PLATINA3
IWT policy platform

D2.1 Report on the zero – emission strategy IWT, update of STEERER work

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Version

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Executive Summary

Introduction and policy background

PLATINA3 is a Horizon 2020 (H2020) project that provides targeted coordination and support activities to promote Inland Waterways Transport (IWT) in Europe. PLATINA3 makes the bridge towards future research, innovation and implementation needs within IWT in Europe.

Deliverable D2.1, building on the work done by a partially similar H2020 project (STEERER), presents actions for the development of a strategy for zero-emission IWT to enable the sector's fleet to achieve its climate targets, while at the same time being in tune with the developments of its sister-segment, the maritime. This will be achieved by taking into consideration the available research, development and innovation (RD&I) funding at the EU level, in particular the Co-Programmed Partnership on Zero-Emission Waterborne Transport (cPP ZEWT). PLATINA3 thus continues the STEERER work of advising the ZEWT Strategic Research and Innovation Agenda (SRIA), but with a bigger focus on the IWT-related RD&I needs and activities, alongside the updates based on the recent policy and/or technological developments.

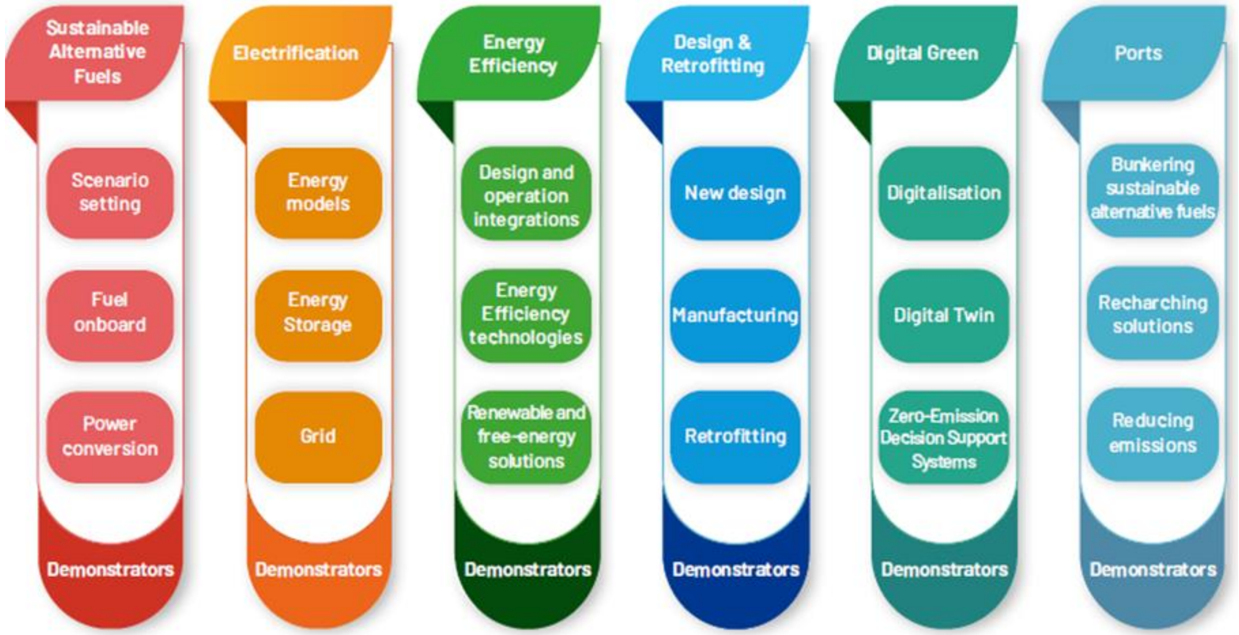
Before delving into the technical and their accompanying regulatory and business aspects, D2.1 undertakes an analysis of the relevant international and the European Union's (EU) legislative developments in particular the 'Fit for 55' proposals package. This enables the sector to understand the current and foreseen main legal requirements that need to be met, which in turn determine the RD&I priorities for funding and investments, so that the stakeholders can have the necessary technologies and comply with the legal provisions.

SRIA intervention Areas ZEWT and relevant actions from the IWT perspective

The Partnership is one of the main instruments in transforming waterborne transport into a net zero-emission mode of transport, through the research to and demonstration of deployable zero-emission solutions suitable for all main ship types and services before 2030. Its objective is to provide and demonstrate zero-emission solutions for all main ship types, on both existing and newbuilds, and services before 2030, which will enable zero-emission waterborne transport before 2050.

It was therefore necessary to have a more systematized approach of the different ship types in waterborne transport, followed by the analysis and planning of how the decarbonisation challenges for these ship types needs to be addressed. All this resulted in the development of implementation pathways for six different types of vessels – long distance ships (freight), cruise ships, ferries, short sea shipping, inland waterways, off-shore vessels.

The technical content of the cPP on Zero-Emission Waterborne Transport is divided into six parallel activities, called Intervention Areas, each of them with several subsections. These are outlined in the figure on the following page.



The Intervention Areas of the Co-Programmed Partnership on Zero-Emission Waterborne Transport

The present deliverable identified for each of the six intervention areas the main topics that are either relevant for the IWT, or that are transversal for both IWT and the maritime sectors. Subsequently, the PLATINA3 partners have proposed a number of key actions for each intervention area and its sections. A multitude of Framework Programme 7 (FP7), Horizon 2020 (H2020) and Horizon Europe (HEU) projects and project calls have also been analysed, to identify which actions need to be prioritized and which activities should not be duplicated.

The refined results are presented in the tables below, including the priority actions for the HEU working programme 2025-2027 and for deployment programmes, respectively. Implementing these key actions is seen as essential in the sector's attempt to reach the target of zero-emissions by 2050. The actions are of regulatory (R), technical (T) or business (B) type. Their importance relates to the ultimate target towards a zero-emission inland shipping sector.

Recommended priority actions for HEU working programme 2025-2027

Type	Action	Intervention area	Importance
R	Engines need to be certified and tested for the (blends) with biofuels as alternative for the fossil diesel, e.g. Stage V engines to be certified for blends of fatty acid methyl ester (FAME) higher than 8%.	SAF – Biodiesel 1	**high**
R	Fuel specifications need to be made stricter, including the measurement and enforcement due to fuel instability, corrosion, susceptibility to microbial growth, and poor cold-flow properties of certain biofuels. Also, proper government measures need to be more widely known and clear to the users and fuel providers.	SAF – Biodiesel 2	**high**

T	Investigate and demonstrate the maintenance needs of methanol as well as types of storage systems. (HEU & Innovation Fund)	SAF – methanol 3	**high**
T	Investigate and demonstrate the maintenance needs of different hydrogen carriers as well as types of storage systems, interoperability and safety of mobile hydrogen storage systems. (HEU & Innovation Fund)	SAF- hydrogen 5	**high**
R	Investigate and prepare the regulations of methane emissions.	SAF – LNG 11	medium
T	Demonstration of the battery design life in operational conditions (HEU & Innovation Fund).	Electrification 1	**high**
R	Further develop ES-TRIN to take into account new battery types, ease battery handling and prevent standardisation issues	Electrification 3	high
T	Develop new bow thrusters that allow operations in extreme shallow waters with equal or increased energy efficiency. The proposed solutions also need to prevent the accumulation of sediments in the thrusters.	Design & Retrofit 1	medium
T	Develop new materials, alloys, composites, etc. for shipbuilding and retrofitting. The new solutions need to offer similar technical characteristics and safety (fire resistance) while at the same time achieving a weight reduction at a reasonable price.	Design & Retrofit 2	medium
T	Investigate the adaptation of existing vessels from local-to-local modifications to the replacement of the aft ship, aiming largely at increasing the cargo capacity at low water while maintaining or improving energy efficiency.	Design & Retrofit 7	medium
T	Further development and testing of advanced systems (collision avoidance, AI, neural networks, sensor fusion and integration, etc.) to move from TRL 5-6 to TRL 8 to enable highly automated navigation in IWT.	Digital Green 1	medium
T	Research cost-effective, widely applicable and standardised bunkering/charging solutions, considering various potential bunkering/charging locations in different ports and the different types of vessels. (HEU)	Ports – SAF 1	medium
T	Studies to making onshore power supply (OPS) points future ready so they can be utilized for (rapid) charging of batteries on board used for propulsion of the vessel	Ports – OPS 1	**high**
T	Standardized components on vessel side for OPS and fast-charging (e.g. connections, length of cables).(HEU)	Ports – OPS 2	medium
R/B	Development and harmonisation of standards & procedures (both of technical and financial-administrative nature) for OPS and (fast) charging at seaports and inland ports (the ship-to-shore interfaces). (HEU)	Ports – OPS 3	medium

Recommended priority actions for deployment

Type	Action	Intervention area	Importance
T	Investigate the development of new types of fuel cells and their reliability (tilting, acceleration, vibrations, etc.) and cost in the waterborne transport environment.	SAF – Common 2	**high**
T	Development/ further optimization of engines systems (including aftertreatment systems) to (nearly) eliminate all types of air pollutants (focus on the most harmful ones first) for traditional fuels, as well as for some technologies converting sustainable alternative fuels. Therefore, new Stage V engines need to become further available and certified for usage of higher blends of biofuels, methanol and hydrogen, either dual fuel or single fuel. (HEU)	SAF – Common 3	**high**
T	Further upscaling of demonstrator projects to identify benefits/push the limits of the different fuels. (Priority for both HEU and the Innovation Fund)	SAF – Common 4	**high**
T	Demonstration of the battery design life in operational conditions (HEU & Innovation Fund).	Electrification 1	**high**
T	Research to bring down the volumetric and gravimetric density of battery modules and pack integration, making onboard storage modular and standardised, and thus competitive with conventional fossil diesel. This could result in other types of hydrogen carriers and convertors and new types of electricity storage technology than the ones used today. (HEU)	Electrification 4	**high**
T	Retrofitting existing vessels by the (optimal) integration of sustainable available solutions, including solutions using renewable energies.	Design and Retrofit 8	**high**
T	Development and implementation of new vessel designs that support multi-fuel engines and fuel cells, including aft-ship replacement for existing vessels. (HEU)	Design and Retrofit 9	medium
T	Investigate and demonstrate the benefits of using multiple (smaller) main engines to optimize engine load distribution and increasing energy management flexibility. (HEU)	Design and Retrofit 10	medium
T	Demonstrator projects on bunkering sustainable alternative fuels at inland and sea ports, including energy providers. (Innovation Fund)	Ports – SAF 2	**high**
T/B	Availability, feasibility and use of swappable battery containers.	Ports – OPS 4	**high**
T	Further development of fast charging infrastructure.	Ports – OPS 5	**high**

List of abbreviations

AFID	The Alternative Fuels Infrastructure Directive
AFIR	The Alternative Fuels Infrastructure Regulation
CAPEX	Capital expenditure
CBAM	The Carbon Border Adjustment Mechanism
CCNR	Central Commission for the Navigation of the Rhine
CCUS	Carbon capture, utilization and/or storage
CFD	Computational fluid dynamics
CSA	Coordination and support action (type of project)
CSRD	The Corporate Sustainability Reporting Directive
DG MOVE	Directorate-General for Mobility and Transport
EC	European Commission
EEDI	The Energy Efficiency Design Index
EGD	European Green Deal
EN	European standard
EP	European Parliament
ESR	The Effort-sharing Regulation
ES-TRIN	European Standard laying down Technical Requirements for Inland Navigation vessels
EU	The European Union
FAME	Fatty acid methyl ester
FC	Fuel cell
FF55	The ‘Fit for 55’ Package (of the European Union)
FP7	The Seventh Framework Programme (of the European Union)
FQD	Fuel Quality Directive
GA	Grant Agreement
GDP	Gross Domestic Product
GHG	Greenhouse gas(es)
GSEG	Green Shipping Experts Group
HEU	Horizon Europe Framework Programme
H2020	Horizon 2020 Framework Programme
ICE	Internal combustion engine
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers

IF	The Innovation Fund
IMO	International Maritime Organization
ISO	International Organization for Standardization
IWT	Inland Waterway Transport
IWW	Inland Waterways
LNG	Liquefied Natural Gas
MeOH	Methanol
MFF	Multi-Annual Financial Framework
MW	Megawatt
NFRD	The Non-Financial Reporting Directive
NOx	Nitrogen oxides emissions
NRMM	Non-Road Mobile Machinery
OPEX	Operational expenditure
OPS	On-shore power supply
PLATINA II	Platform for the Implementation of NAIADES II
PLATINA3	Platform for the Implementation of NAIADES III
RD&I	Research, development and innovation (often interchangeable with R&D and R&I)
RED	The Renewable Energy Directive
SAF	Sustainable alternative fuel
SRIA	Strategic Research and Innovation Agenda
SSMS	Smart and Sustainable Mobility Strategy
SSS	Short Sea Shipping
STEERER	Structuring Towards Zero Emission Waterborne Transport project
TEN-T	Trans-European Network of Transport
Tkm	Tonne-kilometre
TRL	Technology readiness level
US	United States (of America)
WASP	Wind-assisted Propulsion Systems
WP	Work Package
ZEWT cPP	Co-Programmed Partnership on Zero-Emission Waterborne Transport

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1. Introduction

As described in the Grant Agreement (GA), PLATINA3 is a Horizon 2020 (H2020) project that provides targeted coordination and support activities to promote Inland Waterways Transport (IWT) in Europe. PLATINA3 makes the bridge towards future research, innovation and implementation needs within IWT in Europe. A key objective is providing the knowledge base for the implementation of the EU Green Deal in view of further development of EC`s IWT action programme (NAIADES) towards 2030. PLATINA3 addresses priority topics for the success of IWT:

1. integration & digitalisation of IWT in view of modal shift & synchromodality;
2. zero-emission, automated & climate resilient fleet;
3. skilled workforce anticipating to zero-emission & automation;
4. smart & climate resilient waterway and port infrastructure with clean energy hubs.

PLATINA3 is thus structured around the fields of Market, Fleet, Jobs & Skills and Infrastructure.

The project's work package (WP2) addresses the broader 'Fleet' topic and it is divided into seven tasks according to the main issues that need to be addressed by the partners, each with its own deliverable:

- D2.1 Report on the zero – emission strategy IWT, update of STEERER work;
- D2.2 Report on options for shallow water / climate resilient vessels;
- D2.3 Report on vision and roadmap on pathway for automation and on board systems;
- D2.4 Roadmap report for European accurate fleet data;
- D2.5 Report on implementation of funding and financing for energy transition European IWT fleet;
- D2.6 Report on implementation of EU IWT emission label / energy index / GLEC for vessels;
- D2.7 Report on policy recommendations on regulatory pathway towards zero emission fleet.

All WP2 deliverables between D2.2 – D2.7 are meant not just to reply to an identified challenge within IWT, but also to provide essential contributions to a couple of key broader PLATINA3 deliverables – one of them being the current D2.1 deliverable.

Deliverable D2.1 presents actions for the development of a strategy for zero-emission IWT to enable the sector's fleet to achieve its climate targets, while at the same time being in tune with the developments of its sister-segment, the maritime. This will be achieved by taking into consideration the available research, development and innovation (RD&I) funding at the EU level, in particular the Co-Programmed Partnership on Zero-Emission Waterborne Transport (cPP ZEWT).

In this particular case, PLATINA3 is building on the work done by a partially similar H2020 project which addressed the entire waterborne transport sector – both the maritime and IWT segments – the Structuring Towards Zero Emission Waterborne Transport (STEERER[1]) project. STEERER had done an in-depth documentation of the RD&I needs for the waterborne transport sector and subsequently proposed a comprehensive set of actions that are to be taken up and included in the Partnership's

[1] https://www.waterborne.eu/projects/coordination-projects/steerer/about-steerer/

Strategic Research and Innovation Agenda (SRIA), a key document which provide ZEWT with both its strategic direction and its main information source for the waterborne transport calls that appear in Horizon Europe's (HEU) Work Programmes**.** The end result of this work is included in the STEERER deliverable D2.7 Advice to the 2nd ZEWT Research Agenda and its Implementation Plan[2].

Using the STEERER deliverable as a basis, PLATINA3 continues the work of advising the ZEWT SRIA, but with a bigger focus on the IWT-related RD&I needs and activities, alongside the updates based on the recent policy and/or technological developments.

This PLATINA3 deliverable D2.1 takes into account of the results from the other WP2 deliverables (such as D2.2 on options for shallow water / climate resilient vessels and D2.7 on policy recommendations on regulatory pathway towards zero emission fleet). PLATINA3' s partners also ensured that relevant information developed in the other WPs – e.g. from WP4 on ports – was added to D2.1.

Thus, the main purpose of this deliverable is to ensure that the IWT-relevant RD&I needs are better taken into consideration by the ZEWT cPP. Secondly, it will also outline the longer-term RD&I needs of IWT to achieve the zero-emissions goal by 2050, while indicating some of the applicable funding mechanisms available. Finally, as all other PLATINA3 deliverables, the main information from this deliverable D2.1 will also be used as input into the PLATINA3 deliverable D5.1 with the name "Report on consolidated R&D roadmap and implementation plan for IWT" which is planned to be published in June 2023.

2 https://waterborne.eu/images/STEERER_Advice_to_2nd_ZEWT_Research_Agenda_and_its_Implementation_Plan.pdf

2. General Framework and Methodology

2.1 Task Description

The title of Task 2.1 "Zero-emission strategy for the fleet: SRIA, co-programmed partnership", indicates the broad scope of the work and the contents of the deliverable.

The objective here is to build on the previous work done by the STEERER project – the advice to the Partnership – and strengthen the SRIA on the zero-emission strategy and potential activities for the IWT segment. The work on D2.1 was scheduled to take place during the last year of the PLATINA3 project.

A number of initiatives and information are to be explored in the field of zero-emission waterborne transport, both on technologies and concepts for IWT and maritime shipping; in the case of the latter, the partners will only look at those that can be applied to the IWT as well. The H2020 STEERER project had focused on the advising the update of the cPP ZEWT SRIA. The output from STEERER – the main documentation and the information gathered from its advisors, the Green Shipping Expert Group (GSEG) – will be tailored for the purpose of the RD&I Roadmap on IWT in the context of the PLATINA3 project. The results will then feed once again into the SRIA of the Partnership, which will be updated during the same time as PLATINA3 is coming to an end.

Consequently, the task 2.1 activities did first consist of exchanges between STEERER and the PLATINA3 consortium and stakeholders. Then, PLATINA3 partners did focus on updating the D2.1 draft, also with the help of the PLATINA3 Advisory Body, concerning the input from the side of IWT for the SRIA. The information to be added in D2.1 came from the partners' own knowledge, desk research, other PLATINA3 deliverables, interviews with the broader IWT community and with the relevant policy makers at European and national levels, etc.

This deliverable, as mentioned above, takes into account of the results from the other WP2 deliverables (such as D2.2 on options for shallow water / climate resilient vessels and D2.7 on policy recommendations on regulatory pathway towards zero emission fleet). PLATINA3' s partners ensured that any relevant information developed in the other WPs – e.g. from WP4 Task 4.2 on alternative energy infrastructure along waterways and in ports – was added to D2.1.

Furthermore, during the last year of PLATINA3, the document's progress did also rely on the discussions of the D2.1 main information during the workshop at the final PLATINA Stage Event (23 March 2023, hybrid event in Brussels)[3].

2.2 General Framework

This work comes in the context of the effort to achieve the 2050 climate targets. These had been first enshrined at the international level, via the COP21 Paris Agreement, and then at the EU level, via the EU Green Deal and subsequently the 'Fit for 55' package (FF55 package). The latter creates the intermediate, 2030 climate-related targets at the EU level for different economic sectors, including transport. They are reinforced by the Sustainable and Smart Mobility Strategy (SMSS)[4] which, in addition

[3] More information: https://platina3.eu/event/final_stage_event/
[4] More information: https://transport.ec.europa.eu/transport-themes/mobility-strategy_en

to 90% emission reduction to be reached in 2050 compared to 1990, also sets the goal of increasing transport by inland waterways and short sea shipping by 25% by 2030, and by 50% by 2050.

The IWT sector also has a complementary, dedicated policy communication at the EU level, the NAIADES III Action Programme. The NAIADES III main objectives are to continue and enhance the modal shift (in particular for freight) towards the IWT, while at the same time making inland navigation 'greener', 'smarter' and more attractive and sustainable, also in terms of jobs. The NAIADES III came after two previous NAIADES programmes that have supported the IWT sector progress. Previous NAIADES programmes benefitted from two previous PLATINA projects.

The policy and legal developments at the EU level also come with both additional activities and funding opportunities in terms of greening the IWT. And the opportunities concern both the market roll-out and implementation of recent technologies, but also the support for further RD&I activities. During the current Multi-Annual Financial Framework (MFF) 2021-2027, the EC is offering an unprecedented support for the waterborne transport sector in terms of RD&I funding. Testament to this aspect are the creation in the HEU framework of the ZEWT Partnership, with an allocation of up to €530m, but also other opportunities, such as the Clean Hydrogen and BATT4EU Partnerships. In addition, the Innovation Fund is also offering the possibility of bridging the gap between high-TRLs and deployment, even if waterborne transport is not yet listed as one of the main sectors that it addresses.

The whole framework cannot be complete without mentioning the river commissions' work towards the decarbonization of the IWT in their regions, namely the Rhine (CCNR) and the Danube (Danube Commission) basins. Although these organizations do not have the same legal, political and financial clout of the EU, they are important actors in their own regions, often acting as both linchpins and technical/operational knowledge repositories between the different stakeholders, Member States and legal-policy levels. In the Declaration signed in Mannheim in 2018, the inland navigation ministers of the Member States of the Central Commission for the Navigation of the Rhine (CCNR) defined similar target of largely eliminating GHG by 2050, but also largely eliminating other pollutants by 2050. CCNR adopted in 2021 a dedicated roadmap[5] including two transition pathways for the fleet by 2050 as well as policy measures.

The IWT is consequently witnessing a series of 'push and pull' policy, legal, financial and technical factors that are paving its way towards a deep transformation by 2050, and whose main issue concerns the climate-change related targets and requirements. And owing to these extensive challenges and opportunities, the PLATINA3 partners have embarked on a mission to help the sector further advance on its transformative pathway by building upon the previous PLATINA projects and other relevant projects and activities, as well as proposing new solutions and activities. The Deliverable D2.1 is designed to prepare a key part of the IWT for these changes, namely the RD&I needs for IWT fleet.

[5] CCNR, "CCNR Roadmap for reducing inland navigation emissions", Resolution 2021-II-36, December 2021, https://www.ccrzkr.org/files/documents/Roadmap/Roadmap_en.pdf.

2.3 Main Steps to be Implemented

The build-up of this deliverable starts from the work achieved in the STEERER D2.7 deliverable. The Deliverable STEERER D.7 has essentially the same broad aim as compared to the PLATINA3 Deliverable 2.1: to provide advice to the SRIA update of the ZEWT cPP. Consequently, there is a similarity between this PLATINA3 deliverable D2.1 and STEERER D2.7 in both content and purpose. This means that the main structure of STEERER D2.7 has also been largely followed for structuring the contents of PLATINA3 D2.1. However, the technical content itself was updated and expanded specifically for IWT based on the results of PLATINA3 tasks (amongst others Tasks 2.2, 2.5, 2.7, 4.2) and also with specific interviews with IWT stakeholders and further elaboration by PLATINA3 partners involved in Task 2.1.

Therefore, seen this context and structure of the SRIA ZEWT cPP, in order to better understand the structure of the document and the work ahead, it is necessary to give some details about the Partnership and its SRIA.

The ZEWT cPP

The Partnership is one of the main instruments in transforming waterborne transport into a net zero-emission mode of transport, through the research to and demonstration of deployable zero-emission solutions suitable for all main ship types and services before 2030. It will contribute to maintaining and reinforcing Europe’s global leadership in innovative, green waterborne transport solutions. The objective is to **provide and demonstrate zero-emission solutions for all main ship types, on both existing and newbuilds, and services before 2030, which will enable zero-emission waterborne transport before 2050.**

It was therefore necessary to have a more systematized approach of the different ship types in waterborne transport, followed by the analysis and planning of how the decarbonisation challenges for these ship types needs to be addressed.

All this resulted in the development of implementation pathways for six different types of vessels, with a broader description in the Partnership SRIA. This classification was adopted in the STEERER deliverable and was therefore used in this PLATINA3 deliverable as well. This was done to ensure that the results of the deliverable will easily feed in the process of updating the ZEWT SRIA. The figure below presents the main ship types, as defined for the scope of the Partnership, of which one shiptype is “Inland” and thus represents the IWT sector.

Figure 1 Types of vessels for the development of implementation pathways

The technical content of the cPP on Zero-Emission Waterborne Transport is divided into six parallel activities, called Intervention Areas, each of them with several subsections. These are outlined in the figure below. The Intervention Areas will also be a key terminology from the SRIA that will be used throughout this deliverable.

