danube (upper section) Main Elbe
Eastern Europe	Danube (middle and lower section)

Figure 2: Overview of major European inland waterways according to their transport performance, Source: CCNR, 2024

4.2.2. Retrofitting Scope

The fleet under consideration for retrofitting includes various types of inland waterway vessels. For the purpose of this analysis, the retrofitting capacity for both inland waterway cruise vessels and cargo vessels will be examined. This approach is justified because shipyards suitable for retrofitting typically provide services for both types of vessels, making a separate analysis less practical[6]. In detail, for the cruise fleet, only vessels equipped with onboard hospitality facilities (minimum 40 beds) are included in the analysis. In total, the European river cargo fleet includes approximately 15,319 vessels in 2023, while the river cruise fleet comprises about 408 vessels during the same period (CCNR, 2024). Day ships are excluded from the study because their energy consumption and fuel usage significantly differ from overnight ships and cargo vessels; operators of day ships often choose electricity and batteries,

---

[6] This information is based on the weekly meetings the team conducted with United Waterways.

ase they are easy to charge, unlike overnight ships[7]. Furthermore, day ships represent a minimal segment of GHG emissions. Day ships are fundamentally distinct in terms of pricing, emissions impact, and regulatory penalties (such as emissions trading), where they can offset costs by adjusting prices.[8]

4.3. Data Collection

4.3.1. Identification of Relevant Shipyards

The first phase consisted of a systematic desk research to identify shipyards along European rivers (see Section 4.2.1) that offer retrofitting services and to compile an initial contact list. United Waterways provided a preliminary list of six partner shipyards that offer retrofitting services (Appendix II). To identify further European shipyards, desktop research was conducted to find relevant registers, but this effort was unsuccessful. To date, the research team is not aware of a comprehensive or systematic list of shipyards along European rivers. Neither the CCNR, Danube Commission, nor SeaEurope was able to provide the requested information. To compile a more comprehensive sample of shipyards, further identification was carried out using Google Maps, which allowed for the identification of additional shipyards within the study's scope. The resulting list of identified shipyards was compiled in Appendix IV, with a total of 57 shipyards identified.

4.3.2. Survey

In the second phase, the identified shipyards were contacted and invited to complete the survey in Appendix III to provide data on their retrofitting capacities, available technologies, and implementation barriers. The survey was finalized in a roundtable discussion on December 13, 2024 with an engineering expert from United Waterways and an expert from one of its partner shipyards, their expertise further supplemented the survey.

However, due to a low response rate and limited willingness from shipyards to share data, despite repeated follow-ups, the methodology had to be adapted. As a result, the study transitioned to a qualitative research design.

---

[7] This information is based on the weekly meetings the team conducted with United Waterways

[8] The decision to exclude day ships from the focus, as they are negligible in the broader context, was also aligned with the preference expressed by United Waterways.

4.3.3. Interviews and Field Visit

Originally, the research design included one interview with a shipyard representative and one with a ship engineer. However, in response to the limited survey data, this was expanded to include four more interviews. In total, six semi-structured interviews were conducted: four with shipyard representatives, one with two EU Commission IWT experts, and one with a ship engineering expert[9]. These interviews provided valuable qualitative insights into the practical and operational challenges of retrofitting in the sector. Furthermore, a field visit to the Netherlands offered an in-depth understanding of the shipyards' infrastructure, processes, demands, and perspectives.

Field Visit in the Netherlands

Figure a): Dry-dock to do repairs and retrofits on a vessel

Figure b): Ship propellers in a construction hall

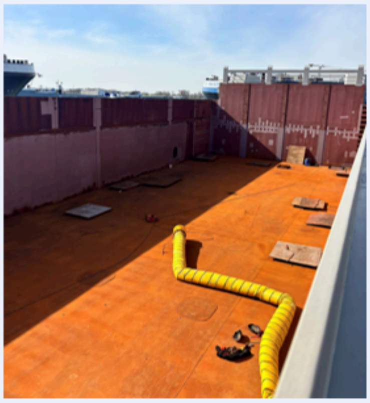


Figure c): Empty cargo space on a vessel that is under construction

On March 21st, 2025, we had the opportunity to travel to the Netherlands and visit two shipyards in collaboration with our partner organization. The field visit provided valuable insights into the infrastructure required for retrofitting and constructing inland vessels. We explored key facilities, including berths, dry docks, *hellings*, and construction halls, and gained first-hand experience of the technical processes involved in ship retrofitting and new builds. Additionally, we got the chance to board cargo and cruise vessels to get insights on vessel design, technologies, and operational requirements. During the visit, we also engaged in discussions with shipyard representatives, which allowed us to clarify technical questions and explore current challenges and solutions in retrofitting for sustainable IWT.

Figure d): A cargo ship at a berth

Source: All pictures were taken by the authors during the field trip.

---

[9] Due to the lack of responses to interview requests from shipyards, EU Commission experts, and other relevant stakeholders as well as time constraints the scope of the interviews could not be expanded.

4.3.4. Additional Data Collection

Furthermore, the Danube Commission, CCNR, and SeaEurope were contacted to gather additional information on the implementation of the EU's decarbonization goals (see contact list in Appendix I). While these organizations are key intermediaries between shipyards and the EU level, and their input would have provided a valuable perspective bridging technical and regulatory aspects in the analysis, none of these organizations could provide relevant data.

4.4. Data Processing and Analysis

The data collected through the various research phases were processed and analyzed by organizing and structuring the responses from the surveys and interviews. Given the limited survey data, the analysis relied more heavily on the qualitative insights of the survey answers and the interviews. The latter were transcribed and together with the survey answers analyzed using inductive qualitative content analysis, following the methodology proposed by Mayring (2010). The aim was to identify key themes and patterns related to the retrofitting capacities of shipyards, barriers to implementation, and the operational challenges faced by industry stakeholders.

Inductive Qualitative Content Analysis

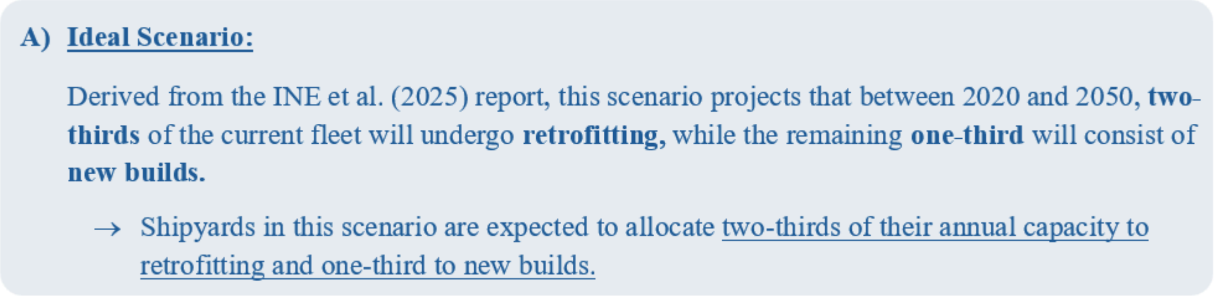
Qualitative content analysis is a systematic methodology that is used to analyze the content of interviews and qualitative survey responses. Its aim is to reduce the complexity of the data while retaining essential meaning. This is achieved through the development of a category system, which defines the aspects of the data that are relevant to the research and helps filter them accordingly (Mayring, 2010).

In this study, an inductive approach is applied, meaning that categories are derived directly from the data material itself (see Table 3). Through a process known as "tagging", sections of interviews and surveys were assigned to recurring categories, enabling a structured analysis to answer the research questions. Related or thematically similar aspects are grouped together and represented through a shared category.

4.4.1. Capacity Calculation

The capacity calculation presented in this report is based on data from the annual report of the CCNR (2024), which details the existing fleet of 15,319 cargo vessels and 408 cruise vessels operating on European IWT.

