D4.2 Report on findings, perspectives and recommendations on clean energy along waterways and ports

Grant Agreement No.	101006364
Start date of Project	01-01-2021
Duration of the Project	30 months
Deliverable Leader	EICB/SPB
Dissemination level	Public
Status	Final
Submission Date	23-12-2022
Author	Salih Karaarslan (EICB/SPB)
Co-author(s)	Niels Kreukniet (EICB/SPB) Virginia Oganesian (DC) Dejan Trifunovic (DC) Kai Kempmann (CCNR Secretariat) Michelangelo De Lisi (CCNR Secretariat) Ruxandra Matzalik Florescu (PDM) Robert Rafael (PDM) Juha Schweighofer (VIA) Mihai Barcanescu (WAT)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006364. The opinions expressed in this document reflect only the author's view and in no way reflect the European Commission's opinions. The European Commission is not responsible for any use that may be made of the information it contains.

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

Version

Version #	Date	Author	Organisation
0.1	06-07-2022	Virginia Oganesian, Kai Kempmann, Michelangelo De Lisi, Ruxandra Florescu, Mihai Barcanescu, Juha Schweighofer Niels Kreukniet and Salih Karaarslan	DC, CCNR, PDM, WAT, VIA and EICB/SPB
0.2	03-08-2022	Niels Kreukniet and Salih Karaarslan	EICB/SPB
0.3	23-09-2022	Salih Karaarslan	EICB/SPB
0.4	27-09-2022	Salih Karaarslan	EICB/SPB
0.5	04-10-2022	Salih Karaarslan	EICB/SPB
0.6	25-10-2022	Salih Karaarslan	EICB/SPB
0.7	28-10-2022	Niels Kreukniet and Salih Karaarslan	EICB/SPB
0.8	16-11-2022	Niels Kreukniet and Salih Karaarslan	EICB/SPB
0.9	07-12-2022	Salih Karaarslan	EICB/SPB
1.0	23-12-2022	Salih Karaarslan	EICB/SPB
Final	29-12-2022		CINEA

Release Approval

Name	Role	Date
Juha Schweighofer	WP4 leader	11-11-2022
Salih Karaarslan	Quality Assurance Manager	16-11-2022
Salih Karaarslan	Quality Assurance Manager	23-12-2022

Table of contents

List of figures

List of tables

Executive summary

This executive summary concisely presents the main findings and recommendations from the deliverable. It first briefly discusses the relevant policy background. This is followed by the main gaps and challenges that lie in the path of clean energy infrastructure to be realised. Finally, it briefly addresses what this means for policy makers.

Policy background

Following the EU Green Deal and Sustainable and Smart Mobility Strategy (SSMS), the inland waterway transport (IWT) sector needs to move towards zero-emission in 2050. A clean energy infrastructure is required to enable this transition. In general, there is a consensus on the need for a transition to cleaner IWT and hence the need for a clean energy infrastructure for IWT. However, there are differences in the details of the vision and approaches for the future clean energy infrastructure and the gaps and challenges that lie on the path. Especially at the level of European IWT countries, it will be crucial to develop and align national and regional strategies for the development of the clean energy infrastructure. The TEN-T corridor programs and European Coordinators of the corridors should coordinate and assist Member States in the creation of joint policy frameworks and strategies.

Need for clean energy infrastructure for IWT to be triggered by demand

At the moment, the greatest challenge for the clean energy infrastructure for IWT has an economic nature and concerns the currently minimal demand from vessel operators for clean energy. Demand and supply should develop in a balanced way. Policies and incentives (i.e. grants) should stimulate combined projects that will ensure a first critical mass of demand for clean energy, considering a corridor approach. This will help ensuring an initial consumption of clean energy which is large enough for suppliers of clean energy to invest in the required energy infrastructure. When the right market conditions are met, clean energy suppliers can move relatively easy given their financial capacity, as compared to small individual vessel owners, and invest in infrastructure once there is a prospect of a market.

Need for synergies and economies of scale

It should be considered though that IWT is seen as a small and fragmented market for energy suppliers, and hence the infrastructure would only support a limited number of forms of clean energy. Otherwise, the infrastructure becomes too costly with potentially a negative impact on factors such as price and availability of the supplied energy. This should be well thought out and synergies should be created wherever possible with other industries and transport modes for the supply of clean energy, e.g. with clean energy hubs.

Clean energy needs to be competitive compared to fossil fuels

The current status of bunkering fossil diesel is one of high availability on short notice, high service, flexibility and relatively low prices. It will, especially in its initial phase, be difficult for the alternative clean energy infrastructure to compete with. Laws and regulations should therefore be facilitative in terms of the realization and operation of the clean energy infrastructure for IWT. The right framework conditions should apply so that clean energy infrastructure operators can compete with the infrastructure for fossil fuels. The same line of reasoning applies for vessel operators sailing on clean energy. The right framework conditions should also be in place for the operators of the vessels, which naturally strengthens the realization of the clean energy infrastructure.

Important to address regulations and permits

There are also economic challenges with regulatory/legal causes, such as cumbersome permitting procedures and rules for the construction and operation of clean energy infrastructure, driving up costs for companies investing in the infrastructure. Experiences were gained with the construction and operation of the LNG bunkering station in Cologne and LNG truck-to-ship deliveries, lessons should be learned from this and rules and procedures should be eased where possible. Rules and procedures can be very different between countries and even at local level. However, for a clean energy provider, it would help if the rules and procedures were aligned. Overall, laws and regulations should be facilitative as much as possible for the development of the clean energy infrastructure. Learning from the LNG bunkering infrastructure for IWT is also possible in other areas. This especially concerns the operation of the bunkering infrastructure, i.e. with operating the bunkering station in Cologne, bunkering pontoons and the truck-to-ship supplies. Lessons can be learned from the technical difficulties in construction and initial operations, this could be very relevant for the future (liquid) H2 infrastructure.

How to use the existing bunkering infrastructure

On the technical front, the challenge is to utilize the existing bunker infrastructure to store and deliver clean energy to vessels. Existing bunkering stations and bunker boats are not necessarily technically suitable for this, depending on the energy carrier to be dealt with; there are also legal bottlenecks here due to safety rules and permits. I.e. existing bunker boats are not allowed to carry H2 stacks. It would help to map the details here to understand if and how the existing bunker infrastructure can be utilized for the storage and delivery of clean energy to inland vessels. This allows the use of an existing and proven infrastructure and avoids stranded assets.

On shore power supply to be uniform and scalable in capacity for charging batteries

For Onshore Power Supply (OPS) it is important to have the necessary electricity infrastructure in place. The grid should reach the quay side (in an effective manner), meet the demand (also from inland cruise vessels) and there should be a uniform concept for the operation of the shoreside power connections and a commonly accepted payment method. 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.

Future of exchangeable energy storage concepts using existing container terminals

With containerized energy storage for e.g. batteries and hydrogen (and possibly also other forms of clean energy), there are technical challenges both on the vessel and ashore. Not all (existing) vessels will be suited to carry containers and large parts of the sector never visit container terminals. Furthermore, a lot of inland terminals are still operated by one crane only and may not be able to take on the additional handling of clean energy-containers. However, swapping locations could also be at shore-side locations along waterways and not necessarily at container terminals. The feasibility of this would need to be mapped.

Build up the new infrastructure step-by-step on corridor level

For suppliers of clean energy it will be technically challenging to provide (full) geographic coverage for their customers, since a large proportion of vessels operate on the spot market and will have varying sailing trajectories and may not be able to bunker and charge clean energy always on the same place. This will imply, especially in the deployment phase, a development of the clean energy infrastructure for specific cases and dedicated routes (e.g. container vessels, ferries, etc.) on limited parts of a corridor.

Mind shift needed in usage of new energy carriers

Clean forms of energy such as H2 are not the same as fossil diesel and require a significant mind shift in the supply and bunkering of the fuel as well as the operations of the vessel. The stakeholders who are going to be affected should become aware of this need for a mind shift in a timely manner.

Will there be sufficient supply of clean energy at competitive prices?

An overarching technical challenge is whether there will be enough supply of clean energy in all European IWT countries to meet the 55% GHG reduction targets by 2030. This is not yet entirely clear and is also going to depend on demand from other modes of transportation and industries. This should be monitored closely and it should be made clear what the prospects are for IWT in the various European countries and regions.

Work to do to develop a facilitating legal framework and procedures

On the legal front, there are many standalone challenges and gaps. In addition, technical and, to a lesser extent, economic challenges can also have a legal basis and/or could be solved by legal measures. Legal bottlenecks that suppliers of clean energy (will) encounter in practice are in the field of supplying/taking alternative clean energy on board of the vessel and the construction and operation of the clean energy infrastructure. This relates e.g. to port bye-laws and legislation at a higher level that need to include provisions for bunkering/charging/swapping clean energy, harmonised bunkering checklists and procedures that are lacking, complex permits and procedures for building the infrastructure and for bunkering alternative clean fuels through truck-to-ship at reserved quays. Complex permits and procedures can also form a bottleneck for supplying clean forms of energy at existing bunkering stations and for providing multiple forms of clean energy next to each other at the same location.

Gaps to be addressed by policy makers, mainly to develop the demand for clean energy

For policymakers, it is of great interest to adequately assess the identified gaps and challenges that lie on the path and take advantage of them for policies and incentives related to the clean energy infrastructure development for IWT. The biggest challenge is seen in developing the demand for clean energy carriers, meaning vessel owners/operators demanding clean energy because they can make a business case or to have a ‘licence to operate’.

List of abbreviations

ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
AFID	Alternative Fuels Infrastructure Directive
AFIR	Alternative Fuel Infrastructure Regulation
CEF	Connecting Europe Facility
CINEA	European Climate, Infrastructure and Environment Executive Agency
DME	Dimethylether
EC	European Commission
EKPI	Environmental Key Performance Indicator
EMS	Environmental Management System
ESIF	European Structural and Investment Funds
ESR	Effort Sharing Regulation
ETS	Emission Trading System
EU	European Union
FC	Fuel Cell
GTL	Gas-to-liquids
H2	Hydrogen
HEU	Horizon Europe
HVO	Hydrotreated Vegetable Oil
IAPH	International Association of Ports and Harbors
ICE	Internal Combustion Engine
IPCEI	Important Project of Common European Interest
IWT	Inland Waterway Transport
LBM	Liquified Biomethane
LNG	Liquefied Natural Gas
LOHC	Liquid organic Hydrogen Carriers
NSB	North Sea-Baltic Corridor
NSM	North Sea-Mediterranean Corridor
OPS	Onshore Power Supply
PEMP	Port Environmental Management Plans
RALP	Rhine-Alpine Corridor
RD&I	Research, Development and Innovation
RDA	Rhine-Danube Corridor
RED	Renewable Energy Directive

RLCF Alliance	Renewable and Low-Carbon Fuels Value Chain Industrial Alliance
RPR	Rhine Police Regulations
RRF	Recovery and Resilience Fund
SRIA	Strategic Research and Innovation Agenda
SSMS	Sustainable and Smart Mobility Strategy
SUMP	Sustainable Urban Mobility Plan
TEN-T	Trans-European Transport Network
TRL	Technology Readiness Level
WAT TP	Waterborne Technology Platform
ZES	Zero Emission Services
ZEWT cPP	Co-Programmed Partnership on Zero-Emission Waterborne Transport

1. Introduction

1.1 Project and task description

The Horizon 2020 PLATINA3 project provides a platform for the implementation of a future inland navigation action programme. PLATINA3 is structured around four fields (Market, Fleet, Jobs & Skills, Infrastructure) of which work package 4 (WP 4) deals with various aspects of the infrastructure such as:

- climate change adaptation
- clean energy[1] infrastructure
- digital and automated inland navigation
- implementation of waterway and port infrastructure investments and proposed solutions.

This report presents the conclusions from Task 4.2 of PLATINA3 and presents the findings, perspectives and recommendations on the clean energy infrastructure along waterways and ports.

1.2 Scope and objective of deliverable

The objective of task 4.2 is to analyse implications and perspectives for the clean energy infrastructure along inland waterways and in ports, to prepare infrastructure managers, policy makers on EU and national level and energy providers for the developments in view of the zero-emission pathways for IWT.

The choice for the forms of alternative clean energy considered in this report is based on recent desk research performed on this topic, the partners' knowledge and the information received from relevant stakeholders in the field as well as from relevant EU-funded projects. The main focus will be laid on the energy carriers which cannot be positioned as drop-in fuels[2] (e.g. drop-in fuels such as biodiesel and liquid biomethane) and will need new infrastructure along waterways (e.g. (green) H2 and electricity to be used in FC's, batteries, non drop-in clean energy in clean ICE's).

In terms of infrastructure, the scope includes, seaports and inland ports, waterways, locks, berths and ferry landings in the four TEN-T corridors North Sea-Baltic (NSB), North Sea-Mediterranean (NSM), Rhine-Alpine (RALP) and Rhine-Danube (RDA).

The main target groups addressed are the seaport, inland port and waterway infrastructure managers, policy makers (EU and MS), energy suppliers and barge owners/operators.

1.3 Structure of report

The report is divided into three main content related chapters (i.e. chapters 2, 3 and 4) followed by the conclusions and recommendations in chapter 5 and subsequent relevant Annexes. Chapter 2 discusses the main policies and recent developments in the IWT market that are relevant to the alternative clean energy infrastructure. In terms of policies, it discusses the EU Green Deal, Sustainable and Smart Mobility Strategy (SSMS), Fit For 55, the Trans-European Transport Network

[1] In the context of this deliverable, clean energy is used as an umbrella-term for all sustainable alternative fuels and green electricity used in either clean internal combustion engines (engines meeting or surpassing the latest emission standards for new engines (NRMM Stage V minimum)), fuel cells, batteries etc.

[2] With drop-in fuels reference is made to renewable fuels that are used as drop-in fuels substituting conventional fossil fuels and are compatible with existing infrastructure and engine systems (i.e. existing diesel and gas engines in inland vessels).

(TEN-T) policy revision and CCNR Roadmap. Regarding developments in the IWT market, chapter 2 zooms in on the expected transition pathways for the fleet which will have strong implications for the required type of clean energy infrastructure. It also shines a light on the current state of clean energy infrastructure by highlighting a selection of relevant developments in this area. Ultimately, chapter 2 provides a good picture of the status quo of the current energy infrastructure for IWT and which relevant policy and market developments will influence the future clean energy infrastructure.

Following the status-quo, chapter 3 provides the detailed perspectives for the desired future state of the clean energy infrastructure for IWT. The perspectives of a large group of relevant stakeholders were identified through desk-research, interviews and questionnaires. This group includes representatives from TEN-T corridors, port authorities, inland waterway infrastructure managers, energy suppliers, inland vessel owners/operators and the Waterborne TP.

Chapter 4 builds upon the findings in chapter 2 and 3 which are translated into gaps and challenges for realising the clean energy infrastructure for IWT, broken down by technical, economic and legal challenges and gaps.

Following the identified gaps and challenges, corresponding conclusions and recommendations are made in chapter 5 of the deliverable.

2. Policies and market review

The objective of chapter 2 is to outline the status quo in two areas. First, the relevant policy background that will influence the current and future development of the alternative clean energy infrastructure for IWT. Second, to outline the (expected) developments in the market, i.e. the expected transition pathways for the IWT fleet towards zero-emission in 2050 and the currently ongoing and announced market initiatives that are important for the development of the alternative fuel infrastructure.

The status-quo outline in chapter 2, together with findings regarding the desired future state for the alternative clean energy infrastructure in chapter 3, forms relevant input for the identification of the gaps and challenges in chapter 4.

2.1 Policies

2.1.1 EU Green Deal and Sustainable and Smart Mobility Strategy

The SSMS[3] of December 2020 points out that the European Green Deal[4], of December 2019, calls for a 90% reduction in GHG emissions from transport by 2050 (to achieve climate neutrality) while also working towards a zero-pollution ambition. In the run-up to 2050, there is an intermediate reduction target of at least 50% and close to 55% by 2030 compared with 1990 (for all sectors). To achieve this systemic change, it is needed to:

- make all transport modes more sustainable.
- make sustainable alternatives widely available in a multimodal transport system.
- put in place the right incentives to drive the transition.

This implies that all policy levers must be pulled to i.a.:

- boost the uptake of lower and zero-emission vessels (and vehicles/aircraft).
- incentivise large scale market deployment of new technologies, including production capabilities and use of sustainable alternative fuels and associated charging and refuelling infrastructure.
- shift more activity towards more sustainable transport modes (e.g. by shifting a substantial amount of freight onto rail, inland waterways, and short sea shipping).
- mobilise research and foster innovations and set the right regulatory and non-regulatory framework for a leading European transport industry, both in clean and connected mobility.

The strategy clearly indicates the importance of a wide uptake of lower and zero-emission vessels as well as the deployment of the required alternative fuel/energy infrastructure. This is also defined as the first flagship area in the strategy, out of the 10 flagship areas with action plans to guide the work in the years to come. Clear references are made to the Alternative Fuels Infrastructure Directive (AFID), becoming the Alternative Fuel Infrastructure Regulation (AFIR) after adoption, TEN-T regulation and the Renewable Energy Directive (RED) in the first flagship area, since these provide a more concrete and binding direction for infrastructure development. The next subchapters elaborate on this.

[3] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12438-Sustainable-and-Smart-Mobility-Strategy_en
[4] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en#policy-areas

2.1.2 Fit For 55

To implement the ambitions described in the previous section, on 14 July 2021 the European Commission presented the Fit For 55 package containing legislative proposals to revise the entire EU 2030 climate and energy framework and pave the way to become the first climate-neutral continent by 2050.[5] The package aims to "**deliver the transformational change needed across our economy, society and industry**".[6] It will have a significant impact across a variety of sectors, including the IWT sector. Generally speaking, there are proposals that are in particular relevant for IWT:

- AFIR/D: Revision of the Directive on deployment of the alternative fuels infrastructure[7]
- RED: Amendment to the Renewable Energy Directive to implement the ambition of the new 2030 climate target[8]
- ETD: Revision of the Energy Taxation Directive[9]

The Effort Sharing Regulation (ESR) is also relevant as the transport sector including IWT are included in it. The ESR sets differentiated and binding national targets for emission reductions in sectors not included in the EU emissions trading system (ETS). With the revision, the objective to reduce emissions in ESR sectors increased from 30% to 40% as compared to 2005 levels. However, it is not yet clear what the exact impact of ESR on IWT will be in the various member states. This will be known only after a "distribution key" has been established by the individual member states for the sectors covered by ESR.

The most relevant proposal from the Fit For 55 package with direct impact on the clean energy infrastructure for IWT is the AFIR proposal and to a lesser extent the amendment of RED. The ETD can, indirectly, have a significant impact by removing disadvantages for clean energy and introducing higher levels of taxation for inefficient and polluting energy. This can make clean energy more competitive and hence eventually positively impact the clean energy infrastructure. However, this deliverable will not focus on the ETD, but mainly on the AFIR which has a direct relationship to the clean energy infrastructure.

It must be noted that the current overview of the Fit for 55 package is based on the proposals as they were published in Spring of 2022[10].

Alternative Fuels Infrastructure Regulation

The Fit for 55 package proposes to revise the AFID and replace it with a regulation, i.e. the AFIR. The change in instrument could give the infrastructure targets a more binding nature, which is required to ensure a swift and coherent development of the clean infrastructure network across the EU.[11]

[5] https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/package-fit-for-55

[6] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550&from=EN (p.2/15)

[7] EUR-Lex - 52021PC0559 - EN - EUR-Lex (europa.eu): Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council. COM/2021/559 final

[8] EUR-Lex - 52021PC0557 - EN - EUR-Lex (europa.eu): Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directive (EU) 2018/2001 of the European Parliament and of the Council, Regulation (EU) 2018/1999 of the European Parliament and of the Council and Directive 98/70/EC of the European Parliament and of the Council as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. COM/2021/557 final

[9] EUR-Lex - 52021PC0563 - EN - EUR-Lex (europa.eu): Proposal for a COUNCIL DIRECTIVE restructuring the Union framework for the taxation of energy products and electricity (recast). COM/2021/563 final

[10] To the understanding of the authors, the only relevant development was the recent EP vote on AFIR. See: https://www.iru.org/news-resources/newsroom/eu-parliament-backs-ambitious-alternative-fuels-infrastructure-plan

[11] https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-directive-on-deployment-of-alternative-fuels-infrastructure#:~:text=The%202014%20Alternative%20Fuels%20Infrastructure,alternative%20fuel%20vehicles%20and%20vessels.

The IWT infrastructure is clearly integrated into the AFIR and hence this proposal has implications for the development of the clean energy infrastructure for IWT. Annex 1 provides a full summary of the main highlights from the proposed revision that have implications for the IWT infrastructure.

In general, it is important to note that the AFIR prescribes that national policy frameworks should consist of detailed strategies to promote clean energy in sectors that are difficult to decarbonise, such as the IWT sector. In particular, Member States should develop clear strategies for the decarbonisation of inland waterway transport along the TEN-T network in close cooperation with the other Member States concerned.

By 1 January 2024, each Member State shall prepare and send to the Commission a draft national policy framework for the development of the market as regards clean energy in the transport sector and the deployment of the relevant infrastructure. That national policy framework shall include a deployment plan for clean energy in inland waterway transport, in particular for both hydrogen and electricity.

It is very much in the interest of the corridor approach and the further development of the TEN-T to align the individual national strategies as much as possible.

In addition to the national policy framework and plans, more specific relevant points for IWT as indicated in the AFIR concern the shore-side electricity and standards/technical specifications. Articles 9 and 10 set out provisions for Member States to ensure installation of a minimum shore-side electricity supply for certain seagoing ships in maritime ports and for inland waterway vessels. Since shore-side electricity facilities can serve as clean power supply and contribute to reducing the environmental impact of vessels. Article 10 includes targets for shore-side electricity supply in inland waterway ports. It states that Member States shall ensure that:

- at least one installation providing shore-side electricity supply to inland waterway vessels is deployed at all TEN-T core inland waterway ports by 1 January 2025;
- at least one installation providing shore-side electricity supply to inland waterway vessels is deployed at all TEN-T 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)[12].

In addition to electricity, AFIR mentions that zero-emission powertrain technologies should enter the IWT market more quickly. Renewable fuels such as renewable methanol can also be used for IWT. A categorisation has been made between “alternative fuels for zero-emission vehicles”[13], “renewable fuels”[14] and “alternative fossil fuels”[15] for a transitional phase. Sustainable alternative fuels that are a good fit for IWT and fit into the IWT transition pathways are clarified in chapter 2.2.1.

In addition, there needs to be a sufficient coverage of Liquefied Natural Gas (LNG

) refuelling stations in the maritime TEN-T ports in order to meet the current and future necessities of vessels travelling within the TEN-T core network by 2025. However, bio-LNG and e-LNG should also

[12] Numbers are based on expert knowledge, but can also be derived from the TEN-T maps, i.e. annexes to the Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Union guidelines for the development of the trans-European transport network (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0812)

[13] Electricity, hydrogen and ammonia

[14] Biomass fuels and biofuels as defined in Article 2, points (27) and (33) of Directive (EU) 2018/2001 and synthetic and paraffinic fuels, including ammonia, produced from renewable energy.

[15] natural gas, in gaseous form (compressed natural gas (CNG)) and liquefied form (liquefied natural gas (LNG)), liquefied petroleum gas (LPG), synthetic and paraffinic fuels produced from non-renewable energy.

be used for operations, not just fossil LNG. This can also influence the IWT segment, especially the routes close to the larger maritime or dual ports.

For refuelling and recharging points in urban nodes, public authorities should consider the possibility and deployment of refuelling and recharging possibilities within multimodal freight centres that can serve multiple transport modes.

As regards the clean energy infrastructure standards, the AFIR notes that new standards are needed to facilitate and consolidate the entry of alternative fuels (electricity supply, hydrogen, methanol and ammonia bunkering) into the market. But there is also a need for standards for communication exchange between vessels and infrastructure. Furthermore, the technical specifications for interoperability of recharging and refuelling points should be specified in European or international standards.

Revision of Renewable Energy Directive

After AFIR, perhaps the second most-important piece of legislation within the proposed Fit For 55 package is the revised RED[16] which foresees 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 the transport sector. Thus, the proposal introduces a target for reducing the greenhouse gas intensity of transport fuels by 13% by 2030 compared to the 2010 level.

It must also be noted that the Fuel Quality Directive (FQD) applies already for transport (including IWT) and includes a 6% reduction target to be reached already compared to 2010 level. This is to be replaced by the RED revision as part of the Fit for 55 package. Member States have the freedom to decide for themselves how to reach the overall target of 6% (FQD) and 13% (RED 2 revision). A risk here is the lack of coordination between (neighbouring) Member States which may result in major differences in prices and distortion of level playing field. Different approaches were foreseen for the FQD implementation in The Netherlands, Germany and Belgium, but as result of concerns on the level playing field it was decided to not impose specific reduction targets on fuels supplied to IWT[17].

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 influence in a number of directions that are of importance for the waterborne transport sector, including the IWT, namely:

- The increase of renewable electricity is foreseen to also be used to produce (more) synthetic fuels for hard-to-decarbonise transport sectors;
- 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 services' developments.

---

[16] Amendment to the Renewable Energy Directive to implement the ambition of the new 2030 climate target | European Commission (europa.eu)

[17] This element will be further addressed in the PLATINA3 Task 2.7 (expected to be published in Q2 2023)

- 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’ 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 not just for the maritime sector but also for IWT to access easily and sometimes directly clean energy – in particular for the IWT segments operating closer to the maritime/dual ports.

2.1.3 Trans-European Transport Network policy revision

On the 14th of December 2021, the European Commission published a proposal for revising the Union guidelines for the development of the TEN-T regulation[18]. The TEN-T regulation is an EU legal framework that aims to build an effective, EU-wide and multimodal transport network across the EU also including inland waterways and ports. Its objective is to develop a reliable and seamless TEN-T network, which offers sustainable connectivity throughout the EU, without bottlenecks and missing links.

The regulation is being revised to prepare the network for the future and align it to the objectives of the EU Green Deal and targets of the EU Climate Law.[19] Improved cohesion, sustainability, efficiency and user benefits are the four key objectives of the revision. Annex 2 of this document provides a full summary of the main highlights from the published proposal for revising the TEN-T regulation and its implications for the IWT infrastructure.

The network needs to be completed by 2050 with intermediate deadlines in 2030 for the core network and intermediate deadlines in 2040 for the extended core network. The proposed revision highlights the importance of an adequate planning of the TEN-T network. This involves the implementation of specific requirements throughout the network in terms of infrastructure, ICT systems, equipment and services, but also the requirements as indicated in AFIR. The availability of clean energy and related infrastructure should be improved throughout the trans-European transport network. Here, it is of utmost importance to safeguard a suitable and concerted deployment of the requirements across Europe taking into account the various transport modes and their interconnection across the network and beyond. This is needed to achieve the benefits of a network approach and contribute to the eventual TEN-T objectives.

[18] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Union guidelines for the development of the trans-European transport network, amending Regulation (EU) 2021/1153 and Regulation (EU) No 913/2010 and repealing Regulation (EU) 1315/2013 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0812&from=EN)
[19] https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_6725

The specific provisions for IWT prescribe in the proposed article 21, i.e., that Member States shall ensure inland ports on the comprehensive network, by 31 December 2050, to be equipped with facilities to improve the environmental performance of vessels in ports, including reception facilities, degassing facilities, noise reduction measures, measures to reduce air and water pollution. Member states shall also ensure that alternative fuels infrastructure is deployed in inland ports in compliance with the requirements of the AFIR. Member States shall ensure that core ports meet these same requirements by 31 December 2040.

The Commission is proposed to adopt implementing acts setting out requirements, which may be related in particular to, i.a., the deployment of clean energy infrastructure to ensure corridor-wide access to alternative fuels and the introduction and promotion of new technologies and innovation for zero-carbon energy fuels and propulsion systems.

In terms of EU funding and financing, the TEN-T regulation is directly linked to the Connecting Europe Facility (CEF) as it defines the projects of common interest[20] that are eligible under CEF. In addition, funding is provided by the European Structural and Investment Funds (ESIF) and the Recovery and Resilience Facility (RFF). With the promotion of IWT related projects of common interest attention shall be given to, i.a.:

- the promotion of sustainable, safe and secure inland waterway transport, including within urban nodes.
- promoting and developing measures to improve the environmental performance of inland waterway transport and transport infrastructure, including zero and low emission vessels.

With the revision, new opportunities arise for IWT in urban nodes, given the specific attention paid to them. The revision states that urban nodes should develop a Sustainable Urban Mobility Plan (SUMP), which includes objectives, targets and indicators underpinning the current and future performance of the urban transport system on i.a. GHG emissions and data on air and noise pollution in cities. Member States should establish a national SUMP support programme. This provides opportunities for clean freight and passenger transport over inland waterways in urban areas.

The European Coordinators should facilitate the coordinated implementation of the European Transport Corridors and of the two horizontal priorities.[21] There will also be a reinforced role for the European Coordinators and the Corridor Fora. The Coordinators will draw up work plans, which will provide detailed analysis of the state of implementation of the corridor and its compliance with the requirements of the TEN-T revision as well as the priorities for its future development. The implementing act to be adopted by the Commission will be based on the first work plan and will set out the priorities for infrastructure and investment planning and for funding.

2.1.4 CCNR roadmap for reducing inland navigation emissions

In accordance with the mandate given by the Mannheim Ministerial Declaration of 17 October 2018[22], the CCNR developed a roadmap[23] aimed at largely eliminating GHG emissions and air pollutants in the IWT 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,

[20] Projects that will contribute to the achievement of the trans-European transport network & objectives, and correspond to the priorities.
[21] The horizontal priorities are the European rail traffic management System and European Maritime Space.
[22] CCNR, "Mannheim Declaration", 17 October 2018, CCNR | Mannheim Declaration [EN].
[23] CCNR, "CCNR roadmap for reducing inland navigation emissions", March 2022, CCNR | Roadmap on emissions reduction [EN].