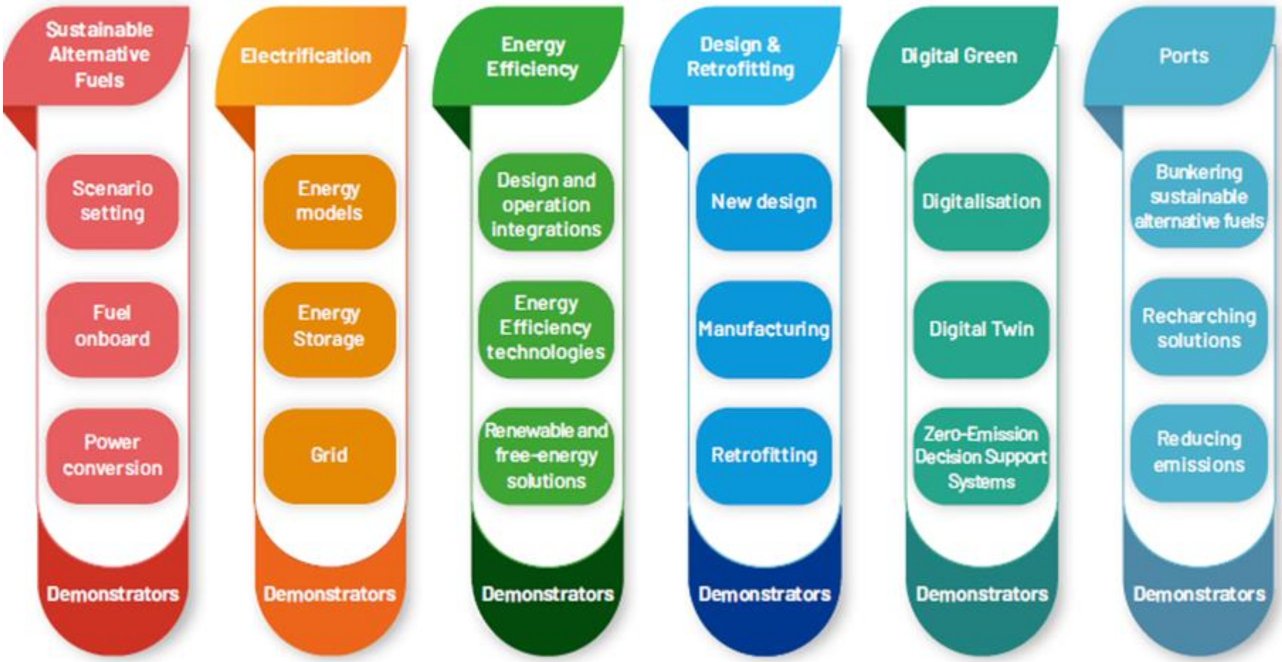


Figure 2 Activities of the Co-Programmed Partnership on Zero-Emission Waterborne Transport

The STEERER Approach

The update of the Partnership's main document requires gathering a large amount of information which then needs to be structured and analysed against the SRIA composition. In this manner, the results can be used to properly and more easily update the relevant chapters in the SRIA which serves as input for future calls in the Horizon Europe programme.

The analysis for the SRIA update had been done in STEERER on the following main points:

1. **The analysis of the international and the European Union's (EU) legislative developments**, applicable to both the maritime and the IWT, in particular the 'Fit for 55' package.
2. **The definition of the scenarios to achieve zero-emissions with quantified targets for 2025, 2030 and 2050**. The aim had been to give the correct overview of the waterborne transport sector's qualitative (technologies business models, etc. that need to be developed and implemented) and quantitative (the reduction in GHG emissions by 2050 with intermediate steps in the decades before) decarbonization challenges.
3. **The definition of the main actions to be undertaken under each of the SRIA intervention areas,** to speed the waterborne transport transition to a zero-emission mode of transport. Most actions proposed are of a technical nature. However, some proposals addressing required actions of 'regulatory' and 'business' nature had also been designed. The former refer to regulatory aspects that are needed to speed up the RD&I activities and then their deployment and market uptake. In most cases, these proposals for regulatory action can also be addressed as side activities in EU-funded RD&I projects, including those from the ZEWT cPP. The proposed actions of business nature concern solutions or needs from a business perspective that also help speed up the RD&I activities and then their deployment and market uptake;
4. A (general) **analysis of the relevant EU-funded projects**, in particular those under FP7 and H2020 but also from the recently awarded Innovation Fund Calls. This analysis had been used not only to have a better understanding of which research topics had already received more attention and which of them would receive a higher support but to also help prepare in WaterborneTP a more in-depth analysis of the recent and current RD&I projects at the EU level. This is a key aspect in calibrating the ZEWT support for the different topics preferred to be included in the Horizon Europe work programmes up to 2027, to achieve the first mature solutions for zero-emissions waterborne transport.

Each piece of information gathered under each chapter has a specific role. They indicate which are the more urgent developments that the sector may be facing up to 2030 and then up to 2050, what RD&I progress has been achieved so far and which are the solutions that should receive the necessary attention (and funding) for faster development and subsequent roll-out, taking into account the current state-of-play in the transition to zero-emission waterborne transport.

Three other key aspects that must be noted in the STEERER approach are:

- although the proposed actions for each of the Intervention Areas are firstly focused on a possible uptake by the Partnership, they also take into consideration the longer-term perspective (and funding mechanisms), as the sector will have to continue working beyond the HEU timeline to fully achieve its zero-emission targets;
- the proposed actions offer a mix of solutions that are either maritime/seagoing focused, IWT-focused or transversal. The latter means that they are applicable to both the maritime/seagoing segments as well as to the IWT segment;

- the overarching approach of STEERER relies on the calculations of the carbon budget of the waterborne transport sector. The scientists involved in the IPCCC have calculated the overall amount of carbon that humanity can still emit until the 1.5° C warming threshold will be reached at the current emission levels. And this total has then been divided equally by sector. Based on this linear allocation, for the waterborne transport sector as a whole, the estimates of STEERER from end-2021 show that the sector's carbon budget will be depleted in approx. 7-8 years' time unless critical actions will be taken. Alternatively, the sector will need to rely on the overperformance of other sectors and/or additional costs, in particular to offset the emissions via Carbon Capture, Usage and Storage (CCUS) technologies and carbon capture straight from the atmosphere. The legal analysis had been used as a complementary factor, to understand how the new legislation will help achieve these targets, and what 'intermediate' targets – until 2030 and 2050 – the sector stakeholders need to be aware of.

The PLATINA3 Approach

Continuing the work of STEERER, PLATINA3 took over most of the deliverable structure and approach. However, given the specific scope of PLATINA3, some changes have been implemented.

First, the current deliverable will focus first on the IWT-related topics, followed by the transversal ones – topics that either address (almost) equally the IWT and maritime segments alike, or that can be fairly easily transferred from one to the other. Thus, the information focused only on the maritime that is in STEERER D2.7 has largely been taken out from this deliverable. The content had then been updated with either IWT-focused information or with transversal topics. In particular also work was done to analyse the ongoing and planned projects, to check what recommendations are already being or planned to addressed. This led to afiltering process where it to arrive at conclusions and recommendations for the key actions to be recommended for Horizon Europe working programme 2025-2027.

However, this deliverable will continue to look not just at the activities to be implemented in the context of the Partnership, but will also consider proposals and actions that can be implemented in the longer term, after 2030 and up to 2050.

The main structure of the document remains as in STEERER, with:

- an updated policy analysis at the European level that is focused on the IWT, and which are the potential impacts of the new legislation in terms of RD&I;
- a set of recommendations for each of the ZEWT cPP Intervention Areas. The recommendations cover either IWT topics or transversal ones. Most of them are technical, but some are also regulatory- or business-oriented;
- an analysis of relevant EU-funded projects. As before, the focus is now on projects that are either IWT-focused, address the IWT to a significant extent, or their results can be fairly easily taken up by the IWT stakeholders. Furthermore, since more information is available from the HEU projects, they will also be included in the analysis. Going a further step away from STEERER, this deliverable will also investigate part of the projects' developments per Intervention Area, in order to have a better view of the activities done, on-going and still needed.

3. Current and Foreseen Relevant Policy Developments

This chapter provides an overview of the main legal developments at the European level relevant for both the IWT and the transversal topics of waterborne transport, and how the new legislation impacts both the climate targets of the sector and its RD&I activities needed to meet these targets. The first part of the chapter is focused on the EU-level developments, in particular those from the 'Fit-for 55' package, followed by those from the CCNR.

Subsequently, the chapter gives an overview regarding the carbon budget for the waterborne transport sector and how the different legal developments can help (or not) to stay within the budget's limits. The analysis for the waterborne transport sector as a whole is relevant for the deliverable's further work on the transversal topics and technologies. Moreover, this analysis also provides an indication of the decarbonisation challenge for the IWT sector as developed in the STEERER project, an exercise needed to better understand the RD&I pace that this segment has to follow in the coming period.

More information regarding the legislative and regulatory changes proposed and/or desired by the project partners can be found in the PLATINA3 deliverable D2.7 "*Report on policy recommendations on regulatory pathway towards zero emission fleet*"[6].

3.1 EU legislative proposals and CCNR roadmap

The 'Fit-for-55' Package

The publication of the 'Fit for 55 package' (FF55 package) is the most recent development at the EU level. Launched on the 14th of July 2021, it is a package of EC proposals to make the EU's climate, energy, land use, transport and taxation policies fit for reducing net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels[7]. They represent in fact the legislative tools to implement a major part of the European Green Deal and to achieve the targets set by the European Climate Law. All proposals are harmonised between themselves, to ensure a coherent overall approach.

In summer 2022 the European Parliament (EP) had started defining its views and counterproposals on the different legislative acts encompassed in the FF55 package, and at the time this deliverable had been finalised the EC, EP and the Council were engaged in trialogues to reach a common agreement on the final versions of these texts.

The legislative proposals that have may have a significant impact on the IWT and the transversal aspects relevant to all the segments of the waterborne transport sector are outlined below, and a succinct analysis is presented.

This information serves two main purposes in relation to the SRIA update:

1. To provide the necessary information for the update of the SRIA parts on policies;

[6] see for the full report: https://platina3.eu/towards-zero-emission-fleet/
[7] More information: https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541

2. To give a first analysis of the RD&I directions that need to be considered for the SRIA update given the foreseen policies for the waterborne transport sector and their impacts.

Note: It must be underlined that the information below concerns the situation of the EU legislation as of November 2022, and that the final legal texts may differ from the information presented below.

The Effort Sharing Regulation

The Effort Sharing Regulation[8] assigns strengthened emission reduction targets to each Member State for buildings, road and domestic maritime transport, inland waterway transport, agriculture, waste and small industries. Recognising the different starting points and capacities of each Member State, these targets are based on their gross domestic product (GDP) per capita, with adjustments made to take cost efficiency into account.

The Renewable Energy Directive

The Renewable Energy Directive (RED)[9] update, as proposed by the EC, will set an increased target to produce 40% of the Union's energy from renewable sources by 2030. All Member States will contribute to this goal, and specific targets are proposed for renewable energy use in different sectors, including transport. *Thus, the proposal introduces a target for reducing the greenhouse gas intensity of transport fuels by 13% by 2030 compared to 2010 level*. However, Member States may decide for themselves how to distribute the targets over the different transport modes which are fuelled in their countries. The targets are not necessarily the same for all modes and differences can occur between Member States. This brings risks with the principle of striving for an equal level playing field.

It must also be noted that the Fuel Quality Directive applies already for IWT and includes a 6% reduction target to be reached already by 2020 and maintained afterwards as compared to 2010 level, setting a maximum limit of 88.45 grams CO_2e per MJ of energy to fuel suppliers. Again, as described in the PLATINA3 deliverable D2.7, Member States can choose themselves whether or not to also impose the targets and requirements to IWT or not. At the moment, in countries such as The Netherlands, Germany and Belgium, IWT fuel suppliers are excluded from specific requirements to reach reductions and higher targets in other modes (mainly road transport) are compensating this. The FQD is to be replaced by the RED revision as part of the FF55 package.

Another potentially relevant aspect for the waterborne transport sector is that in order to meet both the climate and environmental goals, sustainability criteria for the use of bioenergy are strengthened and Member States must design any support schemes for bioenergy in a way that respects the cascading principle of uses for woody biomass.

In more detail, the revised RED will impact the waterborne transport sector and the work that ZEWT is doing, notably:

- the increase of renewable electricity is foreseen to also be used to produce (more) *synthetic fuels for hard-to-decarbonise transport sectors* such as maritime transport;

[8] Effort Sharing Regulation | European Commission (europa.eu)
[9] Amendment to the Renewable Energy Directive to implement the ambition of the new 2030 climate target | European Commission (europa.eu)

- the roll-out of more renewable energy and electrification is translated into an expanding charging infrastructure. In view of the long-life span of recharging points, *requirements for charging infrastructure* should be standardised (or at least harmonised) and kept updated in a way that would cater for future needs, and would not result in negative lock-in effects to technology and service developments;
- increasing the level of the energy-based targets on advanced *biofuels and biogas*, coupled with the introduction of a target for renewable fuels of non-biological origin, should ensure an increased use of the renewable fuels with the smallest environmental impact in transport modes that are difficult to electrify. Consequently, for the 2050 milestone there is a likely increased demand for advanced biofuels, especially in the waterborne transport sector;
- the EU will maintain the 'multipliers'[10] as one of the incentives for the uptake of renewable energy in certain sectors (a multiplier of 1.2 for maritime), thus allowing to account more than the actual energy content consumed. A multiplier of 2 for biogas and advanced biofuels produced from certain feedstocks is also incentivised in such a manner;
- a key element intertwined with the RED is the forthcoming Offshore Renewable Energy Strategy. It *introduces an ambitious objective of 300 GW of offshore wind and 40 GW of ocean energy across all the Union's sea basins by 2050*. Member states should jointly define the amount of offshore renewable generation to be deployed within each sea basin by 2050, with intermediate steps in 2030 and 2040. These objectives should take into account the offshore renewable energy potential of each sea basin, environmental protection, climate adaptation and other uses of the sea, as well as the Union's decarbonisation targets. This is a tremendous opportunity for the ZEWT partners to not only get a better image of the energy sources that they could (almost) directly use, but also to be involved in some of these developments.

The EP proposals to the EC text contain the following main aspects of relevance for the waterborne transport sector: the share of renewable energy to be raised to 45% by 2030; in the transport sector, deploying renewables should lead to a 16% reduction in greenhouse gas emissions, through the use of higher shares of advanced biofuels and a more ambitious quota for renewable fuels of non-biological origin such as hydrogen[11].

The revised Alternative Fuels Infrastructure Regulation

The revised Alternative Fuels Infrastructure Regulation (AFIR, the former AFID)[12] caters for the deployment of infrastructure for certain alternative fuels that require distinct infrastructure and that are market ready. Though this is aimed in particular at the road transport sector, some of its provisions are relevant for the waterborne transport sector as well – in particular, the Regulation requires that ships have access to clean electricity supply in major ports on the TEN-T network.

In more detail, the relevant provisions for the waterborne transport sector are the following:

[10] The achievement of RED targets by the Member-States is facilitated by several 'multipliers' on energy content, both for the transport sectors and for specific fuels. This is done through their use in the calculation of the share of renewable energy in the transport sector (via a methodology is provided by the EC). For the maritime sector it means that the renewable fuels consumed are counted with a weighting of 1.2 in the formula used for the share of renewable energy targets.

[11] Parliament backs boost for renewables use and energy savings | News | European Parliament (europa.eu)

[12] Revision of the Directive on deployment of the alternative fuels infrastructure | European Commission (europa.eu)

- as stated in its explanatory memorandum, the proposed regulation "delivers on the clear requirement of the European Green Deal to oblige docked ships to use shore-side electricity. It is fully complementary to FuelEU Maritime Initiative by ensuring that *sufficient shore-side electricity supply is installed in ports to provide electricity while passenger ships (including ro-ro passenger ships, high speed passenger craft and cruise ships) and container vessels are at berth, and accommodating the demand for decarbonised gases*, i.e. bio-liquefied natural gas (LNG) and synthetic gaseous fuels (e-gas)". Further distinctions are made for other ship types and their needs;
- more precisely, the new legislation foresees that practically all maritime ports (including the dual ports such as Rotterdam, Antwerp, Constanta, etc.) on the *Trans-European Network of Transport* (*TEN-T) Core and Comprehensive networks will have sufficient shore-side power output to meet at least 90% of the electricity demand from the ships*. On the other hand, the requirements for the IWT ports are less stringent: the only target is that all IWT ports on the TEN-T networks need to provide at least 1 on-shore power supply (OPS)[13];
- in addition, there needs to be a *sufficient coverage of LNG refuelling stations* in the maritime TEN-T ports to meet the current and future necessities of ships travelling within the TEN-T core network by 2025. However, biogas and e-gas should also be used for operations, not just the 'regular' LNG. This requirement on LNG does not exist for inland ports but can also influence the IWT segment, especially the routes close to the larger maritime ports;
- together with the FuelEU maritime initiative, it contributes to overcoming the current "chicken-and-egg" issue, which has meant that the very low demand from ship operators to connect to the electric grid while at berth has made it less attractive for ports to invest in short-side electricity – with a focus on the TEN-T ports. Both maritime and inland waterway transport are included in this Regulation;
- within this context, the ZEWT cPP is specifically nominated as one of the non-legislative means to address these topics (on their RD&I aspects).

Member-States also need to prepare and then adopt national plans that ensure the roll-out of the AFIR-targeted infrastructure. PLATINA3 partners have covered this aspect in deliverable D4.2 "Report on findings, perspectives and recommendations on clean fuels along waterways and ports"[14].

Revision of Energy Taxation Directive

A **revision of the Energy Taxation Directive**[15], proposes to align the taxation of energy products with EU energy and climate policies, promoting clean technologies and removing outdated exemptions and reduced rates that currently encourage the use of fossil fuels. It is to be seen as a strong complement to the new ETS proposals and in relation with existing international regulations in this context.

[13] All TEN-T core inland waterway ports by 1 January 2025 and all comprehensive inland waterway ports by 1 January 2030. In the TEN-T network there are in total 173 comprehensive inland ports and 69 core inland ports with 15 hybrid comprehensive ports (sea and inland) and 26 hybrid core ports (sea and inland).

[14] See for more information: https://platina3.eu/clean-energy-infrastructure/

[15] Revision of the Energy Tax Directive | European Commission (europa.eu)

In the cases relevant for the waterborne transport sector, the proposals will support the *deployment and uptake of clean energy and fuels while removing fuel tax exemptions that are in place and increasing the taxation on fossil fuels/energy. The proposal also seeks to exclude the bunkering of ships outside EU ports, thus preventing a de facto carbon leakage*.

Indeed, the directive on the taxation of energy products (Directive 2003/96/EC) currently in force foresees an optional tax exemption for energy products supplied for use as fuel. The rationale behind such an exemption lies in the role that inland navigation already plays in cutting transport-related greenhouse gas emissions. Indeed, a modal shift to less carbon intensive modes of transport, such as inland navigation, is a considerable advantage in terms of reducing greenhouse gas emissions in particular.

Given the current and foreseen structure for the short to medium-term of the mix of energy sources used by the waterborne transport sector, this is likely to lead to a higher impact than on many other sectors. For this reason, some stakeholders have the opinion that any change in the current taxation of energy sources used in inland navigation should in any case be phased in.

Consequently, it is another instrument in determining the waterborne transport stakeholders which R&I measures should be prioritised in the coming years.

The Carbon Border Adjustment Mechanism

The **Carbon Border Adjustment Mechanism (CBAM)**[16] , as proposed by the EC, will put a carbon price on imports of a targeted selection of products to ensure that ambitious climate action in Europe does not lead to ‘carbon leakage'. This will ensure that European emission reductions contribute to a global emissions decline, instead of pushing carbon-intensive production outside Europe.

While the provisions of this initiative do not directly concern the R&I efforts of the waterborne transport sector, it can significantly impact on its future demands and business models. And in addition to this mechanism there are numerous other EU measures designed to mitigate climate change and stimulate circular economy targets, but also to strengthen and at the same time broaden the domestic (EU) industry. These measures can likely result in two major changes for the waterborne transport sector:

- *a decrease in the type of goods carried by deep-sea shipping, in particular by reducing the imports of several raw materials and manufactured goods*, corroborated with a change of the structure of the other types of imports. These changes will have an influence on the size of the deep-sea fleet and its structure (types of ships);
- *an increase in the short-sea shipping and inland waterways transport*, as more and more production sites are brought closer to or within the EU countries. These entail an increase in the short-sea and inland waterways traffic, as well as a change in the structure of the fleets (types of ships) dedicated to these traffic segments.

These new operational demands and business models will likely impact the technological developments *per se*, as well as on the choices of which technologies should first receive more R&I efforts.

[16] Carbon border adjustment mechanism | European Commission (europa.eu)

The EP proposals go even further, with the accelerated phasing in of the CBAM (from 2027) and broadening its scope to include organic chemicals, plastics, *hydrogen and ammonia* as well as indirect emissions[17]. This may have an important impact for waterborne transport as a whole, not just in terms of the new ship types and/or services needed but also in terms of energy supply and costs, since most forecasts estimate that the EU will not be able to satisfy its hydrogen demand solely from domestic sources and will need to import significant quantities from other (neighbouring) countries.

In addition to the relevant provisions from the FF55 package, other EU-level legislation is also of interest for the deliverable scope, as outlined in the sections below.

The EU Taxonomy

The EU Taxonomy is a tool to help financial institutions and investors evaluate whether an economic activity can be classified as sustainable To qualify as sustainable, an investment would need to contribute substantially to at least one of these six objectives without doing significant harm to the other objectives.

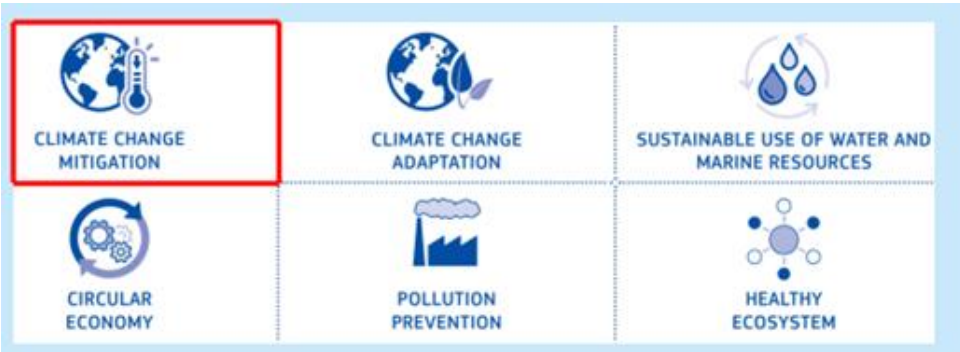


Figure 3 The six objective of the EU Taxonomy

Through delegated acts, for each of these goals, technical screening criteria are defined. The first delegated act, published in December 2021, focuses primarily on Climate Change Mitigation & Climate Change Adaptation. For maritime transport this resulted in three chapters:

- 6.10. Sea and coastal freight water transport, vessels for port operations and auxiliary activities;
- 6.11. Sea and coastal passenger water transport;
- 6.12. Retrofitting of sea and coastal freight and passenger water transport;

A new version of the taxonomy for climate mitigation is expected to be adopted in the course of 2023, in particular revising the requirements post year 2025 and introducing a well-to-wake reduction pathway for CO_2e emissions, as alternative to the zero-emission tailpipe approach which is in the current version. The report made by the Platform Sustainable Finance presents their latest proposals in the publication from October 2022 for the technical screening criteria for climate mitigation for both inland and seagoing vessels, including also manufacturing and retrofitting[18].

[17] Carriages preview | Legislative Train Schedule (europa.eu)

[18] See chapter 6 of the following report (page 275 onwards): https://finance.ec.europa.eu/system/files/2022-11/221128-sustainable-finance-platform-technical-working-group_en.pdf

With respect to the climate change mitigation goal, the following technical criteria were defined in the version of 2021:

- The activity complies with one or more of the following criteria:
    - the vessels have zero direct (tailpipe) CO_2 emissions;
    - until 31 December 2025, hybrid and dual fuel vessels derive at least 25 % of their energy from zero direct (tailpipe) CO_2 emission fuels or plug-in power for their normal operation at sea and in ports;
    - until 31 December 2025, and only where it can be proved that the vessels are used exclusively for operating coastal and short sea services designed to enable modal shift of freight currently transported by land to sea, the vessels have direct (tailpipe) CO_2 emissions, calculated using the IMO EEDI, 50 % lower than the average reference CO_2 emissions value defined for heavy duty vehicles (vehicle subgroup 5-LH) in accordance with Article 11 of Regulation 2019/1242;
    - until 31 December 2025, the vessels have an attained EEDI value 10 % below the EEDI requirements applicable on 1 April 2022 if the vessels are able to run on zero direct (tailpipe) CO_2 emission fuels or on fuels from renewable sources.
- Vessels are not dedicated to the transport of fossil fuels.
- Until 31 December 2025, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in grams of fuel per deadweight tonnes per nautical mile, as demonstrated by computational fluid dynamics (CFD), tank tests or similar engineering calculations.

For inland waterway transport this resulted in three chapters:

- 6.7. Inland passenger water transport;
- 6.8. Inland freight water transport;
- 6.9. Retrofitting of inland water passenger and freight transport.