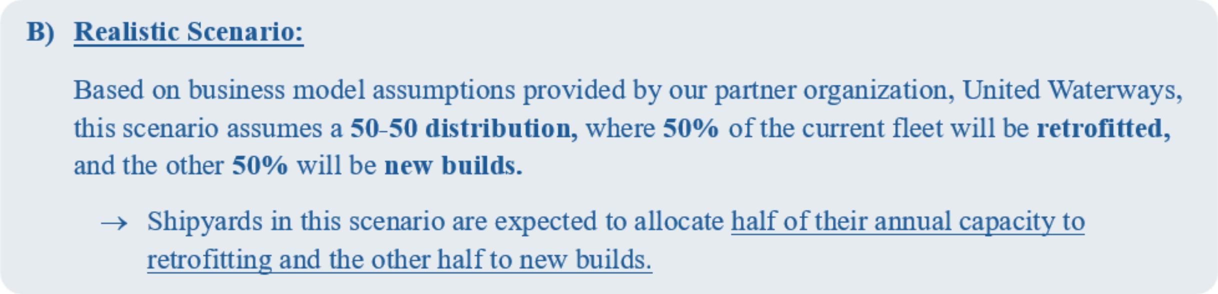
Two scenarios were considered for this calculation, with corresponding implications for shipyard capacity:



A) Ideal Scenario:

Derived from the INE et al. (2025) report, this scenario projects that between 2020 and 2050, **two-thirds** of the current fleet will undergo **retrofitting,** while the remaining **one-third** will consist of **new builds.**

→ Shipyards in this scenario are expected to allocate two-thirds of their annual capacity to retrofitting and one-third to new builds.



B) Realistic Scenario:

Based on business model assumptions provided by our partner organization, United Waterways, this scenario assumes a **50-50 distribution,** where **50%** of the current fleet will be **retrofitted,** and the other **50%** will be **new builds.**

→ Shipyards in this scenario are expected to allocate half of their annual capacity to retrofitting and the other half to new builds.

The calculations are based on several assumptions. Given the uncertainty around the specific technologies that will be used for retrofitting, an average time frame of 3–8 months was mentioned in the conducted interviews. For the calculation, retrofitting a vessel is estimated to take 6 months, and constructing a new build is assumed to require 24 months. These durations are used in United Waterways' business analysis, despite the study by Chandrasekar & Godjevac (2023) suggesting that new ZE vessel construction takes about twice as long as retrofitting. The analysis covers the 25-year period from 2025 to 2050, under the assumption that shipyards operate year-round. Additionally, the capacity of a mid-sized shipyard with 11 berths was used as the basis for these calculations.

The calculation estimates the number of shipyards required to decarbonize the entire current fleet of European IWT vessels, focusing solely on new builds and retrofits. It excludes other routine shipyard activities, such as maintenance and repair work.

Several limiting factors constrained the ability to conduct a more detailed calculation:

1. **Growth Rate for New Builds:** The calculation does not account for new ships entering the market alongside the existing fleet, as reliable growth rate data for new builds is unavailable. However, sustainable shipping is expected to grow significantly, with inland waterway and short-sea shipping traffic projected to rise by 25% by 2030 and 50% by 2050 (European Commission, 2020). Due to inconsistent data from various sources, the impact of this growth on fleet demand and shipyard capacity could not be factored into the calculation.

2. **Number of Comparable Shipyards:** The analysis focuses on the capacity of a mid-sized shipyard, [redacted] with 11 berths. As the initial method did not yield comprehensive data on the availability and retrofitting capacities of European IWT shipyards, the number of similar-sized shipyards remains unknown.

3. **Current Shipyard Workload:** Data on the current workload of shipyards, particularly for repair work and maintenance, is unavailable, as the survey response was limited. This prevents a precise estimation of how much capacity might be available for retrofitting and new builds.

4. **Standardization of Retrofitting:** Retrofitting processes and technologies are not yet standardized, leading to uncertainty about timelines and methods, which further complicates precise calculations.

These limitations highlight areas where further research and data collection would be beneficial for creating a more robust capacity calculation.

4.5. Limitations

The principal limitation of this research lies in its heavy reliance on feedback from shipyards, coupled with significant challenges in identifying and reaching these stakeholders. Specifically:

1. **Lack of a centralized directory:** There is no comprehensive directory of shipyards located for European inland waterways, including details about their size or whether they offer retrofitting services. This creates uncertainties about the total number of shipyards

and complicates efforts to define the study's population size. Therefore, it is difficult to tell how representative the 57 identified shipyards are. The study's scope is limited to major rivers, however, ship new building and retrofitting can also be done in tributary rivers, which were not considered in this study.

2. **Sampling constraints**: Six interviews were conducted, with two interviewees representing the same shipyard. Additionally, the survey received responses from four shipyards, two of which were also included in the interview sample.
3. **Challenges in communication**: Initial contact to all 57 shipyards was made via email to general addresses (e.g., info@domain.com) due to the absence of alternative contact information. Despite email trackers indicating that most emails were opened and read, no responses were received after two rounds of outreach. To overcome this, the approach shifted to direct phone calls, which ultimately resulted in only four survey responses from shipyards. The low response rate could be attributed to several factors, including the lack of a centralized directory, making initial contact difficult, the potential sensitivity of sharing data on capacities and future plans, the high volume of inquiries shipyards may receive, and the lack of motivation to answer to surveys sent out by students with no direct shipyard affiliation.
4. **Potential confirmation bias**: Most of our interviews were arranged through existing networks, particularly through United Waterways. While this helped open doors, it may also have shaped the diversity of viewpoints that are included in this study.

These limitations highlight the difficulties in engaging stakeholders and obtaining representative feedback, which may impact the comprehensiveness and generalizability of the research findings.

Based on our initial findings, a decision was made in consultation with the project supervisor and partner company to shift from a quantitative research approach to a qualitative one. This decision involved focusing on conducting the in-depth interviews with a smaller number of shipyards.

5. Findings and Analysis

This section presents the findings derived from four survey responses and six interviews, supported by data from the literature. The analysis of the interview followed the methodology outlined in Section 4.4 and is structured around five key categories that reflect the core dimensions of retrofitting for decarbonization in the shipping sector that emerged within the context of the research: Technological Conditions, Infrastructure & Capacity, Economic Considerations, Policy & Regulatory Framework, and Market Development & Demand. Additionally, a cross-cutting category on Barriers & Uncertainty as well as Strategies & Future Planning is included to highlight the sector's challenges and long-term outlook. This method allowed for a systematic analysis of the data and the formulation of insights relevant to understanding shipyards' past, current, and future capacities, along with their limitations, challenges, and opportunities. An overview of each category is provided in Table 3. At the beginning of each section, a short summary of the findings is added. Furthermore, Section 5.8 includes literature, survey, and interview data related to the geographic locations of the shipyards, while Section 5.9 elaborates on the capacity calculation.

Table 3: Category System, created by authors

Category	***Content***
1. Technological Conditions	*Available technologies (e.g., electric, hydrogen, drop-in fuels, hybrid systems)*
	Technological readiness (commercial use vs. pilot stage)
	Technical challenges in retrofitting vessels
	Modularity and adaptability of ship design
2. Infrastructure & Capacity	*Shipyard capacity (seasonal differences, newbuilding vs. retrofitting)*
	Port infrastructure (e.g., hydrogen supply, shore power)
3. Economic Considerations	*Investment costs (for retrofits, docks, cranes, etc.)*
	Economic viability of retrofitting vs. newbuilding
	Subsidies and public funding schemes
	Motivation of stakeholders (compliance-driven vs. intrinsic)
	Perceptions of sustainability as a market advantage
4. Policy & Regulatory Framework	*Influence of EU policy (e.g., Fit for 55, ETS, FuelEU)*
	Regulatory uncertainty or gaps
	Expected future regulations (e.g., emissions reporting)
	Role of regulation in driving innovation
5. Strategies & Future Planning	*Short- and long-term planning horizons (2030 vs. 2050)*
	Flexibility and modular design as a strategic tool
6. Market Development & Demand	*Current demand for retrofitting services*
	First-mover disadvantage and hesitation
	Perceptions of market trends
7. Barriers & Uncertainty	*Technological uncertainty (e.g., green methanol not commercially available)*
	Infrastructure limitations (e.g., no hydrogen capability in ports)

5.1. Technological Conditions

The category Technological Conditions includes discussions about the available technologies, their level of readiness, and the technological challenges associated with retrofitting.

Key Findings

- Wide range of technologies: HVO, hydrogen, methanol, electric, hybrid, battery packages
- Short-term: Stage V combustion engines + HVO as most realistic option
- Long-term: Hydrogen, methanol hindered by costs, supply & policy
- Fully electric vessels only for short distances
- Modular ship design & standardization as key enablers for retrofitting

Interviewees expressed a consensus that while various technologies are under discussion for decarbonizing inland navigation, current practical implementation is constrained by readiness levels, lack of standardization, infrastructure gaps, and cost-related risks. Most interviewees referred to the conservative pathway of the CCNR involving Stage V engines in combination with HVO as the most realistic short-term interim solution, especially in combination with modular engine designs to make future upgrades more compatible. This also aligns with the *Statement by the IWT and Ports Sector on the STIP* (2025) more cautious scenario. Given that around 99% of vessels today are still powered by conventional diesel engines, HVO is particularly attractive as it can be used as a drop-in fuel in existing engines without the need for significant investments and changes. Some actors noted that for further emission reduction towards ZE, it requires aftertreatment technologies (e.g., carbon capture) or full system replacement, which is also confirmed by INE et al. (2025).