- largely eliminating GHG and other pollutants by 2050.

Built upon the CCNR study on the energy transition towards a zero-emissions inland navigation sector (hereafter "CCNR study")[24], this roadmap shall be understood as the primary CCNR instrument for mitigating climate change, fostering the energy transition, and contributing to the European IWT policy. As this energy transition represents a crucial challenge to Rhine and European inland navigation, the aim of the roadmap is to contribute to a reduction in emissions from Rhine and inland navigation by:

- setting transition pathways for the fleet (new and existing vessels),
- suggesting, planning, and implementing measures directly adopted or not by the CCNR,
- monitoring the intermediate and final objectives laid down by the Mannheim Declaration.

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. Sub-section 2.2.1 describes the pathways in detail.

Initial estimates show that the financial challenge involved in achieving zero emissions by 2050 is considerable. Depending on the transition pathway, the financial gap to be bridged to achieve the Mannheim Declaration emission reduction objectives varies significantly but is several billions in any scenario. The energy transition-related costs will exceed the financial resources of the inland navigation profession, which will only be able to bear a part of the costs required to achieve this transition. Significant grants are needed to close this gap, and to make the transition pathways economically viable for the inland navigation industry, energy suppliers, and shore-side infrastructure operators. Strong public support is therefore necessary.

To enable the IWT sector's energy transition towards zero emissions, the CCNR has developed an implementation plan taking into account economic, technical, infrastructure, social, and regulatory aspects. This plan aims at suggesting, planning, and implementing measures to be adopted directly or not by the CCNR, as well as monitoring the intermediate and final objectives laid down by the Mannheim Declaration. Among the measures foreseen, a few are of particular relevance in the context of this deliverable:

- develop standards and requirements for allowing the carriage of alternative fuels.
- develop standards and requirements to ease the use of alternative fuels (definition, fuel characteristics, blending and supply), notably biofuels.
- ensure that neither safety nor other provisions relating to bunkering infrastructure prevent the bunkering of alternative fuels.
- ensure that the needs of the inland waterway transport sector in terms of alternative fuel infrastructure are taken into account, notably in the revision of the Directive on the deployment of alternative fuels infrastructure, and ensure interoperability with all types of inland vessels.

The CCNR hopes that this roadmap will contribute to developing a common vision of the energy transition and the associated challenges within the inland navigation sector. The proper development of clean energy infrastructure, including shoreside power supply and charging facilities, as well as alternative fuels bunkering infrastructure, is of course part of this challenge.

Looking ahead, the CCNR undertakes to:

[24] CCNR, "Study on energy transition towards a zero-emission inland navigation sector", October 2020, CCNR | Study [EN].

- 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,
- revise, if necessary, by 2030 the roadmap and the corresponding action plan.

2.2 Developments in the IWT market

2.2.1 Transition pathways for the IWT fleet

To clearly assess the infrastructure-related challenges for IWT, it is vital to understand the possible demands on future energy carriers. These developments are not set in stone. Indeed, today, several scenarios are being studied for achieving the energy transition. It is anticipated that different (modular) options for zero-emission powertrains, using mixes of energy sources/fuels, will play a role in achieving this ambitious objective. The identification of possible transition pathways for the inland navigation fleet contributes to assessing such demand needs. As briefly touched upon in section 2.1.4, such pathways were defined in the CCNR roadmap, on the basis of the CCNR study results[25].

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. A more conservative transition pathway, based on technologies that are already mature, cost efficient in the short-term but with uncertainties on the availability on certain fuels, and a more innovative one, relying on technologies still in their infancy stage but providing more promising emission reduction potential in the long run. The two transition pathways are both sufficiently ambitious to achieve the emission reduction objectives of the Mannheim Declaration. A key conclusion points to the absence of a "one size fits all" technology solution adapted to all types of vessels and navigation profiles. A technologically neutral approach appears therefore relevant to achieve the energy transition.

Such transition pathways describe the expected evolution over time of the entire fleet with a breakdown of the technologies used (energy carriers and converters) to achieve the intermediate and final objectives. The pathways consider the building of new vessels as well as the retrofitting of existing vessels. They also address which role the different technological solutions will play in the energy transition and assess their suitability according to the different fleet families in Europe and the sailing profiles of the vessels. The transition pathways are derived in particular from the following inputs: economic variables, market maturity and availability of technologies, rate of new construction/scrapping, vessel age, and modernisation of existing vessels.

Technologies considered in the pathways

The technologies chosen in the pathways are illustrated in **Table 1** and reflect the state of knowledge as of 2021. It was decided to focus on a set of technologies with a technology readiness level (TRL) of 5 and above. Some were not considered mature enough to be used, especially in light of current cost predictions. However, no technologies should be excluded at this juncture. For instance, other technological options like lithium-air batteries, LOHC (Liquid Organic Hydrogen Carrier), formic acid (hydrozine) or green ammonia in combination with fuel cells (FC) or internal combustion engines (ICE) might play roles in later stages of the energy transition but were not considered in the pathways. Annex 3 provides a longlist of forms of clean energy. Regarding ammonia, for instance, it is

[25] Research question C (Edition 1) on the technical and economic assessment of greening techniques which fit into zero-emission development of IWT and research question C (Edition 2) complementing the findings from Edition 1 in order to come up, in particular, with more refined transition pathways towards zero emission is the most relevant deliverable from the CCNR study on the basis of which the transition pathways were defined.

a serious candidate as an energy carrier for seagoing vessels but still presents important safety issues to be investigated in inland navigation. Eventually, some other technologies which are not known today might be deployed in the next decades.

Table 1: Technologies considered in the pathways - energy carriers and converters[26]

Technologies considered in the pathways	**Description**	**TRL** (1-9) **vessel application**	**TRL** (1-9) **fuel/energy production and supply**	**Emission reduction potential** (in an ideal upstream chain)		
				GHG/ CO_{2e}	**NO_x**	**Particulate matters**
CCNR 2 or below, Diesel	Fossil diesel in an internal combustion engine which complies with the emission limits CCNR 2 or older engine.	9	9	0%	0%	0%
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.	9	9	0%	82%	54%
Stage V, Diesel	Fossil diesel in an internal combustion engine which complies with the emission limits EU Stage V.	9	9	0%	82%	92%
LNG	Liquefied Natural Gas in an internal combustion engine which complies with the emission limits EU Stage V.	9	9	10%	81%	97%
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.	9	9	100%	82%	92%
LBM	Liquefied Bio Methane (or bio-LNG) in an internal combustion engine which complies with the emission limits EU Stage V.	9	8	100%	81%	97%
Battery	Battery electric propulsion systems, with fixed or exchangeable battery systems.	8	7	100%	100%	100%
H_2, FC	Hydrogen stored in liquid or gaseous form and used in fuel cells.	7	7	100%	100%	100%
H_2, ICE	Hydrogen stored in liquid or gaseous form and used in internal combustion engines.	5	7	100%	82%	92%
MeOH, FC	Methanol used in fuel cells.	7	6	100%	100%	100%
MeOH, ICE	Methanol used in internal combustion engines.	5	6	100%	82%	92%

Source: CCNR Roadmap for reducing inland navigation emissions.

To facilitate the understanding of the pathways, it is important to indicate that the CCNR roadmap:

[26] **Remark 1**: Regarding the energy converter, the mono-fuel engine is considered in the transition pathways for each fuel. In practice dual-fuel engines could also be applied, e.g. engines that run on LNG and gasoil but have significantly higher GHG emissions. This could also apply to MeOH and H_2 engines once these enter the market.

Remark 2: CCNR stage 2 refers to the emission limits adopted by CCNR Resolution 2005-II-20[26]. The EU Stage V refers to emission limits adopted by Regulation (EU) 2016/1628 for non-road mobile machinery[26] (categories IWP, IWA, NRE or EURO VI marinised truck engines)

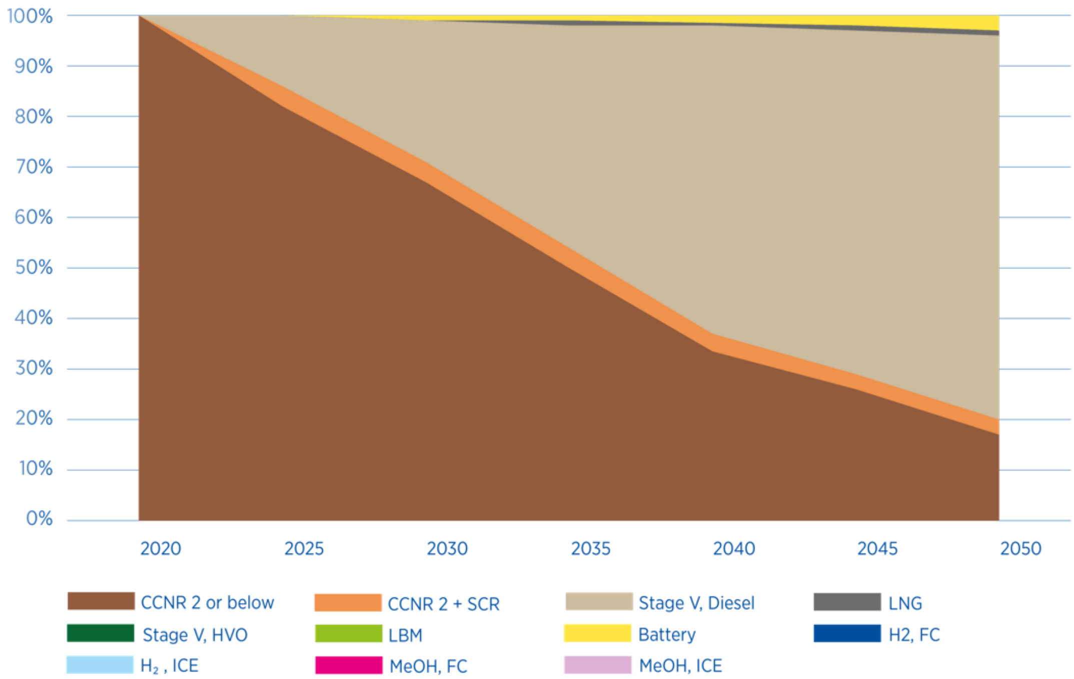
- lays focus on inland navigation meaning the carriage of goods and the transport of passengers by inland waterway vessels - recreational crafts, service vessels and floating equipment were not included at this stage.
- defines emissions as atmospheric pollutants and greenhouse gases (GHG) arising from the operation of an inland navigation vessel's propulsion and auxiliary systems.
- adopts a "tank-to-wake" approach, as an interim solution, until a "well-to-wake" approach is available for the relevant energy carriers. Application of this approach however implies making assumptions concerning the upstream chains (emissions produced and fuel availability) which are idealised. The reasons of this approach are explained in section 3.2 of the CCNR roadmap[27].

The technologies summarised above require different fuels to be delivered on board inland vessels. Therefore, the amounts in which the respective technologies will be used will have a significant impact on future infrastructure demands.

Business-as-usual scenario and transition pathways leading up to 2050

The business-as-usual scenario (see **Figure 1** below) predicts a slight increase in the usage of LNG, batteries, and Hydrotreated Vegetable Oil (HVO). However, the scenario keeps relying heavily on fossil diesel and will have only a limited impact on the infrastructure. More importantly, it does not meet the goals set out in the Mannheim Declaration and will therefore receive no further attention.

Figure 1: Business-as-usual scenario: development of technologies by 2050



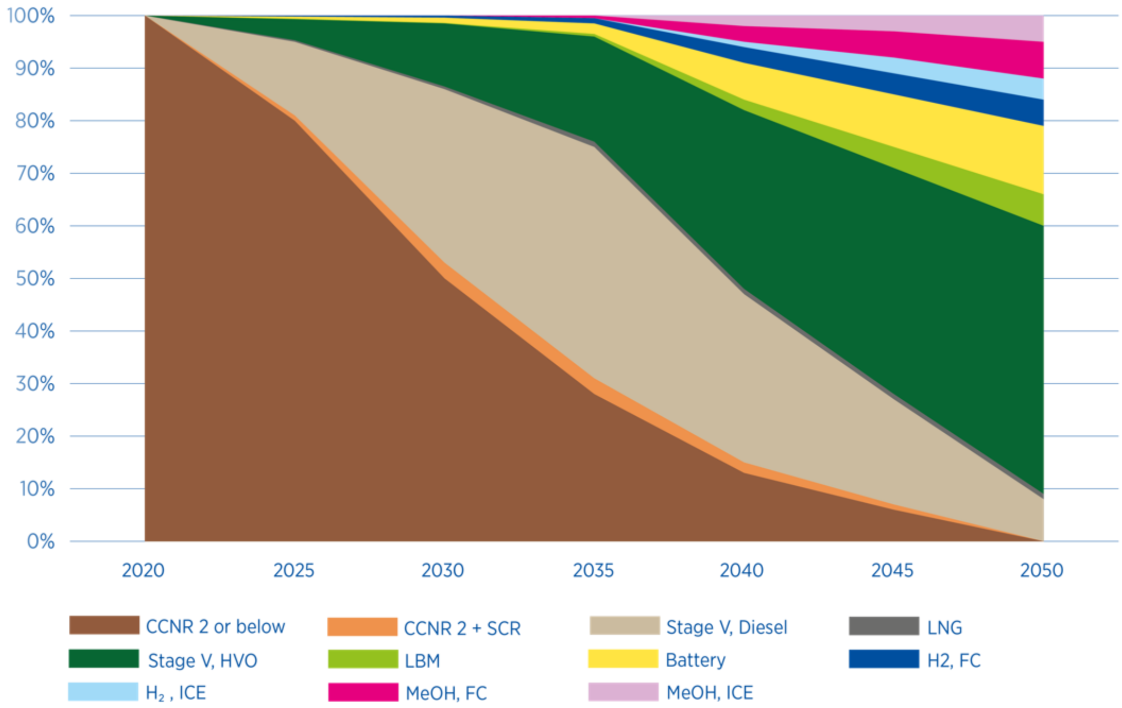
source: CCNR roadmap on the basis of the CCNR study; Resolution 2021-II-36

The conservative pathway (see **Figure 2** below) refers to a transition pathway in which the clean energy and technologies considered are relatively easy to implement and cost efficient in the short-term. Such alternatives consist, for instance, of advanced biodiesel that can be used in existing diesel engines, or Liquified Biomethane (LBM) that can be used in gas engines. These are fuels and

[27] CCNR, "CCNR roadmap for reducing inland navigation emissions", March 2022, CCNR | Roadmap on emissions reduction [EN].

techniques which have a relatively high TRL and are already available on the market. Here, it becomes clear that in 2035 the vast majority of the fleet will still use conventional diesel, a smaller but significant part will use HVO, and an even smaller part will use batteries. Hydrogen, Methanol, LBM, and LNG are used by small fragments of the sector. In 2050 however, the image changes: diesel usage falls steeply and HVO is now the dominant fuel in the sector. LNG, LBM, Batteries, Hydrogen, and Methanol play smaller, but significant roles. It is interesting to note that drop-in fuels HVO and LBM account for a relatively large share, especially in the fleet families with a relatively high installed power. Indeed, vessels in those fleet families will be relatively less suitable for alternatives such as batteries. Although diesel usage falls steeply, most vessels still use internal combustion engines, with HVO as fuel.

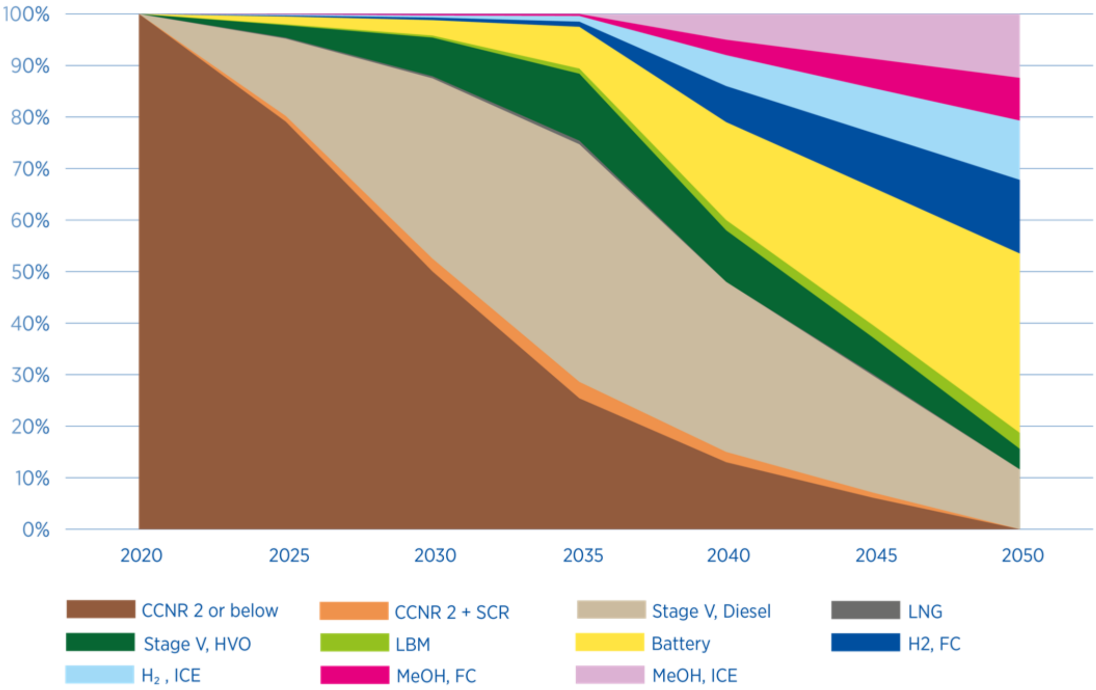
Figure 2: Conservative transition pathway: development of technologies by 2050



source: CCNR roadmap on the basis of the CCNR study; Resolution 2021-II-36

The innovative pathway (see **Figure 3** below) encompasses a more innovative approach, in which the fuels and technologies considered are currently still in their infancy stage (low TRL) and significantly more expensive as compared with advanced biodiesel and LBM. This concerns alternatives like battery-electric and hydrogen-powered propulsion systems, which are zero emission locally. These systems are relatively less mature and need further development. However, they are expected to become more mature in years to come as positive business cases exist only in the long term. The development of the technology shares can be seen in **Figure 3** below. In 2035, the level of fossil diesel used by the sector remains high (similar as in the conservative pathway), but there are more batteries in use next to HVO usage. Hydrogen, Methanol, LBM, and LNG are used by small fragments of the sector. In 2050, the image changes again: batteries and electricity are the dominant technology and form of energy used by the fleet. Fossil diesel keeps seeing significant usage, next to a small user group for HVO. Indeed, the fleet family for the largest pusher boats (>2,000 kW) is characterised by high installed power and a high fuel consumption. Owing to their volume and weight, batteries might be less suitable because of their potentially severe impact on the vessel. It is expected that this fleet family in particular continues to rely on fossil fuel and HVO for their propulsion in the future. Hydrogen and Methanol see a steep increase in demand. Here, the number of techniques used is larger and there will be more demand for a more fragmented field of fuels.

Figure 3: Innovative transition pathway: development of technologies by 2050



source: CCNR roadmap on the basis of the CCNR study; Resolution 2021-II-36

Impact of the different pathways on the sector's fuel consumption

Table 2 below shows the impact of the different pathways on the sector's fuel consumption. In 2015, 1.6 million tonnes of diesel were used, but in 2050 fossil diesel usage will decrease in both pathways by roughly 85%. Both pathways see fragmentation regarding replacement fuels. However, the conservative pathway relies heavily on HVO, a drop-in fuel that is very similar to diesel. The innovative pathway relies most heavily on battery electricity, which will have a significant impact on infrastructure needed to deliver it on board. The same is true for LBM, hydrogen, and methanol which are all seeing significant usage in 2050. This will change the way fuel is delivered onboard and should be kept in mind while making plans for the development of future infrastructure.

Table 2: Fuel needs in tonnes per pathway[28]

Fuel	Conservative Pathway 2035	Conservative Pathway 2050	Innovative Pathway 2035	Innovative Pathway 2050
Diesel	907,365	170,312	899,489	190,322
HVO	277,102	509,481	148,420	73,809
LNG	20,082	8,832	13,462	0
LBM	14,775	113,287	26,482	61,038

[28] Both transition pathways realise an emission reduction of 91% for GHG and slightly higher reduction rates for air pollutant emissions (PM and NOx), with the innovative pathway performing slightly better on air pollutant emissions NOx and PM. As the innovative pathway puts stronger effort into innovative energy carriers and technologies and thus achieves the 90% target faster. As regards LNG, the expectation in the innovative pathway is that fossil LNG will completely be replaced by LBM by 2050 in IWT. Furthermore the share of LNG and LBM is much lower in the innovative pathway which reduces the negative impacts of methane slip on the CO2e emission. Due to the differences in the assumptions on LNG and LBM, the innovative pathway therefore leaves slightly more room for the use of fossil diesel compared to the conservative pathway.

H2FC	2,047	10,534	7,238	37,077
H2ICE	1,205	9,813	3,551	25,293
MeOHFC	20,025	87,784	38,530	159,546
MeOHICE	6,246	66,567	18,490	199,514

Source: CCNR study, Deliverable C (Edition2). Ref: in 2015 the EU IWT sector used 1.6 MLN Tonnes of Fossil Diesel.

It shall be noted that the electricity demand for battery-electric sailing can be expressed in MWh. The following figures apply in addition to the table above:

- **2035 conservative pathway**: 50,813 MWh per year.
- **2050 conservative pathway**: 381,005 MWh per year.
- **2035 innovative pathway**: 317,924 MWh per year.
- **2050 innovative pathway**: 1,120,359 MWh per year.

2.2.2 Current state and selected initiatives in the field of clean infrastructure

This subchapter provides insights into the current state of the IWT energy infrastructure, the current way of bunkering, and the current initiatives in the field of clean infrastructure for IWT. In order to analyse the gaps in the IWT energy infrastructure and gaps as regards bunkering fuel/energy, it is necessary to identify first the current method of bunkering and its technical, economic and legal aspects. Furthermore, it is relevant to identify innovative initiatives in the field of clean energy infrastructure which may already result in relevant outputs that can be taken into account for this analysis and future developments in the clean energy infrastructure for IWT.

Current way of bunkering and state of IWT energy infrastructure

The current energy infrastructure used by IWT for the propulsion of vessels consists largely of the bunkering infrastructure for fossil diesel/gasoil and in much smaller quantities biodiesel (FAME/HVO), Gas-to-liquids (GTL) and LNG. Whereas LNG is not supplied by the conventional bunkering infrastructure, i.e. the existing bunkering stations and bunkering boats.

The Netherlands, and in particular the Rotterdam region, is the main bunkering hub for IWT in Europe.[29] The bunkering volumes are significantly smaller in other regions across Europe. The bunkered fuel predominantly consists of fossil diesel. In the Netherlands approximately 65% of the fuel is delivered by bunkering boat (ship-to-ship) where the remaining 35% is bunkered at a bunker station (station-to-ship). There are approximately 100 bunker boats and 25 bunker stations on pontoons with a shop. Diesel deliveries by truck (truck-to-ship) are practically not happening. In Belgium and Germany bunkering boats have by far the largest share in the delivered amount of fuel.[30]

Bunkering stations and bunkering boats, i.e. station-to-ship and ship-to-ship are the two dominant bunkering methods for IWT. Bunkering stations are usually pontoons on the water including a shop similar to the ones at a road service station. A bunker station often also operates bunker boats and provides ship-to-ship bunkering services. A bunker station such as the Heijmen bunker station in Millingen[31] has a storage capacity of 2000m³. Depending on the stored amount, the fuel can be

[29] CDNI provides official data concerning bunkering quantities in CCNR Member States. This information can be obtained through the following website https://www.cdni-iwt.org/dashboard/?lang=en
[30] Based on expert consultation
[31] https://heijmen.nl/bunkerstation-millingen-aan-de-rijn/

divided in several tanks. For example, the Reinplus Fiwado bunker station in Zwijndrecht[32] provides 10 ppm and 1000 ppm[33] diesel/gasoil and GTL of which the storage is divided into several tanks. The existing installation of a bunker station does not generally lend itself to supplying multiple and very different types of fuel.[34] Bunker boats are usually 38m long and carry diesel, lubrication oil and water. E.g. a typical IWT bunker boat such as "Zwaantje 2"[35] carries 180m³ diesel.

LNG is not being provided by the traditional bunkering infrastructure that provides (bio)diesel and GTL. LNG deliveries are mainly done through truck-to-ship operations. There are bunkering vessels providing LNG, like the ones from the company Titan[36], but these usually don't deliver to inland vessels due to the limited demand from inland vessels as compared to seagoing vessels. Furthermore, there is a fixed LNG bunker station in Cologne delivering to inland vessels.

The technical requirements for bunkering infrastructure and permits/procedures to build and operate conventional bunkering infrastructure (i.e. bunker stations and boats) is very fragmented. The individual components of the station, i.e. such as the Elaflex couplings, are usually standardised according to international standards. Furthermore, there are requirements at the national level that are harmonised at a European level. For example in the Netherlands there is Appendix 3.8. Technical requirements for bunkering stations of the "Binnenvaartregeling" regulation. Technical requirements for bunker boats (or "supply vessels") are also laid down in the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)[37]. For building the bunkering infrastructure (i.e. a bunkering station) local organisations are also relevant, such as landowners and permit applications that must be submitted to local authorities such as the municipality. There may also be relevant national environmental laws one needs to adhere to, such as the "Activiteitenbesluit milieubeheer" in the Netherlands.[38] It is important to mention though that national and certainly local regulations and processes in relation to permits and the construction of bunker infrastructure can vary greatly from one country to another.

Experience with the construction of the LNG bunkering station in Cologne also showed that the construction process of the clean energy infrastructure for IWT can be very complex, time-consuming and costly compared to conventional infrastructure. Numerous legal (complex permit processes and extensive compulsory safety studies) and technical (i.e. with the bunkering equipment, such as the bunkering arm) challenges had to be overcome, not to mention the financial challenges posed by a lack of demand.[39]

Relevant to take note of is that in August 2022 a permit has been given by the "Omgevingsdienst IJmond", a permit authority working in this case on behalf of the Dutch municipality of Velsen, for the bunkering of hydrogen to Windcat Workboats for its Hydrocat hydrogen fuelled workboat. The boat is being used in a pilot out of the Port of IJmuiden to deliver crew to offshore windfarms while

[32] https://www.reinplusfiwado.com/nl/bunkerlocaties/zwijndrecht/
[33] PPM representing the amount of Sulfur present in diesels.
[34] Sometimes for simple reasons, because only one type of fuel is supplied or there is only one pipe system.
[35] https://www.slurink.nl/netwerk/dordrecht/
[36] https://titan-cleanfuels.com/
[37] https://unece.org/sites/default/files/2021-01/ADN%202021%20English.pdf / relevant articles such as 1.6.7.4.1, 9.3.3.21 and 9.3.3.11.7
[38] https://wetten.overheid.nl/BWBR0022762/2021-07-01 / The following webpage of Rijkswaterstaat provides a concise overview of the safety requirements (based on "activiteitenbesluit") for delivering fuels to vessels: https://www.infomil.nl/onderwerpen/veiligheid/activiteitenbesluit/afleveren-brandstof/afleveren-brandstof/#hb52a6126-16ab-4a6e-8127-a64729ec70b8
[39] Based on expert knowledge obtained throughout the CEF funded project "Breakthrough LNG deployment in Inland Waterway Transport".

running on hydrogen. Windcat, the municipality and other relevant partners have done joint research for the necessities to obtain the permit[40].

In addition to requirements in relation to the hardware and construction permits and procedures, there are also guidelines and regulations for the bunkering operation. For example, ports have Port Bye-Laws including provisions for bunkering activities. Police regulations are also relevant, such as the one for the navigation of the Rhine (RPR), drawn up by the CCNR police regulations committee, and contains the navigational rules on the Rhine. The RPR contains instructions for bunkering conventional gasoil and LNG in two articles:

- Article 15.06 Plicht tot waakzaamheid bij het bunkeren (Duty of vigilance in bunkering operations) and;
- article 15.07 Plicht tot waakzaamheid bij het bunkeren van vloeibaar aardgas (Duty of vigilance in respect of bunkering of liquefied natural gas).

Furthermore, the CCNR has drafted, in partnership with the International Association of Ports and Harbors (IAPH), standards for LNG Bunker Checklists truck-to-ship and Bunker station-to-ship.[41] There are no similar detailed standardised bunker checklists for conventional diesel fuel. The fuel supplier and vessel operator make agreements based on a bunker assignment containing the bunker speed, amount, etc.

Economically, the bunkering market is characterized by very small margins requiring large quantities of sales to enable a positive business case. A conventional bunkering station on the water (i.e. a bunkering pontoon) will cost on average between €4-6 mln, whereas a common small bunkering boat of 38m will have an investment cost of around €2 mln.

The current bunkering infrastructure market is a quite mature market. Its geographical coverage is optimised throughout time. There is a tendency to have large hubs with large supply volumes. Usually a vessel operator bunkers at a large coastal hub such as the port of Rotterdam and Antwerp to sail for example up and down to Basel.

The bunkering operation for diesel (and biodiesel, GTL) is being performed with minimal time loss, i.e. with minimal administrative costs, waiting time and bunkering time. Where possible, bunkering is even being performed during sailing by a bunkering boat. With LNG however, there is significant time loss especially in case of truck-to-ship deliveries due to administrative tasks for reserving a quay for bunkering, circumventing to the respective quay, waiting on truck arrival, bunkering operation itself, etc. In the EU funded CEF project LNG Breakthrough the price difference between diesel and LNG, in favour of LNG, was even nullified in one of the pilot demonstrations due to the extra time involved in bunkering LNG.[42]

Selected initiatives in the field of clean energy infrastructure

A non-exhaustive list (see Annex 4) of relevant present projects and initiatives has been identified that will have relevant results for the clean energy infrastructure for the IWT sector. These projects and initiatives show that already a lot is currently being undertaken, i.e. projects that help stimulate the development of the clean energy infrastructure for the IWT sector. The results of these projects should be monitored and lessons learned. A selection of projects is featured below.