With respect to the climate change mitigation goal, the following technical criteria were defined for:

- 6.7. Inland passenger water transport:
    - 1. The activity complies with one of the following criteria:
        - (a) the vessels have zero direct (tailpipe) CO_2 emissions;
        - (b) until 31 December 2025, hybrid and dual fuel vessels derive at least 50% of their energy from zero direct (tailpipe) CO_2 emission fuels or plug-in power for their normal operation.
- 6.8. inland freight water transport
    - 1. The activity complies with one or both of the following criteria:
        - (a) the vessels have zero direct (tailpipe) CO_2 emission;
        - (b) where technologically and economically not feasible to comply with the criterion in point (a), until 31 December 2025, the vessels have direct (tailpipe)

emissions of CO_2 per tonne kilometre (gCO_2/tkm), calculated (or estimated in case of new vessels) using the Energy Efficiency Operational Indicator, 50% lower than the average reference value for emissions of CO_2 defined for heavy duty vehicles (vehicle subgroup 5- LH) in accordance with Article 11 of Regulation 2019/1242. The Energy Efficiency Operational Indicator is defined as the ratio of mass of CO_2 emitted per unit of transport work. It is a representative value of the energy efficiency of the ship operation over a consistent period which represents the overall trading pattern of the vessel. Guidance on how to calculate this indicator is provided in the document MEPC.1/Circ. 684 from IMO. EN 145 EN

  - 2. Vessels are not dedicated to the transport of fossil fuels.

- 6.9. Retrofitting of inland water passenger and freight transport
- Substantial contribution to climate change mitigation
  - 1. Until 31 December 2025, the retrofitting activity reduces fuel consumption of the vessel by at least 10 % expressed in litre of fuel per tonne kilometre, as demonstrated by a comparative calculation for the representative navigation areas (including representative load profiles) in which the vessel is to operate or by means of the results of model tests or simulations.
  - 2. Vessels retrofitted or upgraded are not dedicated to transport of fossil fuels.

In 2023, the taxonomy screening criteria for climate mitigation will be revised, notably the criteria for the situation post year 2025. It is foreseen that the scope will be broadened by means of a well-to-wake approach based on the FuelEU Maritime proposal and RED emission factors for climate emissions. Thus, also combustion engines using fuels with significantly lower carbon intensity could be in scope after year 2025 to fulfil the technical screening criteria as defined in the delegated act for climate mitigation. Furthermore, the Taxonomy criteria may possibly be expanded with technical screening criteria on topics for air pollution and water pollution and there may be more specific criteria for cruise vessels.

The TEN-T Regulation Revision

TEN-T revision aims at **four main objectives**:

- making transport greener by providing appropriate infrastructure and more transport by more sustainable transport modes;
- facilitating seamless and efficient transport, fostering multimodality and interoperability between the TEN-T transport modes and better integrating the urban nodes into the network;
- increase the resilience of TEN-T to climate change and other natural hazards or human-made disasters;
- improving the efficiency of the TEN-T governance tools, at streamlining the reporting and monitoring instruments and at reviewing the TEN-T network design.

The completion of the network remains to be finalized by 2050 with intermediate **deadlines** in 2030 and 2040: the core network by 2030, the extended core network by 2040 and the comprehensive network by 2050. It also supports the uptake of recharging/refuelling infrastructure depending on synergies with a.o. the deployment of alternative fuels infrastructure (**AFIR** proposal).

Of the two horizontal priorities in TEN-T, one is the European Maritime Space. There are also numerous provisions dedicated to the IWT sector, which include: the deployment of alternative fuels' infrastructure (by 2030 and 2050) in compliance with AFIR, the introduction and promotion of new technologies and innovation for zero-carbon energy fuels and propulsion systems, stimulate energy efficiency, etc.

Corporate sustainability reporting requirements

Not only large industry players but also shippers and larger transport operators will be more and more obliged by means of EU legislation to make formal reports on their environmental performance and plans on how to reduce emissions. Moreover, there is pressure also from the side of financial institutions (related to taxonomy screening criteria) as well as the broader public to improve the environmental performance.

On 21 April 2021, the Commission adopted a proposal for a Corporate Sustainability Reporting Directive (CSRD)[19] which would amend the existing reporting requirements of the Non-Financial Reporting Directive (NFRD). This proposal extends the scope to all large companies and all companies listed on regulated markets (except listed micro-enterprises). The proposal requires an audit (assurance) of reported information, introduces more detailed reporting requirements, and a requirement to report according to mandatory EU sustainability reporting standards. All these added elements in the reporting will increase transparency and will have an impact on loan conditions and access to finance for the companies. Therefore, cargo owners in Europe need to be more and more transparent on their sustainability performance. This includes not only their own direct production processes, but also the logistic services which they contract. This includes not only climate change emissions but also air pollutant emissions and other environmental indicators.

The CountEmissions EU[20] initiative of the European Commission DG MOVE also supports this transparency towards transport users for both passenger and freight sector. It can be concluded that inland waterway transport operations will also need to become more transparent and visible regarding climate change and air pollution emission performance (NOx, PM). For the short term, this brings opportunities as IWT has still a benefit in terms of CO_2e emissions per ton transported.

This pressure on shippers brings also more demand for low/zero emission vessels in the market. This results in a better competitive position for clean vessels as also environmental criteria will come into play, unlike till now, only the direct cost-price of the transport service. This may help to get improved contracts and revenues. A pre-requisite however, is that the emission performance of vessels will be reported in a robust, standardised and transparent way to shippers.

[19] https://finance.ec.europa.eu/capital-markets-union-and-financial-markets/company-reporting-and-auditing/company-reporting/corporate-sustainability-reporting_en

[20] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13217-Count-your-transport-emissions-CountEmissions-EU_en

Air Quality requirements being made more strict

Another relevant development is the planned revision[21] by the EC of the air quality standards[22]. The EC published the proposal in October 2022. It is a part of the EU Green Deal. The proposed revision aligns the air quality standards more closely with the recommendations of the World Health Organization. For example, the annual limit value for fine particulate matter (PM2.5) will be reduced by more than half.

The consequence of reducing the annual limits by means of this legislation would be that local governments may have to take strong measures to bring emission limits down. As already many cities have imposed low emission areas for road vehicles, the attention may also come to other emission sources, such as inland navigation vessels. Especially for cities located along inland waterways and close to major ports, this can have an impact on the required air pollutant emission reduction inland vessels and may give another reason to speed up the emission reduction for inland vessels.

The NAIADES III Action Plan for Inland Navigation

The European Commission tabled in June 2021 a 35-point action plan to boost the role of inland waterway transport in our mobility and logistics systems. The core objectives are to shift more cargo over Europe's rivers and canals, and facilitate the transition to zero-emission barges by 2050. This is in line with the European Green Deal and the Sustainable and Smart Mobility Strategy.

The communication states that "*compared to other land-based modes of transport, inland waterway transport is energy-efficient, safe, almost congestion-free and silent. The Commission will propose measures to encourage investment in zero-emission and zero-waste technologies for inland vessels and inland ports and will also support research and innovation*."

The communication addresses the role and importance of the Zero-Emission Waterborne Transport Partnership to promote research in zero-emission vessels technology, innovative propulsion systems and sustainable fuels, also in close collaboration with the Battery Alliance, the European Clean Hydrogen Alliance and the Renewable and Low-Carbon Fuels Value Chain Alliance.

Flagship measures in NAIADES III relate to the speeding up of the certification process for innovative and low emissions vessels, the development of multimodal alternative fuel infrastructure hubs or the need to support the sector and Member States in the transition towards zero-emission, particularly regarding funding and financing, which are key to meeting the energy transition challenge. To meet this challenge, support for the initial deployment of zero-emission vessels and the related recharging/refuelling infrastructure is now proposed through the Alternative Fuels Infrastructure Facility under the 2021-2023 work programme of the Connecting Europe Facility 2. Where possible, funding under the CEF 2 could be combined with other sources of funding to achieve greater impact. Such a new instrument will partially contribute to closing the TCO gap and should be taken into account in the context of this report. In addition, the NAIADESIII action plan includes Action point 33 which indicates the need to facilitate the efforts by stakeholders and Member States to create a fund to complement EU and national financial instruments for the deployment of zero-emissions vessels – a topic which had been explored in more detail by the PLATINA3 partners in deliverable D2.5 "Report on implementation of funding and financing

[21] See https://environment.ec.europa.eu/topics/air/air-quality/revision-ambient-air-quality-directives_en

[22] See the latest WHO Air Quality Guidelines, published on 22 September 2021: https://apps.who.int/iris/handle/10665/345334

for energy transition European IWT fleet"[23]. In addition, MEP Caroline Nagtegaal also advocated to set up a dedicated EU inland waterway fund for the sustainable transition.[24] This confirms that the time is ripe to develop a specific financial instrument dedicated to IWT.

The CCNR Roadmap for Emission Reduction in Inland Navigation

In accordance with the mandate given by the Mannheim Ministerial Declaration of 17 October 2018[25], the CCNR developed a roadmap[26] aimed at largely eliminating GHG emissions and air pollutants in the inland navigation sector by 2050, a long-term vision also shared by the EU. Specifically, the Declaration tasked the CCNR with:

- reducing GHG emissions by 35% by 2035 compared to 2015 levels,
- reducing pollutant emissions by at least 35% by 2035 compared to 2015 levels,
- largely eliminating GHG and other pollutants by 2050.

Building upon the CCNR study on pathways towards a zero-emissions inland navigation sector[27], the roadmap is the primary CCNR instrument for mitigating climate change and accelerating the energy transition. In addition to a business-as-usual scenario, the roadmap outlines two transition pathways for the fleet by 2050, for both existing vessels and newbuilds. The more conservative pathway, based on mature technologies, is cost-efficient in the short-term but fraught with uncertainties about the availability of certain fuels in the long term, while the more innovative pathway relies on technologies still in their infancy stage but providing more promising emission reduction potential. Both transition pathways are sufficiently ambitious to achieve the emission reduction objectives of the Mannheim Declaration, but no "one size fits all" technology solution is adapted to all vessel types and navigation profiles. A technologically neutral approach appears therefore best suited to achieve the energy transition. Figure 1 below describes the pathways in more detail, but without covering all the technical possibilities for each main solution.

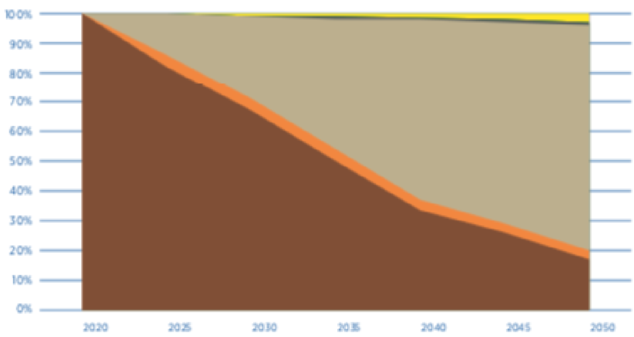
Looking ahead, the CCNR undertakes to:

- report by 2025 on the progress in the implementation as well as the need to update the roadmap;
- at the latest in 2025 evaluate whether it is opportune to revise the CCNR's study, especially on the economic and technical evaluation of the technologies;
- review the tank-to-wake approach in a forthcoming revision of its roadmap;
- evaluate by 2025 whether it is opportune to extend the scope of the roadmap, for example to other greenhouse gases such as N_2O or to emissions associated with other aspects of the vessel's life cycle, to the manufacturing and disposal of propulsion systems, to other types of vessels, or even to the technologies' safety;
- revise, if necessary, by 2030 the roadmap and the corresponding action plan.

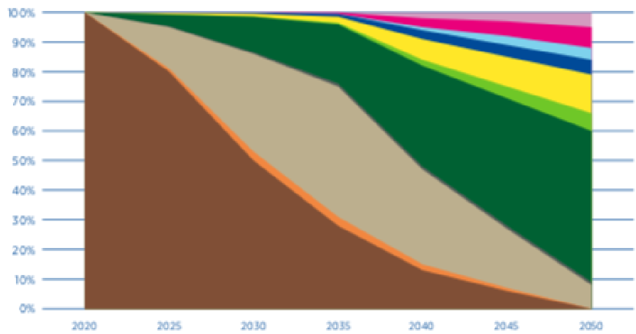
[23] See for more information https://platina3.eu/d2.5/
[24] https://www.europarl.europa.eu/doceo/document/A-9-2021-0231_EN.pdf
[25] CCNR, "Mannheim Declaration", 17 October 2018, https://ccr-zkr.org/Mannheimer_Erklaerung_en.pdf.
[26] CCNR, "CCNR roadmap for reducing inland navigation emissions", March 2022, https://ccr-zkr.org/12090000-en.html.
[27] CCNR, "Study on energy transition towards a zero-emission inland navigation sector", October 2020, https://ccr-zkr.org/12080000-en.html.

By supporting the transition towards a zero-emission fleet, the CCNR roadmap will be a valuable tool to promote the development of clean energy infrastructure. This includes shoreside power supply and charging facilities, and alternative fuel bunkering infrastructure. These themes were the subject of in-depth consultations during expert workshops held under the aegis of the CCNR.

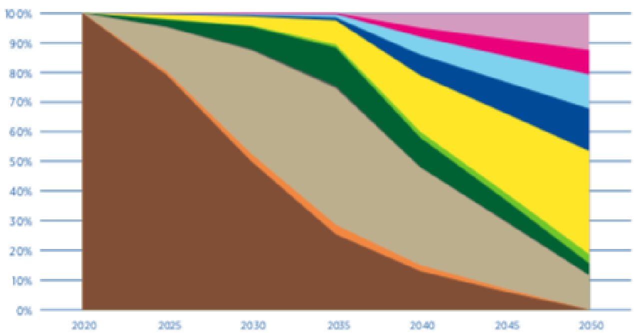
BUSINESS-AS-USUAL SCENARIO: DEVELOPMENT OF TECHNOLOGIES BY 2050



CONSERVATIVE TRANSITION PATHWAY: DEVELOPMENT OF TECHNOLOGIES BY 2050



INNOVATIVE TRANSITION PATHWAY: DEVELOPMENT OF TECHNOLOGIES BY 2050



TECHNOLOGIES CONSIDERED IN THE PATHWAYS

CCNR 2 or below, Diesel	Fossil diesel in an internal combustion engine which complies with the emission limits CCNR 2 or older engine.
CCNR 2 + SCR, Diesel	Fossil diesel in an internal combustion engine which complies with the emission limits CCNR 2 and equipped with an additional Selective Catalytic Reduction system.
Stage V, Diesel	Fossil diesel in an internal combustion engine which complies with the emission limits EU Stage V.
LNG	Liquefied Natural Gas in an internal combustion engine which complies with the emission limits EU Stage V.
Stage V, HVO	HVO in an internal combustion engine which complies with the emission limits EU Stage V. HVO stands for hydrotreated vegetable oil itself (without blending with fossil fuels) and all comparable drop-in biofuels (including e-fuels) as well as synthetic diesel made with captured CO_2 and sustainable electric power.
LBM	Liquefied Bio Methane (or bio-LNG) in an internal combustion engine which complies with the emission limits EU Stage V.
Battery	Battery electric propulsion systems, with fixed or exchangeable battery systems.
H_2, FC	Hydrogen stored in liquid or gaseous form and used in fuel cells.
H_2, ICE	Hydrogen stored in liquid or gaseous form and used in internal combustion engines.
MeOH, FC	Methanol used in fuel cells.
MeOH, ICE	Methanol used in internal combustion engines.

Source: CCNR

Figure 4 Transition pathways for the fleet and considered technologies

3.2 General Legislative impacts for the wider Waterborne sector

A short and comprehensive overview of the main 'Fit for 55 Package' (FF55) provisions, as proposed by the EC, for the overall waterborne transport sector is outlined in the figure below[28] [29].

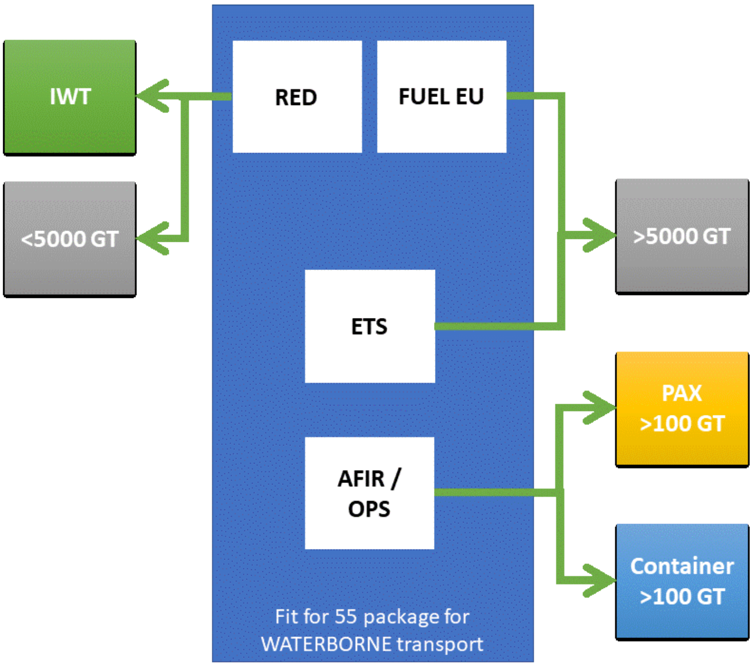


Figure 5 Fit for 55 – Relevance per ship-type

The EP proposals had not been included in this overview and in the calculations below as they are part of the negotiations which are ongoing, and the final outcome of the negotiations between European Commission, European Parliament and Member States is not decided yet. Therefore, the assessment is based on the original EC proposals as published in the Fit-for-55 package.

Based on the above mentioned currently proposed policies, the following trajectories have been elaborated per SRIA ship type and shall provide an indication on how the cumulative directives and allowances, capping the CO_2 emissions, will be reflected in terms of proportional reduction of CO_2 emissions as a direct result of the legislative proposals in Fit for 55, except for the impact of the Effort-sharing Regulation (ESR).[30]

It however shall be noted that the Inland Waterway Sector is covered under the Effort Sharing Regulation for which the regulations proposes specific climate change emission reductions on national level for each Member State.

[28] Elaboration of the STEERER partners, D2.2, page 49
[29] Though the information refers to the direct applicability of these legislative acts, their implementation can also benefit other (smaller) waterborne transport segments – e.g. for AFIR/OPS, the new infrastructure can also be used by ships that are smaller than the indicated limits, thus helping to further decarbonize the sector.
[30] Elaboration of the STEERER partners, D2.2, page 50

*Table 1. CO_2 Emission reduction according to direct impact of FF55 package concerning ETS, EU Fuel Maritime, RED, AFIR related to 2018 levels (**ESR excluded**). Note, only RED 2 revision proposal may have an impact on CO_2 reduction in IWT.*

	2025	2030	2035	2040	2050
Cruise, Ferries, Container Ships >5000GT	5,7%	26,7	47,7%	68,7%	100%
Cruise <5000GT	0%	17%	19%	20%	23%
Ferries <5000GT	0%	16%	17%	19%	21%
Container ships <5000GT	0%	14,9%	15,6%	16,3%	17,7%
IWT	6%	13%	13%	13%	13%
…					

The next figure shows that, following the FF55 package targets, waterborne transport[31] will in fact not keep pace with the overall GHG reduction needed to stay within the 1.5°C climate goal.

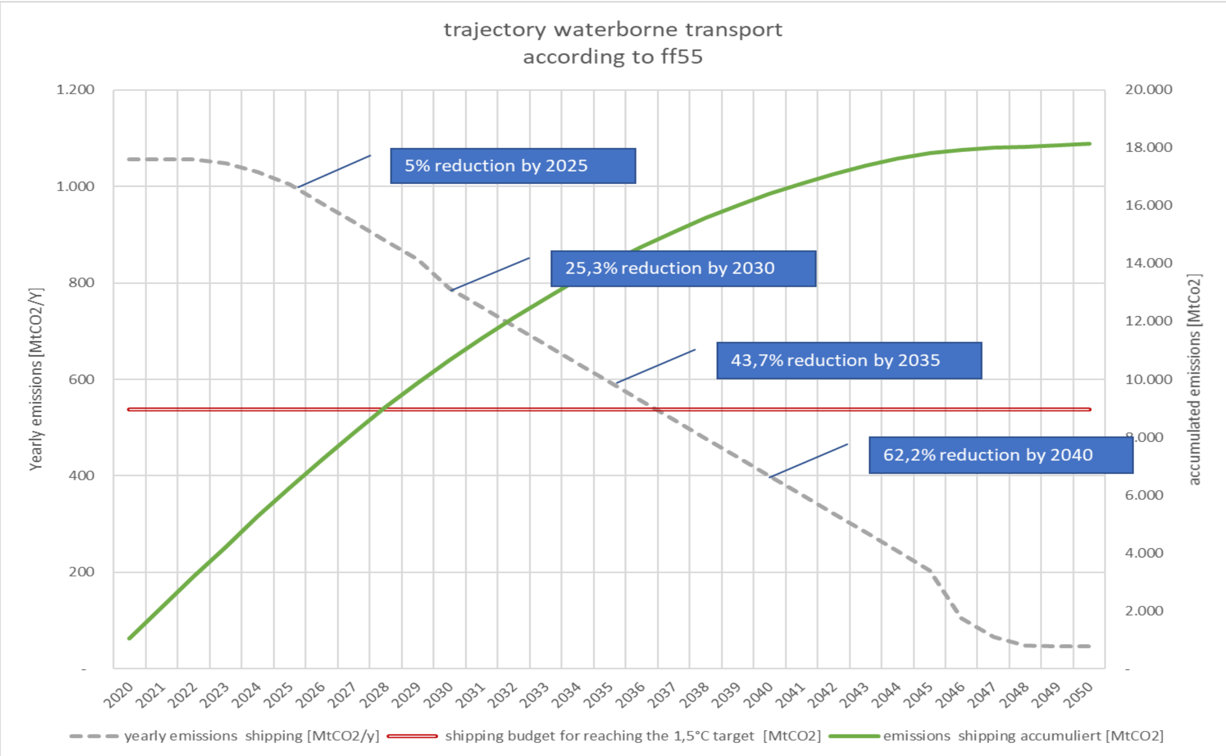


Figure 6 Trajectory of waterborne transport emissions according to FF55 package

The calculated overall carbon budget for shipping (8970 million tonnes (Mt) CO_2) is shown as the horizontal double red line. The yearly emissions starting with 1056 $MtCO_2$/y and are continuously reducing according to the anticipated reduction based on the FF55 package are represented by the dotted grey line. The accumulated emissions over time are represented by the green line. It shows that

[31] Reference is made to the whole waterborne transport here as the background information for the PLATINA3 deliverable comes from STEERER, which has dealt with the entire waterborne transport sector. Moreover, this deliverable will be used to amend the ZEWT cPP SRIA, consequently the reference has been kept to ease the understanding of readers from both the Partnership and the others. For a more detailed information please see sections 2.1 and 2.2 of this deliverable.

even with this reduction trajectory the climate targets based on the linear application of the carbon budget calculation can be reached only if from 2028 onwards an active CCS will be performed, or additional measures are put in place[32], such as an immediate and very large implementation of the most efficient and available technical solutions.

Figure 7 and table 2 indicate the difference of the trajectory of the partial FF55 package (which is eventually a target the sector can achieve) and the trajectory to stay within in the calculated carbon budget to reach the 1.5°C climate target.[33]

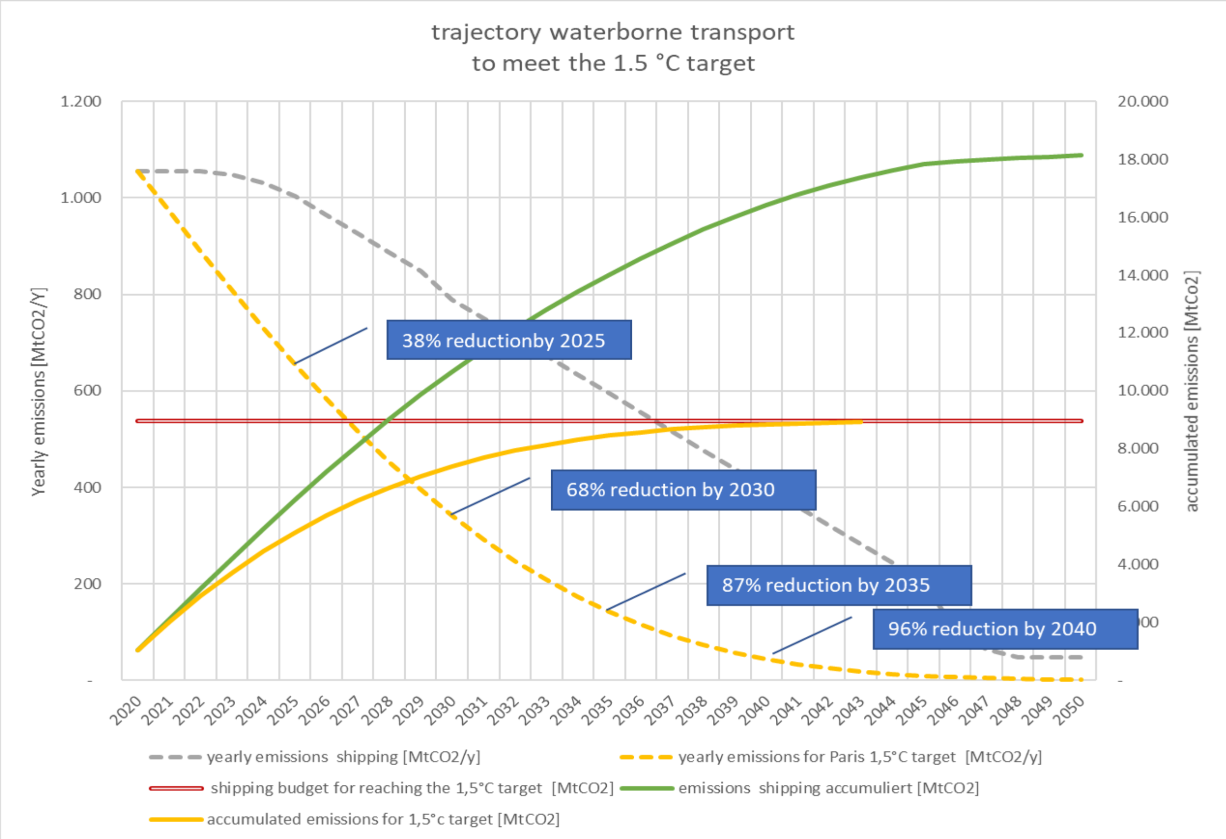


Figure 7 Trajectory of waterborne transport emissions to meet 1,5 °C climate target

Table 2. comparing required emission reductions to meet FF55 impacts due to the policy package proposed (e.g. ETS, EU Fuel Maritime, RED, etc.).and calculated carbon budget for waterborne in relation to an equal contribution to mitigate 1.5 °C global warming.