Liquefied Methanol and hydrogen in combination with fuel cells were acknowledged as promising long-term solutions, but are currently hindered by underdeveloped supply chains, lack of refueling infrastructure, cost reasons (need for major adjustments on board and expensive fuel), and the lack of regulatory clarity. The lower technology readiness level and higher costs compared to HVO were also confirmed by INE et al. (2025). Battery-electric solutions were generally viewed as best suited for short-distance operations and not as a real solution for long-distance travel up to 2050.

Several interviewees emphasized the growing demand for hybrid and dual-fuel systems as a practical step forward. This finding was also confirmed by one of the surveyed shipyards that was not part of the interview sample. Also, INE et al. (2025) and Karaarslan & Quispel (2021) highlight the possibility for a gradual adoption towards ZE with hybrid and dual-fuel systems, enabling vessel operators to spread financial investments over time and flexibility in fuel type.

Some interviewees expressed concerns about supplier dependencies and technological uncertainty. However, technological availability constraints were not recognized by all interviewees. While some clearly stated that the needed technology is not yet available, others mentioned that they do not see technology availability as a limiting factor. The lack of standardization, however, was generally acknowledged as a bottleneck. A standardized retrofitting approach would give more clarity and certainty to the sector. Modular ship design was repeatedly mentioned as a key strategy to enable future retrofitting. The sector was described as still being in a learning phase, with no clear technological standard emerging yet.

5.2. Infrastructure and Capacity

The following discusses shipyard capacities, including seasonal and categorical differences, and the existing infrastructure at the shipyards.

Key Findings

- Different capacities at the shipyards
- Most shipyards retrofit all vessel types (cargo and cruise); 135m length
- Retrofitting time: 3–8 months – vague due to lack of standardized procedures
- Modularity & standardization reduce time and increase capacity
- HVO easiest to integrate with shipyards' infrastructure; Hydrogen/methanol need new infrastructure

The size of the examined shipyards and their types of retrofitting facilities varied significantly. Mentioned facilities included berths, dry-docks, and helling[10], with the choice depending on the type of retrofitting and the size of the ship.

All shipyards, except for one, confirmed that they offer retrofitting services for cargo and cruise vessels. This supports the decision taken in Section 4.2.2. to include all types of ships and not differentiate between cargo and cruise vessels. All interviewees and survey respondents stated that they are capable of retrofitting vessels of any size. In the survey, a standard vessel length of 135 meters was stated. This indicates that neither the type nor the size of a vessel is a decisive factor in determining retrofitting capability.

---

[10] A helling is a transverse slipway used to move vessels out of the water for maintenance, repair, or retrofitting purposes.

While some shipyards are already fully engaged in retrofitting, others are either focused on new builds or are planning to begin offering retrofitting services in the coming years. While some interviewees reported that their shipyards still have capacity, others reported being fully booked for up to ten years.

Retrofitting for decarbonization timelines varied between three to eight months, depending on preparation, labour availability, and project complexity. Seasonal demand patterns (e.g., cruise vessel retrofits and maintenance typically occur in winter, as the main operating season is summer) further limit availability. Preparatory time for engineering and ordering retrofitting materials must also be considered. Standardizing retrofitting packages across a fleet of vessels was identified as a key factor for reducing retrofitting time. Together with modularity in ship design, it was highlighted as a promising approach for the future, enabling faster and more efficient retrofitting as technological standards continue to evolve. Minimizing retrofitting time is crucial for managing limited shipyard capacities, especially in light of the expected increase in retrofitting demand driven by rising sustainability standards and the targeted growth of freight transport on the EU's inland waterways, according to the *SSMS*.

Interviewees expressed differing views on the long-term role of retrofitting. Some saw it as essential for the long-term, others saw it as a viable solution only for the next 10–15 years, after which new builds would likely become dominant due to superior energy efficiency.

The interviewees expressed differing views on whether their capacity and capability would be limited by workforce availability and expertise. Some shipyards considered upskilling their workforce for new technologies as an important element in the decarbonization of IWT, while others did not see it as a decisive factor. The possibility of sharing workforce capacities among neighboring shipyards was mentioned as a potential way to address gaps in labour availability and specialized knowledge.

The energy transition in inland navigation requires not only changes to vessels themselves but also significant upgrades to shipyards' infrastructure and capabilities. This includes both the availability of clean energy refueling and storage and the technical capability to carry out new builds and retrofitting. HVO was generally viewed as the most infrastructure-compatible alternative fuel. Interviewees noted that existing refueling systems can accommodate HVO without major adjustments. In contrast, fuels like hydrogen and methanol were described as requiring substantial investment in supply chains, storage, and bunkering facilities. The lack of market-ready infrastructure for these fuels was considered as a major barrier, creating a "chicken-and-egg" problem where infrastructure will not be built without vessel demand, and vice versa. These findings about infrastructure compatibility and adjustments are also mentioned in the *Status Report of the CLIA and IGRC* (2024) and the *Statement by the IWT and Ports Sector on the STIP* (2025). In addition to the shipyards' space and infrastructure limits (e.g., cranes), retrofitting capacity also depends on broader system constraints, such as canal and dam infrastructure.

5.3. Economic Considerations

The category *Economic Considerations* includes discussions about investment costs, the economic viability of retrofitting versus building new vessels, subsidies and public funding schemes, stakeholder motivations, and the perception of sustainability as a market advantage.

Key Findings

- High investment costs require long-term financial planning (20-year period)
- Retrofitting offers short-term competitiveness (10 years)
- Retrofitting as a cost-effective and time-efficient alternative to new-builds
- Various funding and subsidy schemes from the EU and EU member states are vital to progress retrofitting.
- Stakeholders face compliance pressures but are also driven by sustainability goals to ensure long-term business viability.
- Financial support is critical, but even subsidized projects face delays due to economic, technical, and organizational barriers.

Interviewees highlighted that investment costs for retrofitting or building new vessels are substantial, often requiring a long-term financial outlook. United Waterways' business model structures ship investments around a 20-year timeline. Over this period, vessels are expected to generate revenue sufficient to cover loan repayments and beyond. Significant new investments, such as large-scale retrofitting or new builds, are typically deferred until the original loans are fully repaid, which can pose challenges for initiating major upgrades or replacements.

Another perspective noted that while retrofitting may provide competitiveness for older vessels in the short term (around 10 years), these vessels are unlikely to remain viable in the long term compared to newly built ships. This is mainly due to high investment costs, long-term economic challenges, and inferior energy efficiency compared to new builds. However, stakeholders emphasized that retrofitting remains a cheaper and less time-consuming solution than new builds, which is a critical factor for operators seeking to minimize downtime and avoid the extended lead times associated with vessel construction. EU-level experts advocated for modular retrofitting approaches as a cost-effective solution to maintain alignment with evolving standards over time.

Retrofitting with carbon capture or exhaust treatment systems adds cost and complexity. While technically feasible in pilot cases, these technologies have yet to reach commercial maturity for widespread deployment in IWT (CCNR, 2022). In addition, current price disadvantages of HVO compared to diesel, policy uncertainty, and limited supply capacity were cited as key barriers to large-scale adoption. These challenges are further compounded by the total cost of ownership gap between zero-emission technologies and conventional engines, which remains up to 2.9 times higher under current market conditions (CCNR, 2022).

Subsidies and public funding schemes were seen as critical enablers for both retrofitting and new building. EU experts cited initiatives like PLATINA, which supports the modernization and sustainability of IWT through innovation, green technologies, and policy integration. CEF, while focusing on infrastructure, also provides vessel funding opportunities. One notable subsidy scheme in the Netherlands in 2024 aimed to support vessel retrofitting with new engines, however, shipyards reported a lack of noticeable demand increase, suggesting potential barriers to adoption despite financial incentives. A prevailing view among stakeholders was that without robust funding and subsidies from the EU or EU member countries, significant progress in retrofitting will remain limited. This was also confirmed in the literature, EU and national funding play a vital role in driving sector changes in IWT (CLIA & IGRC, 2025).