[40] See: https://www.portofamsterdam.com/nl/nieuws/eerste-waterstof-bunkervergunning-van-nederland
[41] https://www.ccr-zkr.org/13020500-en.html
[42] https://lngbinnenvaart.eu/wp-content/uploads/2020/02/Pilot-test-report-Werkendam-external.pdf

H2 meets H2O (Austrian project for the implementation of H2 infra and H2 applications in the Danube region, pre-feasibility study starting in April 2022, will pave the way for a larger R&D project): The aim of the project "H2 meets H2O" is to assess the feasibility and applicability of hydrogen supply along the Danube as logistics backbone from a technical, legal and socio-economic point of view. The relevant strategies of the European Union (in particular the European Green Deal), as well as national strategies (e.g. the 2030 Mobility Master Plan), which attempt to provide answers towards climate neutrality, serve as a basis. Therefore, based on a multimodal supply concept, from the production of hydrogen up to the end-users, the logistical basis for a subsequent R&D project with innovative pilot applications for inland waterway vessels, railways and trucks shall be created.

Hydrogen is on the one hand a cargo and on the other hand an alternative fuel that can contribute to the reduction of emissions and emissions in freight mobility. IWT and its infrastructure as core topics play an essential role in creating sustainable and climate-neutral logistics chains. Central unique selling points of the project are the extensive network of the relevant stakeholders in several workshops, the multisectoral access, the exploitation of the development potential of ports as hydrogen hubs, as well as the considerations regarding the international rollout of the innovative solutions in the Danube Region.

The result of the project is a roadmap for the implementation of hydrogen infrastructure, along with hydrogen-based transport and propulsion technologies in shipping, developed in a participatory manner through active stakeholder dialogue. Furthermore, potential synergy effects in multimodal logistic chains are to be analysed and presented. The strong involvement of relevant stakeholders even before the start of the project, as well as within the monitoring process, including the workshops, also leading to awareness-raising, ensures broad acceptance of the elaborated roadmap and the basis for a subsequent implementation project is already formed.

Rhine Hydrogen Integration Network of Excellence (RH2INE) is an initiative of:

- the Province of Zuid-Holland;
- the Ministry of Economic Affairs, Innovation, Digitisation and Energy of North Rhine-Westphalia.

Supported by the Dutch Ministry of Infrastructure and Water Management, the initiative encompasses a comprehensive corridor approach aiming to enable and strengthen synergies between energy, transport and telecom, being one of the key CEF priorities. The initiative seeks to realise market-ready hydrogen applications along the Rhine-Alpine corridor, powered by the first sustainable and interoperable gas and electricity networks in the world.

The initiative is taking the first step towards a zero-emission transport corridor by developing the right conditions and infrastructure for the use of hydrogen for the inland transport chain e.g. IWT, freight transportation by rail and road for the last mile. A targeted structural demand for hydrogen in the mobility sector will be stimulated, aligned with a sustainable hydrogen supply network.

The CEF-funded RH2INE Kickstart Study was launched to gain detailed insights into the sustainable integration of hydrogen as a transport fuel in the full value chain of IWT. The results of the RH2INE Kickstart Study are used to develop a blueprint for the next phases. A so-called RH2INE Kickstart IWT ambition of three vessel-owning companies and IWT operators as part of the RH2INE coalition to build twelve hydrogen vessels and four refilling locations, is submitted to the EU H2 IPCEI First Technology Wave and to the second round of the Dutch Groeifonds Investment Fund. Further opportunities in European funding, such as the EU Alternative Fuels Infrastructure Facility of the CEF programme and in the Horizon Europe programme, are being explored as well.[43]

[43] https://www.rh2ine.eu/

The MAGPIE project (sMArt Green Ports as Integrated Efficient multimodal hubs) is a Horizon 2020 project that aims to accelerate the introduction of green energy carriers combined with the realisation of logistic optimisation in ports automation and autonomous operations. The project is focussed on ports (Port of Rotterdam, Deltaport, Port of Sines and HAROPA). As the consortium states "*The main objective of MAGPIE is to demonstrate technical, operational, and procedural energy supply and digital solutions in a living lab environment to stimulate green, smart, and integrated multimodal transport and ensure roll out through the European Green Port of the Future Master Plan and dissemination and exploitation activities. A living lab approach is applied in which technological and non-technological innovations are developed or demonstrated.*" Through 10 demonstrations and a significant amount of research, the project will deliver a Master Plan for the future European green port- including a handbook for implementation, replication and scale-up of innovations.

MAGPIE's focus on ports includes both Maritime and IWT, but also takes into account the supply chain of Green Energy Carriers. In MAGPIE, considered energy carriers are batteries, green hydrogen, ammonia, LBM and green methanol. The project will consider the chain from source to plug and account for changes flowing from the change in the energy mix regarding infrastructure.

MAGPIE will thus work on researching and demonstrating the useability of Green Energy Carriers. The project also acknowledges that the large-scale uptake of Green Energy Carriers will have an impact on infrastructure. The project will try to achieve infrastructure optimisation in the case of the demonstration focussing on stability for the energy grid and specifically acknowledges that "*Supply chain infrastructure needs to be flexibly capable to cope with the possible energy carriers of the future*". MAGPIE's results are forthcoming.

To help the waterborne transport sector achieve its GHG emission reduction goals, the Horizon 2020 Project **Current Direct** focusses on the creation of a Swappable Waterborne Transport Battery in a container (1MW), backed by an energy-as-a-service Platform. On the infrastructure side, Current Direct will work on national grid standards, supporting infrastructure grid connections, safety and regulations. Furthermore, Current Direct has attention for mechanical and structural consideration for swapping infrastructure. The latter also includes the necessary reach of swapping infrastructure such as cranes. Current Direct will thus work on infrastructure and the proposed innovations will have a significant impact on requirements on the shore-side. These requirements will mainly lie on the energy grid and the necessary connections, but also impact the direct shoreside infrastructure (cranes) to get the swappable batteries on board.

Similar to Current Direct, **Zero Emission Services (ZES)** focusses on the creation of swappable energy containers, so-called ZESpacks. ZES is a private enterprise supported by the Dutch Ministry of Infrastructure, which shares are held by EBUSCO, ING, Wärtsilä and the Port of Rotterdam. The ZESpacks are supposed to be leased/rented by skippers on a pay-per-use basis. To facilitate the use of the ZESpack on vessels, docking stations are needed. ZES currently has two of these docking stations and is planning to increase their number to 20 in the coming years. These stations can be hosted by container terminals and ZES. In the same light as Current Direct, ZES will significantly impact the infrastructure requirements on the shoreside.

Similar to MAGPIE, **PIONEERS** is a Horizon 2020 project focussed on ports and decreasing their carbon footprint. The main PIONEERS ports are those of Antwerp, Barcelona, Constanza and Venlo. PIONEERS pays significant attention to infrastructure: it will strive to enable European ports to use clean energy for their yard vehicles and overall reduce the environmental impact from port infrastructure and enhance green land-use. The project also foresees the replacement of natural gas by hydrogen. Furthermore, the overall greening of the port towards a centre for energy production, storage and supply, another PIONEERS goal, will have impact on energy supply to vessels and other vehicles in the port- significantly impacting infrastructure.

Reviewing the projects above has shown that many innovative actions are already taking place that will impact the working of infrastructure in different ways. This shows the intention of the sector to work towards a greener inland waterway transport, but also shows the need for owners and managers of infrastructure to adapt to that new situation.

2.3 Conclusion

Chapter 2 provided an overview of the relevant policy background as well as relevant ongoing and expected developments in the IWT market that are of interest for the development of the clean energy infrastructure.

The most relevant and recent European/international policy developments indicate a strong policy push towards a cleaner IWT fleet, i.e. a European inland fleet emitting far less pollutant and GHG emissions to reach the 2050 objectives. This means a reduction in emissions of at least 90% in 2050 as compared to 1990 according to the SSMS and EU Green Deal.

The CCNR roadmap goes a step further and has also identified two transition paths to achieve the emission reduction targets and corresponding clean energy and techniques that fit into the pathways. This gives an idea of where things are going in terms of clean energy and energy and therefore provides a picture of the expected fuels/energy carriers that the fleet will need and which will need to be facilitated by the clean energy infrastructure for IWT.

The proposed Fit For 55 package contains legislative proposals to implement this ambition, in particular the AFIR, RED, ETD and ESR are relevant for the IWT sector. The policy push for a greener IWT fleet is also reflected, albeit to a lesser extent, in the clean energy infrastructure needed to facilitate the greening of the fleet. The most relevant proposal from the Fit For 55 package with direct impact on the alternative clean energy infrastructure for IWT is the AFIR, which i.a. prescribes the development of national policy frameworks and detailed strategies for the development of the market as regards clean energy in the transport sector, including IWT, and the deployment of the relevant infrastructure. Specific points are raised in the AFIR for IWT concerning shore-side electricity and standards/technical specifications. However, it should be noted that the focus seems to be mainly on OPS for auxiliary power during berth. For inland vessels, it is important that these OPS points can also provide for (rapid) charging of batteries needed for the propulsion.

The proposal for revision of the TEN-T regulation relates to the AFIR and aims to improve the availability of clean energy and related infrastructure along the TEN-T network. Specific provisions for IWT are included in this respect. Corresponding funding opportunities are and will be available through CEF, but also ESIF and RFF.

In addition to the relevant policies, Chapter 2 also analysed the current state of the energy infrastructure and the concrete developments currently taking place in the market. The current energy infrastructure for IWT predominantly consists of bunkering facilities for fossil diesel which also supplies bio-diesel and GTL. There is also marginal infrastructure for supplying LNG to inland vessels. Bunkering is mainly done through bunkering boats and bunker stations and in large seaports such as Rotterdam and Antwerp. The existing bunker infrastructure does not seem suitable for supplying clean energy such as hydrogen and electricity and hence requires new infrastructure. The existing technical requirements, permits and procedures for building bunkering infrastructure, and guidelines and regulations for the bunkering operation itself are very fragmented. This should be taken into consideration for developing the future clean energy infrastructure for IWT. Lessons can be learned in this respect from the realisation of the (limited) LNG bunkering infrastructure and the recent permit for bunkering H2 in the Netherlands.

Specific gaps and challenges related to the realisation of the energy infrastructure, but also to the identified policy background[44], will be elaborated upon in chapter 4.

[44] For example, interest representatives in the IWT sector have already included shortcomings and points for improvement in relation to the AFIR and TEN-T revision in position papers, which will be elaborated upon in chapter 4. See also https://www.ebu-uenf.org/wp-content/uploads/AFIR-Statement-press-release-2022-01-06.pdf and https://www.inlandwaterwaytransport.eu/wp-content/uploads/Press-release-IWT-sector-on-the-TEN-T-revision.pdf for respectively position papers on AFIR and TEN-T revision.

3. Perspectives for desired future state

The objective of chapter 3 is to analyse the desired future state of the clean energy infrastructure for IWT through interviews with representatives of four TEN-T corridors, port authorities, energy suppliers, vessel owners/operators and Waterborne TP and its members. In addition, questionnaires have been distributed among relevant European IWT countries and inland waterway infrastructure managers and written input has been received. The perspective of all these various stakeholders provide good insights into how the future clean energy infrastructure for IWT should and can look like. Together with the information concerning the status-quo in chapter 2, chapter 3 will provide the necessary input for the identification of gaps and challenges in chapter 4.

3.1 Perspective of four TEN-T corridors and Member States in the corridors

3.1.1 TEN-T corridors

Representatives of four TEN-T corridors (Rhine-Alpine (RALP), North Sea-Baltic (NSB), North Sea-Mediterranean (NSM) and Rhine-Danube (RD)) have been interviewed to assess their perspectives as regards the future clean energy infrastructure for IWT[45]. At a general level, the perspectives between the four corridors for the desired future state of the clean energy infrastructure are similar. The European Green Deal objectives form an important aspiration for all four corridors, however, regional differences between the corridors were also spotted.

First, opinions regarding the expected energy mix for IWT, as analysed in the CCNR studies (see Figures 2 and 3), were gathered. The RALP corridor is not disagreeing with the research results, but wants to underline that flexibility is key in a future energy mix. There is no “one size fits all” solution, so the energy mix should be allowed to stay flexible and technology neutral. The NSB corridor agrees and states that they themselves do not have a particular view as regards the future energy mix for IWT, other than the energy transition should happen. The NSM corridor perspective and vision is in line with the work done in the CCNR studies. Clean energy and the necessary infrastructure for this have been a point of attention within the NSM corridor for some time. This is largely due to the Seine-Scheldt project. There is a Commission implementing decision which contains actions that have to be done within a certain timeframe.[46] It states that France and Belgium shall draw up a policy framework to promote the full deployment of clean energy infrastructure along the whole Seine-Scheldt network by December 2022, with a view to gradual implementation by December 2030. This was already agreed upon under the old TEN-T regulation. The RD corridor wants indeed to set steps towards the energy transition, but first wants to start with the electrification of ports to speed-up the uptake of electrical vessels. Biofuels are seen as a transitional fuel here and although hydrogen seems a good solution, it remains uncertain if enough green hydrogen can be produced locally- and if not, imported hydrogen will be less competitive and cannot be applied everywhere.

Second, it was asked which role the TEN-T corridors could play in the transition to clean energy, and complementary instruments that might be needed for this transition. Both RALP and NSB state that there is no legal basis for them to act, but they see a big role for the TEN-T corridors as a facilitator. TEN-T corridors can help Member States with the implementation of the infrastructure. The RALP corridor wants to be a frontrunner regarding the implementation of clean energy for IWT. By working with stakeholders and keeping the topic on the agenda, corridors have the possibility to act as accelerators. The NSB corridor also wants to play a role by having discussion with Member States, cross modes, regions, stakeholders and keeping the topic on the agenda. The cross modes aspect is

[45] Representatives of the RALP and NSB corridors were interviewed during a joint interview.
[46] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D1118&from=EN

especially relevant here since the proposed revised TEN-T regulation gives attention to cross-modes implementation of clean energy. The NSM corridor stated that the Seine-Scheldt project area has its own advanced plans, whereas the Rhône basin is not as advanced with plans regarding the clean energy infrastructure for IWT. The corridor engages in common working groups and missions since there is overlap between corridors, e.g. a relevant IWT port city as Rotterdam is included both in RALP and NSM. The RD corridor sees the corridor role as having to find the right compromise between all the different needs in the corridor and in the alignment of different Member States in order to ensure that a similar approach is used for the whole river basin. This is supposed to speed up the transition. Alignment of the national strategies with EU objectives is quite crucial.

Thirdly, the corridors were asked if they saw a relevant role for other actors such as the EC, Member States or River Commissions. RALP and NSB corridors stated that Member States have the role of implementor, but that they will need to gather more stakeholders and they all will have their role to play. NSM corridor works with all authorities in charge of the relevant fairways, from VNF in France, to the Compagnie Nationale du Rhône (CNR) and Moselle river commission. Especially for the Seine-Scheldt project and also in relation to the alternative fuel infrastructure, there is a strong cooperation with all the relevant national and regional authorities. The RD corridor states that River Commissions should assist to the Member States who didn't start yet implementing the measures towards the transition regarding decarbonization strategies to set it up as quick as possible. Development of appropriate realistic strategies considering the real capacities of each MS is one of the domains where the EC also has one of the most important roles to play to ensure harmonization across the whole corridor. Common rules have to be established, which will eventually bring benefits to everyone (all the EU MS). Without cooperative work between River Commissions together with TEN-T Corridor Coordinators, the corridor approach will not be feasible.

The fourth question asked how the European Green Deal objectives are translated into AFIR and TEN-T regulations and how this will be implemented in the respective corridors. The RALP corridor responded that there are no specific requirements regarding clean energy per corridor (neither in AFIR or TEN-T regulations). However, the Member States will be required to provide national implementation plans and to ensure cross-border cooperation TEN-T makes a lot of cross-references to clean energy. Clean energy infrastructure will be considered along the corridor. More legislative work is needed as the TEN-T regulation does not have exact requirements per specific sector. NSB stated that the Green Deal will be used as a strategy for further legislation. It is translated into the SSMS and from there, it will be translated further into the policy fields such as AFIR and the TEN-T revision. The RD corridor answered that the Green Deal is the driver for future investments. Thus, future investment programmes will have to be aligned with its goals. To achieve this, coordination with River Commissions and Member States is necessary.

The fifth question asks about the implications of the new draft version of the corridor studies and work plans and the corridors' requirements to integrate IWT in the best way possible. The RALP corridor wants to put emphasis on the greening of the corridor and makes an effort to get all stakeholders to implement greening activities, including the deployment of clean energy. 23 alternative fuel projects have already been finished and 20 more are foreseen to be taken up by 2030. RALP further points to the necessity of publicly accessible bunkering points in combination with exchange of battery containers at commercial terminals. This should be handled in national policy frameworks and implementation plans. NSM stresses that clean energy is only one of the aspects for an efficient transport system as described in the 5th version of the work plans. These work plans indicate where the corridor should head towards and in which fields acceleration is needed. From the corridor perspective, the way for implementation is through discussing and implementing with stakeholders, such as in the Seine Scheldt project. The RD corridor points to the necessary integration of IWT with other transport modes to make it easier to roll out clean energy infrastructure (multi-use infrastructure). The integration of the different modes on the RD corridor is, together with energy transition, going to be one of the topics in the work plans.

The sixth question was about how the corridors are looking at the proposed AFIR that states that each Member State shall prepare its own draft for a national policy framework to develop the clean energy market and deploy the relevant infrastructure, and whether this could be a barrier for the corridor approach. The RALP corridor thinks enough safeguards have been put in place (TEN-T requires that the EC adopts clean energy decision per corridor) and sees the TEN-T corridor programs as the instrument in facilitating coordination between Member States. AFIR also states that Member States need to ensure cross-border coordination. The NSB corridor agrees and states that it sees itself as a supporter of the uptake of these plans. The NSM corridor has similar views and states that the coordinator should coordinate the alignment between Member States to safeguard the corridor approach. The RD corridor sees that no single solution fits all, so local tailor-made policies might be necessary, but they still have to be part of a harmonised approach. Coordination between Member States might be hard but is necessary to undertake. To succeed on the corridor approach is possible only under cooperation between all the Member States involved. Setting a scope at the corridor level can help.

The seventh and last question asks which are the most important technical, legal/regulatory and economic challenges and gaps for the realisation of the clean energy infrastructure for IWT in the corridors. Below, the answers of the corridors have been aggregated per challenge.

- Technical challenges:
  Long lifetime of vessels and engines means it takes longer to replace or retrofit the fleet. The choice of technology is deemed the most important, but it is very hard as it has to be based on criteria such as the operational profiles to choose the optimal technology. The coming years will see the need to ensure the (fast) maturity to market of proposed technologies for IWT, along with the available capacities to develop and implement them along the corridors.

- Legal/regulatory challenges:
  A large challenge here is to present a legislative proposal truly delivering the European Green Deal, including feasible milestones for the SSMS. This is currently in negotiation phase, but many cross-references between the two legislative proposals are in place. The expected adoption of the proposed TEN-T revision will be late 2023. Another important challenge is coordination between national and regional authorities to coordinate investments on both sides of the border. A level playing field across regions for bunkering of clean energy should be established. This should prevent the situation in which a certain fuel/energy is provided in one geographical area but not in another and hence vessels can only use the fuel in just that part of the region supplying the particular fuel.

- Economic challenges
  The economic challenge is perhaps the most important of all. Since IWT is a small and highly fragmented sector, it is unable to apply the required changes (by the European Green Deal) by itself. The solutions are not (yet) economically feasible for vessel owners. It is further noted that deployment of technologies in vessels must be coordinated with infrastructure deployments, there should be a match in the requested and offered fuels. Apart from this, the low energy density of clean energy will demand a higher number of bunkering points, but it is uncertain whether it will be feasible to invest in many bunkering points. Moreover, IWT is not always a priority for all of the stakeholders involved in the broader clean energy

infrastructure. To overcome this, clear plans and goals to invest in IWT greening have to be set up.
Furthermore, timing of investments is also important. Investments should be coordinated in time, so that certain regions don't leap behind in the alternative fuel infrastructure deployment and also to prevent a chicken-egg situation in which vessel owners don't invest because there is no infrastructure in place across the regions in which they operate.

To summarise, the TEN-T corridors interviewed see themselves as coordinators and accelerators of the energy transition and the deployment of clean energy in IWT. However, they are dependent on other stakeholders such as River Commissions and Member States. Especially Member States are important since they have to draw their own national plans for deployment of clean energy. These plans however, should be aligned per corridor so the corridors have a role to play here. Most corridors interviewed worked on the implementation of clean energy infrastructure by bringing stakeholders together and coordinating actions. There are also a lot of relevant projects going on or expected to be started before 2030 in which the corridors will continue to play a facilitating and coordinating role.

3.1.2 European IWT countries

The perspectives of relevant European IWT countries have been captured through a questionnaire[47]. The objective of the questionnaire was to gain insights into the perspective of States and identify the desired end-result for the clean energy infrastructure along the TEN-T inland waterways and ports. Gaining insights into the perspective of these countries is relevant since the proposed AFIR states that Member States shall prepare national policy frameworks concerning clean energy in the transport sector (including IWT) and the deployment of the relevant infrastructure.

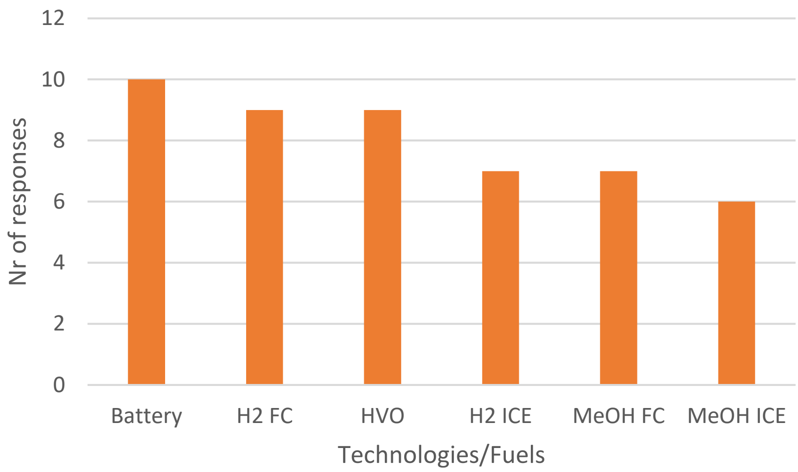
For the purpose of this study and in coordination with DG MOVE, the scope of the questionnaire was limited to the Member States (including Switzerland) actively involved in the NAIADES implementation group. This list was later on enlarged to Hungary, Serbia and Bulgaria. Representatives[48] of these countries were approached by the CCNR and the Danube Commission to fill in the questionnaire. 13 filled questionnaires were received from representatives of Serbia, Bulgaria, Hungary, Poland, Austria, Switzerland, Belgium, Luxembourg, Netherlands, Italy, France and Germany.

The CCNR study results on energy transition were taken as a basis and the respondents were asked whether they share the results and the analysed transition pathways towards zero-emission IWT. Nine of the 13 respondents share the study results for their region/country.[49] From the two transition pathway scenarios, the conservative pathway is being seen as more realistic by the majority of respondents, however, it is being indicated that the innovative pathway should be pursued.[50] One of the respondents rightly observed that eventually the reality can lie somewhere in the middle of both transition pathways. This would mean a more balanced mix between innovative technologies such as H2 FC, MeOH FC, batteries and (drop-in) bio/e fuels in combination with clean ICE's.

[47] The questionnaire can be found in Annex 6
[48] Most of the persons surveyed work for their respective ministries, but the list also includes a few who work for the infrastructure manager and port authority, such as Belgium (De Vlaamse Waterweg and Port of Brussels replied) and France (VNF replied).
[49] Representatives from Serbia, Bulgaria and Hungary do not share the study results for their region/country. A possible explanation is that the study results have given the impression that they mainly apply to IWT in the Rhine area.
[50] 8 respondents assess the conservative pathway as more realistic, though 3 respondents (AT, DVW, IT) emphasize that the innovative pathway should be pursued. The remaining 4 (BG, CH, VNF/FR, DE) indicated the innovative pathway not elaborating upon realism though

Amongst the listed technological solutions, most respondents believe that batteries (battery-electric propulsion) will be the most prospective to produce market solutions by 2030, followed by H2 FC, HVO (and similar bio/e- diesel), H2 ICE, MeOH FC and MeOH ICE. Figure 4 provides an overview.

Figure 4: Most prospective solutions to produce market solutions by 2030



For the required future clean energy infrastructure, it is necessary to have an understanding of how energy demand will develop. However, 8 of the respondents indicated that they have no view on how the energy demand for IWT will develop in their country. 5 of the respondents indicated that they do have a view on this expected future development.[51]

There is no view though on how fast the current energy mix will change to more sustainable alternatives. Uncertainties are raised as the main reason for this, for example the uncertainty in developments in the energy market and regulatory framework.

These uncertainties also contribute to the uncertainty about whether there will be sufficient clean energy supply to IWT. Eight of the respondents do not expect sufficient supply of clean energy in their region which is required to enable the sector to achieve the GHG target of 55% reduction by 2030. Three respondents have no view on this topic whereas 2 of them expect sufficient supply in their region.[52]

Regarding drop-in biofuels like biodiesel (FAME/HVO) and LBM it was asked whether the use of these fuels is actively being promoted or prescribed in their country as a possible blend (e.g. to comply with Fuel Quality Directive). Seven of the respondents indicated that drop-in biofuels are not being promoted and/or prescribed in their region, whereas 6 respondents[53] stated that these fuels are promoted and/or prescribed, applying mostly to HVO (5 replies), LBM (3) and FAME (1). Examples are e.g. the Austrian Mobility Masterplan 2030 in which the use of synthetic fuels in IWT is foreseen. Furthermore, biofuels are also already being blended with fossil fuels which may also be delivered to IWT. Moreover, even if biofuels are not actively promoted, one respondent notices that they will be unavoidable for some very energy demanding vessels, e.g. large pusher boats.

---

[51] Respondents from Austria, Switzerland, Germany, Italy and France indicated that they do have a view on how the energy demand for IWT will develop in their country. The others responded negative.
[52] Respondents from Italy and France expect to have sufficient supply of clean energy in their region. Respondents from Austria, Luxembourg and the Netherlands are not sure/in between, whereas the others are negative.
[53] Respondents from Poland, Austria, Switzerland, Belgium , Netherlands and France stated that these fuels are promoted and/or prescribed.

The questionnaire results so far have shown that the countries expect a forthcoming development towards clean energy in the IWT and also have a more or less clear view on the techniques and fuels. This requires a future energy infrastructure, so that the vessels can be supplied with clean energy. Asked whether there is already a clean energy infrastructure deployment plan for waterways and ports in their country, 7 of the respondents indicated that there is no such plan yet, whereas 5 respondents answered in a positive way.[54] In at least one case the absence of a deployment plan at the national level is due to decentralisation and the fact that federal states and local authorities still hold administrative and legislative powers over ports. Nine respondents expect that feasibility studies will be conducted though, whereas 4 do not expect any future feasibility study including Italy and Hungary probably while it was stated that there is already a deployment plan. This shows that significant work will be done yet on feasibility studies for the deployment of clean energy infrastructure for waterways and ports in the surveyed countries.

Realising this infrastructure involves significant investments, 10 of the respondents stated that both public and private funds will be involved. Respondents from Hungary, Italy and France highlight the importance of public funding and state aid programs. A mentioned example in the case of France are the reserved financial resources in the scope of the National Recovery Plan which includes € 205mln in 2021 for hydrogen development. None of the respondents think that the required infrastructure will be realised through private financing only.

Respondents from Switzerland, Belgium, Netherlands, Italy and France raised that there are already (funding) instruments available to stimulate the development of clean energy infrastructure for IWT. Again respondents from France and Belgium indicated that there are also already plans for future stimulation instruments. There is one under development in Austria. Respondents from the other countries indicated that there are no stimulation instruments at the moment and neither are there plans for the future or they are not sure about future developments.

A relevant ongoing development in the context of the clean energy infrastructure for IWT is the proposed AFIR, which states that countries shall develop draft national policy frameworks for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure. Since AFIR was still under negotiation during the surveying process, only three respondents (from Austria, Italy and France) indicated that there are already concrete ideas on how the IWT sector will be included in the development of these national policy frameworks and the corresponding deployment plans for alternative fuels. Batteries, HVO, LBM and H2 FC were indicated as those fuels/techniques for which the corresponding required infrastructure is being considered.

Since IWT is a cross-border transport activity, and especially for the transport on the Rhine and Danube, it is important to coordinate the development of clean energy infrastructure between the various countries. Asked whether there is a plan to align their national strategy for the clean energy infrastructure with the national strategies of other Members States, 7 respondents indicated that this will be the case whereas respondents from Bulgaria, Hungary, Poland, Germany and Italy indicated that there are no such plans (yet). In the case of Italy and Poland, the reason might be that these countries operate mainly national waterways under their exclusive jurisdiction with limited cross-border linkages.

For the foreseen alignment, respondents indicated that the exchange of information will be organized through their participation in river commissions, CESNI and international partnerships and

[54] Hungary, Austria, Netherlands, Italy and France have one or several strategies to deploy alternative fuel infrastructure.

projects.

The new TEN-T corridor studies and work plans can play a supporting role in the deployment of the infrastructure. With regard to the fulfilment of this role, there is an even split between the options "Collecting information and monitoring role" and "Collecting information and monitoring role & Coordinating role". Respondents from Serbia, Bulgaria, Belgium (De Vlaamse Waterweg only), Luxembourg and Italy raised “coordination” as an additional role they would like to see. Respondents from the Netherlands and Germany only opted for the role of “collecting information”, whereas the respondent from Austria mentioned the “implementation and roll out with CEF means”.