Targets	2025	2030	2035	2040	2050
Reductions for meeting FF55 / EC policy	5%	25%	44%	62%	90%
Reductions for meeting 1.5°C according to calculated carbon budget for waterborne transport	38%	68%	87%	96%	100%

[32] Elaboration of the STEERER partners, D2.2, pag 51
[33] Elaboration of the STEERER partners, D2.2, pag 51-52

3.3 Emission Targets for the IWT Segment

The NAIADES III policy document[34] and also the Central Commission for the Navigation of the Rhine (CCNR) have stated emission reduction ambitions and targets. The EC and CCNR work towards achieving near zero-emission performance in 2050 as compared to 2015.

For the medium term, CCNR aims to reduce at least 35% of GHG emissions in 2035 compared to 2015[35]. As policy instrument, the recent CCNR Roadmap shows the technology pathways and the planned measures to support and promote the transition of IWT to a green transport mode[36]. Therefore, in figure 8 made by STEERER project, these targets have not been taken into account as EU and CCNR have not yet taken enough regulatory additional measures to achieve these targets, except the proposed revision of RED 2 (-13% carbon intensity of fuel by 2030).

The IWT segment emissions have a volume of 4,53 MtCO_2 /y[37]. The regulations which sum up the GHG reduction targets in fuel supply for IWT are derived from the Fuel Quality Directive (FQD), of 6%, and the RED, of 13%, assuming that Member States will actually apply the reduction targets for the whole transport sector to fuel suppliers active in Inland Waterway Transport. However, the actual level of reductions for the IWT is yet to be seen as Member States may decide for themselves on how to divide the overall target to be achieved between modes and users of the transport fuels and how to achieve this. IWT countries with a high share in the bunkering of the inland fleet and in transport performance of IWT such as The Netherlands, Belgium and Germany did not impose until now requirements to fuel suppliers in IWT (for FQD compliance on national / member state level)[38].

Assuming only the possible impact of the revision of the RED 2, the IWT sector would still miss the 2050 target mentioned by the Sustainable and Smart Mobility Strategy (SSMS) by 77% if the 13% reduction target is quickly enforced and nothing further happens. The gap is 87% compared to reaching 100% reduction for the climate change emissions. The latter is the target according to the share of IWT in the global carbon budget for staying within the 1.5°C target.

As indicated, complementary reductions and targets on European and national levels are already applicable and defined, for example as described in NAIADES III Communication and as laid down in the Mannheim Declaration and presented in the CCNR Roadmap. Moreover, there may also be additional EU-level measures for IWT to guide the sector achieve its 2030 and 2050 climate targets.

34 https://transport.ec.europa.eu/transport-modes/inland-waterways/promotion-inland-waterway-transport/naiades-iii-action-plan_en

35 Ministers of CCNR Member States, competent for inland navigation, Mannheim, 2018.

36 https://www.ccr-zkr.org/files/documents/Roadmap/Roadmap_en.pdf

37 Based on data provided by CCNR and results from PROMINENT project, STEERER D2.2 page 56

38 See also PLATINA3 Deliverable 2.7 for more information: https://platina3.eu/towards-zero-emission-fleet/

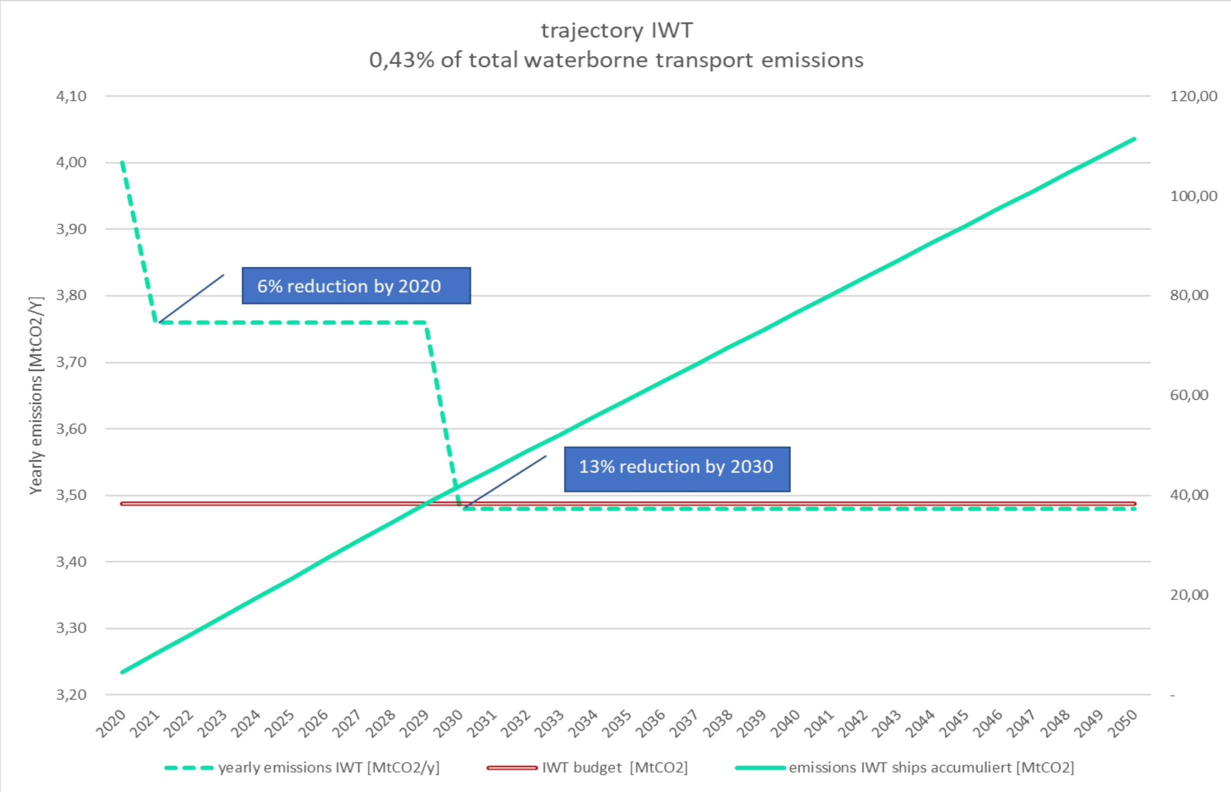


*Figure 8 Emission reduction targets for IWT acc. to FF55 package **excluding ESR***

Clearly, other additional measures, besides the revision of RED2 are needed to increase energy efficiency and to apply less carbon intensive energy sources. These measures are to be elaborated on national levels in Europe in view of the **Effort Sharing Regulation by which the IWT is covered**. Furthermore, there is also an option for Member States to add IWT into the proposed ETS scheme for mobility (opt-in). However, this needs to be harmonised at the international level as much as possible, to avoid a disturbance of the level playing field and to ensure effective regulations. Possibly, river commissions such as the CCNR and the Danube Commission (DC) can play a role here as well to coordinated between their members. Therefore, further specification of national and European policy measures, execution of RD&I tasks and supporting grant funds for deployment are necessary to enable IWT to take higher share in reducing emissions.

4. Actions Proposed for the SRIA Intervention Areas

This chapter encompasses the main information extracted from STEERER D2.7 for all the intervention areas of the ZEWT SRIA. The information was then refined and updated in order to give a clearer direction of the RD&I and deployment activities that need to be undertaken by the Partnership and the waterborne transport stakeholders for the IWT segment and the transversal topics, to help achieve the waterborne transport climate targets by 2050.

All relevant actions foreseen had been listed under three separate themes: technical, regulatory and business. This separation had been done to identify the various solutions and the better way to implement them, including through complementarity.

To clarify what each theme encompasses, a non-exhaustive list of questions is added below:

- Technical (T): How can emissions be further reduced or even eliminated? What is needed to increase the TRL of the related technologies? Are there any knowledge gaps? Is the RD&I pipeline moving?
- Regulatory (R): How can policy support and facilitate the innovations that are needed? Are the safety measures needed in place? Do class guidelines and/or technical requirements need to be developed or updated? What existing regulations need to be updated to increase uptake?
- Business (B): Is it economically feasible to invest in the technology? What is the return on investment? Is retrofitting an option? What is the perception of the technology? Is there enough access to capital for RD&I, pilots & deployment? Is enough information available for the shipowner to decide? Do commercial agreements need to be updated?

Seen that in PLATINA3 there is also deliverable D2.7 “Report on policy recommendations on regulatory pathway towards zero emission fleet” the regulatory actions from STEERER have been updated. Only those regulatory actions were kept which call for significant RD&I work for the IWT or transversal topics. Therefore, for the purpose of this deliverable, the focus has been on the selection and use of the key technical actions. A few actions under the regulatory and business themes have also been mentioned, as the future ZEWT Partnership calls could also include some policy- and business-related activities. The topics that are proposed for support by the HEU (including the ZEWT Partnership) or by the Innovation Fund are indicated as such in the proposals below. As mentioned in section 2.3 of this document, the structure of the intervention areas is the following:

- Intervention Area 1 – Sustainable Alternative Fuels (SAFs);
- Intervention Area 2 – Electrification;
- Intervention Area 3 – Energy Efficiency;
- Intervention Area 4 – Design and Retrofitting;
- Intervention Area 5 – Digital Green;
- Intervention Area 6 – Ports.

It must be noted that during the PLATINA3 Final Stage Event[39] some stakeholders have raised the question of how will it be possible to prevent that multiple projects will be launched at the EU level and

[39] See for more information on the PLATINA3 final stage event: https://platina3.eu/event/final_stage_event/

they will not result in tangible results for the shipowner due to the lack of clear and long-term decisions from the policy makers on the technologies to be used (including the infrastructure investments. There is no clear-cut answer here, since the entire zero-emission transition concerns not only the ships, thus being out of scope for both the Partnership and PLATINA3. But the PLATINA3 (and STEERER) work offers the possibility to have efficient, faster and (hopefully) reasonably-priced decarbonization solutions for the IWT ships, regardless of which technology or technologies will be dominant in this sector. The emergence of one or more ship-related technologies, something that the IWT shipowners can influence, should also be a factor in determining the other stakeholders, including the policy-makers, to select the overall method(s) for decarbonization in the IWT sector.

Another related question during the Final Stage Event had been on the prioritisation of certain types of technologies, in particular the electrification solutions over the fuel-related ones. As there is no 'one size fits all' for the IWT ships, as it is the case for the maritime as well, PLATINA3 (and the Partnership) will look at all relevant technologies in parallel, also to keep the options open seen the many uncertainties which are still existing. The only prioritisation that the report provides is based on the advancement of technologies and the existing calls and projects *within* each Intervention Area.

4.1 Intervention Area 1 – Sustainable Alternative Fuels (SAFs)

In this section, the focus lies on the use of sustainable alternative fuels in waterborne transport (such as onboard storage and energy conversion): (bio- and e-)LNG, (bio- and e-)methanol, (e-)hydrogen, drop-in biofuels (bio-Diesel and HVO). The document will not address the production of the fuels (although key because the two go hand-in-hand). Bunker infrastructure will be covered in the sixth intervention area (Ports).

Before addressing the proposed set of actions for each sustainable alternative fuel separately, each SAF having a dedicated section in the pages below, the following key actions were defined that apply to all the possible sustainable alternative fuels[40].

The topics that are considered of a higher importance for the Partnership's activities have been indicated as 'priority' both in the table below and in the tables throughout this subchapter.

Theme	Key actions
T	Further upscaling of **demonstrator projects** to identify benefits/push the limits of the different fuels. (**Priority** for both HEU and the Innovation Fund)
T	Development/ further optimization of **engines systems (including aftertreatment systems)** to (nearly) eliminate all types of air pollutants (focus on the most harmful ones first) for traditional fuels, as well as for some technologies converting sustainable alternative fuels. Therefore, new Stage V engines need to become further available and be certified for usage of: higher blends of biofuels, methanol and hydrogen, either dual fuel or single fuel[41]. (HEU)

[40] A selection has been made for the actions that are most relevant for the RD&I activities that can be financed under the ZEWT Partnership.

[41] The current Stage V Regulation text is a big bottleneck as it does not encompass H2 and methanol to the reference fuels. Thus, there is a high risk that companies will not invest anymore in developing these engines.

T	Investigate the reliability and cost of fuel cells in the waterborne transport environment (tilting, acceleration, vibrations, etc.).
R	ES-TRIN and NRMM regulations are/is yet lacking provisions for the use of different types of hydrogen carriers (e.g. compressed H2, methanol) and therefore need to be updated/adjusted where needed to facilitate the use of sustainable alternative fuels.
R	Address full **life-cycle emissions** when assessing a fuel (upstream + downstream information, calculation methods, etc.) for **all (NOx, PM, CO, H_2, N_2O, CH_4, CH_2O, CO_2)** harmful emissions (air pollutants + GHGs). (HEU)
R	Safety regulations (training, operational rules, vessel design, etc.) need to be developed/updated where needed to facilitate the use of sustainable alternative fuels and guarantee safety. (HEU)
B	Insights in the cost comparison and broader impacts (e.g. loss of cargo space, bunkering time, etc.) between the different options for sustainable alternative energy as fuel and energy convertor – internal combustion engines (ICE) or fuel cells (FC) – for different vessel types and operational profiles[42].

Additionally, two consolidated technical actions were identified.

Area	Consolidated actions
SAF	Develop, demonstrate and test high TRL cost-efficient and effective power conversion systems for the use of sustainable alternative fuels on board of the vessel. (HEU)
SAF	Develop, demonstrate and test high TRL cost-efficient and effective storage and bunkering systems for sustainable alternative fuels on board of vessels. (HEU)

Liquefied Natural Gas – (bio and e-)LNG

Use of LNG – including bio- and e-LNG – in the IWT fleets.

Theme	Key action
T	Minimize/eliminate methane slip by engine and tank design (possibility of including after treatment systems) and proper design-for-operation.
R	Investigate and prepare the regulation of methane emissions.
R/B	Monitoring and reporting of methane slip will allow further differentiation between existing options and to incentivize the use of the better options (less methane slip). Lower slip levels are technically possible but come at a higher cost.

A large-scale, continuous role for LNG is uncertain due to the uncertain GHG benefits, the additional capital expenditures, uncertain price projections for bio-LNG and e-LNG, and therefore the risk of stranded assets. There are concerns about a possible technology lock-in with a GHG emissions trajectory which would be incompatible with the EU's and CCNR's 2050 climate targets in case methane slip is not eliminated and bio-LNG and e-LNG are not available. Furthermore, there is already a recently launched

[42] The SYNERGETICS (ZEWT Partnership call) and RH2IVER projects will investigate (part of) these elements for the existing fleet and retrofit solutions.

IA project in the framework of the ZEWT Partnership which addresses this topic, which makes it highly likely that the remainder of the RD&I activities will have to be funded either by the companies or through other EU-funded mechanisms available.

There is therefore a clear need for urgent and strong policy action to further regulate methane emissions both in the supply chain of LNG (upstream) and in its use on board existing ships and any newbuilds. For inland waterway transport the already-existing Non-Road Mobile Machinery (NRMM) limits on methane slip would need to be more stringent (e.g. A=3 instead of A=6 in the NRMM Directive). This will be important regardless of whether LNG becomes a significant bunker fuel or not. For example, although downstream methane emissions could be reduced using newer machinery with lower methane slip levels, this would still not address the risk of upstream and midstream methane emissions in the supply chain, the emissions of which are said to be much lower and even negative for bio- and e-LNG, compared to fossil LNG. These present a much more complex problem that is not strictly technological in nature, but would require regulatory changes and enforcement across the numerous jurisdictions where LNG is produced and distributed.

Bio- or e-LNG – is considered as an option to the ships that require a higher engine and energy storage capacity on board. Any remaining RD&I activities that are necessary for this technology should primarily focus on these ship types and/or their operations. The other ship categories and sailing profiles will normally benefit from better alternatives, whether from other types of SAFs or electrification.

(Bio and e-)Methanol

Use of methanol – including bio- and e-Methanol – in the IWT fleets.

Theme	Key action
T	Investigate and demonstrate the maintenance needs of methanol as well as types of storage systems. (HEU & Innovation Fund)
T	Investigate and demonstrate the optimal tank type selection for different operational profiles. (HEU & Innovation Fund)

While the RD&I activities on methanol focused on IWT are few, the maritime sector is investing a lot in it. A number of solutions are already mature while others are in their final development stages, and work is on-going to ensure that they will reach market roll-out in the coming years. Consequently, the methanol-based technologies have a promising outlook to become widely available not just for the maritime sector, but for the IWT as well. However, for IWT specific regulations apply such as ES-TRIN for the on-board storage of methanol and NRMM Regulation for air pollutant emissions of methanol engine. Consequently, significant additional RD&I may still be needed to make (some of) the technology for seagoing vessels also applicable, certified and useable for inland vessels. Moreover, the development of new combustion engines for IWT using methanol as fuel may still take a few years (until 2027/2028), because a full revision is first needed of the current NRMM Stage V regulation[43] to add methanol as

[43] Revision of Regulation (EU) 2016/1628 of the European Parliament and of the Council of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery.

reference fuel in the legislation and to allow new engines using methanol to be sold to the market for usage in IWT.

The paragraphs below describe the latest developments for this fuel segment and their applicability for waterborne transport.

According to the Clarksons' database (November 2022), there are 22 seagoing vessels in service (3 chemical tankers, 1 ferry and all other methanol carriers) and 61 on order (with a delivery expected between 2023-2028): 3 chemical tankers, 4 offshore vessels, 1 cruise ship, while the others are container ships. To make a comparison with the situation from a few years before, the Fuelling Transition report of October 2019 indicated only 11 ships in service and 1 on order. Unfortunately, no more information could be found from before that date. The interest in methanol as a fuel is thus growing substantially, which is reflected in a number of new orders for different ship types. Some examples in 2022 are: Maersk ordered one 2,100 TEU methanol dual fuel container ship (delivery in 2023) and 8 16,000 TEU container ship (delivery in 2024-2025) and CMA-CGM ordered six 15,000 TEU container ships (delivery in 2025). New orders for Methanol ships cover a wide range of different vessel types: Tanker, Offshore supply vessels, Ferries, Tugs and more.[44] In June 2022, MEYER TRUKU started the construction for the first Methanol-ready cruise ship for their customer TUI Cruises.[45]

As regards the IWT segment, on the 16th of January 2023 the CCNR approved an exemption for the use of methanol as fuel for the tanker Stolt IJssel. This is a joint decision of the five member states in application of the Rhine vessel inspection Regulations. This exemption is based on the guidelines for the storage of methanol adopted by CESNI (joint body of the CCNR and the EU) in June 2022. These guidelines could be included as requirements in ES-TRIN 2025. There was also in the past an experiment with a small passenger vessel using methanol and fuel cells (up to 35 kW power in total), the MS Innogy[46]. The demonstration however stopped and was not successful.

The increasing ordering activities are related to methanol fuel cells and engines (TRL 7-8) as well as tank systems (TRL 8) are available and demonstrated in operational environments in sea transport for different vessel types, ranging from RoPax ferries (Stena Germanica) to pilot boats as in the FASTWATER project.[47]

The reason why the TRL does not have a higher score is linked to industry & safety standards that still need to be updated and technical regulations which are missing; specific to the case of the IWT segment, for storage on board and also for certification of new combustion engines (NRMM Regulation) using methanol as reference fuel[48] On regulatory level there should also be a guarantee that the green variants of methanol are acknowledged as green fuels, e.g. to be acknowledged in the revision of EU Taxonomy via a WTW methodology based on the FuelEU Maritime proposal and methodology.

The availability of bio-/e-methanol is limited today[49], but shows rapid growth in the last two years and the increasing number of new ships using methanol as fuel are already on order (e.g. from Maersk, CMA-

[44] https://www.methanol.org/wp-content/uploads/2022/06/Final-On-the-Water-and-on-the-Way-5.pdf
[45] https://www.maritime-executive.com/article/first-large-methanol-ready-cruise-ship-begins-construction-in-finland
[46] https://maritime-executive.com/article/methanol-fuel-cell-powered-passenger-ferry-sets-sail
[47] https://www.methanol.org/wp-content/uploads/2022/06/Final-On-the-Water-and-on-the-Way-5.pdf
[48] For IWT, In June 2022, interim guidelines on methanol storage were adopted by CESNI/PT. They are available for the sector and to help the development of pilot projects. Inclusion of technical requirements in ES-TRIN is foreseen for 2024.
[49] https://www.methanol.org/renewable/

CMG and more), will consequently increase the demand of bio-/e- methanol further. As an example, Maersk announced in March 2022 a global strategic partnership with six leading energy companies to boost the production of bio-/e-methanol with the intent of sourcing at least 730,000 tonnes/year by end of 2025.[50]

The high TRL in combination with a substantial number of vessels operating on methanol and the opportunity to convert existing vessels to methanol makes methanol a convincing option towards net-zero emission shipping.

(e-)Hydrogen

Use of hydrogen – including bio and e-hydrogen – in the IWT fleets.

Theme	Key action
T	Investigate and demonstrate the maintenance needs of different hydrogen carriers as well as types of storage systems, interoperability and safety of mobile hydrogen storage systems. (HEU & Innovation Fund)
T	Investigate and demonstrate the optimal tank type selection for different operational profiles. (HEU & Innovation Fund)
T	Clarify & demonstrate capabilities with regards to new engines' load profile variation and low load operations (e.g. in emergency situations)[51]. (HEU & Innovation Fund)
T	Assess operational fit with regards to energy efficiency / density. (HEU & Innovation Fund)

Hydrogen (compressed) will initially be mainly a suitable option for the smaller waterborne transport segments but not for the vessels with a long range due to its low energy density and extremely high fuel and hardware costs. This could however change in the future if a suitable liquid organic hydrogen carrier (LOHC) is found and economies of scale are reached.

As hydrogen is one of the cleanest solutions available – provided that the hydrogen used is either 'pink', 'blue' or 'green' – and considering the volume and/or weight requirements needed, hydrogen-propulsion technologies are first of all applicable to smaller ships, including the IWT ships. Particular attention should therefore be placed on hydrogen RD&I actions for these ship categories, building on ongoing projects such as RH2IWER which will demonstrate 6 vessels using hydrogen as fuel (containerised, compressed H2) in combination with electric propulsion via fuel cells.

As a second step, hydrogen-related technologies, whether as main or auxiliary power sources, should become more and more applicable to the larger ship categories thus helping achieve the decarbonisation targets.

As regards the development of new combustion engines (ICE) for IWT using hydrogen as fuel it became clear that this may still take a few years (until 2027/2028). This is because a full revision is first needed

[50] https://www.maersk.com/news/articles/2022/03/10/maersk-engages-in-strategic-partnerships-to-scale-green-methanol-production

[51] As previously mentioned, the current Stage V Regulation text is a big bottleneck as it does not encompass H2 and methanol to the reference fuels. Thus, there is a high risk that companies will not invest anymore in developing these engines. In the case of hydrogen, there is also the problem that the maritime-related developments are not fully relevant for the IWT, as the latter uses smaller engines than the former and specific certification procedures need to be followed for IWT, in contracts to certification of combustion engines for seagoing vessels.

of the current NRMM Stage V regulation to add hydrogen as reference fuel in the legislation and to allow new engines using hydrogen to be sold to the market for usage in IWT vessels.

Drop-in biofuels (bio-Diesel and HVO)

Use of drop-in biofuels in the IWT fleets.

Theme	Key action
B	Engines need to be certified and tested for the (blends) with biofuels as alternative for the fossil diesel, e.g. Stage V engines to be certified for blends of fatty acid methyl ester (FAME) higher than 8%.
R	Fuel specifications need to be made stricter, including the measurement and enforcement due to fuel instability, corrosion, susceptibility to microbial growth, and poor cold-flow properties of certain biofuels. Also, proper government measures need to be more widely known and clear to the users and fuel providers.