Motivations for stakeholders were described as both compliance-driven and intrinsic. EU experts noted that sustainability is increasingly seen as essential for long-term business viability. Shipowners, for example, were motivated to retrofit rather than face high fees of the upcoming ETS costs. Shipyards, meanwhile, view retrofitting as a way to position themselves favorably in the market, attracting vessel owners seeking energy efficiency and compliance. Shipowners also emphasized the economic advantage of energy efficiency improvements, which can result in energy savings of 40–60%, providing a clear financial incentive.

5.4. Policy and Regulatory Framework

The category *Policy and Regulatory Frameworks* encompasses discussions on the influence of EU policies, stricter local regulations, regulatory uncertainties, and anticipated future regulatory developments.

Key Findings

- The EU is expected to introduce a clearer regulatory framework for retrofitting IWT vessels within 3-4 years, delayed by the ongoing development of compliance methodologies for GHG emissions and pollutant indicators.
- In the short term, shipowners should focus on improving energy efficiency.
- New regulations may include emission reporting, efficiency standards, advanced fuels (e.g., drop-in, hydrogen, methanol), and an Energy Efficiency Design Index (EEDI) for new builds.
- Stricter regional regulations are being enforced, as seen in Amsterdam.

Interviewees noted the influence of EU policies on IWT, acknowledging that while the sector historically received limited attention due to its relatively small size and lower pollution levels compared to sea-going vessels, it is now becoming a focus of regulatory efforts. Forthcoming regulations, such as the New Land and Multimodal Transport Guidelines, were cited as steps toward greater integration. EU experts highlighted efforts to adapt elements of the FuelEU Maritime legislation to monitor greenhouse gas intensity within the IWT context. One shipyard pointed to Amsterdam's stricter regulations, which exclude vessels using gas oils, diesel oils, and liquefied natural gas from fuel discounts, while incentivizing alternative fuels like hydrogen, electricity, and ammonia (Port of Amsterdam, 2024). Interviewees also noted that in ports like Antwerp and Rotterdam, stricter regulations are emerging too. Rotterdam has already enforced stricter rules, while Antwerp remains more lenient. However, these differences highlight that the issue is as much economic as regulatory.

The inclusion of IWT in the *EU ETS,* starting in 2027 for United Waterways and becoming more impactful by 2031, is seen as a potential game-changer. It is expected to narrow/close the cost differences between alternative fuels and conventional diesel by this date, thereby eliminating cost-based arguments against adopting alternative fuels. However, alternative fuels' lower energy density remains a challenge, requiring either larger fuel tanks, more frequent bunkering, or shorter routes.

Regulatory uncertainty remains a significant concern. EU experts admitted that methodologies for measuring compliance and determining relevant indicators, such as GHGs and air pollutants, are still under development. They emphasized the need for holistic approaches to future-proof vessels while addressing complexities like varied vessel types and operational conditions. Shipowners and shipyards expressed frustration over the lack of clear direction, particularly regarding technological pathways. Policy fragmentation across member states further complicates investment decisions, as differing national interpretations of EU directives result in inconsistent implementation and conflicting local regulations (Karaarslan & Quispel, 2021). Despite these challenges, EU experts were optimistic that comprehensive regulations for IWT would be established within the next 3–4 years, encouraging stakeholders to prioritize energy-saving measures in the interim. Expected future regulations are likely to include advancements in emissions reporting and vessel efficiency standards. EU experts suggested that future solutions will revolve around drop-in fuels, batteries, hydrogen, and methanol, though the viability of ammonia remains uncertain. Proposals such as implementing a "black box" to collect and analyze operational data and introducing an Energy Efficiency Design Index for new builds were viewed as potential steps toward achieving a more sustainable and regulated IWT sector.

As the sector explores more advanced decarbonization pathways such as hydrogen propulsion, new economic and regulatory dimensions emerge. Governments and regulatory bodies are being called upon to develop new standards and safety guidelines for hydrogen fuel usage, and operators must invest in training and safety equipment. Experiences such as that of the FPS Maas, taking approximately 2.5 years for approval, compared to only six months for the FPS Waal, illustrate the improving preparedness of regulatory bodies to quickly adapt to new technologies. This regulatory momentum could further influence the economic attractiveness of retrofitting, particularly when paired with accelerated approval processes and targeted funding for emerging technologies.

5.5. *Strategies and Future Planning*

This section explores how shipyards are strategically planning for the future, with a focus on infrastructure expansion and technological adaptation.

Key Findings

- Shipyards are actively expanding infrastructure and planning for ZE technologies with strategic timelines projecting until 2050.
- Retrofitting is prioritized in the short term, while new builds are expected to become more viable as ZE technology costs decline.
- Workforce upskilling and modular ship design are seen as essential for enabling technological adaptation and future retrofits.

The shipyards operating in the IWT sector demonstrate different strategic directions through their interview responses when planning their operations. The industry-wide shift toward decarbonization requires shipyards to adopt a long-term perspective. Strategic efforts were described as focusing on both upcoming retrofitting projects and infrastructural developments to support ZE vessel technologies, which has also been confirmed by INE et al. (2025).

According to the interviewees, one of the core elements of these strategic plans involves significant infrastructure investment. Some shipyards reported engaging in expansion efforts, including the construction of new facilities and the expansion of their capacity. These measures were seen as a way to increase capacity for retrofitting while also improving workflow efficiency (CLIA & IGRC, 2024). The facility expansion was presented as a response to anticipated demand increases. The construction of extended quays represents a direct solution to handle more ships while supporting complex retrofitting operations. However, Chandrasekar & Godjevac (2023) highlight the need of a significant and rapid expansion of facilities to meet decarbonization targets in the Netherlands.

EU level experts highlighted the significance of modular design in shipbuilding to enable future technological updates through easier retrofitting processes. This method recognizes that vessels must be adaptable for future technology upgrades, including dual-fuel advancements and improved battery systems (INE et al., 2025). The short to medium term requires retrofitting, but new buildings are expected to become more competitive in the long term due to their anticipated cost-effectiveness and energy performance benefits.

5.6. Market Development and Demand

This category examines the current and prospective demand for retrofitting services, potential first-mover disadvantage and related hesitations, and evolving perceptions that shape future market trends.

Key Findings

- Retrofitting is becoming a strategic priority for shipyards, but high costs and uncertainty limit commitment to ZE technologies.
- Standardized retrofit packages and collaboration are viewed as ways to increase market readiness.
- Subsidies alone are insufficient to drive uptake without clearer economic and technical pathways.

For shipbuilding companies, retrofitting could increasingly become a competitive necessity, which drives their need to develop these capabilities. Shipowners show a mix of caution when implementing new ZE technologies due to their high costs and innovative nature. While the potentials of ZE technologies are acknowledged, there remains hesitancy to commit to large-scale ZE solutions without more clarity on their long-term economic and technical viability. Collaboration among shipyards to secure subsidies and jointly develop standardized packages was cited as a promising strategy.

Industry stakeholders predicted in the interviews that the volume of retrofitting projects could rise significantly over the next 10 to 15 years. Interviewees also pointed out multiple logistical and capacity constraints that make the market environment more complex. Clients require fast execution of retrofitting projects while the current slots remain limited. At the same time, concerns about whether retrofitted ships will remain economically competitive against new builds were raised. The development of second-hand ship markets was cited as a variable that might affect market trends. Purchasing existing vessels to refit them offers owners a potentially more budget-friendly solution compared to building new ships.

As previously mentioned, an interviewee noted that in the Netherlands, subsidies were offered to vessel owners for retrofitting engines. However, the initiative had limited uptake and did not lead to increased activity for shipyards. The availability of financial support alone does not appear to guarantee uptake, as technical uncertainties and economic factors continue to influence decision-making processes.

5.7. *Barriers and Uncertainty*

Barriers and Uncertainty addresses the main challenges, such as technological immaturity and limited infrastructure at shipyards. .

Key Findings

- Low technology readiness and missing infrastructure slow ZE adaptation in inland waterway shipping.
- High fuel costs, price volatility, and policy gaps hinder investments in alternative fuels.
- Shipyard capacity and supply chain constraints limit large-scale retrofitting.
- Retrofit projects delays stem from economic, organizational, and technical risks.

These factors continue to slow down the decarbonization of the shipping industry. This aligns with findings from the literature review, which emphasize that despite growing interest, the low technology readiness levels and underdeveloped infrastructure for ZE options continue to act as major impediments to rapid decarbonization (INE et al., 2025).