For the realisation of the infrastructure facilities and energy production, 9 of the respondents foresee synergies with other modes of transport and the energy sector. Mentioned specific potential synergies are as follows:

- H2 applications for trucks and railway locomotives and inland vessels.
- Standardised safety, batteries, plugs and charging stations. Also billing systems for energy purchases.
- Cooperation with other transport modes and hydrogen industries in the area of Port of Antwerp.
- The possibility to set up a hydrogen production plant which could also power vessels as well as trucks used for the first and last miles.
- Production of HVO and BTL as well as hydrogen which may benefit deindustrialised areas around the inland waterway network. Most of the alternative fuels may also be used for road and/or rail transport. Therefore, the production facilities should be integrated along the multimodal network. On the other hand, the development of usages of alternative fuels and electricity may reduce their availability and enhance the competition between modes of transport but also with other industries.

Possible synergies are aimed to be stimulated through i.a.:

- Development of multisectoral strategy for transport system transition to use of alternative fuels.
- Carrying out studies which also address possible synergies.
- Participation in relevant fora that can stimulate possible synergies.
- Through cooperation in specific working groups on hydrogen and pilot projects (e.g. methanol in the port area of Ghent).
- Foreseen pilot projects in the national hydrogen strategy (of Luxembourg).
- Integration of energy sector in terms of peak shaving with modular batteries, combination with onshore power, integration with petrochemical industry for the production of fuels (Tweede Maasvlakte)

4 respondents from Bulgaria, Hungary, Poland and Germany don’t foresee synergies.

The path towards realising the required clean energy infrastructure will have some bottlenecks which need to be overcome. Some of the respondents identified some specific bottlenecks which need to be taken into account:

- The availability of alternative fuels is already a current bottleneck, as well as high price levels compared to conventional fuels.
- Not all vessel propulsion and infrastructure technologies are yet mature and available, and investors want to wait and see so as not to invest money in the wrong propulsion systems or infrastructure.

- Local environmental permits and lacking international standards.
- Local production of hydrogen is limited so imports are necessary for a distribution at national/regional level.
- Realising the energy infrastructure for all forms of clean energy (e.g. supply of green hydrogen and methanol, fast chargers, terminals for swapping containerised energy, etc.) in all ports will be too difficult to realise.
- The excessive fragmentation of competences between central administration and local administrations.
- Insufficient funding instruments for alternative fuels infrastructure.
- Lack of comprehensive and updated strategy/roadmap for IWT with diagnosis of bottlenecks and specific needs for sector.
- Lack of efficient and effective transfer of knowledge between RD&I and businesses (e.g. vessel owners) resulting lack of knowledge among vessel owners concerning suitable technologies and forms of alternative clean energy for their vessel(s) and operational profile(s).

3.2 Perspective of ports, energy suppliers and potential for cross sectoral synergies

3.2.1 Inland and seaports

To stress the importance of inland and seaports for the sustainable development of the IWT network and for economic prosperity with regards to regional development as well as to energy transition, it is important to define the role of ports and the wider port area as logistic hubs and centers of production, utilization and transportation of clean energy. These targets are essential for the successful implementation of the EU Green Deal, SSMS and NAIADES III.

It is clear that certain port development has to take place already in the coming years in order to meet future investment requirements and to be well equipped to fit future industrial logistics as port development strategies are often linked to it. It is clear that from the perspective of clean energy investments, each port needs to be interconnected with other ports of the region but also with its hinterland, that's why alignment of infrastructure development plans between different Member States is important.

Ports and their adjacent areas are not only logistics hubs, but also centers of industrial development, that is why their further development in the light of energy transition and greening is essential. Ports have to accommodate industries adjoining ports. Industrial professional organizations, port operators and waterway administrations, port authorities must be involved in this cooperation. This will contribute to the common goal of fully functional and multi-modal TEN-T corridors by 2030.

In Europe, there are 226 ports on inland waterways, of which 37 are both inland and seaports. There are 198 terminals on the Danube for 75 port locations. Along the Rhine there are around 97 container terminals and in addition a multitude of dry and wet bulk terminals.[55] Ports along the Rhine and Danube have the potential to act as engines of growth in their host cities and regions, being multimodal hubs with varying levels of intermodal facilities, serving as an interface between various transport modes. Of particular importance for Danube and Rhine transport are the numerous

[55] 20 container terminals in Belgium, 3 in France, 41 in Germany, 7 in Switzerland and 29 in the Netherlands https://theses.ubn.ru.nl/bitstream/handle/123456789/3856/Wursten%2C_Robert_1.pdf?sequence=1 (p.23)

industrial sites that are located along the Danube and Rhine Corridors. Ports offer sustainable solutions for attracting key industrial players by providing dedicated facilities for manufacturing, processing and handling of logistics operations, acting as convenient regional business platforms for trade and industry.

SSMS identifies a great potential for inland ports, that will also have to contribute to the achievement of the zero-emission goal, while also paying more attention to sustainable development. NAIADES III emphasizes the requirement of the implementation of an environmental policy, as well as an environmental monitoring program and specific actions to green investments in infrastructure, transport and industrial port operations. Thus, it can be assumed that aforementioned includes the use or even production of green energy in ports. Among other measures, ports should encourage the use of renewable and low-carbon fuels and the supply of renewable energy for vessels at rest. Hence, the proposed AFIR sets the objective of at least one OPS per inland port. The Green Deal for Europe calls for a substantial proportion of the 75% of all inland goods transported by road today to be transferred to rail and inland waterways. Inland waterways transport is set to increase by 25% by 2030 and by 50% by 2050, and this can only be achieved with massive investment in green and efficient port infrastructure and technology, with a favorable regulatory framework. An important part of such a supportive regulatory framework will be adequate pricing of CO_2 emissions in the future. In this sense, the European Commission will propose its Carbon Border Adjustment Mechanism, which will be applied from 2023, to put EU companies on an equal footing with competitors in countries with less ambitious climate policies.

Data provided by the EU Member States on the estimation of maritime and inland vessels and infrastructure developments show these were very sparse. Furthermore, they do not allow for a coherent assessment of the current and planned development of bunkering, e.g., in LNG, and shore-side electricity supply. According to the 4th Work Plan for the Rhine-Danube Corridor completed in May 2020, only the port of Ruse (Bulgaria) currently has LNG bunkering infrastructure (since 2016) for both vessels and trucks. In addition, the port of Enns (Austria) has LNG fuel supply facilities since 2018, but currently only for trucks (can be allocated for vessels too once demand will occur). On the Rhine there is an LNG bunkering station for inland vessels in Cologne[56] and truck-to-ship is the predominantly used way to bunker LNG. Inland ports are often located close to densely populated urban areas and often have to balance the development and management of port activities with the preservation of natural habitats and the quality of urban life.

Regarding the environmental performance of the Danube ports in the field of emission reduction and other environmental aspects, the Danube Commission proposed to its Member States to continue the implementation of a set of environmental key performance indicators (EKPI)[57] for the Danube ports and the environmental improvement measures initiated by the DTP DAPhNE[58] project. The measures will also include the promotion of Port Environmental Management Plans (PEMP) and Green Port Policies and Procedures, including the issues of green energy production, energy monitoring system and energy efficiency in the port sector, as well as the promotion of the establishment of the Environmental Management System (EMS) in inland ports based on the ISO 14001 standard. It could be the basis for a newly created “Environmental Danube Ports Award” or for

[56] https://lngbinnenvaart.eu/first-permanent-lng-bunker-station-in-germany/

[57] The defined 14 priority EKPIs are in line with the ESPO Environmental Report and the Top 10 Environmental Priorities for European Ports. Port administrations could carry out the first review related to EKPIs in 2022 in line with the pilot activities elaborated in the Interreg/DTP DAPhNE (WP4-Green Port Policy Guidelines)[1].

[58] www.interreg-danube.eu/daphne

a “Corporate Social Responsibility Danube Ports Award” after the year 2023.

Renewable electricity is expected to decarbonise a large part of the EU’s energy consumption by 2050. Hydrogen is considered to become a key priority to achieve the European Green Deal and Europe's clean energy transition. The Hydrogen Strategy for a climate-neutral Europe was published on the 8th of July 2020.[59] In relation to this, the German government adopted the National Hydrogen Strategy on the 10th of June 2021, several other countries will do the same. Priority is given to the development of renewable hydrogen, mainly produced with wind and solar energy. The cost of renewable hydrogen could fall gradually in the future.[60] The cost of electrolyser facilities has already been reduced by 60% in the last decade and is expected to halve by 2030 compared to today due to economies of scale. Green Hydrogen is widely expected to be cost competitive by 2030.

The European Hydrogen strategy sets out the goal for the first phase (2020-2024) for the installation of at least 6 GW of renewable hydrogen electrolyser facilities in the EU and producing up to 1 million tons of renewable hydrogen. In a second phase, from 2025 to 2030, hydrogen shall become an integral part of an integrated energy system, with the strategic goal of installing at least 40 GW of renewable hydrogen electrolyser facilities and producing up to 10 million tons of renewable hydrogen in the EU by 2030. In a third phase, from 2030 and up to 2050, renewable hydrogen technologies should be mature and deployed at scale to reach all hard-to-decarbonise sectors where other alternatives may not be feasible or have higher costs.

As indicated in European Hydrogen strategy, in terms of the investment agenda from now until 2030, investments in electrolyser facilities will range between €24 and €42 billion euros. In addition, €220-340 billion would be needed over the same period to expand 80-120 GW of solar and wind energy production capacity and connect it directly to electrolyser facilities to supply the electricity needed. Investment to retrofit half of the existing hydrogen production plants with carbon capture and storage is estimated at around €11 billion. In addition, investments of €65 billion will be needed for hydrogen transport, distribution and storage, as well as hydrogen refuelling stations. From today to 2050, investment in production capacity in the EU would amount to €180-470 billion.

To support this investment and the emergence of an entire hydrogen ecosystem, the "European Clean Hydrogen Alliance" has been established. The Alliance will play a crucial role in facilitating and implementing the actions of the Hydrogen Strategy and supporting investments to increase production and demand for renewable and low-carbon hydrogen. Policy instruments created by the Strategic Forum for Major Projects of Common European Interest (IPCEI) will be very useful to promote well-coordinated or joint investments and actions in several countries aimed at supporting a hydrogen supply chain. Two important lead markets will be the industrial and transport sectors, which can be progressively tapped to exploit the potential of hydrogen for a carbon-neutral economy in a cost-effective way.

In addition to the European Clean Hydrogen Alliance, other alliances have been established as well, to support techniques and alternative forms of energy that fit into the pathway towards a zero-emission EU economy. Examples are the European Battery Alliance[61] and the Renewable and Low-

[59] https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf
[60] The estimated cost of fossil hydrogen in the EU is around 1.5 €/kg. The estimated cost of fossil hydrogen with carbon capture and storage is around 2€/kg, and that of renewable hydrogen 2.5-5.5€/kg. Carbon prices in the range of 55-90€ per tonne of CO_2 would be required to make fossil-based hydrogen with carbon capture competitive with fossil-based hydrogen today; (the average EU carbon price reached 50€ per tonne in early May 2021).
[61] https://www.eba250.com/about-eba250/

Carbon Fuels Value Chain Industrial Alliance (RLCF Alliance)[62], where the latter alliance is focusing relatively more on the application side within the aviation and waterborne transport sectors. The ultimate objective of the RLCF Alliance is to ensure that aviation and waterborne transport have sufficient access to renewable and low carbon fuels, while taking into account the future use of these fuels in road transport. Achieving this target would resolve one of the major uncertainties regarding alternative liquid fuels, which is the availability of alternative fuels such as HVO, e-diesel, etc.

Despite that there are not too many projects in European ports which can demonstrate active uptake of the innovations with regards to alternative fuels production and serving as green hubs, certain successful examples of initiatives are provided in Annex 5 of this report. The listed initiatives in Annex 5 show that ports are moving ahead with their plans that fit into the energy transition. There is especially much going on in the field of hydrogen, ports work on strategies that combine the import/export, production and use of green hydrogen in the port area itself to eliminate emissions from e.g. industrial operations (energy production, steel production, etc.), cargo handling operations, vessels, etc.

In the Danube region ports have significant untapped potential to become hubs for clean energy production and distribution as well. Furthermore, the Danube is also well suited for the production of green hydrogen and transportation in the form of LOHC to Austria and Germany by means of inland vessels. To turn Danube ports into green energy hubs will require, from the port perspective, conduction of a solid assessment of the existing assets from the perspective of infrastructure, transport potential, availability of the local energy producers, storage and capacities, estimation of energy demands in the region, on-going and planned projects on the transport corridors in the Danube region, hinterland connections, alternative fuel infrastructure development projects in ports, as well as projects related to the development of multimodal transhipment facilities.

The EU H2020 projects PIONEERS and MAGPIE are key in this respect. Both projects are active in the field of port development linked to innovations and energy transition and work with a lighthouse and fellow ports concept which enables the transfer of results to any other inland and/or maritime port. Strong attention is given to scale up solutions beyond the project lifetime. The projects aim to accelerate the introduction of green energy carriers such as batteries, hydrogen, ammonia, BioLNG and methanol. MAGPIE for example aims to:

- identify gaps and developments needed throughout the electrical supply chain to ensure that present and future demand for clean renewable electricity is met.
- analyse and set up a green hydrogen supply chain for port and hinterland transport demand.
- create a green ammonia supply chain in the Port of Rotterdam, from source to “plug on” seagoing vessels.
- analyse the needs and effort to produce LBM through liquification with the focus on the two main gaps in the supply chain: production and dedicated bunkering.

Similar objectives are included in the PIONEERS project. The successful demonstration of the applicability and feasibility of solutions should serve as a lighthouse for EU ports. The developed know-how and roadmaps resulting from these projects should be carefully elaborated upon by other ports and their relevant stakeholders, and used to shape the energy transition and realisation of the clean energy infrastructure in their own respective port areas.

[62] https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/alternative-fuels-sustainable-mobility-europe/renewable-and-low-carbon-fuels-value-chain-industrial-alliance_en#:~:text=The%20Renewable%20and%20Low%2DCarbon,Maritime%20and%20RefuelEU%20Aviation%20initiatives.

It is important to stress that ports in different regions have different organizational, financial and governance conditions, this appears for example when ports in the Danube region are being compared with ports along the Rhine. Although the climate goals are the same, the pathways to reach them are different and depend on many factors such as port traffic, hinterland connections, industrial and energy sectors in the port area, stakeholder commitment and engagement, etc. Port authorities/administrations can decide on the greening of their own activities and jurisdiction, but have limited possibilities to influence green behavior of port users (terminal operators, transport companies, etc.). That's why a component of cooperation between stakeholders and development of mutual initiatives across the corridor for future support by EU-funding to create projects of common interests is crucial to achieve energy transition targets and contribute to economic development of the region through industrial production of clean energy.

In addition to desk research, five interviews were conducted by Pro Danube with five port representatives[63] to gain insight into the perspective of the selected ports on deploying clean energy infrastructure, identify their desired wants and needs for clean energy infrastructure as well as identify their perceived technical, economic and legal/regulatory challenges and gaps. All interviewees confirm IWT will move towards using clean energy. However, it seems that not all interviewees have an equally clear view on the expected developments in IWT in the regions where their ports are located. Based on the interview results, it also seems that large combined sea and inland ports in Northwest Europe expect more and faster developments in the energy mix for IWT than, for example, inland ports in the Danube region.

A large port such as the Port of Antwerp-Bruges sees several roles for itself in the development of the clean energy infrastructure. This concerns the role as regulator, landlord, community builder and operator/facilitator:

- As regulator, the port authority needs to provide a clear and transparent framework for bunkering of alternative fuels, including a licensing system for bunkering alternative fuels and as well having bunkering procedures.
- As landlord, the port authority provides information where various fuels can be bunkered and ensures that there is sufficient physical space available for bunkering. The port authority also works on an incentive policy to stimulate the deployment of these alternative fuels.
- As community builder, the port authority collaborates with other ports in international working groups, (research) projects and takes steps to broaden the basis of local support for the deployment of the clean energy infrastructure.
- As operator and facilitator, the port authority takes the lead in setting a good example and kick-starting the market by converting their tugs to run on alternative fuels such as methanol and by opting for all-electric water buses. The use of clean energy is also included as a criterion in tenders issued by the port authority for service providers in the port.

With regard to the first point, it would be preferably from the perspective of vessel operators if bunkering/charging procedures for clean energy will be harmonised across EU ports, and enable effective and efficient bunkering and charging. With regard to the second point, it may help IWT companies if an up-to-date online map is developed, maintained and communicated about at EU level showing all clean energy bunkering and charging possibilities. In general, however, the four roles outlined above provide insight into what a port (authority) can do for the development of the clean energy infrastructure which the IWT sector can make use of.

[63] Interviews were conducted with representatives of the Port of Antwerp-Bruges, Port of Vienna, Hungarian Federation of Danube Ports, Public Ports of Slovakia and Port of Constanta.

Three key challenges were raised during the interview. **From a regulatory perspective**, regulations should not stand in the way of innovation. **From an economic perspective**, supply and demand should develop at the same pace with each other in order to justify investment. In operational terms this means it is important to have at least a minimum service on the supply side (bunkering companies) before demand side (vessel operators) can develop. This is an important point as the same chicken-and-egg problem occurred with LNG in IWT. An initial limited development on the supply side is necessary to get the demand side on board. **A third point raised** indicates that it would be wrong to assume that terminal operators and other players in the port area will welcome bunkering operations in their own backyard without any objection. This must be carefully thought out and handled.

Interviewees from the public ports of Slovakia and the Hungarian Federation of Danube Ports stress that currently there is still a strong preference for conventional diesel and in the best-case scenario ICEs with after treatment and that no change in this preference has been noticed yet. Lack of demand for clean energy from vessel operators support arguments against investments in clean clean energy infrastructure on the short term.

The navigability of the Danube is another additional challenge, which complicates the planned increase in modal split for IWT. The reliability of the navigability and strong transnational commitment from all public and private parties involved are seen as important for the realisation of the clean energy infrastructure. Unfortunately, inadequate fairway maintenance works over several years, climate change and low precipitation levels resulted in a serious degradation of the fairway depth and thus the available draft. Safe and cost-effective navigation is put at great risk and significant financial damage is suffered by barging companies, the ports and by the industry sectors and touristic businesses that depend on Danube transport as a reliable and efficient logistics backbone of the Danube Region. Therefore, achieving a Good Navigation Status (GNS) at corridor level in order to ideally enable a draft of 2.5 m and passing of convoy sizes according to the UN/ECE waterway definition represents one ambitious short-term goal which is meant to further facilitate and support modal shift to the more eco-friendly mode of transport that is IWT. The reliability of the navigability and strong commitment from all public and private parties involved are seen as important for the realisation of the clean energy infrastructure.

The Port of Constanta aims to increase the share of clean energy on a large scale, but rather on the medium term. Port authorities have the responsibility of providing the required port utilities in this respect, however, it is stressed that efforts must be made by both public and private actors. Administrations should provide utilities and operators should upgrade the propulsion of vessels and use fuels and energy with a low or zero carbon footprint. As regards the challenges, mainly economic and legal/regulatory challenges are raised. Fundraising mechanisms are required and available, but rather time consuming. Furthermore, public port authorities must consider national strategies which are at the moment either not established or correlated with each other. Furthermore, public tender procedures are also time consuming.

The interview with Port of Vienna confirms the legal/regulatory bottleneck and indicates that a new and faster way must be developed to overcome legal and regulatory issues and shorten time for approvals and procedures. Furthermore, the interview also confirms the analysis to the ongoing projects and initiatives in Annex 4. Logistics and energy production are getting closer and closer in the port sector and ports will play an important role in both energy production and distribution of clean energy.

Ports are currently serving as a hub for the import and export of goods (including energy), storage, production and consumption, both by themselves and in the port-industrial cluster, including the supply to the logistics sector. Considering this, especially in light of current EU policies towards decarbonization and emissions reduction, it can be assumed that in the nearest future creation of energy hubs in and around ports will be not just an innovation, but a measure to satisfy needs of all the port stakeholders (and far beyond) for energy. The whole EU economy needs to move towards zero emission, and ports and port clusters are ideally suited to be one of the first areas to move forward and can be seen as a location for cross-sectoral synergies in this regard.

3.2.2 Energy suppliers

The perspective of the energy supply side as regards the future clean energy infrastructure along waterways and ports has been mapped through interviews and presentations given during the 1st Platina Stage event by stakeholders engaged in the field of conventional and clean energy solutions for IWT.[64] In addition, desk research has been performed to existing literature.

As of today the energy supply market in IWT consists mainly of commercial parties supplying fossil fuels to vessel owners/operators through their bunkering stations and small bunkering boats. The existing bunkering infrastructure is almost completely focusing on the supply of fossil diesel and alternative fuels that can make use of existing infrastructure such as biodiesel and GTL. The operators of this existing infrastructure indicate that other alternative fuels do not fit into the existing infrastructure. For example, an existing bunker station and bunker boat cannot simply start supplying alternative fuels such as green H2, methanol or electricity. This is not possible from a technical and legal/safety point of view. An existing bunkering station supplying diesel would require significant technical interventions to facilitate the storage and delivery of this type of energy (e.g. new storage facilities, piping, etc.) if possible at all, and this would also require permits from local authorities (e.g. in relation to environmental policy).

There are also concerns regarding the ease of storage and transfer of this clean energy. The bunkering sector has decades of experience in supplying diesel and the entire infrastructure and regulations are geared towards it. The storage of diesel is not complex from a technical viewpoint and bunker deliveries to vessels are quite pragmatic and fast.

These challenges and difficulties were also encountered with the supply of LNG to IWT, which was being considered as a transition fuel to more clean energy. Experiences have been gained by for example Titan LNG and PitPoint LNG that both supply LNG to the waterborne transport sector. During the 1st Stage Event Titan LNG indicated a number of lessons learned through the perspective of the energy supplier:

- Truck-to-ship deliveries are most common
- Difficult for part loads
- Not enough demand to further invest
- Business case should work
- LBM is available but expensive

This shows that truck-to-ship deliveries are the most common way for LNG bunkering for vessels. The reason for this is the limited market size given the lacking business case for LNG from the viewpoint of vessel owners, which prevents further investments into the LNG bunkering infrastructure. However, arranging a truck load and waiting for it costs a barge operator time and rerouting, as the operation has to be planned in advance and truck-to-ship deliveries are only allowed at specific quays.

[64] Presentations during the 1st Stage Event given by the stakeholders Titan LNG, Province South-Holland in relation to the R2HINE initiative, and interviews conducted with ZES and ReinplusFiwado.

Regulations were and are still experienced as a bottleneck for development and operation of the LNG fuel infrastructure. In the CEF funded LNG Breakthrough project the construction process of an LNG bunkering station in Cologne experienced a complex and lengthy permitting procedure set by local authorities. Furthermore, LNG energy suppliers and also the customers experienced inconsistency in regulations, i.e. related to initial support for the roll-out of LNG which subsequently fell away and which translated, for example, into a decrease in the number of bunkering spots where LNG bunkering is possible by truck, due to revoked permits. These are all lessons learned to be taken into account for the development of the energy infrastructure for energy sources like green H2 and green electricity for batteries.

There are two important developments related to these two energy sources, these are the investments currently being made by the ZES company and the R2HINE initiative in the Netherlands and Germany.

Battery-electric propulsion is one of the promising zero-emission solutions for IWT. However, the CAPEX and OPEX are significant from a vessel owners point of view. In order to partly overcome this barrier, ZES developed a pay-per-use model for the use of modular containerised battery systems. The use of modular container solutions rather than fixed batteries on board make it economically more viable and practical in use. Given the lower energy density of battery containers as compared to conventional diesel, a shift in the logistical process is required though, since batteries should be exchanged relatively more often as compared to bunkering diesel. This will be harder but should still be plannable in the logistical process. The development of the required energy infrastructure is an important condition for the development of the battery containers on board of vessels. The slow (bureaucratic) processes in realising publicly accessible charging infrastructure currently appears to be a bottleneck. ZES foresees currently 15 public loading locations at existing private container terminals, consisting of two types of loading stations, destination loading stations and visit-for-loading only stations on strategic points.

The R2HINE consortium includes key parties[65] for the future H2 infrastructure. A CEF funded kickstart study has been conducted.[66] The study results showed that, certainly in the short term, swappable tube-containers with pressurized hydrogen exchanged at container terminals is the way forward as regards the energy infrastructure for IWT. There are clear advantages compared to bunkering to fixed tanks on board due to a.o. shorter bunkering times, cheaper in long run as compared to fixed tanks and the fact that swappable systems allow for modularity and flexibility. The study results indicate that bunkering liquid H2 through truck-to-ship or station-to-ship is a potential solution in the mid-term (5-10 years), whereas bunkering hydrogen carriers is a long-term scenario (10-20 years). However, rules and regulations are currently not in place for bunkering liquid hydrogen and first requires legislation to be developed. Possible locations have been identified for bunkering H2, these are in the ports of Rotterdam, Duisburg and Neuss/Düsseldorf/Köln.

3.3 Perspective of inland waterway infrastructure managers

Waterway management comprises a comprehensive set of different activities carried out by the respective governmental bodies, or authorized agencies and companies. The extent of those

[65] E.g. Nouryon, Air Liquide, Air Products and Shell
[66] https://www.rh2ine.eu/rh2ine-kickstart-study/

activities is different from country to country and organisation concerned. In general, some or even all of the following tasks are conducted to a lesser or greater extent[67, 68]:

- Operation, maintenance, extension and new construction of waterways, including hydraulic structures;
- Operation and maintenance of locks, weirs, bridges, elevators and tow paths;
- Operation of River Information Services (RIS) and traffic management;
- Marking of waterways;
- Hydrography and monitoring of river condition;
- Flood protection;
- Implementation of measures for improved ecology of and in the vicinity of waterways;
- Planning and implementation of public ports and public berths;
- Management of land and assets close to the waterway;
- Development and promotion of inland waterway transport.

In some cases, e.g. Rijkswaterstaat[69], the executive agency of the Ministry of Infrastructure and Water Management in the Netherlands, the scope of activities is even much wider, ranging from waterway management to road-network management including traffic management and modelling. The role and competences of a waterway-infrastructure manager are different in each European country, depending also on its legal status as an authority, administration, executive agency or company. E.g. in France and Germany, the waterway-infrastructure manager has relatively strong competencies. In Slovakia strong privatization has taken place, and the role of the waterway manager is smaller. In Serbia no private property is available. Sites are usually rented for e.g. 99 years and then returned to the state.

Waterway management is of international importance as the waterways in Europe pass through several different countries, having an impact on the inland waterway transport there. International organisations like the Central Commission for Navigation of the Rhine, the Danube Commission, the Inland Navigation Committee of the EU and the UNECE, are bodies which coordinate the achievement of harmonised approaches with relevance to inland waterways and inland waterway transport. In addition, sector organisations play a key role. With respect to inland waterway management on European level, Inland Navigation Europe (INE)[70] is to be mentioned. In the year 2000, INE started as a small group of Austrian, Belgian, Dutch and French organisations, establishing a European platform of waterway authorities and organisations promoting more transport by water. Today, INE counts 19 members and corresponding members in 15 countries across Europe with a common goal to ensure waterways take up their initial trading and mobility role for the many cities and regions they cross.

Table 3: Members of INE and their corporate status[71]

Waterway management organisation	Status
Service Public de Wallonie (SPW)	ministry
De Vlaamse Waterweg	public company
Ministry Public Works & Mobility Flanders	ministry

[67] https://www.gdws.wsv.bund.de/DE/gdws/01_ueber-uns/aufgaben/aufgaben-node.html;jsessionid=55F27281B1D39B1306B80D4BAF42432C.live21321
[68] https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2004_I_177/BGBLA_2004_I_177.pdfsig
[69] https://www.rijkswaterstaat.nl/en
[70] https://www.inlandnavigation.eu/
[71] For completeness, the corresponding members of INE are the Haven Brussel – Port Bruxelles (Belgium), Kammerunion Elbe/Oder (Germany) and RSOE - Rádiós Segélyhívó és Infokommunikációs Országos Egyesület (Hungary).

Directorate of Waterways of the Czech Republic (RVCCR)	public agency
Voies navigables de France (VNF)	public agency
Agenzia Interregionale per il fiume Po (AIPo)	public agency
Ministère de la Mobilité et des Travaux Publics (Luxembourg)	ministry
Koninklijke Binnenvaart Nederland	association of barge owners
Ministry of Infrastructure Poland	ministry
Administração dos Portos do Douro, Leixões e Viana do Castelo (APDL)	port and waterway authority
Administration of the Navigable Canals (ACN)	public company
Administratia Fluviala a Dunarii de Jos (AFDJ)	public agency
Directorate for Inland Waterways (Plovput)	public body of the ministry
Trafikverket Swedish Transport Administration	transport authority
Ministry of Transport and Construction Slovakia	ministry
Via donau – Österreichische Wasserstraßen-Gesellschaft	public company

Source: https://www.inlandnavigation.eu/about-ine/membership/
Source: https://www.inlandnavigation.eu/about-ine/membership/

Relating to the implementation of an infrastructure for alternative fuels, EFIP, INE and the IWT sector formulated a joint position on the Alternative Fuels Infrastructure Regulation[72], acknowledging the fact that Europe's inland ports, waterway authorities and the IWT sector as Enablers of Green Transport and Logistics are major contributors to deliver the EU Green Deal. Together they welcome the direction of the Alternative Fuels Infrastructure Regulation (AFIR) published under the Fit for 55 Package. However, in order to support the sustainable transition of the IWT sector, the AFIR needs to go further than it does in its current wording.

On-shore power supply (OPS) facilities are considered essential in decarbonising the inland waterway sector. Their deployment needs to be realised within the coming years and as such the AFIR sets a very ambitious goal. In order to achieve all the goals put forward in the AFIR, it is expected that continued European support through CEF and other funding programmes will take place. This is especially important as the business case in many situations is still lacking and situational challenges, such as lacking energy infrastructure, still need to be overcome.