However, it is considered that no fundamental technical or research work (RIA, IA projects) is needed within the ZEWT Partnership in this case. Some coordination is however recommended to make sure that there are common standards and incentives to apply these types of drop-in fuels for existing diesel engines.

(e-)Ammonia

Use of ammonia in the IWT fleets.

Though ammonia is in principle one of the options for the waterborne transport sector alongside hydrogen, some of its implications are still not fully assessed – in particular the GHG impact of laughing gases (ammonia emissions) and the safety-related aspects are crucial topics for research. Ammonia as fuel is currently seen by public bodies as unsuitable for IWT due to the high external safety risks, lacking legislation in place (especially on safety). The same position of public bodies may apply to maritime transport, in particular the short-sea, ferry and off-shore categories in case they operate in proximity of densely populated areas such as in seaports or close to cities.

4.2 Intervention Area 2 – Electrification

Even though full electrification using batteries on board will only be applied in waterborne transport segments that have shorter and/or fixed/predictable routes, hybrid solutions have an important role to play in terms of more optimal energy management of certain processes on board of a vessel. New technologies might require additional energy storage systems such as batteries, gensets or supercapacitors to cover the fluctuating load variations and increase the efficiency, reliability and flexibility of the entire power system. A big advantage of full battery electric drive is the high energy efficiency as there is hardly any thermal loss of energy. This amounts to around 5-10% compared to 50-60% of energy thermal loss for internal combustion engines and fuel cells. Especially if there is a shortage of green electricity (also to make e-fuels and green hydrogen), the option of full electric propulsion using batteries charged from the grid is very attractive. Furthermore, these batteries can also be used for peak-shaving and stabilising the electricity grid, seen also the expected increase of fluctuations due to more electricity coming from renewable sources such as wind, water and solar power.

The full electric option should be as much as possible developed and deployed for vessels that have the possibility to recharge frequently or swiftly exchange swappable batteries (short distances and/or fixed routes and timetables). With increased technological performances in particular for the batteries and drivetrains, fully electric can become a good option for some of the IWT segments on short term, and on longer term for all IWT, also depending on the land side infrastructure (e.g. high-capacity recharging facilities and battery swapping terminals along waterways and in ports). Given the current and foreseen developments for both fully-electric and the sustainable alternative fuels, the hybrid option could be relatively inefficient, though the ultimate decision needs to rest on an in-depth analysis of the operational profile, the layout of a specific vessel (e.g. fuel storage options) and the available power/fuel sources in the region and the price levels.

As expected, the uptake of hybrid solutions is rising steadily and at a somewhat faster pace than fully electric, e.g. the ferry fleet is the fleet type that opts most for a hybrid solution together with the offshore fleet (offshore supply vessels). There are also opportunities for further deployment in IWT by the application of swappable battery containers, such as those investigated by the EU-funded CURRENT DIRECT project and demonstrated by the ZES company in The Netherlands for inland waterway transport (short distance inland container service Alphen aan den Rijk <> Moerdijk). Furthermore, the SYNERGETICS project, from a ZEWT Partnership call, will address electrification of (existing) vessels and the possible use of exchangeable battery containers as well as hybrid concepts and fuel cell solutions.

The main key actions identified for this Intervention Area are outlined below.

Theme	Key actions
T	Research to bring down the volumetric and gravimetric density of battery modules and pack integration, making onboard storage modular and standardised, and thus competitive with conventional fossil diesel. This could result in other types of hydrogen carriers and convertors and new types of electricity storage technology than the ones used today. (HEU)
T	Demonstration of the battery design life in operational conditions (Innovation Fund).
T	Developing more DC components to improve the energy efficiency. (HEU & Innovation Fund).
R	Further develop ES-TRIN to take into account new battery types, ease battery handling and prevent standardisation issues

In addition, the following **consolidated** technical action was identified:

Area	Consolidated actions
ELEC 1	Fuel Cell and battery technology development and application on board of vessels, taking into account the waterborne transport segments. Both low TRL level developments focusing on the further development and demonstration of promising new battery technologies on board of vessels and high level TRL developments aiming to bring FC and battery applications closer the market.

4.3 Intervention Area 3 – Energy Efficiency

In order to tackle GHG reduction at fleet scale with significant effect, the existing fleet needs to undertake major changes. Relying on only the replacement of the existing fleet would be a too long process to achieve the greenhouse gas reduction objectives. Early emissions have more climate impact than delayed emissions, thus ship lifetime and its complete lifecycle (including ship construction, solutions lowering the carbon impact, etc.) need to be considered and reflected in actions. Consequently, significant emphasis should be placed on retrofittable solutions for energy efficiency[52] alongside fleet renewal.

Combined with the foreseen acceleration of regulation measures at European and international level, the development of European-manufactured energy efficiency solutions is a large source of competitiveness and employment for shipyards, technology designers and manufacturers, etc, besides the added value in relation to the GHG reduction targets.

Many energy efficiency solutions are demonstrated and available to the market. One of the main challenges is now to increase their individual performances for further opportunities. Once the technologies are demonstrated, regulations can accelerate the actions on GHG emission reduction. On the other hand, without a strong European supply chain dedicated to energy efficiency solutions, the costs of solutions will be high and the solutions won't be available in large enough quantities which would make GHG targets unachievable.

One of the main pitfalls is a lack of data regarding the benefits of the energy saving technologies. Shipowners and/or developers are not always able or willing to share certain data which makes it more difficult to e.g. calculate estimates regarding fuel consumption reduction. It is also not clear what happens when different solutions are being combined and what the effect is on optimal engine load. To get the most out of the systems, they will need to be integrated and the most ideal way to do this is on new builds.

The focus within this intervention area was put on a few major solutions for seagoing vessels – wind-assisted propulsion systems, air lubrication, waste heat – since many promising technologies exist under these categories but need to be demonstrated on different vessel types and operating profiles.

Before addressing the main individual energy efficiency measures selected, each having a dedicated section and set of proposals in the pages below, the following key actions were defined that apply to all of them.

Theme	Key actions
T	Development and demonstration of advanced energy management systems that can determine the optimal use & storage of energy for different systems onboard. (HEU)
T	Investigate which energy efficiency measures (technical and operational) are most interesting to combine (move away from a siloed approach).
T	Setting up an online knowledge platform where a clear overview can be found of different energy efficiency measures and hydrodynamic improvements including the parameters that

[52] (Some) Energy Efficiency data and solutions will be addressed in SYNERGETCIS project (ZEWT Partnership).

	determine GHG reduction potential, the maturity level and which vessel or operating profile would be the best fit.[53]
T	Upgrade the performances of the panel of solutions using renewable energies including wind propulsion, to maintain competitivity and accelerate adoption.
R	Investigate options for energy efficiency requirements in legalisation for vessels, in view of reporting requirements on energy efficiency and possibly setting threshold values [54]

Additionally, one **consolidated** technical action was identified:

Area	Consolidated actions
EEF1	Identification and (further) development of the most promising and future-proof energy efficiency measures, taking into account the waterborne transport segments. The energy efficiency measures need to fit with innovations, in particular those in the fields of sustainable alternative fuels and electrification, and support the transition towards zero-emission, including for the existing fleet. (HEU)

Wind-assisted Propulsion Systems (WASP)

Opportunity for use of wind-assisted propulsion in the IWT fleets is very limited due to the physical barriers which impose height restrictions along waterways (e.g. passing fixed bridges). Therefore, in comparison with potential for the sea going vessels, the potential for application of WASP in inland networks is much smaller and probably only relevant on specific waterways such as lakes and short distance operations without fixed bridges).

The uptake of the technology is rather slow in seagoing vessels since large-scale deployment of this technology is still in its early phase, but progress has been made in the last decade to enhance the design of wind assisted propulsion systems, demonstrate and calculate the expected performances and integrability.

Air-lubrication Systems

The technology works best on flat-bottomed, nonhigh-speed ships when it uses the air cavity lubrication, while the option with microbubbles (the Silverstream technology) works best on faster (maritime) sailing vessels, following the principle: higher speed = higher frictional losses = more gain to be had. The system promises fuel savings of up to 10% for seagoing vessels, which are significant

Experiments with air lubrication systems for inland navigation yet failed to be successful (e.g. Ecoliner vessel). In IWT the situation becomes more complex with the effect on draught and cargo capacity in lower-water periods. Also, the abrasive action of the riverbed is a challenge on some stretches and for some concepts. Therefore, it is not seen as a promising technology to be applied in IWT for now.

[53] A part of this action will already be addressed in the SYNERGETCIS project (ZEWT Partnership).
[54] Note that the topic will also be addressed in the CSA call topic 17 of the HEU 2023/2024 Work Programme

Waste-heat Recovery Systems

In the last couple of decades, Waste-heat Recovery Systems have seen rapid development and adaption in maritime transport because of unstable fuel prices and increasing interest in energy efficiency and emission reduction[55].

The simple way of using recovered waste heat is by using it to supplement the onboard hot water demand. This was done in a local subsidised project in the Netherlands on a floating crane, where cooling water that had been used to cool the main engine was led through a waste heat recovery system. The system facilitates the heating of the cool water by the warmer water, after which the now warmed-up water from the onboard heating system moves on into the onboard heating system. The floating crane uses gas to heat its water and the expected savings on gas lie around 50%[56].

However, as mentioned above, recovered waste heat can also be transformed into electricity. Konur, Colpan and Staatcioglu explain that these systems will typically use the Rankine Cycle, using waste heat to evaporate a fluid of which the vapour expands trough a turbine generating power. This process works best with very high levels of heat, which does not match well with waste heat. To overcome this, the Organic Rankine Cycle (ORC) is used. The ORC uses a fluid with a low evaporation temperature, allowing the system to make use of waste heat of lower temperatures. This system has seen rapid development in maritime applications in recent years.

Currently, these systems are being offered to the IWT sector by a couple of companies specializing in aftertreatment systems and/or sound reduction. Furthermore, in the Netherlands, Waste Heat Recovery systems for inland vessels are applicable for Energie Investerings Aftrek (Energy Investment Deduction), a tax deduction for investments that increase energy efficiency[57].

Despite the overall low uptake, there is a wide variety in the vessel types that choose this technology. It generally applies to the larger and/or higher energy demand ships, for the technology to deliver tangible and cost-effective results. More recent experience shows that the reduction potential is normally up to 8% of the main engine fuel consumption. Given the smaller engines used in inland vessels compared to seagoing vessels, the overall potential of applying waste-heat recovery systems is smaller in IWT compared to the maritime segments.

4.4 Intervention Area 4 – Design and Retrofitting

This section covers topics such as new fuel storage systems, considering the likely lower energy density linked to the new fuels, new energy efficient technologies that require revised energy management systems and investigations of effects on the engine load. All these technological evolutions require the re-thinking of the vessel design and drivetrains. Even though most sustainable alternative fuels are not yet available, considering the average lifetime of a vessel, they need to be designed in a way that a retrofit is relatively feasible once the new sustainable alternative fuels and technologies are available. Simulators will have a more and more important role to analyse the best fit between a certain vessel

[55] Olgun Konur, C. Ozgur Colpan & Omur Y. Saatcioglu (2022) A comprehensive review on organic Rankine cycle systems used as waste heat recovery technologies for marine applications, Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 44:2,4083-4122, DOI: 10.1080/15567036.2022.2072981 // https://doi.org/10.1080/15567036.2022.2072981

[56] EICB provided generalised information. Project by Bonn&Mees BV.

[57] https://www.rvo.nl/sites/default/files/2022/02/BrochureEIA-Energielijst2022.pdf Page 63 Measure 240801

type and operational profile on the one hand and the ideal vessel design on the other hand. Additionally, it needs to be considered that every non-standard vessel comes with additional purchasing costs, so shipowners need to find a way to cooperate to realize economies of scale.

Although both the design and retrofit activities of IWT ships have a long and fruitful history, a lot of improvements are still needed to address the pressing challenges. The first is climate change, which not only requires significant emission reductions, but also poses a specific problem: ensuring navigation in shallow(er) waters, especially for longer periods of time. These come at a time when the sector is also aiming to increase its market share, thus raising the difficulty of the challenges ahead. That is why the IWT needs solutions for both shallow waters and energy efficiency aspects such as new propellors and hull shapes.

Before addressing some specific design and retrofitting measures in a dedicated section and set of proposals further below, the following key actions were defined that apply on a more general level.

Theme	Key actions
T	Development and implementation of new vessel designs that support several energy sources (multi-fuel engines and fuel cells and batteries). (HEU)
T	Investigate and demonstrate the benefits of using multiple (smaller) main engines to optimize engine load distribution and increasing energy management flexibility. (HEU)
T	Optimize design for real operating conditions instead of mainly one load case and one speed. (HEU)
T	Further improvement of simulation tools to faster evaluate new vessel designs and retrofit solutions. (HEU)
T	Retrofitting existing vessels by the (optimal) integration of sustainable available solutions, including solutions using renewable energies.[58]

Also, as a summary to capture the specific measures above, the following two **consolidated** actions were defined, as presented below.

Area	Consolidated actions
DER 1	Improved ship designs and designs for retrofits, specifically related to the developments in the field of adoption of sustainable alternative fuels and electrification, covering all waterborne transport segments and hence various vessel types (modular design). Also, new initiatives should be launched by shipyards and technology suppliers to develop and demonstrate new materials and production processes to improve the production and retrofit processes, and work with sustainable materials.
DER 2	Research into limiting the size of the IWT vessels for low-water events, emission reductions and improved operations. The research also needs to consider the competitiveness of these vessels against the larger vessels.

[58] A part of this action will already be addressed in the SYNERGETCIS project (ZEWT Partnership).

Design

The sections below highlight the main technologies and proposed actions that will help the IWT transport segment overcome these challenges. The information comes from the PLATINA3 partners and is based on several project developments, in particular deliverable D2.2 Options for shallow-water / climate resilient vessels[59]. However, the maritime sector could also benefit from these developments.

The Propeller and Other Parts of the Propulsion System

When it comes to the issue of propellers and other propulsion systems apart the engine, the IWT segment is facing a challenge in terms of both energy efficiency and climate resilience (shallow waters). As different studies have shown, an increase of the thrust loading coefficient results in a decrease of the open water propeller efficiency and greater energy losses. In general, it may be concluded that operation under low water conditions will lead to an increase of the thrust loading coefficient, and, therefore, the open water efficiency will be reduced. If the draught is too low, ventilation occurs and the required thrust cannot be generated. The reduction of the open water efficiency can be overcome by the arrangement of multiple propulsors, e.g. use of 3 propellers instead of 2 where the thrust is distributed to more devices, or technical solutions for provision of additional thrust, e.g. Kort nozzles, being very effective at high thrust loading coefficients. In addition to the losses in efficiency, a high propeller loading may result in cavitation and ventilation, preventing a proper operation of the ship, as well as causing possible damage to the propulsion and rudder devices.

Reducing the thrust load by increasing the cross-sectional area leads to a higher propulsive efficiency.

Consequently, two key actions are proposed in this case.

Theme	Key action
T	Further develop propellers and other parts of the propulsion systems – apart the engine – that will allow ships to both navigate shallow(er) waters and maintain or increase their energy efficiency.
T	Investigate the optimum relationship between water draught and optimal ventilation and propulsion of new vessels via improved model testing numerical simulation testing – these tools also having to be further developed.

Bow Thrusters

For the propeller-related developments, it must be noted that in shallow water at very small draughts of the vessels, the great propeller loading can cause air suction and thereby a loss of thrust, generating energy inefficiency and even preventing the ship from starting moving in the worst cases. This can be overcome by reducing the thrust and load of the propeller using a bow thruster which creates an additional thrust, compensating the lower thrust of the propeller.

In shallow waters, the bow thruster improves: the manoeuvring behaviour of a vessel, which usually becomes worse with decreasing water depth; the stopping distance and time, which increase with

[59] See for more information on the PLATINA3 work on shallow water and climate resilient vessels: https://platina3.eu/options-for-shallow-water-climate-resilient-vessels/

decreasing water depths, but the additional thrust of the bow thruster acting in opposite direction of the movement of the vessel will slow it.

As a result, one key action had been identified in this case.

Theme	Key action
T	Develop new bow thrusters that allow operations in extreme shallow waters with equal or increased energy efficiency. The proposed solutions also need to prevent the accumulation of sediments in the thrusters.

Weight Reduction

According to ECCONET (2012), hulls of commercial conventional ships are built of so-called “mild steel” – steel plates and profiles of standard quality (mechanical characteristics and chemical components) dedicated to shipbuilding. The hull structure must satisfy the prescribed strength requirements. However, standardised structures (cross sections, bar scantlings and plate thicknesses) have been usually developed for minimum building costs but not for minimum weight. The mild shipbuilding steel is characterised by relatively low costs and high durability compared to other materials, being of importance especially when having in mind that the exploitation period of an IWT vessel is 50 years or even more (Radojčić et al. (2021)). Therefore, the hull weight has not changed much over time. However, there are some technical solutions existing having some potential for weight reduction, although most of them will be associated with a significant cost increase.

The first solutions had been to introduce the use of high tensile steel (HTS) and aluminium. Their use can reduce a ship’s weight and thus its energy and environmental footprint. In the case of seagoing vessels, a hull made of 10 % HTS can reduce the steel weight up to around 2 %, while 60 % HTS is expected to result in roughly 10 % of hull weight savings (Radojčić et al. (2021)). According to the same authors, for inland waterway vessels, the total savings would be even less. But both HTS and aluminium are expensive and come with their own drawbacks. Similar solutions can be found with other types of high quality steel or other materials, though for the moment they are linked to higher shipbuilding costs.

Another project that had recorded good progress on such topics is IW-NET.

It is therefore necessary to investigate the designing and building of (parts of) the IWT ships by using other materials, alloys and composites.

At least in the beginning, it is expected that their application will be mostly limited to a part of the hull, such as the wheelhouse or the superstructure, and advancing later to other part of the ship and even the ship as a whole in the longer term.

If other material than steel is used, the equivalent strength has to be proved as in the case of a steel structure. With respect to inland vessels, any lightweight material which is not standard has to be considered on a case-by-case basis and shall comply with the general rules for materials of the classification societies providing guidance relating to usage of uncommon materials and “not-so-proven” technologies not considered in the fully developed rules. The affordability of these materials should also be consider, as a prohibitive price for materials will mean that it will have no market in IWT.

Thus, the following key action is proposed.

Theme	Key action
T	Develop new materials, alloys, composites, etc. for shipbuilding. The new solutions need to offer similar technical characteristics and safety (fire resistance) while at the same time achieving a weight reduction at a reasonable price.

Retrofitting

The retrofitting activities will first of all have to mirror the information and proposed key actions from the 'Design' section – the first four proposals in the table of actions below. In addition, a specific retrofit proposal is mentioned at the end of the table, based on the partners' knowledge and the work developed in other PLATINA3 deliverables, in particular D2.2

While the proposals are mostly aimed at the IWT segment, the maritime sector could also benefit from these developments.

The unified list of key actions for retrofitting is presented below, which ensures the replication of actions from the design section into the retrofit one. In the table below we focus on existing vessels, whereas in the tables above the actions refer to new vessel designs.

Theme	Key action
T	Develop ship-based and equipment-based solutions to retrofit the existing ships with new propellers and other parts of the propulsion systems – apart the engine – that will allow ships to both navigate shallow(er) waters and maintain or increase their energy efficiency.
T	Investigate the optimum relationship between water draught and optimal ventilation and propulsion of the solutions to modify existing vessels via improved model testing numerical simulation testing – these tools also having to be further developed.
T	Develop ship-based and equipment-based solutions to retrofit the existing ships with new bow thrusters that allow operations in extreme shallow waters with equal or increased energy efficiency. The proposed solutions also need to prevent the accumulation of sediments in the thrusters.
T	Develop new materials, alloys, composites, etc. to use in the retrofitting of existing ships. The new solutions need to offer similar technical characteristics while at the same time achieving a weight reduction at a reasonable price.
T	Investigate the adaptation of existing vessels from local-to-local modifications to the replacement of the aft ship, aiming largely at increasing the cargo capacity at low water while maintaining or improving energy efficiency.

4.5 Intervention Area 5 – Digital Green

The 'digital green' term concerns the broadest use of digitalisation to improve efficiency and reduce emissions through making devices smart and connected.

Before addressing the main 'digital green' measures selected, each having a dedicated section and set of proposals in the pages below, the following key actions were defined that apply to all technologies in this intervention area.

Theme	Key action
T	Standardisation of data interfaces to facilitate modularity (HEU).
T	Setting up of waterborne transport demonstrator projects: many technologies are mature but need to be tested and further tailored for vessels. (Innovation Fund)
T	Further development and testing of advanced systems (collision avoidance, AI, neural networks, sensor fusion and integration, etc.) to move from TRL 5-6 to TRL 8 to enable highly automated navigation in IWT.

Obtaining the data is not anymore the real challenge, but making value out of it is the challenge. The sector stakeholders need standards on how to share data and how to use it, and there is a big job ahead on this aspect.

Smart navigation in IWT

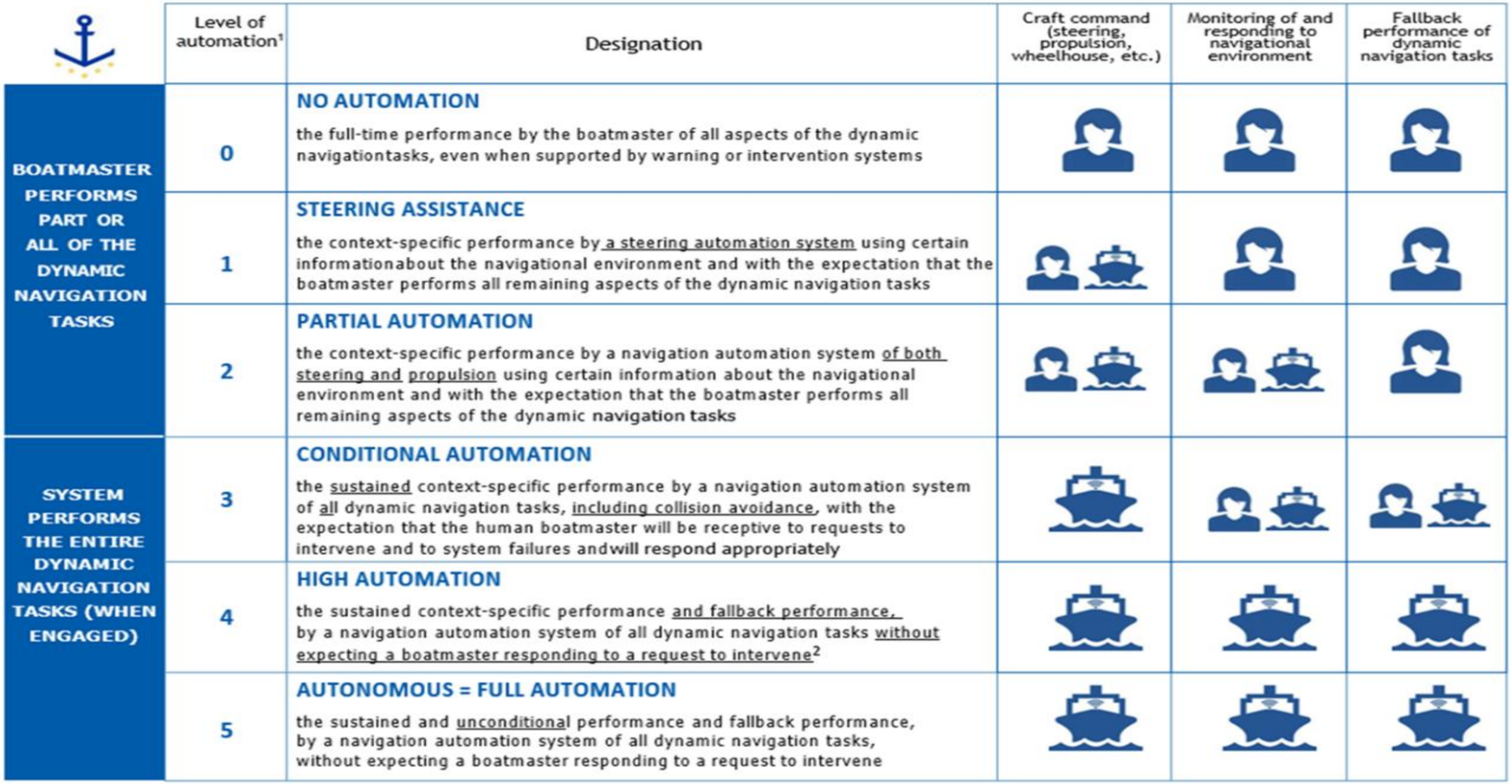
Smart navigation here refers to further developing and promoting digital energy efficiency tools for optimised operations to optimise load rates and sailing schedules and speeds, taking into account fluctuating water levels on free-flowing rivers like Rhine and Danube. There are already best practices in this area in projects and commercial initiatives such as RIS-COMEX, COVADEM, NOVIMAR and RENEW. In other words, there is a broad spectrum of benefits from digitalisation on the vessel, ashore and across the logistics system that can translate into more efficient operations and fuel savings and hence emission reductions. One technical action had been identified for this section, as outlined below.

Theme	Key action
T	Further develop and promote digital energy efficiency tools for optimised operations to optimise load rates and sailing schedules and speeds in IWT, taking into account fluctuating water levels on free-flowing rivers like the Rhine and the Danube.