The interviews suggest that the strategic planning of shipyards for IWT decarbonization faces multiple essential barriers and uncertainties. A primary concern among respondents was the absence of established ZE technologies that are ready for market use. For example, the interviewees expressed skepticism towards green hydrogen as a viable solution due to the lack of sufficient infrastructure along the value chain. Similarly, CLIA & IGRC (2024) point out that hydrogen, while promising, currently lacks the required refueling infrastructure and safety protocols for widespread deployment in IWT.

A further challenge identified was the absence of established standards and clear regulatory frameworks at the EU level. The process of obtaining the required permissions for hydrogen technology implementation was often cited as an example of these regulatory difficulties.

Economic factors were also mentioned as major obstacles to strategic planning. According to the interviewees, the high cost of alternative fuels such as HVO poses a considerable economic barrier, especially when compared to conventional diesel. This challenge is compounded by broader economic uncertainty, unstable price forecasts, and the absence of well-established business models for implementing new fuel systems. Each of which discourages investment and slows decision-making. These concerns are supported by the literature review, which emphasizes that unclear economic returns and volatile fuel markets deter investment and stall the scaling of alternative fuel retrofits (INE et al., 2025).

In addition to these broader market factors, structural limitations on the shipyard side were also noted. Retrofitting capacity for new fuels and propulsion technologies is constrained. Interviewees emphasized that shipyards must invest in upgraded infrastructure, including advanced cranes and modernized harbor facilities, to meet future demand. CLIA & IGRC (2023) similarly identify insufficient physical infrastructure, such as dry docks capable of handling complex ZE retrofits, as a major constraint on capacity scaling. Supply chain issues further exacerbate the situation, with critical components such as batteries being produced by a limited number of suppliers, creating bottlenecks in retrofitting timelines.

If steel tariffs increase, this could create a significant financial obstacle to retrofitting efforts in Europe, given that steel is a key material in shipbuilding. Higher input costs can strain shipyard budgets, delay compliance timelines, and make retrofitting less attractive, especially if domestic supply is limited or global prices rise due to market shifts. This concern was stated by United Waterways representatives.

5.8. Location of the Shipyards

As part of the research, a total of 57 shipyards were identified (see Appendix IV and Figure 3). The one shipyard outside of the research perimeter, located in the west of France, was included, as the desk research revealed that ships operating within the perimeter of this study are also built or retrofitted at that location.

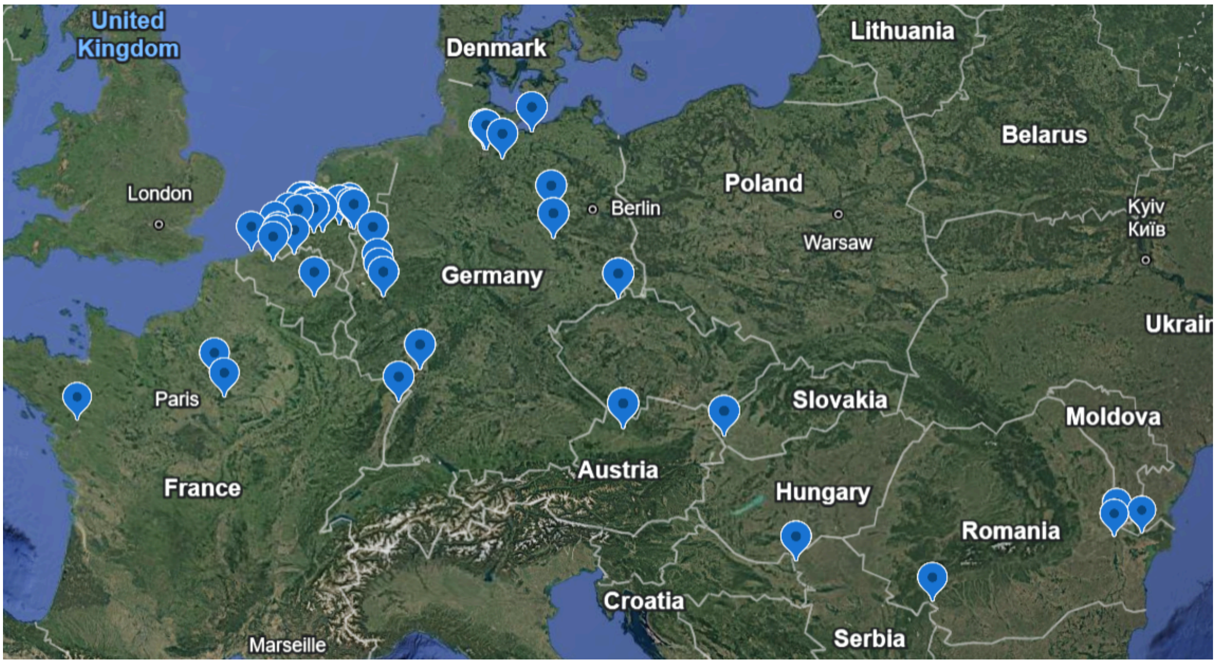


Figure 3: Overview of the identified Shipyards, created by the authors

Although the geographical scope of the study was clearly defined, challenges arose in the context of investigating the Rhine estuary. Its mouth forms a highly intricate river system, which led to the identification of shipyards in the Netherlands situated along its tributaries.

Overall, the desk research revealed a clear concentration of shipyards in the estuarine areas of the Rhine/Waal, Scheldt, and Meuse in the Netherlands and Belgium. This finding was also supported by three of the interviews, where it was emphasized that specialized shipyards for retrofitting are predominantly located in the Netherlands. The findings are reinforced by research observations, notably the concentration of studies conducted in the Netherlands. This is further evidenced by frequent references to the country in the literature, especially in relation to its stringent environmental regulations and leadership in retrofitting innovations.

5.9. Capacity Calculation

The calculation estimates the number of shipyards required to decarbonize the entire European IWT fleet (15,727 vessels) by 2050, based on the methodological approach and assumptions mentioned in subsection 4.4.1. In the 'ideal' scenario (⅔ retrofit & ⅓ new build), 36 mid-sized shipyards operating year-round over the next 25 years would be needed. In the 'realistic' scenario (½ retrofit & ½ new build), this number increases to 54 shipyards (Figure 4).

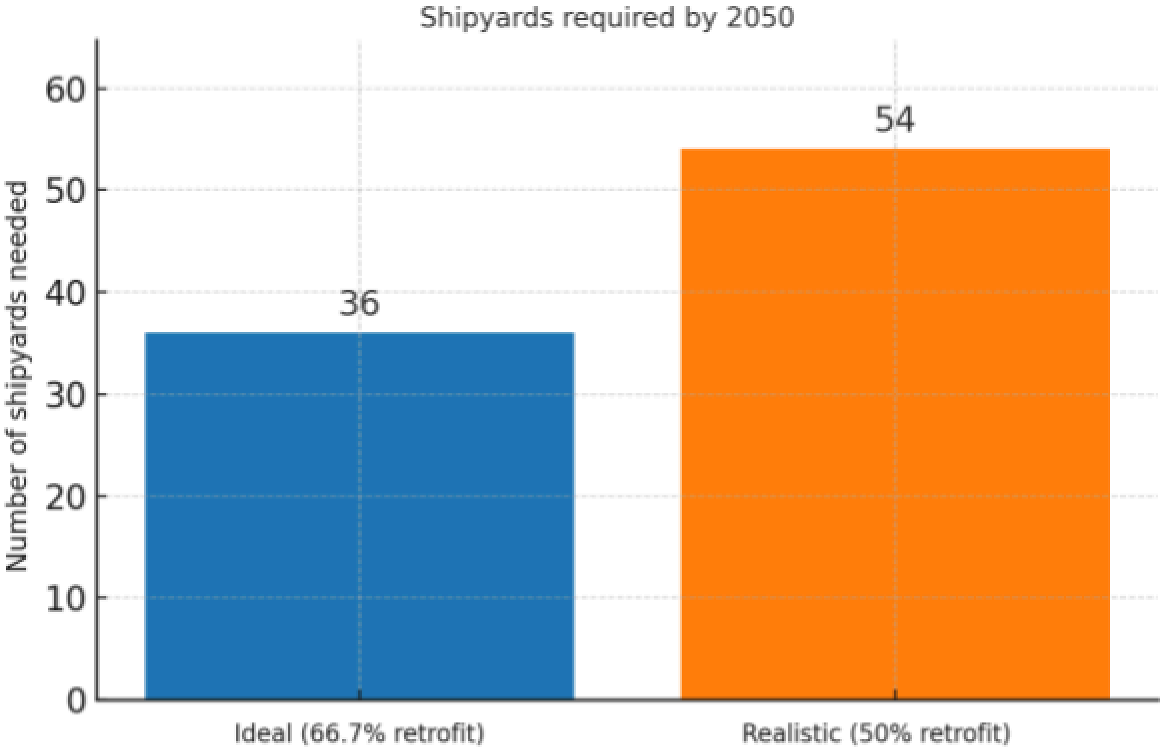


Figure 4: Shipyards needed by 2050 in the 'ideal' and 'realistic' scenarios, created by the authors

In the 'ideal' scenario, the shipyard's annual capacity is 17.5 vessels. However, in the 'realistic' scenario, this capacity decreases to 14.5 vessels per year due to the higher volume of new-build projects, which require longer timelines to complete. In Figure 5, the number of shipyards needed and the corresponding capacities are visible.