The deployment and usage of OPS by the IWT sector is considered to be very dependent on the reach and capacity of existing electric grids. 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.

Battery, hydrogen and other sustainable fuels infrastructure are required to be deployed along a corridor approach. Installing all of said infrastructure in all inland ports is seen as unfeasible. Fixed alternative fuels infrastructure in all ports could lead to oversupply in some areas and undersupply in

[72] https://www.inlandnavigation.eu/wp-content/uploads/2022/01/AFIR-Statement-220125.pdf

others, as inland ports are not evenly distributed.

Fixed targets for all ports would not always make economic sense and could result in underutilised or stranded assets. Instead, the infrastructure must be deployed in a way that serves waterway users, industry needs and geographic realities. As such the European corridors can be used to plan and coordinate the deployment of all alternative fuel's infrastructure along their corridors. At the same time interoperability between corridors should be safeguarded and fragmentation prevented.

It is proposed that the TEN-T Corridors, together with their coordinators, are given a leading role within the creation, dialogue and implementation of the National Policy Frameworks (NPFs). They are expected to deliver on the cross-border elements of the AFIR implementation, aiming at seizing the potential of alternative fuel system solutions in cooperation with industrial sectors in the corridors, enabling economies of scale and contributing to a lower pricing of alternative fuels over a shorter time frame.

In particular, the following legislative suggestions in relation to the AFIR were proposed:

Table 4: Legislative suggestions AFIR

Text proposed by the Commission	Proposed amendment
Article 10 - Paragraph 2 (NEW)	2. As of 1 January 2023 Member States shall take the necessary measures to ensure that the electricity grid is sufficiently extended, in connectivity and capacity, to ensure that the facilities pursuant to paragraph 1 are deployed.
Article 13 – paragraph 4 4. Where necessary, Member States shall cooperate, by means of consultations or joint policy frameworks, to ensure that the measures required to achieve the objectives of this Regulation are coherent and coordinated. In particular, ***Member States shall cooperate on the strategies to use alternative fuels and deployment of corresponding infrastructure in waterborne transport. The Commission shall assist the Member States in the cooperation process.***	4. Where necessary, Member States shall cooperate, by means of consultations or joint policy frameworks, to ensure that the measures required to achieve the objectives of this Regulation are coherent and coordinated. In particular*, European Coordinators, in accordance with Article 45 of Regulation (EU) No 1315/2013, shall be delegated to coordinate and assist Member States as they shall create joint policy frameworks on the strategies to use alternative fuels and deployment of corresponding infrastructure in waterborne transport.*

Source: https://www.inlandports.eu/news/press-releases/position-efip-ine-iwt-afir

In order to obtain a view on waterway-infrastructure-manager level a questionnaire was developed, and the members of INE, as well as Rijkswaterstaat in the Netherlands were approached. Feedback from five organisations covering the Dutch, Belgian and French waterways, as well as the Austrian Danube and the Douro in Portugal was obtained, summarised in the following.

Rijkswaterstaat (RWS) is the executive agency of the Dutch Ministry of Infrastructure and Water Management responsible for the design, construction, management and maintenance of the main infrastructure facilities in the Netherlands. RWS is dedicated to promote safety, mobility and the quality of life in the Netherlands. RWS manages and develops the main road network and waterway network plus the main water systems and endeavours to create a sustainable living environment. Working together with others, it is ensured that the country is protected against flooding, that there is sufficient green space and an adequate supply of clean water, and that the citizens of the Netherlands are able to travel quickly and safely from A to B.

Relating to the implementation of a clean energy infrastructure, no direct investments or developments are taking place except for OPS[73]. However, an activity of relevance of RWS is the provision of licences for initiatives along or in waterways where RWS is the waterway manager. Here, safety aspects are in the foreground, e.g. when clean energy carriers are to be used it is of importance to know do they have an impact on the safety of waterways, locks, berths, etc. In the case a new infrastructure is to be implemented, permits are needed which are obtained from the province, the municipality and/or the waterway manager (e.g. RWS), depending on the location of the infrastructure. In general, the permits are granted when the safety requirements and regulations in force are fulfilled.

In general, RWS assists the ministry in issues relating to policies on safe and smooth transport, as well as sustainable inland waterway transport. For this purpose, knowledge on the latest developments is established through gathering of relevant information and projects. Already in 2020, an internal position paper on sustainable shipping was issued dealing with the main developments on national, international and EU level, the definition of the role of RWS on this topic and the needed actions to facilitate sustainable shipping. RWS is planning to update this position paper, based on a study currently being carried out involving TNO, MARIN and Deltares. In the current position paper (2020) the knowledge gaps on safety aspects of the usage of clean energy carriers were highlighted resulting in the publication of two studies. The report on “Safety aspects of new energy carriers in inland navigation” (2021) contains basic information on the energy carriers considered, as well as safety aspects to be taken into account for a number of different scenarios, e.g., when the vessel is sailing, at a lock, at berth or mooring, and bunkering. The energy carriers considered are ammonia, hydrogen, battery-electric solutions, methanol and LNG. The second study considers safety aspects of different energy carriers (i.e. gasoil, hydrogen, methanol, batteries and LNG) simultaneously being offered at a clean energy hub (Veiligheidsaspecten van nieuwe energiedragers bij Clean Energy Hubs, 2022). Besides these studies, RWS also developed three guidelines with basic knowledge on hydrogen, methanol and battery-electric sailing and the needed steps when providing licences for initiatives along or in the waterways.

With respect to the facilitation of shore-side power, the plan is to equip all state berths where this is possible and useful (around 500 state berths).

The government shipping company (‘Rijksrederij’), which is part of Rijkswaterstaat, manages and maintains the governmental fleet, and greening of this fleet is an important issue. This involves also the elaboration and establishment of solutions how clean energy can be provided to the fleet (e.g. usage of trucks for hydrogen or methanol). There is no one-size-fits-all solution. A closer look is taken on the different vessels, demanding different solutions (e.g. small vessels may be operated battery-electric, bigger vessels may require other solutions such as hydrogen and methanol).

Summarised, RWS does not see its role in the direct implementation and operation of a clean energy infrastructure except for OPS. Its main role relates more to the facilitation of the implementation of the respective infrastructure, this by provision of the necessary licences in first instance.

[73] On behalf of the Dutch Ministry of Infrastructure and Water Management, Rijkswaterstaat is responsible for investing in the installation of shore power facilities for around 500 state berths. Currently, discussions are taking place on the ‘business model’ to use for this initiative.

Service Public de Wallonie (SPW)[74] is a governmental body implementing the policy decided by the Walloon Government, in the competences and matters devolved to it. It is also the first interface between regional institutions and the citizen. Through the many actions carried out and the measures implemented within the framework of regional competences, the SPW is also proving to be an essential partner of local authorities. The department responsible for waterways is Mobilité et Infrastructures (Mobility and Infrastructure). The tasks carried out are widely identical with the ones listed in the beginning of this section. In addition, assets managed comprise also industrial areas and berths along the waterways granted to autonomous port authorities with the purpose of developing navigation on the waterways.

In relation to the development and implementation of clean energy infrastructure for IWT, SPW Mobility and Infrastructure has the intention to make sure that inland vessels navigating on its waterway network can be supplied with clean energy. It is planned to elaborate a general strategy together with SPW Energy. The activities are just in an initial stage. On policy level no actions are reported. However, it is mentioned that SPW Energy is working on a hydrogen strategy. With respect to regulations, SPW Mobility and Infrastructure is following the negotiations on the revision of the Directive on the deployment of alternative fuels infrastructure.

As a service provider to waterways users, SPW Mobility and Infrastructure sees its role in making it sure that clean energy can be supplied on the waterways, in the same way as other services are supplied. For this purpose, it is necessary to collaborate with SPW Energy responsible for the supply of energy to initiate a deployment along the waterways. Moreover, it is realized that inland waterways and ports have a role to play in the energy transition, as energy carrier and energy hub.
SPW Mobility and Infrastructure will not conduct clean energy infrastructure developments, however, it would like to initiate and participate in undertakings and future projects followed by a comprehensive implementation project funded through CEF. Nevertheless, as administration it is not supposed to take contacts with private parties to mount collaboration projects.

With respect to the involvement in the implementation of clean energy infrastructure at mooring places and berths managed or locks and ferry landings a participation was neither excluded nor confirmed.

In general, SPW Infrastructure and Mobility sees its main role in acting as an enabler and service provider.

VNF - Voies navigables de France[75], established in 1991, is a public administrative body under the supervision of the French Ministry of Transport responsible for the maintenance, operation and development of the majority of France's inland waterways network. VNF is responsible for 6700 km of canals, rivers and canalised rivers on two connected networks: 2400 km of wide gauge waterways (freight network) and 4300 km of small gauge waterways (tourist network). It is responsible for 40000 hectares of public domain and ensures the operation of more than 4000 structures including locks, navigation dams and canal bridges.

The activities and responsibilities comprise the development of sustainable inland waterway logistics, including the improvement of the competitiveness of waterborne transport and modernisation of the fleet, as well as encouraging innovation. Further tasks relate to contributions to the development of river domains, e.g. promotion of river tourism and waterfront activities, and ensuring the overall management of the water resource, e.g. managing the hydraulic system,

[74] https://www.wallonie.be/fr
[75] https://www.vnf.fr/vnf/

securing the different uses of water (drinking water, irrigation, industrial activities), preserving biodiversity, fighting floods and water stress, as well as fostering the development of hydroelectricity.

Voies Navigables de France has several strategies to deploy alternative fuel infrastructure:

- by 2025: Stratégie connexions quais: deployment of on-shore power supply for all freight, touring and cruising vessels;
- by 2025: Stratégie Corridors verts: deployment of recharging infrastructure for electric inland waterway mobility for pleasure boats on the tourist network.

Following the recent legal reinforcement of the sustainable development and energy transition objectives imposed on the Member States of the European Union and in the wake of the new environmental constraints imposed in the framework of the Mannheim agreements and France's low-carbon objectives, VNF has also launched the FLUENT study. This study aims to provide the institution with a national strategy for greening the river sector, which will then enable it to build a roadmap for the distribution and possibly production of new energies on its territory. The study consists of a master plan of prospective greening scenarios and the new energy supply needs of the national river fleet. It takes up and generalises to all French river basins the analysis and models of a previous study on the Rhône-Saône basin, which made it possible to set up, on the basis of input data specific to the river sector, a multi-criteria evaluation methodology for greening scenarios on the basis of an energy, economic and environmental comparison. This approach, which is part of the research and development process, also aims to substantially improve the knowledge of players in the river sector and to support them in the greening of their activities. This study does not have any direct industrial and/or decision-making implications, but will be used to guide professionals of the sector in their choice of future propulsion technologies.

As part of the implementation of the Paris Climate Agreement and the national low-carbon strategy, the French State is aiming for carbon neutrality by 2050 and the decarbonisation of all modes of transport, which account for the largest share of emissions. A review of the French strategy for the development of clean mobility is underway, notably within the framework of the law on the orientation of mobility, in order to move towards carbon neutrality of all modes of transport by 2050.

In April 2021, VNF signed an objective and performance contract for 2020-2029 with the State, which includes the development of new energies in the river sector.

In June 2021, Voies navigable de France co-signed with the Ministry of Transport and other agencies a roadmap for green growth for inland navigation. The signatories have committed themselves to five objectives:

- defining the objectives of the "ecological transition of the inland waterway sector”;
- reducing polluting emissions from inland waterway transport for existing engines;
- deploying electric power at the quay side;
- preparation of the deployment of low-carbon energy solutions in inland navigation;
- controlling the environmental footprint of inland navigation.

Directive (EU) 2016/2284 of 16 December 2016 sets targets for improving air quality set at European level, which are implemented at national level by the national plan to reduce air pollutant emissions adopted in May 2017, and by local authorities. Targets have also been set by the national action framework for the development of alternative fuels in the transport sector and the deployment of the corresponding infrastructure, adopted in 2017 in the application of Directive 2014/94/EU of 22 October 2014.

VNF is coordinating a financial aid programme to support these innovations: the PAMI (Plan d'aide à la modernisation et à l'innovation de la flotte). The institution also supports other "greening" solutions such as the development of electric terminals at the quayside and alternative fuel supply, which are gradually being installed on VNF's property

viadonau[76] is a company with limited liability owned by the BMK- Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology of Austria. It operates waterways (mainly the Austrian Danube) and executes sovereign functions on behalf of the federal authorities of Austria. The tasks conducted are stipulated in the Federal Waterways Act (BGBl. I no. 177/2004), largely in line with the ones listed in the beginning of this section.

The main efforts with respect to the implementation of clean energy infrastructure are expected to take place in ports and by private (vessel owner) or public (municipality) organisations along the waterway if such stations become necessary, e.g. due to shorter voyages caused by the limited amount of energy carried onboard. For the establishment of bunkering facilities, viadonau may act as a facilitator by renting the land to the energy provider. Locks seem to play no role. Ferry landings could play only a role if the landing station is to be built on the land managed by viadonau. viadonau will not operate the landing or bunker station. The role of viadonau is more on the initiation, coordination and conduction of undertakings and projects relating to the implementation of the clean energy infrastructure. Moreover, viadonau sees its role in the promotion of developments on political and sectoral level, this in Austria, the Danube region as well as in the EU. Through knowledge gained from relevant projects and dedicated investigations, viadonau supports the BMK and the sector in relevant questions, as well as contributes to the development of standards within Austrian Standards International. Strategies and policies of relevance where viadonau has been involved are the Mobility Master Plan Austria 2030[77] (BMK, 2021), Freight Transport Master Plan (BMK, currently under elaboration, 2022), Action Programme Danube 2030 (BMK, currently under elaboration, 2022), viadonau Strategy 2030 (2021) and self-sufficiency strategy of viadonau.

Concrete activities with physical implementations of charging stations have been limited to shore-side electricity up to now. The decision which other energy carriers are to be considered has not been made yet as it is not clear which technologies will finally become market ready. However, recent projects under work deal with the application of hydrogen (H2 meets H2O, nationally funded) as well as different other energy carriers e.g methanol (Horizon Europe Synergetics, to be started in 2023). Internally, viadonau foresees the installation of an infrastructure for clean energy, e.g. photovoltaics and the usage of synthetic fuels (e.g. HVO) in order to become climate neutral in its operations on short-term. In addition, the viadonau Strategy 2030 mentions the creation of planning bases for infrastructure for alternative fuels.

APDL, Administração dos Portos do Douro, Leixões e Viana do Castelo, S.A[78]., is a joint-stock company of exclusively public capital. APDL's mission is to manage the Douro, Leixões and Viana do Castelo ports and the inland waterway of the Douro River, undertaking their economic exploitation, conservation and development, including the assigned port authority powers. These responsibilities include waterway maintenance, operation of RIS, support for the development of inland waterway transport and promotion. APDL manages Douro's inland waterway, its berths and commercial ports

[76] https://www.viadonau.org/en/home
[77] https://www.bmk.gv.at/dam/jcr:eaf9808b-b7f9-43d0-9faf-df28c202ce31/BMK_Mobilitaetsmasterplan2030_EN_UA.pdf
[78] http://www.apdl.pt/header

(when not under concession). The five locks are managed by EDP – Gestão da Produção, a private operator, as per the concession contract with the Portuguese State regarding the hydroelectric use of the river Douro.

APDL has already a strategy to install OPS in all major berths along the 200 km of Douro river waterway. OPS are already available at nine locations (up to 400 A) and four additional ones will be available by 2023. In addition, APDL has a pilot project relating to the retrofit/building of a small tug powered by hydrogen and/or electricity.

APDL, as a port authority, has recently developed a roadmap for energy transition towards decarbonization by 2035 for the port of Leixões (main Business Unit of APDL). The main strategies will be disseminated to the other business units, namely renewable energy production - looking for self-sufficiency (solar, wind); making OPS available; electrification of all port activities, alternative green fuels bunkering and supply (green H2, green methanol and others); air quality control and; digitalization.

In the study of the implementation of alternative fuels in the port of Leixões and the Douro's inland waterway, an analysis of the current situation of the Port of Leixões and the Douro inland waterway has been carried out. For each, berthing docks and vessels have been characterized and finally, those docks with greater potential for implementation of OPS technology have been chosen, for which the studies and works for electrical connection are being carried out.

Internally, APDL is reviewing is tariffs and sustainability will be considered in the new regulation, in order to promote "green practices" amongst stakeholders.

Relating to the creation of regulations with respect to the implementation of clean energy infrastructure, no direct involvement is reported. However, APDL is represented in ESPO and PIANC.
The initiation or coordination of activities relating to the implementation of clean energy infrastructure has been already started. However, it is stressed that vessel owners and regulation need also to be aligned on a decarbonization strategy in order to achieve good results.

With respect to the implementation of clean energy infrastructure at locks or ferry landings, no strategy has been defined for this particular case. Nevertheless, OPS are already available along the river and the infrastructure is being expanded.

Along with river cruise and cargo operators, APDL has the clear objective of contributing to the implementation of clean energy infrastructure at the river Douro waterway, hopefully based on self-sufficient units.

3.4 RD&I Perspective Waterborne TP and partnership

Waterborne TP (WAT TP) is the European-wide technological platform which provides waterborne transport sector representatives, including policy makers, and also stakeholders from connected domains (e.g. fuel suppliers), the opportunity to discuss RD&I developments and contribute to their funding opportunities. Although the focus is on the transport aspects and in particular the vessel related developments, there is considerable knowledge and expertise with the WAT TP members that are also active in the upstream chain of the energy industry. Last but not least, some of the WAT TP members can provide information regarding the upstream energy developments due to the nature of their organizations.

For the purpose of this deliverable, the RD&I relevant work to be done by WAT TP and its members is in the context of the Co-Programmed Partnership on Zero-Emission Waterborne Transport (ZEWT cPP), part of Horizon Europe (HEU). The Partnership will focus in particular on the ship-to-ship and ship-to-shore interfaces, technologies and activities, as well as on the storage of the energy and/or clean energy in the vessels for propulsion or auxiliary means. The scope of work here is therefore narrower and more vessel-oriented, but it will have a significant impact by providing rapid developments, upscale (and standardization or harmonization) of solutions.

This input will come first of all from two main sources. The first is the ZEWT Strategic Research and Innovation Agenda (SRIA) document, which gives the main directions for RD&I activities within the Partnership up to 2027. Concerning ports, the Partnership will tackle the development of safe technologies and procedures for:

- the (flexible) bunkering of clean energy at inland and maritime ports. This concerns not only the development of the technologies themselves, but also the development of consistent rules, regulations and procedures that will support the introduction of the sustainable alternative shipping fuels in the safest way possible for the infrastructure, the environment and the surrounding population.
- the supply of electricity to vessels, taking into account new necessary systems for clean energy solutions (i.e. recharging and transhipment points for exchangeable battery containers in the case of electrification). Here, the Partnership will also develop technical standards for recharging equipment and power supply solutions, such as integration with smart grids and mobile solutions.
- systems for reducing emissions from waterborne transport within ports.

All solutions are not only critical in reducing the emissions of GHG and other pollutants in or near ports and thus complying with the current and foreseen policy and legal targets developed in the context of the EU Green Deal. They also ensure the correct positioning of the waterborne transport sector in respect to the overall decarbonization and electrification trend in all transport sectors and in particular in the road sector. Such an approach will also help reduce the risk of a reverse modal shift towards road transport from both IWT and (short sea) maritime shipping.

The second main input will come from the Structuring Towards Zero Emission Waterborne Transport (STEERER) project, whose main aim is to provide advice and support to the update of the ZEWT SRIA in the first years of the Partnership's lifetime. The main advice is first encompassed in two STEERER deliverables, D2.5 and D2.7 *Advice to the ZEWT Research Agenda and its Implementation Plan,* which will look at the latest policy, technological and economic developments in the sector and subsequently advise on what solutions should be added or prioritized for research in the context of the Partnership. Port-related needs and solutions such as the OPS are among the main aspects investigated by the STEERER partners. Another relevant source of information will be the STEERER deliverable D2.4 *Public policy instruments and interventions and other appropriate mechanisms, incentives and business models to increase the take-up and deployment from R&I activities arising from the ZEWT Partnership*, which outlines the complementary measures (policy, taxation, incentives, etc.) that should accompany the ZEWT work in order to ensure that its progress is quickly being scaled-up and then rolled-out. Part of the work addresses the energy-related aspects, their challenges and the potential solutions that the waterborne transport stakeholders can come up with.

A recent CSA project originating from the ZEWT calls, NEEDS, will look into the different scenarios for the use of clean energy by the waterborne transport sector. Two study cases – the inland navigation on the Rhine and the short-sea shipping traffic between the Greek mainland and islands – are key components of this work. Though the final results will appear too late for the timeline of this deliverable, the future results from the NEEDS project can form valuable input for policy makers and port authorities.

3.5 Perspective of barge owners and operators

The needs and wants of owners and operators of Barges have been assessed by holding interviews with vessel operators active in the wider Rhine and Danube regions.

Rhine region

EICB has spoken with three barge operators that operate in the Netherlands, the wider Rhine area and (north-) western Europe in general. Their wants and needs regarding the deliverance of fuels on board are currently met for diesel by a wide network of bunkering locations, that offer fast services even with little forewarning. Apart from that, in the Netherlands, Belgium and Germany it is common to easily arrange for a bunker barge to come alongside for the bunkering to take place, in a lot cases even while the vessel keeps sailing on to minimise loss of time.[79] Since the Amsterdam-Rotterdam-Antwerp area in western Europe is very close to large seaports, diesel tends to be relatively cheaper there. This attracts a lot of customers who prefer to delay their bunkering moment until they reach this area. The latter is possible since bunkering is not needed very often, most barges can easily perform a roundtrip on their tank(s) filled with diesel. From an operator perspective, this is all very efficient.

The current status of bunkering fossil diesel is one of high availability on short notice, high service, flexibility and low prices. This is partly due to a bunker market that has been able to develop and continuously improve over the past decades. This means that the current demands from barge operators regarding availability, service, flexibility and price-setting are high. Operational profiles in the IWT sector are for a large part very flexible. Large portions of the sector are active on the spot market and do not know always where they will be going after they finish their current trip and are thus only capable to plan bunkering moments very roughly and with short notice. Furthermore, a significant portion of vessel operators have strong preferences for fluid fuels that can be handled in practical ways similar to diesel. Operators also indicate that regulations for bunkering of alternative fuels must be in place, in combination with the right kind of infrastructure on the right place and standards for procedures and equipment used.

Alternative sustainable energy and technologies like hydrogen/fuel cells and green electricity/batteries are deemed to be achievable for vessels sailing on dedicated routes. Important factors to be considered here are the operational profiles of vessels which should match the fuel/technology and the way of bunkering (battery containers on container vessels that sail between container terminals for instance), the business case and (monetary) have the support of shippers. But the presence of these factors, which create the right situation for the application of alternative sustainable fuels and technologies, do not apply to the vast majority of the IWT sector and not with the current framework conditions in place.

For the wider IWT sector, implementation of alternative fuels will be very hard. Operators see a few reasons for this: first of all, it is still not certain which alternative fuel is going to 'make it', so a set of alternatives will have to be offered in the beginning stages. This is detrimental because the current

[79] Bunkering fossil diesel during sailing is a type of bunkering operation often conducted. Of course, there are rules attached to this and it cannot be applied everywhere, but yet on many routes. For e.g. the Rhine Police Regulation contains rules for bunkering on p.123/198 including a reference to bunkering during sailing https://www.ccr-zkr.org/files/documents/reglementRP/rp1nl_01062022.pdf
In the Netherlands bunkering during sailing is forbidden on a limited number of locations https://www.arbo-binnenvaart.nl/userfiles/file/validatie%20bunkeren/BPR%20RPR%20bunkeren.pdf

bunkering network is not suited to offer multiple fuels. One of the interviewed vessel operator's fuel supplier was offering the Change TL fuel next to regular diesel. This has proven hard to organise since extra space needs to be made clear, and most bunker vessels have room for a maximum of two types of fuels. This fuel supplier was already hard-pressed to roll out Change TL (which is similar to diesel) and it would have been very hard to impossible for them to offer even more types of fuels- let alone alternative sustainable fuels such as methanol, hydrogen, etc. Furthermore, as alternative fuels have lower volumetric and gravimetric densities than fossil diesel, it is expected that more frequent bunkering- and thus more infrastructure- is needed. Containerised solutions such as containerised battery systems seem to be able to offload this need to existing terminals. However, barge operators warned that large parts of the sector never visit container terminals, and that it is not a set case that all terminals will be able to (or willing to) take on the handling of alternative-fuel/energy-containers. A lot of terminals in the hinterland are still operated by one crane only, and it is far from certain that the owners of the terminals would be able and willing to add another task to that crane. This would decrease the normal handling capacity of the terminal. The process of truck-to-ship bunkering would be interesting in the early stages of adaptation of alternative fuels. It is relatively cheap to implement as a first step, but there needs to be a level playing field and regulations need to be clear for this to work. Truck-to-ship bunkering and bunkering by exchanging containers at a terminal are probably to be planned in advance, which would be harmful for the flexibility and which is important for business operations, especially for vessel operators active in the spot market.

Some operators have already experienced the roll-out of an alternative relatively sustainable transitionary fuel, namely fossil LNG. The LNG roll-out started in a period when a positive business case for LNG usage was to be expected. The first vessels faced a chicken-and-egg problem: because of low actual and expected demand for LNG by the sector, and LNG suppliers in turn not willing to invest in LNG infrastructure for IWT. Initially, this was solved by bunkering from truck-to-ship, but the steps to a strong and stable bunkering network for LNG were never completed. Due to a narrowing price difference between LNG and diesel fuel after the oil dip in mid-2014, the positive business case for investing in an LNG propulsion system disappeared. In return, the roll-out of bunkering options also stalled. As of today, there is only one operational LNG bunkering station for inland vessels that is being regularly used, i.e. the one Cologne, Germany. However, LNG usage in other sectors has seen a rise in recent years. One operator pointed out that this actually made it harder for inland vessels to make an appointment to be serviced by an LNG-truck to be bunkered. After all, higher LNG demand from other sectors meant that LNG-supplying trucks have more customers to service and thus have busier schedules. The current effect is that LNG vessels now have to make an appointment to be bunkered earlier than before (increase from two days to four days in advance). This shows that the roll-out of alternative fuels should go hand in hand with roll-out of bunkering infrastructure, otherwise the limited infrastructure available might hardly be able to keep up with demand. After all, the flexibility that is a core part of the business operations of a large part of the sector would be hampered by a four day lead time to schedule a bunker appointment. In addition to the time factor, operators of LNG driven vessels also stress, based on experience with bunkering LNG, that we should be wary of super long checklists and administrative burdens for bunkering future alternative fuels.

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.

Danube Region

Regarding the Danube Region (DR), PDM contacted three major operators, but only two agreed to have an interview. The DR market is to a large extent dominated by a few major cargo owners who deal with a relatively small number of service providers. Most of the existing shipping companies are large companies (compared to the small/family business on the Rhine) that originate from former state-owned companies. These companies underwent major privatization processes in the aftermath of the political events that occurred starting with 1989. They provide cargo space for the transport of traditional bulk goods. Despite this development, a niche of smaller shipping companies and independent ship-owners made also its way into the market. Given the current market situation, these smaller companies and private vessel owner-operators prove to be more flexible, serving certain niches and short-term requirements for transport services.

There are three basic types of contract and transport solutions concluded for cargo transport on the Danube:

- Contract Trips: Transportation of an annual agreed quantity, between specific agreed and fixed locations without fixed timeframes of cargo deliveries.
- Spot transport: fixed delivery times for an agreed quantity on short notice.
- Multimodal liner services: The vessel is transporting cargo according to a fixed timetable and to specific defined ports; the cargo is then further transported via truck or train.

As for the bunkering process, this is regarded as a very easy one in line with the experiences in the wider Rhine region. The first step relates to the checking of the market bunkering price for the gasoil to be bunkered. Once the decision is taken which bunkering station to use, the vessel then arrives at the bunkering place and starts to fill in the gasoil it requires taking into account relevant safety regulations[80]. The whole process will take between two and six hours, depending on the bunkering station and depending on the amount of gasoil for intake. After the physical bunkering was completed, a delivery note on the amount and temperature is issued and kept until the invoice for payment is generated.

Taking into consideration the current way of bunkering, which takes place since decades, the expectations regarding the change from fossil diesel to a mix of clean energy and technologies are in close correlation with the existing experience. As such, the bunkering frequency and the number of bunkering locations as well as the duration for the bunkering process itself need to match the existing situation.

Judging it from an economical point of view, it is clear, that whatever alternative form of energy will be used in the future, it is expected to be more expensive than today's diesel. Savings which could be created by a shorter duration for the bunkering/charging process or higher frequency of bunkering/charging stations could limit a further negative impact to this mode of transport. A preferred solution would be placing bunkering/charging stations directly in port basins. This would allow to perform bunkering and charging operations during the time of loading/unloading and hence avoid additional stops on the main carriage line. Regarding the future technical solution, whichever alternative fuel or mix of fuels will there be, it needs to be available and aligned along all navigable inland waterways in Europe.

Navigability is a very important factor which still needs to be taken into account also when considering about new investments for bunkering and charging infrastructure. There are areas where navigability has been increased significantly, which is a great gain for the sector when it comes to planning and the quality of the services. It does not only increase the sectors' reliability and resilience – but also decreases the emissions, while raising transport efficiency. However, on the Danube there

[80] Relevant safety measures need to be taken such as engines that must be turned off, ensuring electrical grounding, staff wearing helmets and other personal safety equipment.

still are about 5-6 real bottlenecks e.g. in Austria, in Hungary and the worst one – when sailing from or to the Black Sea - the common Romanian-Bulgarian section – which is currently the decisive factor.

3.6 Conclusion

Chapter 3 analysed the desired future state of the clean energy infrastructure for IWT. For this purpose, interviews were conducted with 17 organisations and questionnaires have been distributed and filled in by 13 organisations. This allowed to capture the view of various stakeholders as regards the state of the clean energy infrastructure for IWT. This concerns the view of four TEN-T corridors (RALP, NSB, NSM, RD), European IWT countries at the level of the national authority, ports, energy suppliers, infrastructure managers, barge owners/operators and (members of) the Waterborne Technology Platform.