Automation

In 2018, the Central Commission for the Navigation of the Rhine (CCNR) adopted the first internationally recognized definition of the various levels of automation in inland navigation (levels ranging from 0-5)[60], which were reviewed and updated in January 2023. Automated navigation now covers a wide spectrum of technical processes spanning numerous use cases, from simple navigational assistance to fully automated (autonomous) navigation. The CCNR levels of automation constitute therefore the variable that offers the best understanding of the concept of automation in inland navigation, as it is tailor-made for the sector. It ranges from steering assistance and partial automation (levels 1-2) to progressive delegation of tasks without intervention of the boatmaster (levels 3-4). Fully autonomous vessels correspond to level 5 (independent command with no human involvement), the most advanced stage of automation. An overview of the various levels of automation can be found in the figure below.

[60] CCNR, "Definition of levels of automation in inland navigation", November 2021, CCNR | Automation levels [EN].



	Level of automation[1]	Designation	Craft command (steering, propulsion, wheelhouse, etc.)	Monitoring of and responding to navigational environment	Fallback performance of dynamic navigation tasks
BOATMASTER PERFORMS PART OR ALL OF THE DYNAMIC NAVIGATION TASKS	0	**NO AUTOMATION** the full-time performance by the boatmaster of all aspects of the dynamic navigationtasks, even when supported by warning or intervention systems			
	1	**STEERING ASSISTANCE** the context-specific performance by a steering automation system using certain informationabout the navigational environment and with the expectation that the boatmaster performs all remaining aspects of the dynamic navigation tasks			
	2	**PARTIAL AUTOMATION** the context-specific performance by a navigation automation system of both steering and propulsion using certain information about the navigational environment and with the expectation that the boatmaster performs all remaining aspects of the dynamic navigation tasks			
SYSTEM PERFORMS THE ENTIRE DYNAMIC NAVIGATION TASKS (WHEN ENGAGED)	3	**CONDITIONAL AUTOMATION** the sustained context-specific performance by a navigation automation system of all dynamic navigation tasks, including collision avoidance, with the expectation that the human boatmaster will be receptive to requests to intervene and to system failures andwill respond appropriately			
	4	**HIGH AUTOMATION** the sustained context-specific performance and fallback performance, by a navigation automation system of all dynamic navigation tasks without expecting a boatmaster responding to a request to intervene[2]			
	5	**AUTONOMOUS = FULL AUTOMATION** the sustained and unconditional performance and fallback performance, by a navigation automation system of all dynamic navigation tasks, without expecting a boatmaster responding to a request to intervene			

[1] Different levels of automation may make use of remote control but different conditions to be defined by competent authorities might apply in order to ensure an equivalent level of safety.

[2] This level introduces two different functionalities: the ability of "normal" operation without expecting human intervention and the exhaustive fallback performance. Two sub-levels could be envisaged.

Figure 9 Definition of levels of automation in inland navigation. Source: CCNR

Funded by the Horizon H2020 Programme of the European Union under grant agreement No 101006364

Highly automated navigation has seen many developments in recent years in the IWT sector. In particular, the industry is working on technical (partial) solutions, such as advanced track pilot systems, lidars, sensors, etc. to enable highly automated sailing in a commercial setting. Furthermore, the CCNR published a vision to support the harmonised development of automated navigation via a holistic and technologically neutral approach.

In terms of Technological Readiness Levels (TRL) and outstanding RD&I needs, it appears that most of the systems needed for low level automated navigation (levels 1-2) are already in a relatively high state of market readiness. This includes the core systems allowing automation (RADAR, LIDAR, cameras, GNSS, communications, global internet, track pilots etc.), which are considered to have reached a high TRL level. On the other hand, techniques and systems for high automation and autonomy (levels 3-5) have comparatively low TRL levels. Indeed, the most advanced systems (collision avoidance, AI, neural networks, sensor fusion and integration, etc.) still need additional technical improvements to move from TRL 5-6 to TRL 8. Furthermore, on some small sections of the Rhine and on most of the Danube, high speed internet connectivity (4G/5G) remains unavailable, which is a virtual precondition for operating a significant share of automated vessels, especially remote-controlled vessels. Finally, encryption, data integrity, and cybersecurity systems and protocols still need additional testing and improvements to become fully mature.

Some systems allowing high levels of automation are currently in use, although there is always a human as a supervisor and backup - either onboard or in an RCC. More testing locations for automation levels 3 and above are needed to gather as much data as possible. This data is necessary for developers to improve the performance of their systems and for regulators to make informed decisions.

The figure below outlines the automation concept(s) used in the maritime segments, for reference. There are both similarities and differences between the two segments.

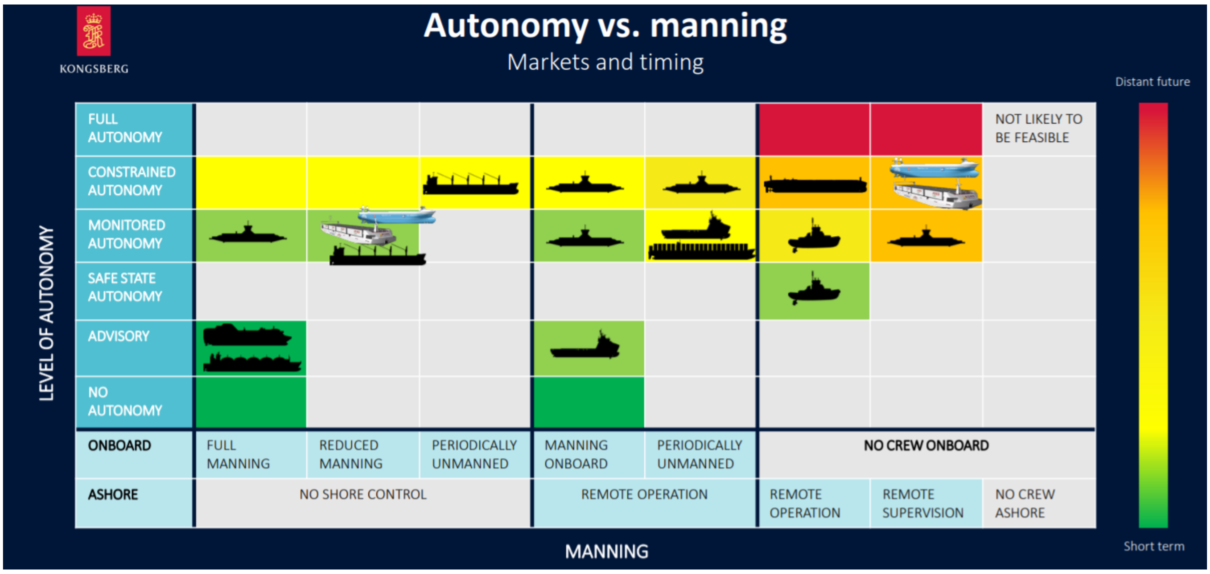


Figure 10 Levels of autonomy by Kongsberg[61]

[61] Kongsberg: MASS session 27 January 2022

Several inland/estuary vessels are already controlled remotely with seafarers onboard in Belgium, the Netherlands and Norway. Through the use of sensors, AI is also already being applied for the detection and identification of objects (situational awareness), which is needed to further evolve. Other EU-funded projects such as MOSES look at more complex operations such as AI controlled tugboats to automate mooring and docking of large vessels to reduce time spent on manoeuvring, reduce docking time and reduce human error.

A comprehensive research action proposed in this section is outlined below.

Theme	Key action
T	Further development and testing of advanced systems (collision avoidance, AI, neural networks, sensor fusion and integration, etc.) to move from TRL 5-6 to TRL 8 to enable highly automated navigation in IWT when it improves efficiency and reduces emissions.
R	Support the development of legislation to enable and facilitate advanced automated navigation in view of manning requirements, on board systems and communication / interface with on-shore systems and waterway and port infrastructure.

Digital Twin

A digital twin is a virtual representation of an object or system that spans its lifecycle, is updated from real-time data, and uses simulation, machine learning and reasoning to help decision-making.

The conclusion of the STEERER & PLATINA3 partners and that of the waterborne transport experts that have advised the STEERER project is that there is a lot of mature technology in place within this intervention area and the costs are also very high for limited benefits – in particular for the IWT segment. However, **one of the biggest hurdles is the standardization of modules**. Because standardization is a more general key action that can apply to all technologies that fall under digital green, the digital twin will not be described separately. Furthermore, in this respect two EU RD&I projects were launched recently, the “CRISTAL” project that includes tasks on the topic of Digital Twins and the “DT4GS” project which is predominantly about Digital Twins in the waterborne transport sector. Future results from these studies could be exploited by the waterborne transport industry for the further development, standardisation and application of Digital Twins, especially since one other ZEWT call for Digital Twins will be issued.

4.6 Intervention Area 6 – Ports

Before addressing the main measures related to ports and ship-to-ports interfaces selected, each having a dedicated section and set of proposals in the pages below, one key action was defined for future RD&I activities applicable, as outlined below.

Theme	Key action
T	Research cost-effective, widely applicable and standardised bunkering/charging solutions, considering various potential bunkering/charging locations in different ports and the different types of vessels. (HEU)

Additionally, one **consolidated** action was identified.

Area	Consolidated actions
Ports	Initiatives are needed that focus on the development of cost-effective, high TRL and standardised bunkering and charging concepts on the ships and the ship-to-shore and/or ship-to-ship interfaces, taking into account the various vessels in the different waterborne transport segments and the various geographical locations.

Inland ports can also be considered as energy hubs which means that synergies might be created when bundling energy- and transport-related investments. Energy produced / stored in inland ports can be served to industrial stakeholders, whereas – where applicable – also as sustainable alternative fuels for vessels.. This bundling might reduce CAPEX at the infrastructure side which shall benefit in lower costs and higher availability of green solutions for vessels. Having a SAF production facility nearby/in the IWT port cluster would be ideal from a business point of view, a win-win for both the IWT and the energy companies, with additional benefits for other stakeholders; however the inland ports/port clusters are often small and in the vicinity of cities, something that poses a big challenge in terms of space availability, safety, environmental aspects, etc

Sustainable Alternative Fuels (on-shore)

As the sustainable alternative fuels may require more complex storage and transfer facilities than for conventional fuels (particularly those that are stored at high pressures and/or low temperatures, such as hydrogen), the additional facilities may have significantly higher costs. The figure on the next page gives an overview of estimated CAPEX and operational expenditures (OPEX) related to the bunkering infrastructure of sustainable alternative fuels in seaports in relation to maritime (seagoing) transport[62]:

[62] Ricardo Energy & Environment: Technological, Operational and Energy Pathways for Maritime Transport to Reduce Emissions Towards 2050, p.95

Table 3. Assumed costs for refuelling infrastructure for alternative fuels[63]

Fuel type	Bunker capacity (tonnes/annum)	Port facility lifetime (years)	CAPEX ($ million)	OPEX ($ million per year)	Source
HFO	1,000,000	30	10.00	0.50	No detailed data found. Estimated value to provide some balancing cost reductions.
MDO	1,000,000	30	10.00	0.50	Assumed same as HFO
LNG	1,935,000	30	53.27	5.03	LNG bunkering financing opportunities (Ocean Shipping Consultants, 2016[59])
BioLNG	1,935,000	30	53.27	5.03	Assumed same as LNG
Hydrogen	255.5	30	23.00	0.92	Feasibility of hydrogen bunkering (ITM Power, 2019[60])
Ammonia	255,500	20	41.00	1.33	A blueprint for commercial-scale zero-emission shipping pilots (Energy Transitions Commission, 2020[61])
Methanol	255,500	20	8.00	0.17	Same source as Ammonia
FAME	1,000,000	30	10.00	0.50	Assumed same as HFO
HVO	1,000,000	30	10.00	0.50	Assumed same as HFO

In this case, the following actions have been identified:

Theme	Key action
T	Demonstrator projects on bunkering sustainable alternative fuels at inland and sea ports, including energy providers. (Innovation Fund)
T	Development methods and technologies for faster bunkering. (Innovation Fund)

[63] Ricardo Energy & Environment: Technological, Operational and Energy Pathways for Maritime Transport to Reduce Emissions Towards 2050, p.95

Onshore Power Supply (OPS) and (Fast) Charging Infrastructure

In contrast to ocean going vessels, the use of onshore power supply (OPS) is quite common in IWT, especially in Northwest Europe. For example, of the 2,500 up to 3,250 public moorings in the Netherlands for inland vessels, 1,000 are expected to be equipped with shore-side electricity.[64] Furthermore, there are multiple initiatives in European countries to increase the number of OPS points in (inland) ports to be used by inland vessels.[65]

However, following the STEERER GSEG advice, it must be noted that during the last heat waves there, California itself derogated from the rule of mandatory OPS for larger vessels, due to the lack of available electricity. Such situations may also affect future OPS use by inland vessels in EU ports. These aspects need to be considered in the EU framework where we have our own energy scenario(s) and specific concerns, in particular due to the war in Ukraine. OPS in EU ports will require a lot of electricity and the question of sufficient energy supply needs to be addressed. Normally, the energy needs for OPS (and battery charging) in ports can and should largely be met in the period towards and especially after 2030 through the developments of off-shore wind farms, based on the forthcoming EU's Off-shore Renewable Energy Sources (RES) Strategy. This is something agreed to and supported by the EU ports, as noted during the GSEG consultation.

Furthermore, the GSEG have pointed out that there are existing common standards from the International Electrotechnical Commission (IEC), the International Organization for Standardization (ISO) and the Institute of Electrical and Electronics Engineers (IEEE) for connection between the maritime ships and the onshore power: IEC/ISO/IEEE 80005-1, 80005-2, IEC 62613-1. This approach must also be developed in parallel and reconciled with the European standards (EN) used in IWT for electrical shore connection: EN 16840 and EN 15869.

Given the current OPS landscape in European ports, it can be stated that the further deployment and usage of OPS by the IWT sector will be very dependent on three aspects that can pose a challenge. **This relates to how much energy an energy producer can provide, the capacity of the grid transporting electricity to the port and whether the port area has the right electric cables at the berths**. These are challenges related to both the port infrastructure and outside the port infrastructure.

More specifically, the grid does not always reach to the quay side of the port area or in an effective manner. Additionally, inland cruise vessels require substantially more electricity and at a higher wattage. The existing grids are not always able to address these demands. The AFIR does not address this challenge and this could make the deployment of the required OPS by 2030 impossible.

Vessel operators are also hoping for more OPS points. They should be located close to loading/unloading areas, and otherwise in relevant spots, and the focus of the electrification trend should shift from providing for the electricity demand on board during rest or waiting times to providing adequate electricity to charge large battery packs used for propulsion. The objective of minimum 1 OPS per inland port, as proposed by AFIR, is a good start but might not be enough.

There should also be a uniform concept for the operation of the shoreside power connections and a commonly accepted payment method.

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[64] https://www.schoneluchtakkoord.nl/publish/pages/195605/sla-kennisdocument-thema-schone-havens-en-binnenvaart-fase-1.pdf

[65] Examples are mentioned in PLATINA3 D4.2

Finally, it is important to note that battery-electric propulsion systems and accumulators for self-sufficient power supply bear the risk that OPS connections providing electricity during berth operations might become a bridging technology in the future, especially if battery technology greatly increases battery and battery containers capacity. In the middle to long term, the energy demand of certain vessels for berth operations could be met by onboard batteries, meaning existing shoreside power infrastructure might not be required any further for this specific purpose. To avoid dead-end investments, shoreside power infrastructure should be planned to be as flexible and as service-oriented as possible to allow adaptation to future needs. These multipurpose service platforms could then not only be used for shoreside power but also for giving access to water, internet, communication, and other services when at berth.

Looking to the future, it is also essential to set up OPS points in such a way that they can also be utilized for (rapid) charging of batteries on board used for propulsion of the vessel. However, it does appear that this is technically very complex and requires a lot of infrastructural modifications to make a regular OPS point ready to serve as a charging point to charge batteries on board of vessels used for the propulsion of the vessel.

Based on the data gathered by the consortium and following the discussions with the experts within the STEERER project and given the results from PLATINA3 deliverable D4.2[66], below is a set of RD&I proposals concerning OPS and charging infrastructure.

Theme	Key action
T	Standardized components on vessel side for OPS and fast-charging (e.g. connections, earthing system, length of cables). (HEU)
T	Studies to making OPS points future ready so they can be utilized for (rapid) charging of batteries on board used for propulsion of the vessel
T/B	Availability, feasibility and use of swappable battery containers.
B	Further development of fast charging infrastructure. (Innovation Fund / CEF)
R/B	Development and harmonisation of standards & procedures (both of technical and financial-administrative nature) for OPS and (fast) charging at seaports and inland ports (the ship-to-shore interfaces). (HEU)

[66] https://platina3.eu/clean-energy-infrastructure/

5. Complementary Initiatives and Synergies

5.1 CESNI Developments

The European Committee for drawing up Standards in the field of Inland Navigation (CESNI) was set up in 2015 by the CCNR and the European Commission to adopt technical standards regarding vessels, crew and information technology. The respective regulations at the European and international level, including those of the European Union and the CCNR, refer to these standards with a view to their application. These standards are ES-TRIN (technical requirements for vessels), ES-QIN (crew qualifications and requirements), and ES-RIS (information technology requirements for river information services). The three standards are developed by three working groups, i.e. CESNI/PT, CESNI/QP and CESNI/TI respectively.

As an example, a vessel operating on EU waterways or Rhine must carry either a Union inland navigation certificate or a Rhine vessel inspection certificate. Both certificates are issued by the competent national authorities (inspection bodies) and confirm the full compliance with ES-TRIN).

5.2 H2020, HEU and Other Projects' Results to Consider

FP7 and H2020

Throughout the past years both the public (particularly the EU) and the private sector stakeholders have invested a considerable amount of resources in developing new technologies, procedures, skills, business models and other types of solutions that address the different challenges faced by the waterborne transport sector. Many of these investments directly address the climate-related challenges while others, though having a broader spectrum or a different focus, still provide relevant information and achievements in terms of climate-oriented solutions.

Among the myriad of projects to date, those funded through the FP7 and in particular H2020 instruments stand out due to their enhanced focus on climate mitigation, their size in terms of both sheer numbers and the associated efforts (budgets and numbers of partners), but also due to their ever more coherent organisation and approach. The latter elements come not only from the experience and results built during the past EU R&I funding programmes, but also from the ever-growing concern in the public and private sectors alike for the negative effects of climate change.

Moreover, these continuous developments have also led the private sector to propose and then team-up with the EC to create the ZEWT cPP, which enables them to better focus the research, coordinate their efforts and concentrate the resources available.

It is therefore only natural that there needs to be a clear and strong link between the FP7 and H2020 projects on the one hand, and the ZEWT SRIA and projects to be funded through this cPP on the other hand, to ensure a smooth transition and progress. And this needs to consider two factors which go hand in hand.

The number one factor is to build upon, where possible, the FP7 and particularly the H2020 results – a prerequisite for the sector if it is to deliver by 2030 reliable technologies that would decarbonize the sector, and in particular achieve the zero-emissions target by that year. This needs to be realized by ensuring a delicate balance between on the one hand the IPR of the partners from the previous projects, and on the other hand the adequate stakeholder access to the designed calls and the relevant information, to build upon (some of) the previous achievements. Otherwise, the calls risk either tilting the balance in favour of those few stakeholders that had been involved in the previous projects, or giving a lower TRL at the start, thus delaying the developments.

The second factor is avoiding the duplication of efforts on subjects that have already been brought to a high TRL level, or that have been proven inadequate for the sector's requirements.

Starting from the research done in STEERER, below is a table with a broad yet still intermediate overview of the FP7 and H2020 projects that have been undertaken by the waterborne transport sector stakeholders and are relevant for this deliverable. The table contains IWT-focused projects (e.g. PROMINENT, NOVIMAR) and but also projects that are either addressing IWT and maritime segments in significant proportions, or that are maritime-focused but have a high potential for transferability of results to the IWT with little additional efforts. In addition, the projects have been allocated the ZEWT SRIA Intervention Areas where they contribute significantly. It must however be noted that this allocation does not mean that the projects do not have contributions to the other Intervention Areas.

SAFs	Electrification	Energy Efficiency	Design & Retrofitting	Digital Green	Ports
BioSFerA	**CURRENTDIRECT**	*AIRCOAT*	*E-FERRY*	**AUTOSHIP**	**AUTOSHIP**
e-SHyIPS	*E-FERRY*	**AUTOSHIP**	e-SHyIPS	COREALIS	COREALIS
FASTWATER	***FLAGSHIPS***	*EONav*	***FASTWATER***	*DataPorts*	*DataPorts*
FLAGSHIPS	***HyShip***	*eSHaRk*	*FIBRESHIP*	*EfficienSea2*	***FASTWATER***
FLEXI-GREEN FUELS	*MAGPIE*	*E-FERRY*	FIBRE4YARDS	*EONav*	H2Ports
GASVESSEL	**PROMINENT**	*FIBRESHIP*	*GATERS*	H2H	*HySeas III*
GLAMOUR	SEABAT	FIBRE4YARDS	GASVESSEL	**IW-NET**	***HyShip***
HySeas III	***TrAM***	*GATERS*	HOLISHIP	*LOGIMATIC*	**IW-NET**
HyShip	**VIRTUAL-FCS**	***NAVAIS***	*HySeas III*	*MAGPIE*	*LOGIMATIC*
H2Ports		**NOVIMAR**	***HyShip***	*Mari4_YARD*	*MAGPIE*
IW-NET		**PROMINENT**	**IW-NET**	**MOSES**	**MOSES**
MAGPIE		*SeaTech*	*Mari4_YARD*	***NAVAIS***	**NOVIMAR**
PIONEERS		*SleekShip*	***NAVAIS***	**NOVIMAR**	**NOVIMOVE**
PROMINENT		***STREAMLINE***	**NOVIMOVE**	**NOVIMOVE**	*PIONEERS*
SeaTech		***TrAM***	**PROMINENT**	*PIONEERS*	PortForward
VIRTUAL-FCS		VESSELAI	*RAMSSES*	PortForward	*SleekShip*
			RESURGAM	PREPARESHIPS	
			SEABAT	**PROMINENT**	
			SeaTech	*RESURGAM*	
			SHIPLYS	SCIPPER	
			STREAMLINE	SHIPLYS	
			TrAM	***STREAMLINE***	
			VEVESSELAI	VESSELAI	

Table 4. Overview of Relevant EU-funded RD&I from FP7 and H2020[67]

Legend (examples):
GASVESSEL – RIA projects
E-FERRY – IA projects
PROMINENT – project with a high IWT focus

[67] PLATINA3 partners' elaboration

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A first overview of the list of projects shows that there are 48 projects that address the IWT segment and/or the transversal topics with the maritime segment, while at the same time being in the scope of the ZEWT Partnership.

Below, the projects are further categorised, and the preliminary analysis also includes the information from the STEERER project.

Sustainable Alternative Fuels (SAFs). There are 16 projects in this category, out of which 7 IAs and 9 RIAs. Through these projects all the main SAFs are addressed that are of interest for the IWT: bio-/e-LNG, biofuels, methanol, hydrogen. These are the main SAFs seen as acceptable by the IWT segment and are already encompassed in the CCNR transition pathways; however, it is expected that LNG, though acting as a transition fuel, will not be used for a long period of time due to its GHG emissions, and will be either phased out or fully replaced with bio- and e-LNG . Ammonia-oriented projects have not been included in the analysis, as ammonia is considered too risky for the IWT due to environmental aspects.

Some of projects, such as FASTWATER, IW-NET and PROMINENT, address the IWT segment directly, which will ensure that some technologies, once matured, will be easily adopted by the sector stakeholders. Moreover, since LNG and biofuels receive significant attention, this is a signal that current RD&I could ensure a good emissions' reduction rate of IWT while still using part of the same (type of) equipment used for fossil fuels, assuming an growth of biofuels and/or e-fuels usage to replace fossil fuels used in the engines. However, it is not yet clear whether this will be an advantage in the medium-to long-term, or a hurdle towards higher emission cuts.

The projects can provide a set of results which can be used in the process to shape the next ZEWT calls. The RIAs would in principle be the best suited due to the lower TRL level achieved, though some of the IAs can also be relevant. In addition, the information can be used in the discussions with other partnerships, to create cross-fertilization and convergence common efforts and results. High TRL results from these projects can also be used for some of the next Innovation Fund calls that can also address the waterborne transport sector needs.

The STEERER work, including the consultation with the experts, had revealed a number of projects which have developed or are developing technologies worth considering for the future Partnership calls, the most important being: BioSFERA, e-SHyIPS, FLAGSHIPS, FLEXI-GREEN FUELS. The challenge when having such a list of projects and the Partnership's calls is, among others, to see how to integrate the different technologies and their investment horizons into a harmonized approach.

Electrification. There are 9 projects identified in this category, 5 IAs and 4 RIAs. As there are numerous RD&I activities specific for IWT in six of out the nine projects, the present list shows a closer interaction and overlap between the maritime and IWT research. And as in the case of the maritime, research shows that the main candidates for electrification in IWT are ships that operate at short- to medium-ranges, and with a fixed or more structured timetable, such as the ferries. Furthermore, the current projects show that the technology is or will soon be available for the full electrification of such ships, thus skipping the 'hybrid' stage. As with the SAF projects, the results of the electrification projects are of high relevant for both the ZEWT Partnership – FLAGSHIPS had been identified as of particular importance by STEERER – and the other funding mechanisms such as the Innovation Fund.