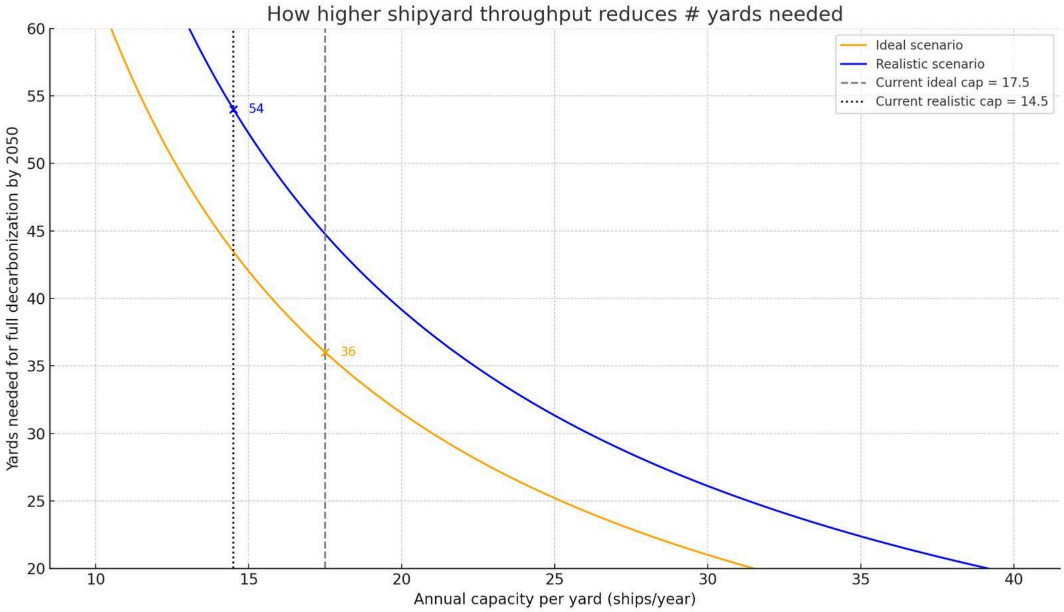


Figure 5: Correlation between needed Shipyards and Annual Capacity per Shipyard, created by the authors

The analysis identified 57 existing shipyards of various sizes. While the estimated need is 36–54 mid-sized, the calculation excludes repair and maintenance work, as well as additional new build vessels that would expand the current fleet, indicating huge additional demand for shipyards. Additionally, seasonal demand patterns (e.g., summer business of the cruise sector) impact capacities. Insights from our partner organization suggest that the required number of mid-sized shipyards, [redacted] is lacking. This suggests that current shipyard capacity may be insufficient to handle retrofitting and new builds through 2050, and additional shipyards that offer retrofitting/new build or a significant increase in efficiency and capacity at existing shipyards is needed. However, these conclusions should be viewed cautiously due to the limitations of the calculation.

6. Conclusion

This research aimed to identify the locations of shipyards that are equitable for retrofitting and their retrofitting capacities to decarbonize the European IWT. Answering the following research questions:

Research question 1 - Where are the river shipyards suitable for retrofitting, and how many such yards currently exist across Europe?

A concentration of IWT shipyards is evident in the estuarine areas of the Rhine/Waal, Scheldt, and Meuse in the Netherlands and Belgium, with interviews confirming that retrofitting shipyards are predominantly located in the Netherlands.

Research question 2 - Are the existing European river shipyards sufficient to meet the decarbonization targets by 2050, or is there a need for additional investment in building new retrofitting facilities?

Over the next 25 years, 36 to 54 mid-sized shipyards will be required to focus exclusively on new-builds and retrofitting to decarbonize the IWT fleet. This estimate excludes repair, maintenance, and market growth for new-built ships, suggesting the actual need may be even higher. Discussions with United Waterways indicate that the current number of mid-sized shipyards is insufficient to reach the decarbonization goal by 2050.

Besides the findings that directly are in support of answering the research questions, some additional conclusions can be drawn. The findings indicate that retrofitting plays a vital role in reducing emissions and achieving ZE goals for the current IWT fleet, without requiring the construction of entirely new vessels. This is especially relevant in high-traffic corridors such as the Rhine and Danube, where emissions are heavily concentrated. Despite notable engineering challenges and significant upfront investment, retrofitting presents a cost-effective and time-efficient alternative to new builds, enabling substantial emissions reductions. Major obstacles slowing the transition include limited availability and scalability of alternative fuels, uncertain cost-competitiveness, lack of policy support, and regulatory uncertainty. While discrepancies exist between the literature and stakeholder feedback regarding the long-term balance between retrofitting and new builds, the development of standardized retrofit packages and modular designs emerge as key enablers. These innovations can significantly reduce both the time and cost per retrofit, enhancing the overall feasibility and attractiveness of this transition pathway.

6.1. Recommendations

Develop a Centralized Shipyard Database	A comprehensive, publicly accessible database detailing the location, size, technical capabilities, and retrofitting services of European shipyards would significantly improve planning and resource allocation across the sector.
Standardize Retrofitting Packages	EU-level guidance on standard retrofitting configurations (e.g., for HVO-compatible systems or hybrid-electric modules) could reduce costs, increase shipyard efficiency, and de-risk investment for operators.
Expand and Tailor Subsidy Schemes	Existing subsidy mechanisms should be expanded and streamlined. Tailored schemes addressing retrofitting timelines, vessel types, and geographic disparities would enhance accessibility, especially for small-to-medium enterprises.
Support Workforce Development	Establish training programs in partnership with vocational schools and technical universities to equip the next generation of workers with the skills needed for retrofitting technologies.
Enhance Infrastructure Readiness	EU and national governments should co-invest in alternative fuel infrastructure, particularly hydrogen and methanol bunkering facilities, to eliminate the “chicken-and-egg” problem facing ZE fuels.
Promote Modular Ship Design	Encourage modularity in new builds and retrofits to future-proof vessels and enable phased technology adoption.

6.2. Areas for Future Research

Shipyard Workload and Retrofitting Allocation Models	Future studies could quantify the current operational load of European shipyards and develop dynamic models to project how retrofitting demand can be absorbed without disrupting other services.
Life-Cycle Cost-Benefit Analyses	There is a need for comparative life-cycle economic assessments between retrofitted vessels and new ZE builds, incorporating variables such as alternative fuel prices, real-time emissions taxes, and maintenance costs.

Geospatial Optimization of Retrofitting Infrastructure	Further research could apply GIS and logistics modeling to optimize the placement of new shipyards or retrofitting hubs in underserved or high-potential regions.
Behavioral Economics of Shipowners	Understanding the decision-making process and perceived risks from the perspective of shipowners could highlight non-technical barriers to retrofitting uptake.
Assess Modular Ship Design	Assess modularity in retrofits and new-builds to future-proof vessels and enable phased technology adoption.