In general, there is a consensus on the need for a transition to cleaner IWT and therefore on the need for adjustments to the energy infrastructure for IWT. However, there are differences in the details of the vision and gaps and challenges that lie in its path. The analysis of the gaps and challenges is presented in the following chapter 4.

4. Gaps and challenges

The objective of chapter 4 is to list the gaps and challenges identified through the analysis in chapter 2 Policies and market review and chapter 3 Perspectives of desired future state. By analysing the current relevant policies and the current market developments which are relevant to the clean energy infrastructure, and the perspectives of a wide range of stakeholders as regards the future clean energy infrastructure, gaps and challenges have been identified in technical, economic and legal/regulatory fields. This concerns not an inexhaustible list of all possible gaps and challenges, but rather the most salient ones as indicated by external stakeholders and experts during interviews, through questionnaires and own desk research. A selection of key gaps and challenges were presented during the 5th PLATINA3 Stage Event and an interactive discussion was organised using the Wooclap tool to have an in-depth discussion regarding some of the main gaps and challenges in realising the clean energy infrastructure.[81] The results from this discussion validated already some of the identified main gaps and challenges, on the one hand, and offered new insights in the form of new gaps and challenges, on the other.

Some of the gaps and challenges listed below are at a more general level, whereas others are quite specific in nature. Many gaps and challenges are strongly interrelated though and therefore cannot be seen in isolation and require an integrated approach to overcome them. The identified gaps and challenges should help prepare public and private stakeholders for the developments in view of the energy transition to a zero-emission IWT.

4.1 Technical

The following enumeration contains 16 gaps and challenges with a technical nature, to be taken into account for the development of clean energy infrastructure:

1. It is often not possible to facilitate the bunkering, charging and swapping (with containerised energy storage systems) of clean energy on existing bunkering stations. This is due to technical complexities, since alternative forms of energy such as hydrogen require different types of storage, piping, physical size limitations, etc.

2. Available space in ports is scarce and may limit the realisation of bunkering, charging and swap sites, especially for forms of energy that have a low energy intensity and require relatively more storage space.
3. Currently, bunker boats are often used to supply fossil diesel to inland vessels. These existing bunker boats are not equipped to provide alternative forms of sustainable energy such as green hydrogen, electricity, methanol, etc.

4. Thanks to studies, insights have been gained in terms of the possible future fuel mix for IWT. But fuel suppliers also need some flexibility in case of possible technological breakthroughs (e.g. in battery technology) that could change today's expected fuel mix for the future. This uncertainty complicates infrastructure investment decisions.

5. Currently, a majority of vessel operators is active on the spot market. This will make it difficult for clean energy suppliers to provide (full) geographic coverage for their customers. Because a large proportion of vessels will have varying sailing trajectories and may not be able to bunker and charge clean energy always on the same place.

[81] The answers to the questions raised during the interactive discussion using the Wooclap tool, can be found in Annex 7

6. There will probably not be a sufficient supply of clean energy in all European IWT countries and regions to enable the sector to achieve the GHG target of 55% reduction by 2030.

7. Although the climate goals are the same, the pathways for ports to reach them are different and depend on many factors such as port traffic, hinterland connections, industrial and energy sectors in the port area, stakeholder commitment and engagement, etc.

8. The navigability of the Danube is a challenge, which complicates the planned increase in modal split for IWT. The reliability of the navigability and strong commitment from all public and private parties involved are seen as important for the realisation of the clean energy infrastructure.

9. Containerised batteries and H2 containers for fuel storage seem to be feasible options (and possibly also for other forms of clean energy), at least on the short term. However, not all types of vessels might be technically suited to use containerised energy storage and large parts of the inland fleet, e.g. passenger vessels and tankers, never visit container terminals.

10. Not all terminals will be able to take on the handling of alternative-fuel/energy-containers. A lot of terminals in the hinterland are still operated by one crane only, and it is far from certain that the owners of the terminals would be able and willing to add another task (additional container handlings) to that crane. This would decrease the normal handling capacity of the terminal.

11. Charging points (energy for propulsion) should be located close to loading/unloading areas, and the infrastructure behind them should allow to charge/swap batteries during loading/unloading operations.

12. 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. This is a challenge related to both the port infrastructure and outside the port infrastructure.

13. Inland cruise vessels require substantially more electric energy. The existing grids are not always able to address these demands.

14. There is no uniform concept for the operation of shoreside power connections, and no agreement on a commonly accepted payment method.

15. Battery-electric propulsion systems and accumulators for self-sufficient power supply bear the risk that shoreside power/OPS connections providing electricity during berth operations might become a bridging technology in the future, especially if battery technology greatly increases battery/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.

16. The current way of operations in IWT requires a change in mindset and the way of shipping. Most of the clean alternative forms of energy require a mind shift for how to operate the vessel, especially regarding aspects such as flexibility, time between bunkerings, safety, etc. This means that existing logistical operations have to be adapted once using clean alternative forms of energy. The future clean energy infrastructure must be tuned to this.

4.2 Economic

The following enumeration contains 17 gaps and challenges with an economic nature, to be taken into account for the development of clean energy infrastructure:

1. The development of the demand side for clean energy in the overall European IWT sector is still very marginal. This was being regarded as the main bottleneck for realising the clean energy infrastructure for IWT by the audience during the PLATINA3 5th Stage Event.[82] There are initiatives and projects for applying clean energy on dedicated routes (e.g. for container transport) and for specific type of ships (e.g. harbour tugs, ferries). But in general there is still a strong preference for diesel and ICE's. The framework conditions to stimulate investments by vessel owners in clean propulsion techniques and energy are insufficient. With lacking demand suppliers of clean energy will be hesitant to invest in the clean energy infrastructure.

2. Currently, the bunkering market is characterized by very small margins requiring large quantity sales to enable a positive business case for the energy supplier. With alternative forms of energy, which have a significantly lower energy density, there will eventually be a need for more bunkering and charging points than the current number of bunker points for fossil diesel, which would put even more pressure on the business case.

3. The current status of bunkering fossil diesel is one of high availability on short notice, high service, flexibility and low prices. It will, especially in its initial phase, be difficult for the alternative clean energy infrastructure to compete with.

4. Bunkering during sailing by bunkering boat is not possible for alternative forms of energy, which is at the expense of time efficiency and having a negative economic impact for vessel operators used to this way of bunkering.

5. Operational profiles in the IWT sector are for a large part very flexible. Large portions of the sector are active on the spot market and do not know always where they will be going after they finish their current trip and are thus only capable to plan bunkering moments very roughly and with short notice. Future clean energy infrastructure must be able to meet this flexibility demand and/or vessel operators must adjust their bunkering behaviour.

6. Experience with the construction of the LNG bunkering station in Cologne showed that the construction process of the clean energy infrastructure for IWT can be very complex, time-consuming and costly compared to conventional infrastructure.

7. It will be of key importance to boost the demand side/market for alternative fuels in order for fuel suppliers to invest in the infrastructure. Demand and supply should develop in a balanced way though. Policies and incentives (i.e. grants) should stimulate combined projects that will work on ensuring a first critical mass, i.e. an initial consumption of alternative clean energy which is large enough for suppliers of clean energy to invest in the required energy infrastructure. Although the clean energy market is a difficult one in economic terms, both

[82] 32 out of the 45 participants to the Wooclap session inserted an answer and most of them highlighted "demand" as the main bottleneck for realising the clean energy infrastructure for IWT. See also Annex 7.

for suppliers and users, when the right market conditions are met, clean energy suppliers can move relatively easily given their financial capacity, as compared to small individual vessel owners, and invest in infrastructure once there is a prospect of a market. But as of now, there are not much developments in this regard, there are too few newbuilds and retrofitted vessels to sail on alternative forms of energy.

8. It remains uncertain if enough green hydrogen can be produced locally- and if not, imported hydrogen will be less competitive and cannot be applied everywhere.

9. It will be complex to ensure reliable access for both inland vessel operators and service provides to container terminals for swapping energy containers, since there may not always be an (economical) incentive for container terminal operators to offer these services, especially to vessels that are no clients of the container terminal and exclusively arrive to swap energy containers.

10. Terminal operators and other players in the port area may not always welcome bunkering, charging and swapping operations in their immediate environment without any objection.

11. Within a small and fragmented market like the IWT, only a limited number of forms of clean energy can be supported. Otherwise, the infrastructure becomes too costly with potentially a negative impact on factors such as price and availability of the supplied energy.

12. A level playing field should be established across regions and investments should be coordinated in time, so that certain countries and regions don't leap behind in the clean energy infrastructure deployment. This should prevent the situation in which a certain fuel is provided in one geographical area but not in another and hence vessels can only use the fuel in just that part of the region supplying the particular fuel.

13. Substantial amounts of public funding will be required to realise the clean energy infrastructure for IWT. Corresponding stimulation instruments may not always and everywhere be available in the required amounts.

14. There are currently not too many projects in European ports, which can demonstrate active uptake of the innovations with regards to alternative fuels/green electricity production and serving as green energy hubs.

15. Vessel operators have strong preferences for fluid fuels that can be handled (i.e. stored, bunkered, etc.) in practical ways similar to diesel. (Drop-in) liquid biofuels and e-fuels such as HVO and green methanol are suitable for this purpose. However, this will pose a challenge for other alternative forms of clean energy such as green hydrogen and electricity, which will require a different approach.

16. A corridor approach is required for the development of the clean energy infrastructure. Fixed alternative fuels infrastructure in all ports could lead to oversupply in some areas and undersupply in others, as inland ports are not evenly distributed. Fixed targets for all ports would not always make economic sense and could result in underutilised or stranded assets. Instead of going for "island solutions" there has to be a coordinated and harmonised approach which works on the corridor level.

17. Cost factors related to the production and procurement of alternative clean energy, for transport, storage and supply and other regular cost factors are currently seen as very high

from the perspective of energy suppliers. Inland vessel owners/operators will, in most cases, not be willing and able to pay a high enough price to outweigh these costs for the energy supplier. Hence, the current economic conditions may prevent a wide uptake of the clean energy infrastructure.

4.3 Legal/regulatory

The following enumeration contains 19 gaps and challenges of a legal/regulatory nature, which need to be taken into account for the development of clean energy infrastructure:

1. Permits and procedures for building conventional bunkering infrastructure (i.e. bunker stations and boats) are very fragmented and may differ between regions and countries. This process will be even more complex for the construction of the clean energy infrastructure.[83]

2. Existing bunker station supplying fossil diesel will not be able to store and supply alternative forms of energy such as green hydrogen, methanol and electricity without permits from (local) authorities, due to legal/safety reasons.

3. Supplying multiple forms of clean energy, physically, next to each other might not be possible due to safety reasons and permits.

4. Reserving a quay for a truck-to-ship delivery of clean energy is cumbersome and takes a relatively large amount of time and administrative effort for a vessel operator.

5. Not all (container) terminals have a relevant exploitation authorization for handling dangerous goods, which is necessary to have though for swapping energy containers such as H2 containers. The same will apply to quays on which energy containers will be swapped.

6. There is a limited amount of dangerous goods allowed at a terminal, this should be considered with facilities for swapping energy containers.

7. Harmonised bunkering procedures/checklists need to be drafted for inland vessels bunkering/charging clean energy.

8. Port Bye-Laws need to include provisions for bunkering of clean energy.

9. Regulations and IWT legislation (e.g. police regulations) will need to be adjusted/developed to allow bunkering, charging and swapping clean energy to the extent that this is not already possible.

10. It will be crucial to align the national and regional strategies for the clean energy infrastructure with EU objectives. National and regional authorities will need to coordinate investments on both sides of the border as vessels operate internationally and cross borders. The TEN-T corridors, together with their coordinators, need to play a facilitating role in this respect.

[83] The Commission proposals to accelerate permit-granting procedures for renewable energy projects may have a positive effect and eventually (partially) eliminate this bottleneck. This concerns the proposals for an amending directive on RED (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022PC0222&from=EN) and a Council Regulation (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52022PC0591)

11. Not all member states, and relevant regional authorities, have clear strategies yet for the deployment of the clean energy infrastructure for IWT.

12. Not all IWT country representatives surveyed have an equally good understanding of how the energy demand of the IWT sector will evolve towards the future, even though this is an important starting point for discussions on the required clean energy infrastructure for IWT.

13. Drop-in biofuels like biodiesel (FAME/HVO) and biomethane are actively being promoted or prescribed in some but not all surveyed European IWT countries. This difference could have an unbalanced impact on the development of the clean energy infrastructure, in which there are e.g. more bunkering facilities for drop-in biofuels in some of the countries and other countries provide more for other forms of energy.

14. Inland ports are often located close to densely populated urban areas and often have to balance the development and management of port activities with the preservation of natural habitats and the quality of urban life. This may stress the development of the clean energy infrastructure on sites close to urban areas.

15. Port authorities/administrations can decide on the greening of their own activities and jurisdiction, but have limited possibilities to influence green behaviour of port users (terminal operators, transport companies, etc.).

16. In the past, suppliers of LNG to IWT and its customers experienced inconsistency in regulations, i.e. related to initial support for the roll-out of LNG which subsequently fell away and led to a decrease in the number of bunkering spots where LNG bunkering is possible by truck, due to revoked permits. This experience may make some parties reluctant to invest in clean energy infrastructure for IWT.

17. In order to enable cross border projects, funding for projects in neighbouring non-EU will also be necessary. It needs to be ensured that co-funding of neighbouring countries under CEF needs to continue in the revised TEN-T proposal.

18. A number of points not explicitly addressed in the proposed AFIR are seen as gaps that may lead to challenges in the realization of the clean energy infrastructure. These are the following:
    a. The proposed AFIR focuses relatively much on shore-side electricity supply but less on infrastructure for other fuels. Furthermore, with on shore-side electricity supply, the focus for IWT should be increasingly on recharging points to charge and swap batteries used for propulsion of the vessel and less on on-shore electricity supply for the hotel function (i.e. power required during idling).
    b. The proposed AFIR does not address specific technical challenges, such as the fact that the deployment and usage of OPS will be very dependent on the reach and capacity of existing electric grids. Member States could take the necessary measures to ensure that the electricity grid is sufficiently extended, in connectivity and capacity.
    c. The proposed AFIR should emphasize more explicitly the role of the European Coordinators to coordinate and assist Member States in the creation of joint policy frameworks on the strategies to use alternative clean energy and deployment of the corresponding infrastructure.

19. There are two potential shortcomings in the proposed revised TEN-T regulation that could pose potential challenges, these are:

a. An inland port should be part of the comprehensive network when it has an annual freight transhipment volume exceeding 250.000 tonnes instead of 500.000 tonnes, since smaller inland ports might not be able to meet the threshold of 500.000 tonnes as foreseen in the current proposal. Furthermore, no mention is made about passenger traffic either as threshold condition to be part of the comprehensive network. Whereas the IWT passenger sector itself is a front runner in terms of greening and adaptation of its fleet to the energy transition and highly depending on the publicly accessible recharging and waste collecting infrastructure along the trans-European transport network. Hence, sector representatives indicate that a reference amount for passenger traffic volume should be included as well, being a total annual volume of passenger traffic volume exceeding 500 000 persons.
b. The proposed regulation should foresee requirements for maintenance of clean energy infrastructure (as per form of energy) to ensure that the TEN-T network will continue to function properly during its operational life cycle. Currently there are no regulations or technical investigations, which shall be applied to future maintenance of clean alternative fuels bunkering / recharging infrastructure in ports and on the waterways, especially from the point of view of safety requirements.

4.4 Conclusion

Chapter 4 listed the most salient challenges and gaps on the path towards realising the clean energy infrastructure for IWT. In total 52 gaps and challenges have been identified out of which 16 have a merely technical character, and 17 were of economic nature and 19 of legal nature.

The main challenges are:

- The first economical challenge, that of a failing development of demand from shipowners/-operators for clean energy, is arguably the central concern. This runs parallel with the issues shipowners/-operators have with developing business cases for using clean energy. Speaking broadly: there is low demand from the IWT sector for clean energy, but this follows from low demand for sustainable transport by the sector's customers.
- From a legal/regulatory perspective, the most important challenge is to ensure a corridor approach and align the regional and national strategies and deployment plans for clean energy infrastructure. In addition, the lack of current regulation covering the bunkering of clean energy, and the long and/or complicated process needed to obtain the necessary permits to start clean energy bunkering operations.
- The largest technical challenge is the fact that it is often not possible to facilitate the bunkering, charging and swapping (with containerised energy storage systems) of clean energy on existing bunkering stations. This is due to technical complexities, since alternative forms of energy such as hydrogen requires different types of storage, piping, physical size limitations, etc.

Almost all gaps and challenges are strongly interrelated and therefore cannot be seen in isolation and require an integrated approach to overcome them. Chapter 5 provides corresponding recommendations.

5. Conclusion and recommendations

The existing bunkering infrastructure does not seem suitable for supplying clean energy and hence requires new infrastructure for the IWT fleet that will transition towards zero-emission by 2050. The desired future state of the clean energy infrastructure for IWT has been mapped through interviews with 18 organisations and questionnaires that have been distributed and filled in by 16 organisations. This includes representatives from Ministries and infrastructure managers of European IWT countries, TEN-T corridors, port authorities, energy suppliers, vessel owners and operators, and research institutions. The findings have also been presented and discussed with an audience of around 70 persons during the 5th PLATINA3 Stage Event.

In general, there is a consensus on the need for a transition to cleaner IWT and therefore on the need for adjustments to the energy infrastructure for IWT. However, there are differences in the details of the vision and gaps and challenges that lie in its path. Based on all the insights gathered, it can be concluded that the greatest challenge for the clean energy infrastructure for IWT has an economic nature and concerns the currently lacking demand from vessel operators for clean energy. This poses an economic challenge for producers of clean energy and operators of the energy infrastructure. **With the very first initial uptake and small number of vessels running on clean energy, supply can be provided with, for example, flexible truck-to-ship deliveries. However, demand and supply should develop in a balanced way.** Policies and incentives (i.e. grants) should stimulate combined projects that will ensure a first critical mass of demand for clean energy, considering a corridor approach. This will help ensuring an initial consumption of clean energy which is large enough for suppliers of clean energy to invest in the required energy infrastructure. When the right conditions are there, clean energy suppliers can move relatively easily, as compared to small individual vessel owners, and invest in infrastructure once there is a prospect of a market.

This balanced development is a big challenge, but there are initiatives in the right direction, for example as listed in Annex 5 there are multiple projects in European port areas for the production of clean energy and the corresponding infrastructure. Policies such as the Sustainable and Smart Mobility Strategy, EU Green Deal, proposed Fit For 55 package and proposed TEN-T revision are stimulating such projects and initiatives. For IWT, the CCNR roadmap provides good insight into how the fleet could evolve to meet the 2050 goals and which fuels and technologies are promising in this regard. This provides insights in which way to go with the clean energy infrastructure needed for the IWT sector.

Economic gaps and challenges

The failing development of demand from shipowners/-operators for clean energy follows from a lacking business case for clean energy from the perspective of the vessel owner. This lacking demand is being regarded as the main bottleneck for realising the clean energy infrastructure. Furthermore, IWT is seen as a small and fragmented market for energy suppliers, and hence would only support a limited number forms of clean energy. Otherwise, the infrastructure becomes too costly with potentially a negative impact on factors such as price and availability of the supplied energy. This should be well thought out and synergies should be created wherever possible with other industries and transport modes for the supply of clean energy, e.g. with clean energy hubs.

Furthermore, the current status of bunkering fossil diesel is one of high availability on short notice, high service, flexibility and low prices. It will, especially in its initial phase, be difficult for the alternative clean energy infrastructure to compete with. Laws and regulations should therefore be facilitative in terms of the realization and operation of the clean energy infrastructure for IWT. The right framework conditions should apply so that clean energy infrastructure operators can compete with the infrastructure for fossil fuels. The same line of reasoning applies for operators of clean energy vessels. The right framework conditions should also be in place for the operators of the vessels, which naturally strengthens the realization of the clean energy infrastructure.

Legal gaps and challenges

There are also challenges with regulatory/legal causes, such as cumbersome permitting procedures and rules for the construction and operation of clean energy infrastructure. These experiences were gained with the construction of the LNG bunkering station in Cologne, lessons should be learned from this and rules and procedures could be eased where possible. Rules and procedures can be very different between countries and even at the local level. However, for a clean energy provider, it would help if the rules and procedures were aligned. A tangible solution would be to harmonise, simplify and shorten the permitting process for the realisation of clean energy infrastructure projects across the European IWT countries.

Other legal bottlenecks that suppliers of clean energy (will) encounter in practice are in the field of supplying/taking alternative clean energy on board of the vessel and the construction and operation of the clean energy infrastructure. This relates e.g. to port bye-laws and legislation at a higher level that need to include provisions for bunkering/charging/swapping alternative clean energy, harmonised bunkering checklists and procedures that are lacking, complex permits and procedures for building the infrastructure and for bunkering alternative clean fuels through truck-to-ship at reserved quays. **Complex permits and procedures can also form a bottleneck for supplying alternative forms of energy at existing bunkering stations and for providing multiple forms of clean energy next to each other at the same location.**

The findings of interviews and surveys held also show that not all representatives of European IWT countries have an equally good understanding of how the energy demand for IWT will evolve towards the future, whereas this is an important starting point for discussions on the required clean energy infrastructure for IWT. There are neither clear strategies yet for the development of the clean energy infrastructure for IWT. However, **aligned national strategies and deployment plans are crucial for a balanced development of the clean energy infrastructure at the corridor level.** At the EU level, the proposed AFIR and TEN-T revision are relevant for the clean energy infrastructure for IWT and have some specific shortcomings as indicated in chapter 4.

Technical gaps and challenges

On the technical front, **the challenge is to utilize the existing bunker infrastructure to store and deliver clean energy to vessels. Existing bunkering stations and bunker boats are not technically suitable for this**; there are also legal bottlenecks here due to safety rules and permits. I.e. existing bunker boats are not allowed to carry H2 stacks. It would help to map the details here to understand if and how the existing bunker infrastructure can be utilized for the storage and delivery of clean energy to inland vessels. This allows the use of an existing and proven infrastructure and avoids stranded assets.

For suppliers of clean energy it will be technically challenging to provide (full) geographic coverage for their customers, since a large proportion of vessels operate on the spot market and will have varying sailing trajectories and may not be able to bunker and charge clean energy always at the same location. This will imply, especially in the deployment phase, a development of the clean energy infrastructure for specific cases and dedicated routes (e.g. container vessels, ferries, etc.) on limited parts of a corridor.

Containerized energy storage for e.g. batteries and hydrogen (and possibly also other forms of clean energy) seems currently a suitable option to reach a necessary degree of geographical coverage with swapping energy containers at existing container terminals. However, there are technical challenges both on the vessel and ashore. Not all (existing) vessels will be suited to carry containers and large parts of the sector never visit container terminals. Furthermore, a lot of inland terminals are still operated by one crane only and may not be able to take on the additional handling of clean energy-containers. However, swapping locations could also be at shore-side locations along waterways and not necessarily at container terminals. The feasibility of this would need to be mapped.

An overarching technical challenge is whether there will be enough supply of clean energy in all European IWT countries to meet the 55% GHG reduction targets by 2030. This is not yet entirely clear and is also going to depend on demand from other modes of transportation and industries. This should be monitored closely and it should be made clear what the prospects are for IWT in the various European countries and regions. Furthermore, clean energy such as H2 is not the same as fossil diesel and require a significant mind shift in the supply and bunkering of the fuel as well as the operations of the vessel. The stakeholders who are going to be affected should become aware of this need for a **mind shift** in a timely manner.

For OPS (onshore power supply) it is important to have the necessary electricity infrastructure in place. The grid should reach the quay side (in an effective manner), meet the demand (also from inland cruise vessels) and there should be a uniform concept for the operation of the shoreside power connections and a commonly accepted payment method. Looking to the future, it is also essential to **set up OPS points in such a way that it 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. Another infrastructural requirement is the navigability of especially the Danube. The reliability of the navigability is seen as a key condition for the realisation of the clean energy infrastructure.

Last, learning from the LNG bunkering infrastructure for IWT is also possible in other areas than only the legal one. This especially concerns the operation of the bunkering infrastructure, i.e. with operating the bunkering station in Cologne, bunkering pontoons and the truck-to-ship supplies. Lessons can be learned from the technical difficulties in construction and initial operations, this could be very relevant for the future (liquid) H2 infrastructure.

Policy recommendations

Given the identified gaps and challenges, the following policy recommendations can be made:

- Regulatory recommendations:
    - Harmonising and, where possible, easing permit procedures and rules for the construction and operation of the clean energy infrastructure (e.g. a bunkering station for alternative fuels, procedures for reserving quays for truck-to-ship bunkering, etc.).
    - Critically **review the experience gained with LNG** in IWT and draw lessons from it, in various areas.
    - Regulations that facilitate the roll-out of bunkering of clean energy should be drafted and accepted at a high pace. If it is not an option to realise this in the near future, the focus might first be laid on those aspects of the transition that are deemed to be in operation first. E.g. truck-to-ship bunkering will probably be a starting point for many forms of clean energy, the same goes for containerised energy bunkering.

- Economical recommendations:
  - Stimulating the creation of a market for clean energy by setting the required framework conditions, a.o. through sufficient funding for deployment of "green" vessels (e.g. CEF, Innovation Fund, national funding).
  - Facilitating the development of the clean energy infrastructure by providing the required physical conditions (e.g. as regards the electricity grid) and a better utilisation of available funding for infrastructural projects in IWT.
  - In relation to the two points above, funding programmes of the EU and member states should focus on closed-circle projects: projects including the demand-side, supply-side and all intermittent parties necessary for IWT operations on clean energy.
  - More emphasis should be placed on developing the electricity (transmission and supply) infrastructure from renewable energy sources for the IWT, for both OPS and battery charging points or swappable containers. This is because electricity is and will be the only source of energy that will be common for all the IWT segments. And while the exact necessities will only later become apparent, the current AFIR requirements provide a good starting point for the 'minimal requirements' that need to be met.
  - The actions on the shore-side should be matched by increasing the demand from ships through enforcing, speeding up or creating the conditions for the use of electricity in ports, the uptake of more hybrid or fully-electric ships, etc.
  - Given the existing significant number of ships using Stage V certified diesel or LNG engines, coupled with a still existing trend to use these technologies (also due to previous legislation and incentives), the use of biofuels and e-/bioLNG should be encouraged as much as possible for these ships.

- Harmonization recommendations:
  - Following the proposed AFIR and TEN-T revision, member states should set up clear strategies for the development of the clean energy infrastructure, adopting a corridor approach and aligning national strategies between IWT countries as much as possible. The TEN-T corridor programs and European Coordinators of the corridors should coordinate and assist Member States in the creation of joint policy frameworks and strategies. This is to ensure the creation of a **level playing field**, where no border-crossing acts as detriment to innovation.
  - With the proposed revision of the TEN-T, opportunities open up for clean freight and passenger transport over inland waterways in urban areas. Member States should explore how IWT could be integrated as much as possible in the Sustainable Urban Mobility Plans for urban nodes.
  - When drafting strategies, funding programmes and other policy instruments, the focus should be on a **Corridor Approach**. Investments in clean energy infrastructure should be done keeping in mind the corridor which it serves, not only the port it is located in. Focussing on corridors ensures a better spread of (publicly funded) investments rather than focussing on local or regional levels, or even individual ports.
  - Relevant policy makers at European IWT countries need to gain in-depth insights into regional and national energy demand of IWT and the impact of the potential future energy mix on the energy infrastructure for IWT.

Annex 1 Summary AFIR proposal

Annex I provides a summary of the proposed Alternative Fuels Infrastructure Regulation (AFIR)[84] that are relevant for the alternative fuel infrastructure along waterways and ports. The relevant highlights are as follows summarised in bullet points:

- Articles 9 and 10 set out provisions for Member States to ensure **installation of a minimum shore-side electricity supply** for certain seagoing ships in maritime ports and **for inland waterway vessels**. The articles also define further the criteria for exempting certain ports and set requirements to ensure a minimum shore-side electricity supply.

- **Shore-side electricity facilities can serve** maritime and inland waterway transport **as clean power supply and contribute to reducing the environmental impact** of seagoing ships and inland waterway vessels.

- Such biofuels and synthetic fuels, substituting diesel, petrol and jet fuel, can be produced from different feedstock and can be blended into fossil fuels at very high blending ratios. They can be technically used with the current vehicle technology with minor adaptations. **Renewable methanol can also be used for inland navigation** and short-sea shipping. Synthetic and paraffinic fuels have a potential to reduce the use of fossil fuel sources in the energy supply to transport. All of these fuels can be distributed, stored and used with the existing infrastructure or where necessary with infrastructure of the same kind.

- LNG is likely to play a continued role in maritime transport, where there is currently no economically viable zero-emission powertrain technology available. The Communication on the Smart and Sustainable Mobility Strategy points to zero-emission seagoing ships becoming market ready by 2030. Fleet conversion should take place gradually due to the long lifetime of the ships. **Contrary to maritime transport**, **for inland waterways**, with normally smaller vessels and shorter distances, **zero-emission powertrain technologies**, such as hydrogen and electricity, **should enter the markets more quickly**. LNG is expected to no longer play a significant role in that sector. Transport fuels such as LNG need increasingly to be decarbonised by blending/substituting with liquefied biomethane (bio-LNG) or renewable and low-carbon synthetic gaseous e-fuels (e-gas) for instance. Those decarbonised fuels can be used in the same infrastructure as gaseous fossil fuels thereby allowing for a gradual shift towards decarbonised fuels.