Energy Efficiency. With a good list of 16 projects out of which 11 IAs, it is important to note that four projects that are IAs and have been identified in the STEERER analysis as of particular importance for the future activities of the ZEWT Partnership: AIRCOAT, eSHaRk, SleekShip, STREAMLINE. This shows the emphasis that both the IWT segment and the waterborne transport sector in general put on energy efficiency measures, applicable to both new-builds and retrofitting. While the focus on energy efficiency will continue, it remains to be seen whether additional RD&I activities are still needed, or whether in the near future the emphasis needs to be placed on finalising the research – including with the help of the Innovation Fund – and quickly ensuring market uptake.

Design and Retrofitting. It is the Area with the most numerous projects, both IWT-focused and covering transversal issues, together with Digital Green. There are 23 projects, 13 of them IAs and 10 RIAs.

This section displays the 2nd biggest concentration of high-TRL projects, surpassed only by the 'Energy Efficiency' section in percentage. However, the latter is smaller. We can therefore conclude that the biggest number of high TRLs has been achieved or is about to be achieved within this Intervention Area. And many of the projects either have a clear IWT component, or address topics and technologies that can easily be transferred to the IWT – e.g. new materials.

This fact calls into question two main aspects for the Partnership: which solutions from or related to these projects should still be considered for further developments, and which solutions that have not been researched should now be addressed. Moreover, other EU funding sources, either within the HEU or other funding instruments, offer opportunities to address this type of research, including the continuation of the results from these projects to bring the technologies closer to the market.

The STEERER analysis had determined that some of these projects – GATERS, HOLISHIP – have good links with the current ZEWT calls, and this is expected to continue in the future calls. Several relevant projects have also been recently launched, and it is necessary to add them to the list. Consequently, it is advisable to investigate in more detail:

- which of these projects already have a follow-up in the recent HEU calls;
- which RIA projects from this list do not have a follow-up and then determine in a more detailed manner which of them/their outcomes would be best suited for take-up by the ZEWT calls.

Digital Green. There are 23 projects listed in this category, out of which 10 are IAs, the rest being RIAs. Their description shows that these projects address a lot of the issues identified both in the Digital Green section of the previous chapter, but also in the PLATINA deliverable D2.3 Report on vision and roadmap on pathway for automation and on board systems. There is also a considerable connection between the developments focused on IWT and those on maritime, and a strong link with the ports. And as correctly identified by the PLATINA3 (and STEERER) partners, while some of the digital technologies are well advanced, other are still at a low TRL level, hence the high number of RIAs.

The STEERER analysis on these projects had also revealed that some cover broader aspects of the digitalization, e.g. safety and uses of the Galileo system. It must be discerned which of their topics can be taken-up by ZEWT and which not, especially given the fact that some related projects are about to start. Projects AUTOSHIP, MOSES and VesselAI are seen as promising candidates for follow-up in the ZEWT calls, but others could follow.

Port Operations. There are 16 relevant projects, 8 IAs and 8 RIAs, in this category. This number of projects is partly because the deliverable looks first at the different ship-to-shore/ports interfaces, which limits considerably the number of overall port-oriented projects that are useful for this analysis. Interestingly enough, the digital aspect in the selected projects is generally very strong.

While the ZEWT scope in this case is quite limited, there is potentially a wealth of information to be extracted from these projects and other similar ones, information that can be used in the discussions with other partnerships, in particular the ones involved in the energy sector (e.g. the Clean Hydrogen Partnership). The results here would also be very relevant to future Innovation Fund calls as well as for the additional investments to be made by the private side or by the public authorities.

It must also be noted that a lot of technologies which are of interest for the shore-side are either already mature or are approaching the roll-out level. The problems arise from the high investment costs necessary, e.g. for the production, transport and distribution of energy, and these investments are already competing with other infrastructure-related needs from other sectors. Finally, the port-related developments, including for ICT, must be connected to the current and forthcoming projects that are funded via the CEF or another deployment funding mechanism.

Horizon Europe – Ongoing Projects and Future Project

The next step undertaken by the project partners has been to identify and the evaluate the recently-awarded RD&I projects in the HEU framework – from the 2021-2022 calls – as well as the upcoming calls – the HEU 2023-2024 calls. This approach has been taken to get a better understanding on how the recent and foreseen projects can contribute to the IWT RD&I needs and climate targets.

As these projects have only recently started, and given the fact that the 2023-2024 calls only give an indication of the RD&I activities to be funded, the analysis in this section will provide more of a helicopter view. Nevertheless, the partners have tried to understand what are the main topics that the HEU is/will be funding, which will also help identify (part of) the technologies for which the support should be prioritized during the last HEU calls.

The points below present this first analysis of the PLATINA3 partners on the current and foreseeable HEU projects, based on the six Intervention Areas. As with the previous analysis, the partners have considered both the projects that have a big IWT focus, but also those that propose results which are relevant (and relatively easy to transfer) for the IWT. It must also be noted that a project can be counted for several intervention areas, according to the technologies that it develops.

SAFs. For this Area there are 7 projects, 5 IAs and 2 RIAs; 3 IAs and one RIA have a particular focus on the IWT sector. Hydrogen is the main focus of the projects during this period, both as fuel and fuel cells. Methanol and biodiesel are/will be covered to a lesser extent, and there is also a project for LNG. A welcome fact is that this Intervention Area contains the largest number of awarded projects that address the IWT sector to a high degree. The relevant 2023-2024 calls are only two, one IA and one RIA, with the former paying significant attention to IWT. The low number of projects may lead to a necessity for more IWT-oriented projects in the future, but this will be determined after a deeper analysis, later in time.

Electrification. There are 9 projects for this Area, 5 IAs and 4 RIAs; 2 IAs and one RIA have a major focus on the IWT. It is the Intervention Area that is also well addressed in terms of IWT relevance, even if many projects are targeting the maritime sector. The good outlook here is due to both the mentioning of IWT among the applicability of the project results, but also because of the nature of the technologies being developed, which will help the sector to further electrify, including the full electrification of the power & propulsion systems. However, there is only one RIA relevant call in the 2023-2024 HEU list.

Energy efficiency. It is addressed by 8 projects, 2 IAs and 6 RIAs; 2 RIAs have a major focus on the IWT. This distribution is largely expected, as many energy efficiency technologies are already mature or very close to the market level, and many of the new ones need to include the novel technologies that have started to be implemented (SAFs, electrification, etc.). Given the transversal nature of the Area, many calls and projects automatically yield results that are applicable to the IWT, hence the relatively long list of both projects and calls. More importantly, the 2023-2024 provides an even better outlook, with 6 relevant calls (3 IAs and 3 RIAs) out of which 4 calls (2 IAs and 2 RIAs) have a strong IWT component.

Design & Retrofit. There are 10 relevant projects, evenly split between RIAs and IAs. Two IAs and one RIA have a greater IWT focus. A similar situation can be observed here with that of ‘Energy efficiency’, since the topic of many calls/projects includes design and/or retrofit aspects without them necessarily being the main focus. For the 2023-2024 period only two calls have been identified, one IA and one RIA, but both of them with a major IWT focus. This situation must also be placed in the context of the H2020 & FP7 projects’ analysis, where the ‘Design & Retrofit’ topics had also received particularly high attention. While a more detailed analysis will be needed to assess the true impact of the 2021-2024 calls and projects, it is clear that this type of activities receives strong support in terms of public funding.

Digital Green. There are 5 relevant projects, out of which 4 IAs. The IWT sector benefits in particular from 3 IAs in this list. However, it must be noted that some of these projects have actually as their main focus topics that are outside the ZEWT SRIA, thus their contribution is to a certain extent limited – e.g. the infrastructure side of the IWT sector. In terms of future calls, there are 4 relevant ones, 2 RIAs and 2 IAs; the IWT sector again receives a good attention in both RIAs and one IA. Worth mentioning is the fact that the topic of Digital Twins is covered by one existing project and one call, respectively, and both of them are in the ZEWT framework. It can thus be concluded that this topic (and many of the connected ones) already benefit from a high level of support in terms of RD&I. Another aspect identified by the partners is the increasing attention in these projects for climate resilience aspects, which is also an important aspect, and connected with the Partnership’s goals.

Ports. There are 6 projects in the list, all IAs, with 4 of them having a good IWT component. As it had been the case with the H2020-FP7 projects’ analysis in the section above, the number here is restricted because the deliverable looks first at the different ship-to-shore/ports interfaces, which limits considerably the number of relevant port-oriented projects. And it must be noted that in fact none of these projects is port-focused. However, part of the projects are ZEWT projects that focus on other relevant topics, and their port component is meant to ensure the proper ship-to-shore integration. In addition, just as in the case of the ‘Digital Green’, there is increased attention on the climate resilience of ports. Concerning the future calls, 2 IAs have been identified, one of which has a good IWT component. Given the fact that the partnership has a lower focus on the ports’ side as compared to the ships, the numbers show that this intervention area still receives a good attention. The ship-based RD&I developments will be key in shaping the later ZEWT calls for the ports segment as well, including IWT.

	SAFs	Electrification	Energy Efficiency	Design & Retrofitting	Digital Green	Ports
Projects Awarded in HEU, in particular the ZEWT cPP Framework	*GREEN RAY* ***HyEkoTank*** **RESHIP** ***RH2IWER*** SHIP-AH2OY *SHYpS* ***SYNERGETICS***	**AENEAS** *FLEXSHIP* *HYPOBATT* *NEMOSHIP* POSEIDON ***RH2IWER*** SHIP-AH2OY ***SYNERGETICS*** V-ACCESS	**AENEAS** CoPropel DT4GS *FLEXSHIP* *GreenMarine* POSEIDON **RESHIP** SHIP-AH2OY	CoPropel DT4GS *GreenMarine* *GREEN RAY* ***HyEkoTank*** *NEMOSHIP* POSEIDON **RESHIP** SHIP-AH2OY ***SYNERGETICS***	***CRISTAL*** DT4GS *FLEXSHIP* ***PLOTO*** ***ReNEW***	***CRISTAL*** ***HyEkoTank*** *HYPOBATT* ***PLOTO*** ***ReNEW*** *sHYpS*
Future relevant calls in HEU, in particular the ZEWT cPP Framework	HORIZON-CL5-2023-D5-01-11 ***HORIZON-CL5-2023-D5-01-12*** HORIZON-CL5-2023-D6-01-08	**HORIZON-CL5-2024-D5-01-11**	HORIZON-CL5-2023-D5-01-11 ***HORIZON-CL5-2023-D5-01-12*** *HORIZON-CL5-2023-D5-01-13* **HORIZON-CL5-2023-D5-01-16** ***HORIZON-CL5-2024-D5-01-12*** HORIZON-CL5-2024-D5-01-15	**HORIZON-CL5-2023-D5-01-16** ***HORIZON-CL5-2024-D5-01-12***	***HORIZON-CL5-2023-D5-01-12*** *HORIZON-CL5-2023-D5-01-13* **HORIZON-CL5-2023-D5-01-16** HORIZON-CL5-2024-D5-01-15	***HORIZON-CL5-2023-D5-01-12*** *HORIZON-CL5-2023-D5-01-13*

Table 5. Overview of relevant EU-funded HEU projects and future HEU calls[68]

Legend (examples):
SHIP-AH2OY – RIA projects/calls
GREEN RAY – IA projects/calls
SYNERGETICS – project/call with a high IWT focus

[68] Elaboration of PLATINA3 partners.

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Projects and Future HEU Calls With a High Relevance for the IWT

The information below has been taken mostly from the EC resources, such as CORDIS

SYNERGETICS

SYNERGETICS https://cordis.europa.eu/project/id/101096809
The extent of shipping decarbonization and reduction of air pollutant emissions remains limited, despite the rapid development of greening technologies. This is particularly valid for existing inland vessels and coastal ships.

A large scale retrofit of the fleet would accelerate the greening transformation. However, there is a wide variety of ship types with different power demands and different required volume of energy carriers. Alternative fuels require more space on board and/or more frequent bunkering. The bunkering infrastructure for such fuels is scarce, and their future price levels are uncertain. Most measures are associated with considerable investments. In addition, the existing regulatory framework still does not provide an adequate support.

The question arises: which retrofit solution would be the most adequate for a ship of certain dimensions, type, and operational profile? To answer this question, the project SYNERGETICS (Synergies for Green Transformation of Inland and Coastal Shipping) will:

- create synergies between the leading research institutions in ship hydrodynamics and energy transition, innovation centres and shipbuilding industry, regulatory bodies, ship owners, and technology providers with the goal to provide a catalogue of retrofit solutions which will accelerate the green transformation of inland vessels and coastal ships.
- demonstrate the greening capacities of retrofit by implementing hydrogen and methanol combustion in internal combustion engines on selected existing ships in real life operational conditions;
- address the greening potential of hydrodynamics improvements, by demonstrating the effectiveness of the aft-ship replacement which comprises the optimized shape of the aft part of the hull, duct, propeller, and rudder design, and implementation of exhaust gas after-treatment and hybrid propulsion systems;
- contribute to electrification of fleets by further developing swappable battery container services and a system for power management of ships with hybrid propulsion.

AENEAS

https://cordis.europa.eu/project/id/101095902
AENEAS aims to contribute towards climate-neutral and environmental friendly water transport through three new next generation clean energy storage solutions. Eventual impact is an increase of the global competitiveness of the EU waterborne transport sector by European technology leadership for energy storage solutions for diverse waterborne applications. It will focus on increased and early deployment of climate neutral energy storage solutions and significant electrification of shipping. AENEAS will provide solutions to improve overall energy efficiency and drastically lower energy consumption of

waterborne transport vessels, founded upon innovative electric energy storage, which is safe and cost competitiveness compared to traditional batteries.

- To achieve this, AENEAS will develop three innovative electric Energy Storage Solutions (ESS) for waterborne transport, which are advanced beyond the traditional battery systems:
- Solid-state batteries (SSB) for constant load waterborne transport applications.
- Supercapacitors (SC) for water-borne transport applications for shaving of power peak demands and peaks during loading.
- Hybrid system, which combines SSB and SC for waterborne transport applications requiring high energy and power density energy storage solutions

The solutions enable (partial or full) electric shipping, taking into account conditions specific ships might encounter, including adverse conditions outside sheltered waters or going upstream on rivers. AENEAS will evaluate them for a range of applications and end uses in short-sea shipping and in-land waterways. For each of these three ESSs, one use-case will be demonstrated at TRL 5. At the same time AENEAS will define the pathway for the three ESSs for application in different ship types, achieving a comprehensive understanding of the ESSs and their applicability for diverse waterborne transport. Finally AENEAS will define a roadmap for full scale on-board demonstrators of two ESSs by 2027.

HyEkoTank

https://cordis.europa.eu/project/id/101096981

The HyEkoTank project will develop cost-effective technology for retrofitting seagoing and inland waterway vessels with hydrogen PEM fuel cell systems for emission-free operations. Retrofit solutions are urgently needed to transform the waterborne transport and reach the reduction of green house gas emissions established by EU and IMO by 2050. HyEkoTank project proposes the design, development, approval and demonstration of a 2.4 MW hydrogen fuel cell system. The technology will be developed by a consortium of 10 partners who are experts in the field and demonstrated by retrofitting a 18600 DWT tanker, EK Stream, under operation at 3 different journeys from Porvoo in the Baltic Sea. The main challenges that need to be resolved concern the development of a cost-efficient fuel cell system specifically designed for maritime applications and suitable to retrofit existing vessels, as well as the assessment and creation of hydrogen infrastructure and logistics for vessel refueling in ports, as well as safe hydrogen storage and handling. We aim at approving the HyEkoTank technology to deploy it for any type of vessel and operation, while demonstrating the expected environmental impacts: 55% GHG reduction during voyage, 100% reduction in port, and 62% total reduction yearly. The project will take the technology from TRL 4/5 to TRL 8.

RESHIP

https://cordis.europa.eu/project/id/101056815

Under the framework of Zero Emission Waterborne Transport (ZEWT), hydrogen as the future fuel for ships offers an opportunity to zero the GHG emission. Nevertheless, the challenges for onboard hydrogen storage and utilisation obstruct this long desired revolution. Novel and effective technology solution is urgently needed.

The project, RESHIP, aims to redefine the onboard energy saving solutions for newbuilds and retrofits in marine and inland waterway with disruptive technologies in two distinct areas, Energy Saving Devices (ESDs) and onboard hydrogen utilisation. Regarding the ESDs, the project proposes to research and develop hydrogen compatible ESD solutions in standalone/combined applications, centered around

Tubercle Assisted Propulsors (TAPs), to improve the vessel's propulsive energy efficiency and to optimise towards hydrogen power and drive system. With the novel and energy efficient hydrogen carrier technology HydroSil, RESHIP links the ESD technology to the research of the energy efficient onboard hydrogen utilisation technology to systematically reshape the hydrogen driven ships with a holistic energy saving solution. Together, RESHIP aims to achieve a minimum overall 35% energy saving and to half the hydrogen storage demands on space and/or weight, comparing to the state-of-the-art hydrogen powered vessels.

RH2IWER

https://cordis.europa.eu/project/id/101101358

The main aim of RH2IWER is to create a solid basis for the acceleration of hydrogen fuel cell powered vessels in inland waterway shipping by demonstrating six commercially operated vessels. These vessels are of varying lengths and types – 86m, 110m and 135m; container, bulk and tanker vessels with installed power ranging from 0.6 to ~2 MW. The project will also work with standardization of containerized fuel cell and hydrogen solutions.

With the demonstration, standardization work and multi-level analysis, combined with vigorous dissemination and communication measures, RH2IWER project will create a basis on which the shipping industry can significantly reduce their environmental footprint and remove emissions from their entire fleet in the future. The inland waterway fleet comprises a total of more than 15,000 vessels and the vessels within RH2IWER are representative of the typical dry and liquid cargo vessels in the Rhine and Danube fleets, amounting to 12,800 vessels or roughly 80% of the inland waterway fleet. The lessons learned from developing fuel cell and hydrogen solutions for the vessels in this project could be applied more or less directly to these vessels, which would then immediately reduce the GHG emissions from these ships to zero.

CRISTAL

https://cordis.europa.eu/project/id/101069838

It is the key objective of the project CRISTAL (36 months) to increase the share of freight transport on inland water transport (IWT) by a minimum of 20% and to demonstrate on its three pilot sites (Italy, Poland and France) strategies to improve reliability by 80%.

CRISTAL project will assure IWT capacity at 50% even during extreme weather events. Towards that CRISTAL will co-create, test and implement integrated, cooperative and innovative solutions in its three pilot partners' areas identified in Italy, France and Poland. The project will include the aspects of technological innovation/development and digitalization; further advancement towards the Physical

Internet, governance solution and business models, will be proposed while targeting sustainability and infrastructure resilience requirements.

PLOTO

https://cordis.europa.eu/project/id/101069941

It is the key objective of the project CRISTAL (36 months) to increase the share of freight transport on inland water transport (IWT) by a minimum of 20% and to demonstrate on its three pilot sites (Italy, Poland and France) strategies to improve reliability by 80%.

CRISTAL project will assure IWT capacity at 50% even during extreme weather events. Towards that CRISTAL will co-create, test and implement integrated, cooperative and innovative solutions in its three pilot partners' areas identified in Italy, France and Poland. The project will include the aspects of technological innovation/development and digitalization; further advancement towards the Physical Internet, governance solution and business models, will be proposed while targeting sustainability and infrastructure resilience requirements.

ReNEW

https://cordis.europa.eu/project/id/895296

ReNEW represents a multidisciplinary group composed of 24 participants from 11 countries of the European Union capable of playing a key role in supporting the transition of IWT to smart, green, sustainable and climate-resilient sector. To achieve this, the project will build on previous results, will capitalise on cooperation opportunities with ongoing projects and initiatives and will deliver:

- An interdisciplinary IWT Resilience and Sustainability decision-support framework incorporating innovative models for IWT infrastructure networking interdependencies linking to probabilistic risk and safety analyses and resilience quantification (Resilience Index), supporting the identification of short- and long-term measures that enhance resilience utilising SOA building blocks from Reference Projects
- Targeted innovative infrastructure resilience and sustainability solutions building on autonomy developments and maturing green energy options;
- A Green Resilient IWT Dataspace and generic Digital Twin providing primarily data sharing between infrastructure monitoring, RIS and traffic management and emergency systems and climate solutions;
- Four Living Labs designed to provide exemplars from a) LLs focusing on integrated IW and hinterland infrastructure [Gent-urban, Douro- corridor, Netherlands – EU network perspectives] and a LL addressing specifically inland waterway resilience;
- ReNEW Outreach and Upscale activities designed to maximise impact pathways.

HORIZON-CL5-2024-D5-01-11

Developing the next generation of power conversion technologies for sustainable alternative carbon neutral fuels in waterborne applications (ZEWT Partnership)

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2023-d5-01-11

HORIZON-CL5-2023-D5-01-12

Demonstrations to accelerate the switch to safe use of new sustainable climate neutral fuels in waterborne transport (ZEWT Partnership)

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2023-d5-01-12

HORIZON-CL5-2023-D6-01-08

Future-proof GHG and environmental emissions factors for accounting emissions from transport and logistics operations

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2023-d6-01-08

HORIZON-CL5-2023-D5-01-16

Developing small, flexible, zero-emission and automated vessels to support shifting cargo from road to sustainable Waterborne Transport

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2023-d5-01-16

HORIZON-CL5-2024-D5-01-12

Combining state-of-the-art emission reduction and efficiency improvement technologies in ship design and retrofitting for contributing to the "Fit for 55" package objective by 2030 (ZEWT Partnership)

https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/horizon-cl5-2024-d5-01-12

The Innovation Fund

The EU Innovation Fund (IF)[69] is one of the world's largest funding programmes for the demonstration of innovative low-carbon technologies. It will provide funding until 2030, depending on the carbon price, for the commercial demonstration of innovative low-carbon technologies, aiming to bring to the market industrial solutions to decarbonise Europe and support its transition to climate neutrality.

The ultimate objective of this programme is to assist businesses to invest in clean energy and industry to boost economic growth, create local future-proof jobs and reinforce European technological leadership on a global scale. This is done through calls for large and small-scale projects focusing on:

- innovative low-carbon technologies and processes in energy-intensive industries, including products substituting carbon-intensive ones;
- carbon capture and utilisation (CCU);
- construction and operation of carbon capture and storage (CCS);
- innovative renewable energy generation;
- energy storage.

The EU ETS, the world's largest carbon pricing system, is providing the revenues for the IF from the auctioning of €450 million allowances from 2020 to 2030, as well as any unspent funds from the NER300 programme. For the period 2020-2030, the IF may amount to about €38 billion (at €75 / tCO_2), depending on the carbon price. In parallel to the IF, the EU ETS provides the main long-term incentive for these technologies to be deployed.

Since July 2020 there have already been 2 calls for small-scale projects[70] and 3 calls for large-scale ones[71], with the latter having been opened on the 3rd of November 2022. And while the waterborne transport sector is not currently outlined as one of the key industries intended to benefit from the IF, the scope and conditions of the Fund allow waterborne transport stakeholders to compete and win IF projects - usually under the 'general decarbonisation window (calls)' of the IF. Proof of this is the fact that during the previous IF calls different waterborne transport stakeholders had applied for funding, and currently (Nov. 2022) there are 3 such projects selected for funding:

- "GREENMOTRIL": Development of a green energy community in the port of Motril (Spain, small-scale call 2020, €4.3 million);
- "FirstBio2Shipping": Waste-gas to bio-LNG as a drop-in fuel (Netherlands, small-scale call 2020, €4.3 million);
- "N2OWF": Large offshore wind plant with electrolyser capacity. Hydrogen used for fuelling service operation vessels as part of the project (Germany, large-scale call 2021, funding volume to be disclosed after grant signature).

rts sustainability report 2020
.eu/clima/policies/innovation-fund_en"Innovation Fund | Climate Action (europa.eu)
[70] Projects with total capital costs below €7.5 million
[71] Projects with a capital expenditure above €7.5 million

In addition, three other projects from the waterborne transport sector had been selected for Project Development Assistance (PDA)[72], all concerning innovative, zero/low-emission ships.

With the new REPowerEU Plan, the IF will be used to accelerate the deployment of technologies within the scope of this EU initiative, and some of these are relevant for the waterborne transport sector, namely:

- Clean Tech Manufacturing: electrolysers and fuel cells or energy storage solutions (both stationary and mobile use;
- Mid-sized pilots, for industries in the IF scope that come up with solutions that have: a higher degree of innovation, deep decarbonisation or net carbon removal, project viability (rather than profitability, as for the other calls), etc. These calls offer up to €40 million per project and a less stringent formula for the cost-efficiency criterion;
- A new instrument for competitive bidding and (carbon) contracts for difference – to be developed at a later stage.

Such developments offer ample promises for the waterborne transport sector, in particular for the H2020 and HEU projects (to be) developed.

The GSEG had already indicated a number of projects that could benefit directly from the IF calls, without any further support from the Partnership. The information will be discussed internally in WaterborneTP, however, it will be up to the projects' partners to undertake the necessary steps to benefit from the IF opportunities in the coming period.