Bibliography

Bundes Ministerium für Verkehr [BMV]. (2024). *Verwaltung und Betreuung der Wasserstraßen*. https://www.bmv.de/SharedDocs/DE/Artikel/WS/foerderrichtlinie-nachhaltige-modernisierung-binnenschiffe.html

Central Commission for the Navigation of the Rhine [CCNR]. (2022). *CCNR Roadmap—For Reducing Inland Navigation Emissions*. https://www.ccr-zkr.org/files/documents/Roadmap/Roadmap_en.pdf

Central Commission for the Navigation of the Rhine [CCNR]. (2024). *Annual Report 2024—Inland Navigation in Europe, Market Observation*. CCNR. https://www.ccr-zkr.org/files/documents/om/om24_II_en.pdf

Chandrasekar, A., & Godjevac, M. (2023). *Assessment of the scalability of (hydrogen) retrofit solutions as a greening solution across the inland waterway fleet*. https://futureproofshipping.com/wp-content/uploads/2023/05/ZEM-Ports-NS_WhitePaper1_forPublishing89.pdf

Chircop, A., Doelle, M., & Gauvin, R. (2018). *Shipping and Climate Change: International Law and Policy Considerations*. https://primarysources.brillonline.com/browse/climate-change-and-law-collection/shipping-and-climate-change-international-law-and-policy-considerations;cccc013620180136003

Chirica, I., Presura, A., & Angheluţă, C. M. (2019). Retrofit Solutions for Green and Efficient Inland Ships. *Journal of Physics: Conference Series*, *1297*(1), 012009. https://doi.org/10.1088/1742-6596/1297/1/012009

Cruise Lines International Association [CLIA], & European River Cruise Association [IGRC]. (2024). *KNOWLEDGE BASIS FOR THE EUROPEAN CRUISE INVESTMENT PLAN - Status report* (Status Report 2024–1605, Rev. 3). DNV Maritime Environment Advisory.

Cruise Lines International Association [CLIA] & European River Cruise Association [IGRC]. (2025). *Knowledge basis for the European Cruise Investment Plan. Foresight report*.

Dmitry. (2024). *The EU Emissions Trading System In Shipping: Impact In 2024*. https://maritimepage.com/eu-emissions-trading-system-in-shipping/

DNV. (n.d.). *FuelEU Maritime*. DNV. Retrieved December 13, 2024, from https://www.dnv.com/maritime/insights/topics/fueleu-maritime/

Esposito, F. (2024). The Innovation Fund 2024: Opportunities for Green Transformation in Inland Waterway Transport. *Inlandwaterwaytransport*. https://www.inlandwaterwaytransport.eu/the-innovation-fund-2024-opportunities-for-green-transformation-in-inland-waterway-transport/

European Commission. (n.d.-a). *European Climate Law*. Retrieved November 24, 2024, from https://climate.ec.europa.eu/eu-action/european-climate-law_en

European Commission. (n.d.-b). *Fit for 55: Delivering on the proposals*. European Commission. Retrieved December 13, 2024, from https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal/fit-55-delivering-proposals_en

European Commission. (n.d.-c). *Ports and infrastructure | European Alternative Fuels Observatory*. European Commission. Retrieved December 13, 2024, from https://alternative-fuels-observatory.ec.europa.eu/transport-mode/inland-waterways/ports-and-infrastructure

European Commission. (n.d.-d). *Revision of the Energy Taxation Directive*. https://taxation-customs.ec.europa.eu/taxation/excise-taxes/revision-energy-taxation-directive_en

European Commission. (2019). *MITTEILUNG DER KOMMISSION AN DAS EUROPÄISCHE PARLAMENT, DEN EUROPÄISCHEN RAT, DEN RAT, DEN EUROPÄISCHEN WIRTSCHAFTS- UND SOZIALAUSSCHUSS UND DEN AUSSCHUSS DER REGIONEN Der europäische Grüne Deal.* https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=COM:2019:640:FIN

European Commission. (2020). *Sustainable and Smart Mobility Strategy – putting European transport on track for the future*. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0789

European Commission. (2021). *NAIADES III: Boosting future-proof European inland waterway transport* (52021DC0324). European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0324

European Council, C. of the E. (n.d.). *Ein europäischer Grüner Deal*. Europäischer Rat, Rat Der Europäischen Union. Retrieved November 24, 2024, from https://www.consilium.europa.eu/de/policies/green-deal/#what

European Environment Agency [EEA]. (2023). *Transport and Environment Report 2022* [Briefing]. European Environment Agency. https://www.eea.europa.eu/publications/transport-and-environment-report-2022/term-2022

European Inland Barging Innovation Platform [EIBIP]. (2019). State aid scheme for modernisation of inland waterway freight transport vessels. *EIBIP*. https://eibip.eu/funding/state-aid-scheme-for-modernisation-of-inland-waterway-freight-transport-vessels/

European Maritime Safety Agency. (n.d.). *ETS Extension to maritime*. Retrieved December 13, 2024, from https://www.emsa.europa.eu/reducing-emissions/extension-ets.html

European Parliament. (n.d.). *P9_TA(2021)0367 Towards future-proof inland waterway transport in Europe. European Parliament resolution of 14 September 2021 towards future-proof inland waterway transport in Europe (2021/2015(INI)*. https://www.europarl.europa.eu/doceo/document/TA-9-2021-0367_EN.pdf

Hader, A. (2024). *The River Cruise Fleet Handbook.*

INE, EBU, EFIP, Waterborne, IWT, ESO-OEB, EICB, & Platina4Action. (2025). *Statement by* *the inland waterways transport and ports sector on the Sustainable Transport Investment Plan (STIP)*. https://www.inlandwaterwaytransport.eu/statement-by-the-inland-waterways-transport-and-ports-sector-on-the-sustainable-transport-investment-plan-stip/

Innovation Fund—European Commission. (2025). https://cinea.ec.europa.eu/programmes/innovation-fund_en

International Maritime Organization [IMO]. (2020). *Fourth IMO GHG Study 2020. Executive Summary*.

Jacobs, K. (2022). *Inland waterway transport in the EU* (Briefing PE 698.918). European Parliament. https://www.europarl.europa.eu/RegData/etudes/BRIE/2022/698918/EPRS_BRI(2022)698918_EN.pdf

Karaarslan, S., & Quispel, M. (2021). *Study on Financing the energy transition towards a zero emission European IWT sector*. CCNR.

Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M. I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J. B. R., Maycock, T. K., Waterfield, T., Yelekçi, Ö., Yu, R., & Zhou, B. (Eds.). (2021). *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. https://doi.org/10.1017/9781009157896

Mayring, P. (2010). Qualitative Inhaltsanalyse. In G. Mey & K. Mruck (Eds.), *Handbuch Qualitative Forschung in der Psychologie*. Springer Fachmedien Wiesbaden GmbH.

PLATINA3 IWT Policy Platform. (n.d.). Retrieved December 7, 2024, from https://platina3.eu/

Platina4Action. (n.d.). Platina4Action. https://platina4action.iwtprojects.eu/

Port of Amsterdam. (2024). *Environmental discount for ships | Port of Amsterdam*. Port of Amsterdam. https://www.portofamsterdam.com/en/environmental-discount-ships

Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 Establishing the Framework for Achieving Climate Neutrality and Amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law') (2021). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32021R1119

Roux, L., Quispel, M., Karaaslan, S., Laget, V., Matzalik Florescu, & Robert, R. (n.d.). *Funding and financing the energy transition of the European IWT fleet D2.5*. CCNR.

RVO, N. E. A. (n.d.). *Subsidy scheme sustainability of inland vessels (SRVB)*. Business.Gov.Nl. Retrieved May 15, 2025, from https://business.gov.nl/subsidy/sustainable-inland-vessels/

Tianlin, N., Zhenying, S., & Geyi, Z. (2024). *Toward greener freight: Overview of inland waterway transport for freight in the European Union*. International Council on Clean Transportation. https://theicct.org/publication/overview-of-inland-waterway-transport-for-freight-eu-aug24

United Nations Framework Convention on Climate Change [UNFCCC]. (2016). *Paris Agreement*. United Nations. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:22016A1019(01)

United Nations [UN]. (2016). *The Paris Agreement*. United Nations. https://www.un.org/en/climatechange/paris-agreement

United Waterways. (n.d.). https://unitedwaterways.com/

Van Lier, T., & Macharis, C. (2024). Assessing the environmental impact of inland waterway transport using a life-cycle assessment approach: The case of Flanders | Request PDF. *ResearchGate*. https://doi.org/10.1016/j.rtbm.2014.08.003

Viadonau. (2025). *Climate and environmentally friendly shipping support program*. https://www.viadonau.org/en/economy/climate-and-environmentally-friendly-shipping-support-program?utm

AI Statement:

Descript and ChatGPT 4o were used to refine grammar and transcribe shipyard interviews.