- Hydrogen fuelled vehicles should be able to refuel at or close to the destination, which is usually located in an urban area. To ensure that publicly accessible destination refuelling is possible at least in the main urban areas, all urban nodes as defined in Regulation (EU) No 1315/2013 of the European Parliament and of the Council should provide such refuelling stations. Within the **urban nodes**, public authorities should consider to deploy the **stations within multimodal freight centres** as those are not only the typical destination for heavy-duty vehicles but could also serve hydrogen to other transport modes, such as rail and **inland shipping**.
    - è "energy hubs" for multiple modes of transport.

[84] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the deployment of alternative fuels infrastructure, and repealing Directive 2014/94/EU of the European Parliament and of the Council COM/2021/559 final (https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021PC0559)

- In order to promote alternative fuels and develop the relevant infrastructure, the **national policy frameworks should consist of detailed strategies to promote alternative fuels in** sectors that are difficult to decarbonise such as aviation, maritime transport, **inland waterway transport** as well as rail transport on network segments that cannot be electrified. **In particular**, **Member States should develop clear strategies for the decarbonisation of inland waterway transport** along the TEN-T network in close cooperation with those Member States concerned. Long term decarbonisation strategies should also be developed for TEN-T ports and TEN-T airports, in particular with a focus on the deployment of infrastructure for low and zero emission vessels and aircraft as well as for railway lines that are not going to be electrified. On the basis of those strategies the Commission should review this Regulation with a view to setting more mandatory targets for those sectors.

- Maritime transport and inland navigation need **new standards to facilitate and consolidate the entry** into the market of alternative fuels, in relation to electricity supply and hydrogen, methanol and ammonia bunkering, but also **standards for communication exchange between vessels and infrastructure.**

- **Technical specifications for interoperability of recharging and refuelling points** should be specified in European or international standards. The European standardisation organisations ('ESOs') should adopt European standards in accordance with Article 10 of Regulation (EU) No 1025/2012 of the European Parliament and of the Council[85]. Those standards should be based on current international standards or ongoing international standardisation work, where applicable.

- 'alternative fuels' means fuels or power sources which serve, at least partly, as a substitute for fossil oil sources in the energy supply to transport and which have the potential to contribute to its decarbonisation and enhance the environmental performance of the transport sector, including:
    - (a) 'alternative fuels for zero-emission vehicles':
        - electricity,
        - hydrogen,
        - ammonia,
    - (b) 'renewable fuels':
        - biomass fuels and biofuels as defined in Article 2, points (27) and (33) of Directive (EU) 2018/2001,
        - synthetic and paraffinic fuels, including ammonia, produced from renewable energy,
    - (c) 'alternative fossil fuels' for a transitional phase:
        - natural gas, in gaseous form (compressed natural gas (CNG)) and liquefied form (liquefied natural gas (LNG)),
        - liquefied petroleum gas (LPG),
        - synthetic and paraffinic fuels produced from non-renewable energy;

[85] Regulation (EU) No 1025/2012 of the European Parliament and of the Council of 25 October 2012 on European standardisation, amending Council Directives 89/686/EEC and 93/15/EEC and Directives 94/9/EC, 94/25/EC, 95/16/EC, 97/23/EC, 98/34/EC, 2004/22/EC, 2007/23/EC, 2009/23/EC and 2009/105/EC of the European Parliament and of the Council and repealing Council Decision 87/95/EEC and Decision No 1673/2006/EC of the European Parliament and of the Council (OJ L 316, 14.11.2012, p. 12).

- Article 10 **Targets for shore-side electricity supply in inland waterway ports**. Member States shall ensure that:
    - (a) at least one installation providing shore-side electricity supply to inland waterway vessels is deployed at all TEN-T core inland waterway ports by 1 January 2025;
    - (b) at least one installation providing shore-side electricity supply to inland waterway vessels is deployed at all TEN-T comprehensive inland waterway ports by 1 January 2030.
    - In the Annex to the AFIR references are being made to the technical specifications and that these shall comply with Commission Delegated Regulation (EU) 2019/1745[86]

- By 1 January 2024, each **Member State** shall **prepare** and send to the Commission a **draft national policy framework for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure**.
  That national policy framework shall contain at least the following elements:
  …
    - (o) a **deployment plan for alternative fuels in inland waterway transport**, **in particular for both hydrogen and electricity**;

  …

- On the basis of national policy frameworks and national progress reports of Member States pursuant to Article 13 (1) and 14 (1), the Commission shall publish and regularly **update information on the national targets and the objectives submitted by each Member State regarding**:
    - (c) the infrastructure for shore-side electricity supply in maritime and inland ports of the TEN-T core network and the TEN-T comprehensive network;
    - (e) the number of refuelling points for LNG at maritime and inland ports of the TEN-T core network and the TEN-T comprehensive network;
    - (h) refuelling and recharging points for other alternative fuels at TEN-T core and comprehensive maritime and inland ports;

[86] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1745&from=EN Mentions a.o. that CEN and Cenelec informed the Commission of the standards recommended to be applied to shore–side electricity supply for inland waterway vessels. The standards EN 15869-2 'Inland navigation vessels — Electrical shore connection, three phase current 400 V, up to 63 A, 50 Hz — Part 2: Onshore unit, safety requirements (in process of being amended to increase amperage from 63 to 125)'and EN 16840 'Inland navigation vessels – Electrical shore connection, three phase current 400 V, at least 250 A, 50 Hz'should apply to that electricity supply. Therefore, point 1.8 of Annex II to Directive 2014/94/EU should be supplemented accordingly.

Annex 2 Summary TEN-T revision proposal

Annex II provides a summary of the Commissions proposal[87] for a revision of the TEN-T Regulation of 21 December 2021, both a general concise summary and specifically of the relevant implications for the alternative fuel infrastructure along waterways and ports. The relevant highlights are as follows summarised in bullet points:

- Treaty on the Functioning of the European Union (TFEU) is the legal basis and stipulates the establishment and development of trans-European networks.
- TEN-T provides all relevant actors with a common policy framework (establishes guidelines) which works towards the gradual completion of the common and consistent European transport infrastructure network.
- Legislative proposal for the revision of the regulation is a key action of the EU Green Deal and the Sustainable and Smart Mobility Strategy. Also the relevance of the zero-pollution ambition is being raised in the document.
    - For IWT this a.o. means increasing the market share by 25% by 2030 and by 50% by 2050.
- **Aim** of the TEN-T Regulation is to build an effective EU-wide and multimodal network of rail, inland waterways, short sea shipping routes and roads which are linked to urban nodes, maritime and inland ports, airports and terminals across the EU.
- TEN-T revision aims at **four main objectives**:
    - making transport greener by providing the appropriate infrastructure and to have transportation by more sustainable transport modes.
        - Sustainability a.o. by a reliable inland waterway network across the Union
    - 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

    ➔ In short; cohesion, sustainability, efficiency and user benefits.
- Completion of the network by 2050 with intermediate **deadlines** in 2030 and 2040. Completion of core network by 2030, extended core network by 2040 and comprehensive network by 2050.
    - Maps of the different types of network can be found in the Annexes. The IWT map in Annex I shows there is only a core network for inland waterways and no extended core and comprehensive. For ports, there is a distinction between core and comprehensive ports.
- uptake of recharging/refuelling infrastructure depends on synergies with a.o. the deployment of alternative fuels infrastructure (**AFIR** proposal).
- In terms of **funding/financing** the TEN-T regulation is directly linked to CEF, funded by ESIF and RRF.

[87] Note that it concerns a proposal which is still subject to discussions with Member States and the final approved version can still deviate/be modified from the proposal.

- Impact assessment: three policy options assessed on economic, social and environmental aspects. Option 3, is the most ambitious (accelerating the completion of TEN-T network) and preferred option.
- Reinforced role for **European Coordinators** and the **Corridor Fora**.
- Revised regulation will deviate from the current regulation and be **organised by transport mode** and not anymore by network layer (core and comprehensive).
- **Horizontal priorities**:
    - European rail traffic management System
    - European Maritime Space.
- **Projects of common interest**: projects that will contribute to the achievement of the trans-European transport network & objectives, and correspond to the priorities. Implementation should depend on maturity, compliance with Union/national legal procedures and availability of financial resources, without prejudging the financial commitment of a Member State or of the Union. These projects have European added value, as they contribute to a high-quality, interoperable and multimodal European network, increasing sustainability, cohesion, efficiency or user benefits.
  Member States should ensure that appropriate measures are taken to finalise projects of common interest of the core, extended core and comprehensive network by 2030, 2040 and 2050 respectively.
  In the CEF Transport blending facility only projects which can be identified as projects of common interest identified in the TEN-T Guidelines may receive Union financial assistance.
- A **project of common interest shall**:
    - (a) contribute to the objectives falling within at least two of the four categories set out in Article 4;
    - (b) be economically viable on the basis of a socio-economic cost-benefit analysis;
    - (c) demonstrate European added value.
- **European Transport Corridors**: should cover most important long-distance transport flows and consist of key European transport multimodal axis, based on parts of the trans-European transport network, be multimodal and open to all transport modes and cross at least two borders and involve at least three transport modes. ➔ parts of TEN-T, which are of the highest strategic importance.
- TEN-T requirements should take into account the specific hydro-morphology of each waterway (for example free-flowing or regulated rivers) as well as the objectives of environmental and biodiversity policies. Such an approach should be considered at river basin level.
- urban nodes should develop a Sustainable Urban Mobility Plan (**SUMP**); a long-term, all-encompassing integrated freight and passenger mobility plan for the entire functional urban area. This should include objectives, targets and indicators underpinning the current and future performance of the urban transport system, at minimum, on greenhouse gas emissions, congestion, accidents and injuries, modal share and access to mobility services, as well as data on air and noise pollution in cities.
  MS should establish a national SUMP support programme.
    - This provides opportunities for clean urban freight/passenger city logistics over inland waterways.
- **Planning** of TEN-T is required, including **implementation of specific requirements** for a.o. **alternative fuel infrastructure rollout** as defined in AFIR. ➔necessary to ensure adequate and concerted deployment of such requirements across Europe for each transport mode and for their interconnection across the trans-European transport network and beyond.

- the availability of alternative fuels and related infrastructure should be improved throughout the trans-European transport network.
- European Coordinators should facilitate the coordinated implementation of the European Transport Corridors and of the two horizontal priorities.
- **TEN-T funding** should comply with this regulation and in particular be based on Regulation (EU) No 2021/1153 of the European Parliament and of the Council (CEF). In addition, network funding should also build on funding and financing instruments provided under other Union law, including InvestEU, the Recovery and Resilience Facility, Cohesion Policy, Horizon Europe and other financing instruments established by the European Investment Bank.
- **Ambitious reforms** should be implemented by Member States to address the challenges of sustainable transport. The commission supports Member States through the Technical Support Instrument providing tailor-made technical expertise to design and implement reforms.
- To ensure uniform conditions for the implementation of this Regulation, **implementing powers** should be conferred on the **Commission** as regards **implementing acts** which specify reference water levels and minimum requirements per river basin (good navigation status),..
- facilitate inland waterway transport with third countries
- in the development of the (extended) core and comprehensive network, general priority shall be given to measures that are necessary for: (a) **increasing freight and passenger transport activity of more sustainable modes of transport** in view of a reduction of GHG emissions from transport;
    - Complementary: **particular consideration** shall be given to measures that are necessary for: (a) contributing to transport emission reduction and increased energy security by **promoting the use of zero-emission** vehicles and **vessels** and **renewable** and EN 40 EN **low-carbon fuels**, through the **deployment of corresponding alternative fuels infrastructure**;

The following is a one-to-one copy of chapter 3 specific provisions section 2 for **Inland Waterway Transport Infrastructure**:
Article 20
Infrastructure components
1. Inland waterways infrastructure shall comprise, in particular:
   a) rivers;
   b) canals;
   c) lakes;
   d) related infrastructure such as locks, elevators, bridges, reservoirs and associated flood and drought prevention and mitigation measures which may bring positive effects to inland waterway navigation;
   e) access waterways and last mile connections to multimodal freight terminals connected by inland waterways, in particular in inland and maritime ports;
   f) mooring and rest places;
   g) inland ports, including basic port infrastructure in the form of internal basins, quay walls, berths, jetties, docks, dykes, backfills, land reclamation and the infrastructure necessary for transport operations within the port area and outside the port area;
   h) associated equipment;
   i) ICT systems for transport, including RIS;
   j) the connections of the inland ports to the other modes in the trans-European transport network;

k) infrastructure related to facilities for alternative fuels as defined in Regulation (EU) […] [on the deployment of alternative fuels infrastructure];
l) infrastructure necessary for zero waste operations and circular economy measures.

2. Equipment associated with inland waterways may include equipment for the loading and unloading of cargos and storage of goods in inland ports. Associated equipment may include, in particular, propulsion and operating systems that reduce pollution, such as water and air pollution, energy consumption and carbon intensity. It may also include waste reception facilities, shore-side electricity power supply and other alternative fuels infrastructure for supply and generation and used oil collection facilities, as well as equipment for ice-breaking, hydrological services and dredging of the fairway, port and port approaches to ensure year-round navigability.

3. An inland port shall be part of the comprehensive network where it meets the following conditions:
(a) it has an annual freight transhipment volume exceeding 500,000 tonnes. The total annual freight transhipment volume shall be based on the latest available three-year average, based on the statistics published by Eurostat;
(b) it is located on the inland waterway network of the trans-European transport network.

Article 21
Transport infrastructure requirements for the comprehensive network
1. Member States shall ensure that **inland ports on the comprehensive network**, by 31 December 2050:
(a) will be connected with the road or rail infrastructure;
(b) offer at least one multimodal freight terminal open to all operators and users in a non-discriminatory way and which shall apply transparent and non-discriminatory charges;
(c) are equipped with facilities to **improve the environmental performance of vessels in ports**, including reception facilities, degassing facilities, noise reduction measures, measures to reduce air and water pollution.

2. Member States shall ensure that **alternative fuels infrastructure** is deployed in inland ports in compliance with the requirements of Regulation (EU) […] [on the deployment of alternative fuels infrastructure].

Article 22
Transport infrastructure requirements for the core network
1. Member States shall ensure that the **inland ports of the core network** meet the requirements set out in Article 21(1), points (a) and (b), by 31 December 2030 and in Article 21(1), points (c), by 31 December 2040.
2. Member States shall ensure that the inland waterway network, including connections referred to in Article 20(1), point (e), is maintained to enable efficient, reliable and safe navigation for users by ensuring minimum waterway requirements and levels of service and by preventing the deterioration of these minimum requirements or any of its defined underlying criteria (Good Navigation Status).
3. Member States shall in particular ensure that:
(a) Rivers, canals, lakes, inland ports and their access routes provide a navigable channel depth of at least 2.5 m and a minimum height under non-openable bridges of at least 5.25 m at defined reference water levels, which are exceeded at a defined number of days per year on a statistical average.

The reference water levels shall be established on the basis of the number of days per year on which the actual water level exceeded the specified reference water level. The Commission shall adopt implementing acts specifying the reference water levels referred to in the previous subparagraph per river basin. Those implementing acts shall be adopted in accordance with the examination procedure referred to in Article 59(3).

When specifying the reference water levels the Commission shall take into account the requirements that are set out in international conventions and in agreements concluded between Member States.

(b) Member States shall publish on a website accessible to the public the number of days per year as referred to under point (a) during which the actual water
(c) level exceeds or does not achieve the specified reference water level for navigation channel depth as well as the average waiting times at each lock;
(d) operators of locks shall ensure that locks are operated and maintained in such a way that waiting times are minimised;
(e) rivers, canals and lakes are equipped with RIS for all services according to Directive 2005/44/EC51, so as to guarantee real-time information to users across borders.

51 Directive 2005/44/EC of the European Parliament and of the Council of 7 September 2005 on harmonised river information services (RIS) on inland waterways in the Community (OJ L 255, 30.9.2005, p.152).

4. At the request of a Member State, in duly justified cases, exemptions from the minimum requirements referred to in paragraph (3), point (a), may be granted by the Commission by means of implementing acts. Any request for exemption shall be based on a socio-economic cost-benefit analysis, the assessment of specific geographic or significant physical constraints and/or of potential negative impacts on environment and biodiversity.

Deterioration of the minimum requirements caused by direct human action or by lack of diligence in the maintenance of the inland waterway network shall not be considered as a case justifying the granting of an exemption.

Member States may be granted an exemption in case of force majeure. Member States shall rehabilitate the navigability conditions to the previous status as soon as the situation allows for it.

Any request for exemption shall be coordinated and agreed with the neighbouring Member State(s) where applicable.

5. The Commission shall adopt **implementing acts** setting out requirements complementing the minimum requirements established in accordance with paragraph (3), point (a), second subparagraph, per river basin. These requirements may be related in particular to:

(a) complementary parameters for waterways specific for free flowing rivers;
(b) specifications for inland waterway infrastructure;
(c) specifications for infrastructure of inland ports;
(d) appropriate mooring places and services for commercial users;
(e) **deployment of clean energy infrastructure** to ensure corridor-wide access to alternative fuels;
(f) requirements for digital applications of the network and automation processes;
(g) resilience of the infrastructure to climate change, natural hazards and human-made disasters or intentional disruptions;
(h) introduction and promotion of new technologies and innovation for zero-carbon energy fuels and propulsion systems.

The implementing act referred to in the first subparagraph shall be adopted in accordance with the examination procedure referred to in Article 59(3).[88]

[88] Article 59 (3) says: Where reference is made to this paragraph, Article 5 of Regulation (EU) No 182/2011 shall apply. Where the committee delivers no opinion, the Commission shall not adopt the draft implementing act and the third paragraph of Article 5(4) of Regulation (EU) No 182/2011 shall apply. Article 5(4) of Regulation (EU) No 182/2011 prescribes the examination procedure: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0182&from=EN

6. The Commission shall ensure a coherent approach on the application of the good navigation status in the Union and may adopt guidelines thereto. When establishing minimum requirements for paragraphs (e) and (f), the Commission shall ensure that the interoperability between river basins is not compromised.

Article 23

Additional priorities for inland waterway infrastructure development

In the promotion of projects of common interest related to inland waterway infrastructures, and in addition to the general priorities set out in Articles 12 and 13, attention shall be given to the following:

(a) where appropriate, achieving higher standards for modernising existing waterways and for creating new waterways, in order to meet market demands;
(b) prevention and mitigation measures against flooding and droughts;
(c) the promotion of sustainable, safe and secure inland waterway transport, including within urban nodes;
(d) modernisation and expansion of the capacity of the infrastructure necessary for transport operations within as well as outside the port area;
(e) promoting and developing measures to improve the environmental performance of inland waterway transport and transport infrastructure, including zero and low emission vessels and measures to mitigate impacts on water bodies and water-dependent biodiversity, in accordance with the applicable requirements under Union law or relevant international agreements.

Below is a **summary** in bullet points of some highlights **from the revision after to chapter 3** specific provisions section 2 for Inland Waterway Transport Infrastructure:

- Multimodal freight terminals can be located in inland ports of the trans-European transport network.
- Multimodal freight terminals shall comprise, in particular: (e) infrastructure related to facilities for alternative fuels.
- When developing TEN-T in urban nodes, MS shall ensure:
  - a) availability of alternative fuels recharging and refuelling infrastructure, including in logistics platforms and for public transport in full compliance with the requirements of Regulation (EU) […] [on the deployment of alternative fuels infrastructure];
  - by 31 December 2030:
    - (i) for **passenger transport**: sustainable, seamless and safe interconnection between rail, road, air, the active modes of transport and, as appropriate, **inland waterway** and maritime infrastructure;
    - (iii) for **freight transport**: sustainable, seamless and safe interconnection between rail, road, and, as appropriate, inland waterway, air and maritime infrastructure as well as appropriate connections with logistics platforms and facilities;
- In order for the trans-European transport network to keep up with innovative technological developments and deployments, Member States shall aim in particular to:
  - a) **support and promote** the decarbonisation of transport through transition to **zero- and low-emission** vehicles, **vessels** and aircraft and other innovative and sustainable transport and network technologies such as hyperloop;
  - (b) make possible the decarbonisation of all transport modes by **stimulating energy efficiency, introduce zero and low emission solutions, including hydrogen and**

electricity supply systems, as well as other new solutions such as sustainable fuels, and provide corresponding infrastructure…

- **European Transport Corridors** are an instrument to facilitate the coordinated implementation of parts of the trans-European transport network and are intended, in particular, to improve cross-border links and to remove bottlenecks within the Union.
- Designation of one European Coordinator for each Corridor and for each horizontal priority.
- For each European Transport Corridor and horizontal priority, the respective European Coordinator shall be assisted in the performance of his/her tasks concerning the work plan and its implementation by a secretariat and by a consultative forum, respectively the "**Corridor Forum**" and the "**consultative Forum for the horizontal priorities**".
- The "Corridor Forum" and "consultative Forum for the horizontal priorities" shall be formally established and chaired by the **European Coordinator**.
- With the agreement of the Member States concerned, the European Coordinator may set up and chair **corridor working groups.**
- Each European Coordinator of the European Transport Corridors and the two horizontal priorities shall draw up, at the latest **two years** after the entry into force of this Regulation and thereafter **every four years**, a **work plan** that provides a detailed analysis of the **state of implementation** of the corridor or horizontal priority under his/her competence and its **compliance with the requirements** of this Regulation as well as the priorities for its future development.
- **Based on the first work plan** of the European Coordinators, the Commission shall **adopt an implementing act** for each work plan of the European Transport Corridors and the two horizontal priorities. This implementing act **shall set out the priorities for infrastructure and investment planning and for funding.**
- By 31 December 2033 assessment of the implementation of the core network.
- By 31 December 2033, review of the implementation of the extended core and the comprehensive network.

Annex 3 Longlist of clean forms of energy

Table 5: Longlist of clean forms of energy

Hybrid Combinations	**Clean Internal Combustion Engines**	**Engines**	NRMM Stage V IWP, IWA	
			NRMM Stage V NRE	
			EURO VI	
			SCR & DPF retrofit	
		Fuels	BioDiesel (FAME, HVO)	E-diesel
			BioMethane (Bio-LNG)	E-methane
			BioMethanol	E-methanol
			Blue hydrogen (H2), gas or liquid	E-H2 (green hydrogen), gas or liquid
			Blue ammonia (NH3)	E-ammonia
	Electrification	**Batteries**	Lithium Ion NMC technique	
			Lithium LiFePO4 technique	
			Flow batteries	
		Fuel Cells	PEM FC (automotive)	
		Energy carriers for Fuel Cells	Blue ammonia (NH3)	E-ammonia

			Blue hydrogen (H2), gas or liquid	E-H2 (green hydrogen), gas or liquid
			BioMethanol	E-methanol

Above, the longlist of clean energy options for the energy transition used in the report “Toekomst Duurzame Binnenvaart” by EICB and TNO in 2020 have been given. This to illustrate that more fuel options exist than those used in the scenarios used in the CCNR study. However, still other fuels that are not yet currently in view might emerge in the coming years.

Annex 4 List of IWT clean energy infrastructure initiatives

The table below provides a present list of non-exhaustive projects and initiatives that can have relevant results for the clean energy infrastructure for IWT.

Table 6: Overview of relevant projects/initiatives for clean energy infrastructure IWT

	RD&I programme / funded by	Project/initiative	Timeline	Link
1	-	H2ermes	-	https://www.portofamsterdam.com/nl/nieuwsbericht/nouryon-tata-steel-en-port-amsterdam-werken-samen-aan-project-h2ermes-groene-waterstof
2	Interreg	H2Ships	2019-2022	https://h2ships.org/
3	Interreg	ISHY	2019-2022	https://www.interreg2seas.eu/en/implementation-ship-hybridisation
4	Multiple funding authorities	RH2INE (Rhine Hydrogen Integration Network of Excellence)	2020-2030	https://www.portofrotterdam.com/nl/nieuws-en-persberichten/klimaatneutrale-rijn-alpen-corridor
5	-	Studie transport H2	-	https://www.portofantwerp.com/nl/news/samenwerkingsakkoord-voor-transport-waterstof?_cldee=ai52b2dlbGFhckBiaW5uZW52YWFydC5ubA%3d%3d&recipientid=contact-36935c1c6528e41189126c3be5bebf30-48e7726824004cc0b96e717f66edfbd2&utm_source=ClickDimensions&utm_medium=email&utm_campaign=201912_Radar_NL&esid=ce97aba0-d020-ea11-a810-000d3a4b2a09
6	-	Study on zero-emissions hydrogen shipping	-	https://www.nouryon.com/news-and-events/news-overview/2019/partners-cast-off-for-study-on-zero-emissions-hydrogen-shipping/
7	Multiple funding authorities	Waterstof voor walstroom	-	https://greenshippingwaddenzee.nl/projecten/waterstof-voor-walstroom/
8	CEF	Bio2Bunker	2020-2024	https://titan-lng.com/titan-lngs-ambitious-bio-lng-breakthrough-project-receives-eu-funding/
9	CEF	Electrification of the Seine Axis: onshore power and water supply for fluvial units	2020-2023	https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2019-fr-tm-0159-w

10	CEF	Towards more Efficient and Resilient IWW in Wallonia	2020-2024	http://mobilite.wallonie.be/home.html
11	H2020	IW-NET	2020-2023	https://www.iw-net.eu/
12	H2020	Current Direct	2021-2023	https://www.currentdirect.eu/
13	In-house	K2	-	https://www.waterstofaanboord.nl/#gebruik
14	Multiple funding authorities	Kennisdocumenten Schone Lucht Akkoord	-	https://www.schoneluchtakkoord.nl/thema/binnenvaart-havens/
15	-	Waterfront Shipping first STS methanol bunkering operation	2021	https://www.portofrotterdam.com/en/news-and-press-releases/waterfront-shipping-takes-leadership-role-demonstrating-simplicity-methanol
16	-	ZES	2020-present	https://zeroemissionservices.nl/
17	-	Port of Rotterdam studies to OPS	2021-2023	https://www.portofrotterdam.com/en/news-and-press-releases/the-municipality-of-rotterdam-and-port-authority-studying-possibilities-of?utm_campaign=&utm_content=C%26EA_NEWS_port-in-action_NB-januari-2022_EN&utm_medium=email&utm_source=Eloqua
18	H2020	MAGPIE	2022-2027	https://www.magpie-ports.eu/
19		H2meetsH20		
20	IPCEI on Hydrogen	IPCEI Green Hydrogen @ Blue Danube		https://www.hydrogenious.net/index.php/en/references/blue_danube/ https://www.hydrogenious.net/index.php/en/references/blue_danube/
21	H2020	Pioneers		https://pioneers-project.eu/
22		Towards more Efficient and Resilient IWW in Wallonia		https://ec.europa.eu/inea/en/connecting-europe-facility/cef-transport/2019-be-tm-0120-s

Annex 5 Projects in ports

Port of Rotterdam[89]

When speaking about maritime port being a future green hub, the port of Rotterdam as the largest European maritime port must be put in front.

Various ongoing initiatives for port development are based on the creation of a large-scale hydrogen network in the port complex, making Rotterdam an international hub for hydrogen production, import, application and transport to other countries in Northwest Europe. Being the largest maritime port in Europe today together with large-scale hydrogen production will enable Rotterdam to transform into important energy port for Northwest Europe in the future.

It has to be emphasized that the port of Rotterdam is going beyond the creation of production facilities for green energy in its complexes. The Netherlands is building up a concept of the hydrogen economy, where the country can take a leadership considering ports as key elements in the economy. The port of Rotterdam is an energy hub for Europe already for decades now and with a new industrial facility – integrated operational cluster – it will for sure become a "green" energy hub of Europe.

The port of Rotterdam will have a hydrogen system that combines production and use, particularly in industry, but also imports and transit flows of hydrogen to other parts of the Netherlands and Northwest Europe (estimated import of hydrogen from the port of Rotterdam by 2030 is 4 million tons). The Port Authority and Gasunie are working on an initiative to have a backbone for hydrogen running through the port as early as 2023. This main transport pipeline will supply companies with hydrogen produced at conversion parks in the port. The backbone will be connected to Gasunie's national infrastructure throughout the Netherlands and to corridors leading to industrial areas in Chemelot in Limburg, and North Rhine-Westphalia. In time, there are also plans for a terminal to facilitate imports of hydrogen. This will give Rotterdam a leading infrastructure in the field of hydrogen that will stimulate market development. In addition to making an important contribution to the national climate targets, a hydrogen system of this kind will also boost the earning power of the port complex, whilst maintaining the important role of the port for the Dutch economy in the future.

Hydrogen production is not a new activity for the port of Rotterdam, yet, grey hydrogen produced in the port before was based on LNG. Another option considered – is low-carbon production of blue hydrogen based on capturing and storing the CO2 below the seabed in depleted gas fields. CO2 can also be used in greenhouses as a growth accelerator.

A third option is carbon-free green hydrogen, which is produced by electrolysing water using green power, for example from offshore wind farms. No CO2 is released and combustion does not emit any greenhouse gases either.

The first conversion park for hydrogen production will open on the Maasvlakte in 2023. Hydrogen is produced centrally here and transported to companies through the backbone. Eneco is building a wind farm on the outer edge of Maasvlakte 2, commissioned by the Directorate-General for Public Works and Water Management. The wind farm comprises a total of 22 wind turbines that will collectively generate 416 GWh of green electricity a year, as of 2023. The work will be carried out from mid-February to the end of November 2022.[90]

[89] https://www.portofrotterdam.com/en/port-future/energy-transition/ongoing-projects/hydrogen-rotterdam

[90] https://www.portofrotterdam.com/en/building-port/ongoing-projects/maasvlakte-2

Port of Duisburg (Germany)

The Port of Duisburg is the world's largest inland port and the leading logistics hub in Central Europe. It is located in the heart of Europe's largest consumer market with more than 30 million consumers over a radius of 150 kilometres. 20,000 ships and 25,000 trains are processed per year.[91] In 2020 port of Duisburg published its statement to become a hydrogen hub. To implement this statement into a real project it was necessary to ensure that there is a high hydrogen demand in port and around port. The idea started with initiatives, research, cooperation and establishment of partnerships and resulted with the construction project of new climate neutral container terminal (to be the biggest inland container terminal in Europe – 1 million TEU handling capacity).