While the IF is meant to finance the deployment of high TRL projects that are mostly out of scope for HEU calls, its current projects and its future calls are of relevance for the ZEWT cPP. The IF calls can first help ZEWT project results deploy, as one of the Fund's intended goals is to help with the market roll-out of Horizon project results. Furthermore, the IF calls and their results can signal not just research areas that may not need further activities and funding, but also the connected topics which still require (relatively high TRL) research in order to obtain a holistic and efficient approach for the decarbonization of the waterborne transport sector.

[72] Rejected proposals which met some minimum requirements and have the strongest potential to improve their maturity are offered project development assistance.

6. Assessment of priorities and needs for research and deployment projects

Given the key actions as proposed for the SRIA intervention areas in chapter 4, an analysis has been made to see into what extent the actions are taken-up or planned to be addressed already. Therefore, insight was gained from recently finalised, ongoing or to be launched projects (Horizon Europe calls) as regards their technical contents to see into what extent the projects will cover some of these key actions. We refer to the descriptions of projects and calls in chapter 5 of this report. In addition, for the key actions related to regulatory matters, is has been checked whether there is ongoing or expected work by regulators (such as EU, CCNR, Member States) or standardisation body (such as CESNI) in which these regulatory key actions are (or will be) already addressed.

Based on this inventory, it is concluded for each key action whether or not this action is already addressed. If not addressed, it is flagged as an action to be prioritised for HORIZON EUROPE's **2025-2027 work programme**. In other words, if it turns out that certain key actions have already been addressed in recently completed or ongoing projects, or in expected future projects from the HORIZON EUROPE's 2023-2024 work programme, then there seems no need to prioritise this action for the 2025-2027 work programme and no project needs to be developed for it. If this is the case, the tables below will show a "**NO**". If it is relevant to the work program 2025-2026, a "**YES**" is displayed.

Of course, the question is to what extent a particular key action has been or will be solved in ongoing or future projects. If in the near future it turns out that the key action has not been addressed well enough in projects or calls from HEU 2023-2024 have not been successful to develop IWT projects, the key action can be reprioritised for a subsequent work programme. Therefore, there is a clear need to monitor the status of projects and their results and to update the analyses accordingly in view of the further work programmes for RD&I in Europe.

It is also possible to conclude that a particular key action is very relevant for the 2050 target, but that it is no longer a subject of research, due to the already existing calls and projects, but rather belongs in the category of support for deployment of the innovation. This means that the action should be prioritised for deployment programmes such as **CEF** and the **Innovation Fund** instead of Horizon Europe. On the other hand, key actions with a research character (e.g. the need for studies and investigations) are not relevant for deployment programs. Therefore, in the tables below these actions are characterized as "**irrelevant**" under the columns for deployment funding. Regulatory key actions are anyway not relevant for deployment programs and this is also displayed as such.

Based on gained expertise and insights from PLATINA3 and other projects on the zero-emission transition key driving factors, barriers and opportunities, the assessment has been made to indicate the importance of each key action in relation to the ultimate target towards a zero-emission inland shipping sector. This relevance is expressed in **low**, **medium** or **high**.

The key actions are shown below per theme area and in the four adjacent columns the findings in relation to relevance for the HEU work program 2025-2026, the funding programs and their importance for achieving the ultimate objective in realising a near zero-emission IWT sector.

As mentioned in the previous chapter, it must also be underlined that given the very high number of projects that had to be analysed by the partners, not all of the projects' detailed information could be thoroughly extracted and analysed. It is also possible that a small number of relevant H2020 and HEU projects and calls had escaped the attention of the partners. Consequently, a future analysis could provide partly different results, especially regarding the HEU projects, which have either recently started or are just in the proposal phase.

Sustainable Alternative Fuels – Common Actions

#	Key actions		Priority for WORK PROGRAMME 2025-2027 HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	SAF					
	Theme	**Key actions**				
1	R	Address full life-cycle emissions when assessing a fuel (upstream + downstream information, calculation methods, etc.) for all (NOx, PM, CO, H2, N2O, CH4, CH2O, CO2) harmful emissions (air pollutants + GHGs). (HEU)	NO	**high**	irrelevant	irrelevant
2	T	Investigate the development of new types of fuel cells and their reliability (tilting, acceleration, vibrations, etc.) and cost in the waterborne transport environment.	NO	**high**	**YES**	**high**
3	T	Development/ further optimization of engines systems (including aftertreatment systems) to (nearly) eliminate all types of air pollutants (focus on the most harmful ones first) for traditional fuels, as well as for some technologies converting sustainable alternative fuels. Therefore, new Stage V engines need to become further available and certified for usage of: higher blends of biofuels, methanol and hydrogen, either dual fuel or single fuel. (HEU)	NO	medium	**YES**	**high**
4	T	Further upscaling of demonstrator projects to identify benefits/push the limits of the different fuels. (Priority for both HEU and the Innovation Fund)	NO	low	**YES**	**high**

5	R	ES-TRIN and NRMM Stage V regulations are/is yet lacking provisions for the use of different types of hydrogen carriers (e.g. compressed H2, methanol) and therefore need to be updated/adjusted where needed to facilitate the use of sustainable alternative fuels.	NO	**high**	irrelevant	irrelevant
6	B	Insights in the cost comparison and broader impacts (e.g. loss of cargo space, bunkering time, etc.) between the different options for sustainable alternative energy as fuel and energy convertor – internal combustion engines (ICE) or fuel cells (FC) – for different vessel types and operational profiles.	NO	**high**	irrelevant	irrelevant
7	R	Safety regulations (training, operational rules, vessel design, etc.) need to be developed/updated where needed to facilitate the use of sustainable alternative fuels and guarantee safety. (HEU)	NO	medium	irrelevant	irrelevant

This table illustrates that the first key action is very important but no longer relevant since there is already a HEU 2023 call addressing it, and a lot of work had already been done in this case. 2025-.

For the subsequent six key actions, it is recommended not to prioritize them for the next work program of HEU. Action point 2 is already partly addressed in recently launched projects and projects to be launched. However, it is very relevant to test and improve fuel cells in deployment programs through pilot deployment projects. Action point 3, focussing on the need for new Stage V type approved engines is relevant but also fits better in a deployment funding programme, provided that the applicable legal framework is also improved. The same applies to the subsequent action point 5, pilot deployment projects for various SAF projects can be funded in deployment programmes. Action points 5 up to 7 have a regulatory or business character and are already covered in existing projects and not relevant for funding programmes.

Sustainable Alternative Fuels - Drop-in biofuels, (e-)/(bio)methanol, (e-)Hydrogen and LNG

#	Key actions		Priority for WORK PROGRAMME 2025-2027 HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	SAF/ Drop-in biofuels (bio-Diesel and HVO)					
1	R	Engines need to be certified and tested for the (blends) with biofuels as alternative for the fossil diesel, e.g. Stage V engines to be certified for blends of fatty acid methyl ester (FAME) higher than 8%.	**YES**	**high**	**YES**	**high**
2	R	Fuel specifications need to be made stricter, including the measurement and enforcement due to fuel instability, corrosion, susceptibility to microbial growth, and poor cold-flow properties of certain biofuels. Also, proper government measures need to be more widely known and clear to the users and fuel providers.	**YES**	**high**	irrelevant	irrelevant
	SAF/ (e-) or (bio-) methanol					
3	**T**	Investigate and demonstrate the maintenance needs of methanol as well as types of storage systems. (HEU & Innovation Fund)	**YES**	**high**	NO	low
4	**T**	Investigate and demonstrate the optimal tank type selection for different operational profiles. (HEU & Innovation Fund)	NO	low	irrelevant	irrelevant

	SAF/ (e-)Hydrogen					
5	T	Investigate and demonstrate the maintenance needs of different hydrogen carriers as well as types of storage systems, interoperability and safety of mobile hydrogen storage systems. (HEU & Innovation Fund)	**YES**	**high**	NO	low
6	T	Investigate and demonstrate the optimal tank type selection for different operational profiles. (HEU & Innovation Fund)	NO	medium	irrelevant	irrelevant
7	T	Clarify & demonstrate capabilities with regards to new engines' load profile variation and low load operations (e.g. in emergency situations). (HEU & Innovation Fund)	NO	low	irrelevant	irrelevant
8	T	Assess operational fit with regards to energy efficiency / density. (HEU & Innovation Fund)	NO	low	irrelevant	irrelevant
	LNG					
9	T	Minimize/eliminate methane slip by engine and tank design (possibility of including after treatment systems) and proper design-for-operation.	NO	low	irrelevant	irrelevant
10	R/B	Monitoring and reporting of methane slip will allow further differentiation between existing options and to incentivize the use of the better options (less methane slip). Lower slip levels are technically possible but come at a higher cost.	NO	low	irrelevant	irrelevant
11	R	Investigate and prepare the regulations of methane emissions.	Medium	Medium	irrelevant	irrelevant

The table above takes a closer look at three specific fuels within the SAF broader category. These three fuels have been prioritized in the STEERER project in consultation with the SC and GSEG. It turned out that the first three action points are not or not sufficiently addressed in existing or expected projects. Certainly, the first action point is also relevant to include in deployment programs, because with this key action results can be achieved in the field of emission reduction in the very short term.

The second point relates to fuel specifications. This is currently a major issue in the IWT sector and is relevant for further research. However, given the nature of the action, it is irrelevant for deployment programs.

The third point is still relevant given the many uncertainties and developments in the field of maintenance needs for different hydrogen carriers and forms of storage on board a ship. This is therefore still very relevant for the next work programme. However, given its research nature, it is less relevant for funding programmes.

For the next five key actions, it is advised not to prioritize them for the next work programme. These points are or are already being addressed in completed, ongoing or expected projects or are simply not essential in contributing to the eventual 2050 objective. Due to the nature of these actions, they are also irrelevant to the deployment programs. However, the last actions are relevant in terms of making LNG a better (transitional) fuel; as there is already one HEU/ZEWT call addressing the LNG topic, we the partners had decided to keep the action but with a low profile.

Electrification

#	Key actions		Priority for WORK PROGRAMME 2025-2027HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	Electrification					
1	T	Demonstration of the battery design life in operational conditions (HEU & Innovation Fund).	**YES**	**high**	**YES**	**high**
2	T	Developing more DC components to improve the energy efficiency. (HEU & Innovation Fund).	YES	low	**YES**	low
3	R	Further develop ES-TRIN to take into account new battery types, ease battery handling and prevent standardisation issues	**YES**	**high**	irrelevant	irrelevant
4	T	Research to bring down the volumetric and gravimetric density of battery modules and pack integration, making onboard storage modular and standardised, and thus competitive with conventional fossil diesel. This could result in other types of hydrogen carriers and convertors and new types of electricity storage technology than the ones used today. (HEU)	NO	**high**	**YES**	**high**

The first two actions are relevant to address in the emerging working programme. Despite work already being done in existing projects and expected projects, it is still necessary to investigate this further in research projects as well as for the first two research-deployment projects in deployment programs. The third is something to be addressed in CESNI and not relevant to deployment programmes. The fourth point has been and will be addressed in existing and upcoming projects and commercial initiatives, especially the modular aspect. It has been and will be addressed in existing and upcoming projects and commercial initiatives, especially the modular aspect.

Energy-efficiency

#	Key actions		Priority for WORK PROGRAMME 2025-2027HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	Energy-efficiency					
1	T	Development and demonstration of advanced energy management systems that can determine the optimal use & storage of energy for different systems onboard. (HEU)	NO	medium	NO	medium
2	T	Investigate which energy efficiency measures (technical and operational) are most interesting to combine (move away from a siloed approach).	NO	low	irrelevant	irrelevant
3	T	Setting up an online knowledge platform where a clear overview can be found of different energy efficiency measures and hydrodynamic improvements including the parameters that determine GHG reduction potential, the maturity level and which vessel or operating profile would be the best fit. HEU Project Synergetics will already address this for inland existing vessels.	NO	low	irrelevant	irrelevant
4	R	Investigate options for energy efficiency requirements in legalisation for vessels, in view of reporting requirements on energy efficiency and possibly setting threshold values	NO	medium	irrelevant	irrelevant

None of the action points in the energy efficiency theme are relevant to prioritize for the next work program of HEU. This does not mean that they are not relevant to the final emission reduction targets, but are already largely addressed in completed, ongoing and future projects. This finding can of course be reassessed on the basis of the (expected) results. In terms of importance level, these actions also contribute to a lesser extent to the hard emission reduction, in contrast to, for example, actions in the themes of electrification and SAF. Also, it is not necessary to prioritize these actions for other funding programs, as they are irrelevant or simply not prioritizable due to the nature of the action.

Design and Retrofit

#	Key actions		Priority for WORK PROGRAMME 2025-2027 HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	Design and retrofit					
1	T	Develop new bow thrusters that allow operations in extreme shallow waters with equal or increased energy efficiency. The proposed solutions also need to prevent the accumulation of sediments in the thrusters.	**YES**	medium	irrelevant	irrelevant
2	T	Develop new materials, alloys, composites, etc. for shipbuilding and retrofitting. The new solutions need to offer similar technical characteristics and safety (fire resistance) while at the same time achieving a weight reduction at a reasonable price.	**YES**	medium	irrelevant	irrelevant
3	T	Optimize design for real operating conditions instead of mainly one load case and one speed. (HEU)	**YES**	low	**YES**	medium
4	T	Further improvement of simulation tools to faster evaluate new vessel designs and retrofit solutions. (HEU)	**YES**	low	irrelevant	irrelevant
5	T	Further develop propellers and other parts of the propulsion systems – apart the engine – that will allow new and retrofitted ships to both navigate shallow(er) waters and maintain or increase their energy efficiency.	**YES**	low	irrelevant	irrelevant

6	T	Investigate the optimum relationship between water draught and optimal ventilation and propulsion of new and retrofit vessels via improved model testing numerical simulation testing – these tools also having to be further developed.	**YES**	low	irrelevant	irrelevant
7	T	Investigate the adaptation of existing vessels from local-to-local modifications to the replacement of the aft ship, aiming largely at increasing the cargo capacity at low water while maintaining or improving energy efficiency.	**YES**	Medium	irrelevant	irrelevant
8	T	Retrofitting existing vessels by the (optimal) integration of sustainable available solutions, including solutions using renewable energies.	NO	high	**YES**	**high**
9	T	Development and implementation of new vessel designs that support multi-fuel engines and fuel cells, including aft-ship replacement for existing vessels. (HEU)	NO	medium	**YES**	medium
10	T	Investigate and demonstrate the benefits of using multiple (smaller) main engines to optimize engine load distribution and increasing energy management flexibility. (HEU)	NO	medium	**YES**	medium

The first 7 design and retrofit actions are extremely relevant given the low water problem in the IWT sector, which has had a major negative impact on water transport in recent years, as vessels could not sail or could carry less cargo on certain routes. This then had a detrimental effect on the climate due to a partial reverse modal shift it brought about or ships that carried less cargo and were therefore less optimally utilised. These key actions are therefore relevant to include in the next work programme, especially given their relevance in the present time, but given the scope of the SRIA they are characterized as less important. Also, given the nature of the actions, except for key action no. 3, they are not relevant for deployment programs.

Key actions 8-10 focus more on emission reduction. However, these action points are already being worked on in a commercial setting and are also being addressed in (expected) projects. These actions are considered important, especially given the fact that most emission reductions can be achieved in the existing fleet. However, the recommendation is to first wait and see what existing and expected projects will deliver and, if necessary, to re-evaluate on the basis of this whether these actions can still be prioritized for the work program after 2025-2027. There are also enough innovative technical possibilities in the field of retrofits, designs and engine setups. It is recommended to stimulate this in pilot deployment projects through deployment funding.

Digital Green

#	Key actions		Priority for WORK PROGRAMME 2025-2027 HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	Digital Green					
1	T	Further development and testing of advanced systems (collision avoidance, AI, neural networks, sensor fusion and integration, etc.) to move from TRL 5-6 to TRL 8 to enable highly automated navigation in IWT.	**YES**	medium	irrelevant	irrelevant
2	T	Setting up of waterborne transport demonstrator projects: many technologies are mature but need to be tested and further tailored for vessels. (Innovation Fund)	**YES**	low	**YES**	low
3	T	Standardisation of data interfaces to facilitate modularity (HEU).	**YES**	low	irrelevant	irrelevant
4	T	Further develop and promote digital energy efficiency tools for optimised operations to optimise load rates and sailing schedules and speeds in IWT, taking into account fluctuating water levels on free-flowing rivers like the Rhine and the Danube.	**YES**	low	**YES**	low
5	R	Support legislation to enable and facilitate advanced automated navigation in view of manning requirements, on board systems and communication / interface with on-shore systems and waterway and port infrastructure.	**YES**	low	irrelevant	irrelevant

The Digital Green theme includes actions that can be addressed in the work program 2025-2027, because they still require research for further development to result in improved commercial products and services. Their effect on emission reduction is often limited though and indirect (e.g. with innovations relating to data interfaces, automated sailing, energy efficiency, etc.), which is why they are assigned the importance levels low to medium.

Ports

#	Key actions		Priority for WORK PROGRAMME 2025-2026 HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2026 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
	Ports					
1	T	Research cost-effective, widely applicable and standardised bunkering/charging solutions, considering various potential bunkering/charging locations in different ports and the different types of vessels. (HEU)	**YES**	medium	irrelevant	irrelevant
2	T	Demonstrator projects on bunkering sustainable alternative fuels at inland and sea ports, including energy providers. (Innovation Fund)	NO	high	**YES**	**high**

The first key action is not yet covered in sufficient detail in existing and anticipated projects. It is really necessary to investigate this in detail and the work program 2025-2027 would lend itself well to this. The results of will be important for a timely and efficient roll-out of the necessary clean energy infrastructure. Given its research nature, this action is not relevant for a deployment programme. The second key action, however, is really focussing on pilot deployment and fits perfectly into deployment programmes such as CEF and IF. It is certainly now very relevant to demonstrate this in real-life settings and learn from it.

Ports – OPS and charging

#	Key actions		Priority for WORK PROGRAMME 2025-2027 HEU for IWT (YES/NO)	Priority for WORK PROGRAMME 2025-2027 HEU for IWT (importance level: low, medium, high)	Priority for (pilot) deployment funding such as CEF, IF, etc. (YES/NO/irrelevant)	Priority for deployment funding such as CEF, IF, etc. (importance level: low, medium, high, irrelevant)
OPS and charging						
1	T	Studies to making OPS points future ready so they can be utilized for (rapid) charging of batteries on board used for propulsion of the vessel	**YES**	**high**	irrelevant	irrelevant
2	T	Standardized components on vessel side for both OPS and fast-charging (e.g. connections, length of cables). (HEU)	**YES**	medium	irrelevant	irrelevant
3	R/B	Development and harmonisation of standards & procedures (both of technical and financial-administrative nature) for OPS and (fast) charging at seaports and inland ports (the ship-to-shore interfaces). (HEU)	**YES**	medium	irrelevant	irrelevant
4	T/B	Availability, feasibility and use of swappable battery containers.	NO	high	**YES**	**high**
5	T	Further development of fast charging infrastructure.	NO	high	**YES**	**high**

The first three actions are relevant for the next HEU work program 2025-2027. Certainly, in the field of fast charging, there is still a great need for RD&I. In contrast to the maritime sector, the IWT sector already has a lot of experience with OPS points and it is also important to investigate whether and how existing OPS points can be used for fast charging, or whether new stand-alone fast charging points should be installed, and what the corresponding technical bottlenecks and solutions will be. Given the research nature of these three actions, it is not relevant to address them in deployment programs. However, the following two actions are particularly suitable for deployment, are very relevant to realize in the short term, and are therefore extremely suitable for deployment programs such as CEF.

7. Conclusions and recommendations

This deliverable presented the actions for the development of a strategy for zero-emission IWT to enable the sector's fleet to achieve its climate targets, while at the same time being in tune with the developments of its sister-segment, the maritime. For each of the six intervention areas the main relevant topics have been identified and a number of corresponding actions have been proposed. A multitude of FP7, H2020 and HEU projects and project calls had also been analysed, to identify which actions need to be prioritized and which activities should not be duplicated.

Based on the assessment presented in chapter 6 the actions can be selected according to their priority assessment and their assessed importance and next to relevance for deployment programmes and/or Horizon Europe working programme 2025-2027. The refined results are presented in the two tables below. Implementing these key actions is seen as essential in the sector's attempt to reach the target of zero-emissions by 2050. The actions are of regulatory (R), technical (T) or business (B) type. Their importance relates to the ultimate target towards a zero-emission inland shipping sector.

7.1 Recommended priority actions for HEU working programme 2025-2027

Type	Action	Intervention area	Importance
R	Engines need to be certified and tested for the (blends) with biofuels as alternative for the fossil diesel, e.g. Stage V engines to be certified for blends of fatty acid methyl ester (FAME) higher than 8%.	SAF – Biodiesel 1	**high**
R	Fuel specifications need to be made stricter, including the measurement and enforcement due to fuel instability, corrosion, susceptibility to microbial growth, and poor cold-flow properties of certain biofuels. Also, proper government measures need to be more widely known and clear to the users and fuel providers.	SAF – Biodiesel 2	**high**
T	Investigate and demonstrate the maintenance needs of methanol as well as types of storage systems. (HEU & Innovation Fund)	SAF – methanol 3	**high**
T	Investigate and demonstrate the maintenance needs of different hydrogen carriers as well as types of storage systems, interoperability and safety of mobile hydrogen storage systems. (HEU & Innovation Fund)	SAF- hydrogen 5	**high**
R	Investigate and prepare the regulations of methane emissions.	SAF – LNG 11	medium
T	Demonstration of the battery design life in operational conditions (HEU & Innovation Fund).	Electrification 1	**high**
R	Further develop ES-TRIN to take into account new battery types, ease battery handling and prevent standardisation issues	Electrification 3	high

T	Develop new bow thrusters that allow operations in extreme shallow waters with equal or increased energy efficiency. The proposed solutions also need to prevent the accumulation of sediments in the thrusters.	Design & Retrofit 1	medium
T	Develop new materials, alloys, composites, etc. for shipbuilding and retrofitting. The new solutions need to offer similar technical characteristics and safety (fire resistance) while at the same time achieving a weight reduction at a reasonable price.	Design & Retrofit 2	medium
T	Investigate the adaptation of existing vessels from local-to-local modifications to the replacement of the aft ship, aiming largely at increasing the cargo capacity at low water while maintaining or improving energy efficiency.	Design & Retrofit 7	medium
T	Further development and testing of advanced systems (collision avoidance, AI, neural networks, sensor fusion and integration, etc.) to move from TRL 5-6 to TRL 8 to enable highly automated navigation in IWT.	Digital Green 1	medium
T	Research cost-effective, widely applicable and standardised bunkering/charging solutions, considering various potential bunkering/charging locations in different ports and the different types of vessels. (HEU)	Ports – SAF 1	medium
T	Studies to making onshore power supply (OPS) points future ready so they can be utilized for (rapid) charging of batteries on board used for propulsion of the vessel	Ports – OPS 1	**high**
T	Standardized components on vessel side for OPS and fast-charging (e.g. connections, length of cables).(HEU)	Ports – OPS 2	medium
R/B	Development and harmonisation of standards & procedures (both of technical and financial-administrative nature) for OPS and (fast) charging at seaports and inland ports (the ship-to-shore interfaces). (HEU)	Ports – OPS 3	medium

7.2 Recommended priority actions for deployment

Type	Action	Intervention area	Importance
T	Investigate the development of new types of fuel cells and their reliability (tilting, acceleration, vibrations, etc.) and cost in the waterborne transport environment.	SAF – Common 2	**high**
T	Development/ further optimization of engines systems (including aftertreatment systems) to (nearly) eliminate all types of air pollutants (focus on the most harmful ones first) for traditional fuels, as well as for some technologies converting sustainable alternative fuels. Therefore, new Stage V engines need to become further available and certified for usage of: higher blends of biofuels, methanol and hydrogen, either dual fuel or single fuel. (HEU)	SAF – Common 3	**high**
T	Further upscaling of demonstrator projects to identify benefits/push the limits of the different fuels. (Priority for both HEU and the Innovation Fund)	SAF – Common 4	**high**
T	Demonstration of the battery design life in operational conditions (HEU & Innovation Fund).	Electrification 1	**high**
T	Research to bring down the volumetric and gravimetric density of battery modules and pack integration, making onboard storage modular and standardised, and thus competitive with conventional fossil diesel. This could result in other types of hydrogen carriers and convertors and new types of electricity storage technology than the ones used today. (HEU)	Electrification 4	**high**
T	Retrofitting existing vessels by the (optimal) integration of sustainable available solutions, including solutions using renewable energies.	Design and Retrofit 8	**high**
T	Development and implementation of new vessel designs that support multi-fuel engines and fuel cells, including aft-ship replacement for existing vessels. (HEU)	Design and Retrofit 9	medium
T	Investigate and demonstrate the benefits of using multiple (smaller) main engines to optimize engine load distribution and increasing energy management flexibility. (HEU)	Design and Retrofit 10	medium
T	Demonstrator projects on bunkering sustainable alternative fuels at inland and sea ports, including energy providers. (Innovation Fund)	Ports – SAF 2	**high**
T/B	Availability, feasibility and use of swappable battery containers.	Ports – OPS 4	**high**
T	Further development of fast charging infrastructure.	Ports – OPS 5	**high**

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