Appendices

Appendix I: Contacted People from Different Institutions

Name	Affiliation
[redacted]	European Commission
[redacted]	CCNR
[redacted]	Danube Commission
[redacted]	CCNR
[redacted]	Danube Commission
[redacted]	Sea Europe
[redacted]	Sea Europe
[redacted]	European Climate, Infrastructure and Environment Executive Agency
[redacted]	Sea Europe
[redacted]	Hoffman Center
[redacted]	European Commission
[redacted]	Innovation Hub Netherlands
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Inland Waterway Transport Platform
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission
[redacted]	European Commission

Appendix II: Shipyard Contacts from United Waterways

River	Contact	Country
Rhine	[redacted]	Germany
Rhine	[redacted]	Netherland
Rhine	[redacted]	Netherland
Rhine	[redacted]	Netherland
Rhine	[redacted]	Netherland
Danube	[redacted]	Austria

Appendix III: Survey for Shipyard Operators

Information

We are a student team from the Geneva Graduate Institute, working on an Applied Research Project (ARP) in collaboration with United Waterways. As part of our ARP on the decarbonization of inland waterway transportation (IWT) in Europe, we are conducting an assessment of shipyard infrastructure and their retrofitting capacities. Our goal is to identify shipyards that play a role in retrofitting the European fleets toward zero-emission vessels in line with EU Green Deal targets for 2050.

By participating in this survey, you will contribute to research that will inform EU policymakers, industry stakeholders, and investors about sustainable waterway transportation. This study will also help identify potential gaps in infrastructure and capacity required to achieve climate neutrality.

Confidentiality Statement

We understand the sensitive nature of some of the information being requested. As an academic research process, we will strictly adhere to the Geneva Graduate Institute's Institutional Review Board (IRB) standards for data confidentiality. If you request, your answers will be anonymized. All responses will be used for academic and research purposes only. No information provided in the responses will be shared with third parties in a way that can be traced back to individual participants without prior consent. Additionally, all questions are optional, and participants may choose not to answer any question.

If you have any concerns regarding data privacy or confidentiality, please do not hesitate to contact our research team at arp2024.decarbonization@graduateinstitute.ch.

Interviewee

First Name, Last Name: ____________________________________

Signature: ____

Date: ____

Survey Questions

Section 1: General Information

1. **Shipyard name**	
2. **Contact person** (name, title, email, phone number)	
3. **Location of the shipyard** (country, city, address, geographical coordinates if available)	
4. **Size of the shipyard** (Number of berths, total capacity, etc.)	

Section 2: Retrofitting Capabilities

5. **Does your shipyard offer retrofitting services for inland vessels?** (Yes/No)	
5.1 If not, do you have plans to introduce retrofitting services in the future? (Yes/No)	
6. **What types of vessels do you typically retrofit?** (select all that apply) *Cargo ships, Cruise ships, Tanker ships, Other (please specify)*	
7. **Can you retrofit vessels of any size (max. 135m)?** (Yes/No)	
7.1 If not, what is your maximum ship length?	
8. **What types of retrofitting services are offered at your shipyard?** (select all that apply and please specify your answer if possible)	

Changes of engine: (Yes/No) *Change of propulsion system: (Yes/No)* *Installation of battery packs: (Yes/No)* *Measures to reduce overall energy consumption (digitalization technologies, etc.): (Yes/No)* *Other (please specify):*	
9. What is approximately the current annual retrofitting capacity of your shipyard? (Number of ships per year)	
10. How many vessels were approximately retrofitted in the past 3 years? *2022, 2023, 2024*	
11. What is your planned/booked retrofitting capacity for vessels until 2030, expressed both as a percentage and in absolute terms? 2025: ____________% ______ships 2026: ____________% ______ships 2027: __________% ______ships 2028: _________% ______ships 2029: ____________% ______ships 2030: ____________% ______ships After 2030 (if available): ______% __________________ships	
12. What is the average retrofitting time for each vessel? (Approximate time frame in weeks/months. To simplify, we think of a rough retrofit package of changing the engine, fuel tank, and propulsion system, adding battery packs, and some (easier) adjustments to reduce overall energy consumption, such as LED lighting systems or HVAC optimizations)	

Section 3: Retrofitting Capacity Planning

13. What are your future plans to expand retrofitting capacity at your shipyard?	
13.1 Plans for capacity increase (Yes/No)?	
13.2 If yes, describe the expansion plans (e.g., building new dry docks, hiring additional staff, etc.)	
14. Do you plan to adopt any new technologies for retrofitting services in the coming years? (Yes/No)	
14.1 If yes, please specify which technologies (e.g., hydrogen fuel cells, new propulsion systems, alternative fuel infrastructure)	

Section 4: Market Demand and Policy Impact

15. Is demand for retrofitting services increasing, decreasing, or remaining stable at your shipyard? *Rapidly Increasing, Slowly Increasing, Stable, Decreasing*	
16. If you want to elaborate further on a question from before, please do so here.	
17. Do you think the demand for retrofitting will increase until 2050 because of decarbonization standards? Please explain why or why not.	
18. Do you have any additional comments or suggestions regarding retrofitting for inland waterways?	

Section 5: Additional questions

19. What is your total capacity for new builds and retrofits? What is the effective share for newly built vessels vs. retrofitted ones?	
20. Are you aware of any subsidies for shipowners?	
20.1 If yes, elaborate further, EU-level, national or regional level?	
21. Are you aware of any subsidies for shipyard owners?	
21.1 If yes, elaborate further, EU-level, national or regional level?	
22. Could you recommend any shipyards we might reach out to for additional interviews?	
23. Could you recommend someone from the EU whom we could contact for further interviews?	

Appendix IV: List of Identified Shipyards - Outreach Tracker

Name	River	Country
kds koeln	Rhine	Germany
Den Breejen Shipyard	Rhine	Netherland
TeamCo Shipyard B.V.	Rhine	Netherland
Damen Shipyards Group	Rhine	Netherland
Concordia Damen	Rhine	Netherland
Schiffswerft Karcher	Rhine	Germany
Josef Braun GmbH & Co. KG	Rhine	Germany
Ritzdorf Schiffs- u. Industrietechnik GmbH	Rhine	Germany
Lux Werft und Schifffahrt GmbH	Rhine	Germany
Neue Ruhrorter Schiffswerft	Rhine	Germany
Meidericher Schiffswerft GmbH & Co. KG	Rhine	Germany
Shipyard De Hoop Lobith	Rhine	Netherland
Markerink B.V.	Rhine	Netherland
VAHALI Shipyards	Rhine, Waal	Netherland
River Harbour	Rhine, Waal	Netherland
Scheepswerf De Werken	Rhine, Waal	Netherland
Holland Shipyards Group	Rhine, Waal	Netherland
Volharding Shipyard	Rhine, Nieuwe Merwede	Netherland
VEKA Shipyard	Rhine, Nieuwe Merwede	Netherland
Fa. R. Lugthart & Zonen/Stevendok	Rhine, Volkerak	Netherland
Scheepswerf van Duivendijk	Rhine, Volkerak	Netherland
Shipfix Techniek	Rhine, Dordtsche Kil	Netherland
A.M. Bruinsma	Rhine, Dordtsche Kil	Netherland
Dockside Shipsfacilities	Rhine, Niewue Maas	Netherland
Van Grevenstein	Rhine, Niewue Maas	Netherland
Jansma Shipyard	Rhine, Niewue Maas	Netherland
ROG Shiprepair	Rhine, Niewue Maas	Netherland
Sheepswerf Hoogerwaard	Rhine, Niewue Maas	Netherland
Rotterdam Ship Repair	Rhine, Niewue Maas	Netherland
Open Shipyard Arnhem	Rhine, Nederrijn	Netherland
Ceske Lodenice	Elbe	Czech
Roßlauer Schiffswerft GmbH & Co. KG	Elbe	Germany
SET Schiffsbau	Elbe	Germany
Hitzler Werft	Elbe	Germany
Meyer Wismar	Elbe	Germany
Norderwerft	Elbe	Germany
Schiffswerft Heinr. Buschmann & Söhne	Elbe	Germany
Merré	Seine	France
Chantiers de la Haute-Seine	Seine	France
Etablissements Rousseau	Seine	France
MEUSE AND SAMBRE SHIPYARD	Meuse	Netherland
EDR ANTWERP SHIPYARD	Scheldt	Belgium
Shipyard IDP	Scheldt	Belgium
Norden Shipyard	Scheldt	Belgium
Carron Marine bvba	Scheldt	Belgium
Port Service	Scheldt	Belgium
Shipyard Reimerswaal	Scheldt	Netherland
oeswag	Danube	Austria
PBM Slovakia	Danube	Austria

Shipyard Apatin	Danube	Serbia
SEVERNAV SHIPYARD	Danube	Romania
Vard Braila SA/repair	Danube	Romania
VARD Brăila Shipyard	Danube	Romania
Navrom Shipyard	Danube	Romania
Damen Shipyards Galati	Danube	Romania
Vard Tulcea	Danube	Romania
Rujenberg Shipyard	Amer	Netherlands