The terminal will have an integrated system – smart grid with the following features:

- Innovative crane system for electricity saving and noise reduction;
- Use of 100% green electricity;
- Use of hydrogen-powered shunting locomotives;
- Development of intelligent energy networks combined with decentralized energy production;
- Abandonment of use of terminal vehicles: all the movements of containers in this terminal are designed to be done only by cranes, no fork-lifts, no reach-stackers, no heavy-duty vehicles, no other container handling equipment except for cranes.
- Provision of short-side power.

This shows that to become an energy hub, for port it is necessary to look into its own activities and to see what can be restructured in order **to create own demand** for energy sources generated within the port.

Port of Duisburg considered several options to go green. First idea was based on implementation of combined heat and power (CHP) gas system, which was a greener yet not innovative option. The port was working with several partners to ensure that energy supply to the terminal will be climate neutral. To do this it was decided to build a hydrogen-based supply network ready for operation by 2023. The proposed solution will include several technologically sophisticated options for energy conversion and storage. Eventually, based on collaboration with Rolls-Royce it was decided to use mtu fuel cell solutions for electrical peak load coverage as well as mtu hydrogen heat and power generation station will supply the future terminal with electrical energy and heat in a sustainable way. This approach is based on the idea of decentralized energy supply in port and smart grid.

Smart grid combines all the parts of terminal which produce energy with the ones consuming the energy, of estimated total consumption - 4 megawatts. The goal is to provide this energy decentralized with green H2 and solar energy, which will also require lots of storage to have an energy stock when there is no sun.

H2 system to be deployed in Duisburg harbour based on mtu hydrogen Ecosystem (gridUP), which consists of polymer electrolyte membrane (PEM) fuel cells, hydrogen CHP units, storage, control system on the asset level, electrolysers (when needed). Electrolysers for the port of Duisburg will not be used at the first stage of project implementation, but for the follow-up project of local H2 production.

Two combined heat and power plants with mtu hydrogen engines convert hydrogen energy into electrical energy, which is fed into the supply network of the future container terminal or into the public grid. The waste heat is used for process heat or for heating buildings in and around the port.

[91] https://www.duisport.de/hafeninformation/?lang=en

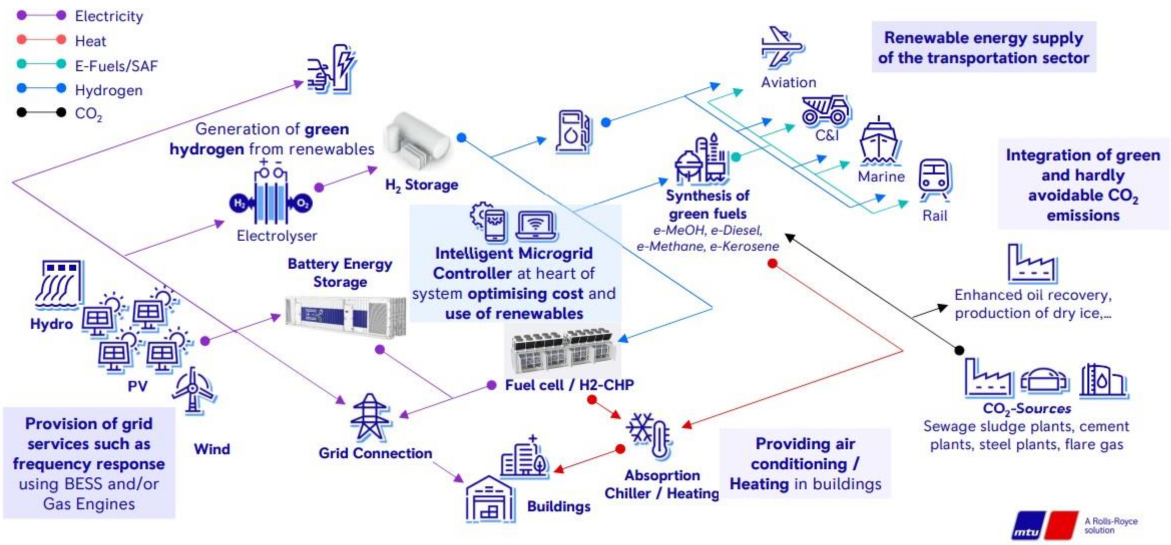
The project is being funded by the German Federal Ministry for Economic Affairs and Energy for a period of four years as part of the "Hydrogen Technology Offensive".[92]

The reason to produce H2 in the port of Duisburg was stipulated by its unique location as a large hub, which has an access to renewable energy, to green energy, to heat, to multimodal connections, which will also estimate demand in H2 for future. Taking into account that vessels can get FC, container handling (hydrogen CHP units) will be also decarbonized, the whole port will be emission free.

What is already estimated in advance and reflected in CBA, port itself will be using the green energy, but also will have a lot of customers consuming energy for heating.

It is planned to install modules of 1.5 megawatt in fuel cells, 2.3- 2.5 megawatt in hydrogen engines in combination with battery, storage and photovoltaic panels (PV). All this together will provide port with green energy day and night. Due to the smart grid installed, the system will be optimizing itself with off-grid, on-grid depending when it is better to use hydrogen or PV.

Figure 5: Renewable Cross-Sectoral Energy System – A Rolls – Royce Solution



Project idea was based on connection of the terminal and its energy system with all the companies around the terminal. Bringing together different sectors through provision of energy for industrial and residential areas around. This is the main goal of the project. Companies and sector around the port are large consumers of the energy. Same goes for residential area in a proximity to the port, which will use green energy for heating. That's why demand for the energy produced in port is already estimated. "Sector coupling" approach – bringing several sectors together was used in port of Duisburg to estimate the demand for green energy produced by port.

The concept developed in the port of Duisburg is deployable in any other port, because it starts for own demand on the energy for port`s needs and goes broader for local consumers.

Port of Basel (Switzerland)

Another example of hydrogen production in ports can be given from the perspective of port of Basel with the project on building-up H2-Ecosystem. Due to its favorable location and proximity to the largest European ports (Amsterdam, Antwerp, Rotterdam) port of Basel undertook an initiative to

[92] https://www.rolls-royce.com/media/our-stories/discover/2022/duisburg-container-terminal-goes-climate-neutral.aspx

turn into a green energy hub by building up port Eco-Systems considering its future potential not only from perspective of hydrogen production, but also further transportation/distribution.

Port is using the Eco-System definition in the economic sense, which describes a network of companies (typically three to about ten) that is aligned by an orchestrator towards a common value creation. From the customer's point of view, the performance of the entire ecosystem exceeds the sum of the individual contributions of all participants. (Wikipedia DE)

The initiative of hydrogen supply in port started in cooperation with existing 100-megawatt hydrogen power plant (operating 2.5 - megawatt electrolyser) located close to the port of Basel. Basel governance model is port landlord, which means that major investments in the port will not be undertaken by the port itself, but given as a decision to main concessionaires - to private companies. Basel has lots of companies operating mineral oil transhipments in the port, which have experience of handling and enough storages for dangerous cargoes. From the perspective of supply, there are also consumers in port or/and located in a proximity to the port: industries, logistic companies, producers etc. Port of Basel already has an experience from the joint venture with Hyundai, where 46 fuel cells truck units are operating already for 2 years with planned increase of up to 1600 units until 2025, for which new fuel stations in the port are being built. High demand is being identified for hydrogen not only locally in Switzerland, but for the entire Rhine region. Green energy for the barges in port will be offered too in the nearest future.

The need for hydrogen is based on the following considerations:

- fossil tank storage will decline to zero until 2050;
- Switzerland will also need energy import;
- H2 / hydrogenated substances (methanol, EFuels) will be a part of national greening solution;
- H2 will also be a part of energy sources.

As mentioned above, the port is not involved in the investment process for this initiative, but is playing a role of a platform to bring together different partners and to solve institutional problems.

There are lots of questions to foresee, to solve about logistics, storage, distribution and delivering to direct users. Despite this a first step has been undertaken and partnerships were established with local energy / heating providers (Industrielle Werke Basel), fuel traders and fuel station operators (Fritz Meyer), mineral oil company (Varo Energy).

Eco-System approach is divided into several phases:

Phase I: Concretization → Development of a clear ecosystem vision → Development of all the auxiliary and complementing measures→ Elaboration of the roadmap for the project → Defining the project organization in which project ecosystem be implemented

Phase II: Development use cases → Visualization of concrete use cases → Identification of the potential hydrogen sales volumes → Rough cost estimations for different use cases

Phase III: Winning partners → Identification of the potential partners with whom use cases can be implemented → Identification of conditions to attract potential partners

Phase IV: Preparation for implementation → Step-by-step approach for implementation framework → Development of cross-partnership within the project → Decision on funding distribution.

Port of Basel is considering several options for future hydrogen activities in port:

- Option: import of green energy via Rhine – port serves as a transportation hub;
- Option: H2 storage / logistic in port – port serves as distribution centre;
- Option: H2 consumer in port industry, green vessels or trucks, intra logistics – port serves as a supplier.

Port of Mannheim (Germany)[93]

The oil production in Mannheim's harbour Bonadieshafen, with an annual capacity of over 1 million tons is one of the biggest in Europe, operating in the port since 1887, when six German oil mills joined forces and created the „Verein deutscher Ölfabriken" („German Oil Mill Association").

Today it is the Bunge Group, one of the world's largest trading and processing companies of oil and grain seeds.

In 2013, the Mannheim Bio Fuel GmbH, which had been operated as a joint venture, was fully taken over, in order to achieve an even more efficient execution of the highly interdependent production processes. With this acquisition and others, BEMEA is one of the largest industrial producers of biofuels in Europe.

In 2016, the Mannheim Bio Fuel GmbH was successfully merged into the Bunge Deutschland GmbH. The Merger was published on August 15th, 2016 and is valid from January 1st 2016. The Merger is a milestone of the Optimization-Program in the Biodiesel Branch.

The nominal capacity at their production site in Mannheim is currently 120.000 tons of biofuel per year. Its strategically favourable location in the upper Rhine region offers the best prerequisites for delivery to customers along the Rhine River. The main supply of rapeseed oil is provided by Bunge Deutschland through an environmentally friendly direct pipeline.

Products are delivered directly to European mineral oil companies, mineral oil trading companies, independant gas stations and logistic companies. In addition to biofuel, MBF also sells high-quality crude glycerin which is a by-product of the biofuel production process.

Danube ports – future green energy hubs

The Danube region´s river and sea ports are important logistics and transport nodes in supply chains and contribute substantially to regional economic development and cohesion as industrial hubs. In the context of the energy transition, ports have significant untapped potentials to become hubs for clean energy production and distribution as well as for the development of the circular economy. Against the backdrop of the Paris Agreement, the EU Green Deal and non-EU Danube States with similar national commitments have set ambitious climate goals for 2030 and 2050 that require immediate and targeted action to decarbonise all sectors of the economy, including the mobility sector.

One of the initiatives, which could develop a chain of production, transportation and utilisation of green hydrogen in the Danube region using IWT and inland ports as hubs was presented in IPCEI Green Hydrogen @ Blue Danube during Platina3 1st Stage event (Budapest sessions).

The idea of creation of trans-European value chain, reaching a synergetic effect of decarbonization, production of sustainable fuel and transportation by means of the most sustainable transport mode connecting industries, mobility and energy was reflected in this project initiative.

Considering lower industrial density in the Danube region than in North – West Europe it is important to start with analysis of potential of alternative fuels production, current investment trends and projects dedicated to construction and operation of corresponding facilities (refineries in case of biofuels, electrolysis plants for hydrogen, recycling stations – for waste generated fuels etc.) as well as national strategies related to production of alternative fuels in the region.

93 https://www.bunge-deutschland.de/en/company/locations/mannheim/

When speaking about hydrogen, already today it is possible to assume to a much higher degree, that Danube states like Austria, Germany just like most Western European countries, will rely on imports of green hydrogen to achieve their ambitious climate targets. In this regard, recently completed project H2FUTURE shall be mentioned here.

H2FUTURE is a European flagship project focused on the generation of green hydrogen from electricity from renewable energy sources. Under the coordination of the VERBUND, the steel manufacturer Voestalpine and Siemens Energy, a proton exchange membrane (PEM) electrolyser manufacturer, a large-scale 6 MW PEM electrolysis system will be installed and operated at the Voestalpine Linz steel plant in Austria. The Austrian transmission system operator (TSO) Austrian Power Grid (APG) will support the prequalification of the electrolyser system for the provision of ancillary services. The Netherland's research centre TNO and K1-MET (Austria) will study the replicability of the experimental results on larger scales in EU28 for the steel industry.[94]
Given that Austria and Germany will not be able to produce enough hydrogen, production of green hydrogen from renewable electricity in south-eastern Europe could be a solution, proposed by IPCEI Green Hydrogen @ Blue Danube. There, wind, solar and hydropower could be converted into hydrogen directly on site and then transported as LOHC via the Danube River to main hydrogen users in Austria and Germany.

From the perspective of hydrogen production in south-east Europe it has to be mentioned that potential of the Danube riparian states for production and transportation of hydrogen by IWW where Danube ports can play a role of green hubs was studied by the Secretariat of the Danube Commission and its Member States and followed by discussions during the Danube Commission expert group meetings on ports and port operations. In particular, wind and solar potential of countries like Romania, Bulgaria and Ukraine is being investigated. In this regard, for example, in Romania, with establishment of corresponding production sites (off-grid), as close to Danube port as possible, with the corresponding electrolyser, LOHC hydrogenation capacity and storage can be a starting point. Taking into account that the focus shall be put on decarbonization, it means that the whole supply chain must be decarbonized in future (or to be low-carbon). But for initial stage conventional existing facilities can be used for transportation of hydrogen with future scenario of gradual inclusion of green IWT fleet into supply chain through following steps of introduction of designated fleet with low-carbon powertrain and further development of H2- propelled ships and barges.

It has to be mentioned that various initiatives on the national level are ongoing in Romania with regards to production of renewables. In order to reach its 2030 renewables target of 30.7%, Romania plans to add around 6 GW of new capacity in wind farms and solar power plants, according to the National Energy and Climate Plan (NECP) for the period 2021-203095. Various ongoing initiatives on the governmental level, such as deployment of additional 950 MW of renewable energy capacity (wind and solar projects), photovoltaic (PV) deployment etc. demonstrate intentions of the government to increase production of green energies.

Ukraine joined the Green Hydrogen for the European Green Deal initiative and established in 2018 energy association "Ukrainian hydrogen council" - "a first hydrogen energy association of leading energy, industrial and public companies of Ukraine, joined by the desire and understanding of the necessity for integration of modern energy technologies into the Ukrainian economic model, modernization of the energy complex of Ukraine and implementation of a sustainable development

94 https://www.h2future-project.eu/

95 https://balkangreenenergynews.com/romanias-necp-6-gw-of-solar-wind-to-be-installed-by-2030/

for a global transition to renewable hydrogen energy resources".[96] There are currently several pilot hydrogens projects in Ukraine for the production, use, and transportation of hydrogen. One of them is a project to create an energy cluster in Southern Bessarabia (Odessa region) focused on the production of electricity from renewable energy sources, the production of green hydrogen, and its export to the European Union. The plans are to implement the construction of an electrolytic power plant with a capacity of 3,000 MW and a solar power plant with a capacity of 5,000 MW. In the Rivne region, it is planned to build a wind farm with a capacity of 72 MW for the production of environmentally friendly hydrogen. It will be sold to the Rivneazot plant for ammonia production. Currently, the project is at the stage of development and feasibility study.[97] Taking into account war situation in Ukraine today and intentions of Ukrainian government to fully eliminate usage of Russian energy it can be though emphasized that with potential Ukraine has for production of green energy it will continue with its developments towards hydrogen after the end of the war and liberation from Russian occupation. Current intentions of the Ukrainian government are reflected in existing so-called hydrogen cases.[98]

Wrapping up aforementioned assumptions it can be stated that potential for production (Lower Danube) and consumption (Middle, Upper Danube) of renewables (in particular, high demand for hydrogen) is already been indicated in the Danube region. The role of the Danube waterway in this regard is also been estimated. Transportation of hydrogen in LOHC, will allow use existing transport facilities and infrastructure.

In the long run, pipelines for hydrogen transportation will most likely take place in long-term perspective (considering time needed for construction of the pipeline network all over Europe), yet, in short- and mid- term perspective transportation by IWT in the Danube region is considered as the most cost-efficient and easy to implement solution.

Coming to the role of the Danube ports as to a specific case of alternative fuels infrastructure applications it makes it clear that to turn Danube ports into green energy hubs will require, from the port perspective, conduction of a solid assessment of the existing assets from the perspective of infrastructure, transport potential, availability of the local energy producers, storage and capacities, estimation of energy demands in the region, on-going and planned projects on the transport corridors in the Danube region, hinterland connections, AFI development projects in ports, as well as projects related to the development of multimodal transhipment facilities.

Investment needs in ports shall be evaluated for future investment in infrastructure/superstructure of selected ports for the previously identified potential deployment of AFI and corresponding facilities.

It has to be mentioned that important role in deployment of AFI and, in particular, industrial development regarding production of green energies in ports, shall be given to comprehensive analysis of regional economic development strategies, policies & programs to provide a better overview and closer look into relevant (regional) economic development strategies, policies and programmes of interest for ports development. With regards to the Danube region, this is an important work, which is currently being conducted within DTP DIONYSUS project.[99]

Same goes for analysis of European & national transport policies, strategies & programs with regard to the Danube Ports (Summary Report & Country Reports) developed within DTP DIONYSUS and

96 https://hydrogen.ua/en/

97 https://hydrogen.ua/en/news/1281-blue-danube-an-opportunity-to-develop-the-hydrogen-economy-in-ukraine

98 https://cleantechnica.com/2022/06/20/ukraine-primes-the-green-hydrogen-pump-for-eu-membership/

99 https://www.interreg-danube.eu/approved-projects/dionysus

providing an in-depth insight of all port-related development documents on both European and national levels.

Even though the project is not directly linked to alternative fuels infrastructure and corresponding activities in ports, its assessment of the existing gaps in regional development and transport policies provides certain recommendations on the gaps needed to be closed in order to provide harmonized port development also in context of future energy transition.

National Infrastructure Master Plans, elaborated by DIONYSUS will also include accompanying organizational and regulatory measures, will identify responsibilities and will address issues of financing the proposed investment.

Another project, which can serve as example from the perspective of building a Transnational Implementation Plan for bioenergy related developments in the ports and harmonization of individual prefeasibility pilot studies is DTP project "ENERGY BARGE – Building a Green Energy and Logistics Belt".[100]

NAIADES III Study on greening of inland ports, launched in April 2022, will also provide lots of measures and steps for port to be undertaken to go green. It can serve as a guideline for public authorities and private operators, as well as a guideline for future projects applications.

Danube Commission already undertook certain steps, supported by experts from Danube riparian states, to support Danube ports to develop strategies, action plans and projects to reduce ports' greenhouse gas emissions by 55% by 2030 and ensure the sustainability of port development and operations. In this way, in order to bring together port authorities, port administrations, port operators and other port businesses to implement concrete measures to reduce greenhouse gas emissions and ensure sustainability of port development and operations as well as to activate intensive cooperation and coordination between port actors across borders and across economic sectors at transnational level it was proposed to sign a "Declaration on decarbonization and sustainability of river and sea ports in the Danube region". The Declaration was signed by number of ports already, and will be submitted presumable in March 2023 during the next expert group meeting on ports and port operations. The proposed declaration will provide a platform for targeted cooperation between ports in the Danube Region and contribute to the creation of a pipeline of concrete implementation projects. The special focus of this declaration is dedicated to the role of ports as important hubs for industry, clean energy and circular economy development, as well as to decarbonization of ports and port operations through the implementation of a range of different measures and accompanied by public and private stakeholders.

The declaration underlines the following measures to be undertaken by the undersigned public and private port stakeholders:

- Identify, assess and monitor the environmental impact of port operations (air, water quality, waste, noise, dust, sediments);
- Develop and implement Environmental and Sustainable Management Systems (ESMS);
- Identify and implement new, environmentally friendly and sustainable solutions that support the increase of energy efficiency and the transition to the use, generation and distribution of renewable energy and to zero-emission port operations;
- Initiate/participate in the development of strategies, action plans and implementation projects aimed at reducing greenhouse gas emissions and achieving sustainability goals;
- Facilitate the implementation of alternative and renewable fuels infrastructure;

100 https://www.interreg-danube.eu/approved-projects/energy-barge

- Facilitate the exchange of know-how and other cooperation activities between ports and engage in cross-sectoral cooperation, research and development initiatives and projects to promote the greening of port development and operations;
- Support urban and short-distance inland waterway transport (water buses, ferries, urban logistics, etc.) where possible;
- Investigate and exploit opportunities arising from digitalization of port management and operations to increase efficiency and support sustainability.

DC has been following changes in the port infrastructure for years. The “Album of Ports” was first released by the DC Secretariat in 2007 in tabular form with a basic dataset and published on the DC website as well as on CD. For the album, ports located on the Danube, Sava and Tisza rivers were described based on 24 parameters and were first displayed on an interactive map in 2017. There is a proposal how to expanding the Danube ports database by incorporating additional parameters related to port infrastructure (physical, digital and environmental) using the GIS system.

DC Secretariat provides a concept for data collection by a web interface[101] where each port administration will receive access data and a password. Preparatory activities will be completed by the end of July of 2022 and progress will be reviewed at EM Ports meeting in March 2023 with aim on full implementation from 2023.

In order to provide a better overview of the availability of alternative fuels' infrastructure facilities in the Danube Region, the Danube Commission is planning to expand its database on Danube ports[102], which was created in 2017, and is getting updated on a regular basis by the Danube Commission Secretariat. At the current moment, the database contains information about 75 ports and 198 terminals on the Danube and is planned to be expanded with data on alternative fuel bunkering facilities as per type of particular fuel and data on OPS terminals in ports. Danube ports infrastructure database could become an instrument for promotion & monitoring port infrastructure development in terms of availability of AFI across the Danube River. This can be an open source platform of the deployment of AFI on the Danube corridor.

To conclude aforementioned, it is important to stress that ports in the Danube region have different organizational, financial and governance conditions. Although the climate goals are the same, the pathways to reach them are different and depend on many factors such as port traffic, hinterland connections, industrial and energy sectors in the port area, stakeholder commitment and engagement, etc. Port authorities/administrations can decide on the greening of their own activities and jurisdiction, but have limited possibilities to influence green behavior of port users (terminal operators, transport companies, etc.). That's why a component of cooperation between stakeholders and development of mutual initiatives across the corridor for future support by EU-funding to create projects of common interests is crucial to achieve energy transition targets and contribute to economic development of the region through industrial production of green energies.

It is important to emphasize that a key point in turning inland ports into energy hubs is in **creation of own demand within ports for green energy**. Port as a large center, which provides energy supply not only for cargo-handling operations and vessels operations, but also storage of goods, the receipt and delivery of those goods, in many cases ports are accommodating different suppliers and production

101 http://www.danubecommission.org/dc/en/danube-navigation/danube-ports-map/

102 http://www.danubecommission.org/dc/en/danube-navigation/danube-ports-map/

sites at their territories, which are also large consumers of energy. Considering this, especially in light of current EU policies towards decarbonization and emissions reduction, it can be assumed that in the nearest future creation of energy hubs in ports will be not an innovation, but a measure to satisfy needs of all the port stakeholders (and far beyond) for energy and successful practices being developed and spread through aforementioned projects initiatives and current on-going projects in ports will become a part of traditional activities in ports portfolios.

In recent years the growing role of ports as community builders, initiating partnerships and strong coalitions to bring partners together by port authorities becomes more and more visible. Building up these coalitions is important because energy transition is definitely requiring a joint effort where collaboration will be key over the next decades and this is where collaboration between partners, logistic services providers, industries, cities and regions both globally and locally is crucial. It is addressing the challenges for ports to reduce environmental impact while remaining competitive in the sector, which is marked by continuous growth.

EU PIONEERS & MAGPIE lighthouse and fellow port projects

Two recently initiated and prominent projects amongst ongoing projects in the field of port development linked to innovations and energy transition are PIONEERS[103] and MAGPIE[104].

The framework proposed and elaborated within PIONEERS with the lighthouse and fellow ports can be transferred to any other inland/maritime ports with the corresponding adaptations. Main aim of PIONEERS is based on emissions reduction in ports (which is visible from the abbreviation of the project), yet it is addressing different aspects of port operations, such as: innovations towards clean energy production and supply, sustainable port design to implement circular and low emission building techniques for infrastructure, stimulation of modal shift and flows optimizations; delivering Green Ports Masterplan by carrying out concrete actions based on monitoring CO2 emissions reduction in ports and transferability of best practices to other ports of the region. All this can result in a strategy for dedicated ports and will further blend with the Green Ports Masterplan for other ports of the region to become Green Ports (including neutral or low emissions IWT). This means that the idea developed in PIONEERS for lighthouse ports, where the majority of the demonstrations will be showcased to guide the pathways towards energy transition can be adapted to the conditions of the other ports. In the case of the Danube region, considering that the port of Constanta is now being represented as one of the fellow ports in PIONEERS, it can serve in future as a lighthouse port in the Lower Danube region. It can also address multimodal mobility issues, which exist currently in the Danube region.

An example of port of Antwerp as a center of not only maritime, but also of logistic and chemical industrial activities in the PIONEERS project, spreading efficient and sustainable practices to other ports can be taken as a good concept to be established for the ports of Rhine-Danube corridor taking as lighthouse ports the main industrial port-clusters within the corridor/region.

Using the demos of the PIONEERS transformed for the Danube Region port cases to be tested in the fellow ports (smaller ports of the region around main lighthouse ports, for the Danube region – port

[103] https://pioneers-ports.eu/
[104] https://www.magpie-ports.eu/

of Constanta or port of Enns, Linz) to scale up the innovative solutions beyond the project and after the project life span as well.

Main demos of PIONEERS, which have direct relation to energy transition and alternative energies facilities deployment in ports, such as: clean energy production & supply and sustainable port design cover following areas of know-how transfer between ports:

- Hydrogen refuelling infrastructure;
- A corridor of modular docking stations for energy containers;
- Battery storage and Smart Management of Green Energy in terminal operations;
- Hydropower Turbine;
- Hydrogen heating for buildings.

One of the targets of the project is to develop feasibility and technical studies to transfer some of the demos from lighthouse ports to fellow ports. As an example, of demo cases which can be transformed and potentially studied for the Rhine-Danube corridor is a corridor of modular docking stations for energy containers, which are currently studied for applications on IWT transportations between maritime port of Antwerp (Belgium) to inland port of Venlo (Netherlands).

Same principle can be applied for another demo: energy production from the renewable sources, storage of energy in batteries, using of batteries for multiple purposes and intelligent management system, where the battery will be used to feed with energy of electrical vehicle charges from electrical vehicle terminal in the port of Antwerp. Currently port of Constanta is interested in development of the artificial intelligent operation system and combination of the electric vehicle-chargers, battery energy storage system and local grid metering to a platform with control for creating a complete energy management system.

MAGPIE is another similar project with Rotterdam as lighthouse port and ports of Sines, Haropa and DeltaPort as fellow ports. Also MAGPIE aims to accelerate the introduction of green energy carriers (batteries, hydrogen, ammonia, BioLNG and methanol). For example, the project aims to:

- identify gaps and developments, needed throughout the electrical supply chain to ensure present and future demand for clean renewable electricity is met
- analyse and set up a green hydrogen supply chain for port and hinterland transport demand
- create a green ammonia supply chain in the PoR, from source to “plug on” seagoing vessels
- analyse the needs and effort to produce BioLNG through liquification with the focus on the two main gaps in the supply chain: production and dedicated bunkering

More specifically for IWT, it is aimed to specify the baseline of inland shipping energy scenario's and future energy volumes providing insights into the required clean energy.

A living lab approach is applied in which technological and non-technological innovations are developed or demonstrated. Demonstrators will lead into the Master Plan for the European Green including a roadmap and handbook for implementation. Based on the demonstrations within this project and by using other actions as case studies, the Master Plan describes concrete steps and milestones for ports, authorities (e.g. European Committee, IMO, River Committees) and other stakeholders (like operators and shippers) to accelerate the deployment of sustainable solutions. It also develops a comprehensive 2050-vision to achieve GHG neutrality and minimal pollution in maritime and inland port areas, including a roadmap to address this topic by 2030, 2040 and 2050.

Other port examples:

Examples from maritime ports as energy hubs (source Royal Haskoning):

Uniper and Ørsted have signed a memorandum of understanding (MoU) to jointly develop offshore wind with hydrogen on a large scale. Hydrogen production will be achieved from offshore wind power at the **Port of Wilhelmshaven (Germany)**. Uniper began developing the "Wilhelmshaven Green Hydrogen" project in 2020. It is expected that an electrolysis plant with a capacity of 70MW will be installed from 2025, to be expanded to 410MW by 2030. The renewable electricity required for the electrolysis will prospectively come from Ørsted offshore wind turbines.

As specified by Uniper, thanks to the existing substations and its proximity to the coast, the Uniper site in Wilhelmshaven has all the necessary prerequisites to play a key role in the local energy transition. In addition, the direct conversion of renewable electricity into green hydrogen means that any power grid bottlenecks can be avoided.

Wilhelmshaven could develop into a hydrogen center for Lower Saxony and serve as an example for similar projects.

Potential for export to other markets as well as hinterland market in Germany and beyond

Under the name "Green Wilhelmshaven," Uniper also plans to establish a German national hub for hydrogen in Wilhelmshaven with both local hydrogen production via electrolysis and import of hydrogen via ammonia.[105]

"The import terminal for green ammonia that is planned will be equipped with an "ammonia cracker" for reconversion of the ammonia to green hydrogen and nitrogen. The terminal will be connected to the planned hydrogen network and would be capable of supplying around 295,000 metric tons or 10% of the demand expected for the whole of Germany in 2030. The NH3 splitting plant or "ammonia cracker" for the production of green hydrogen from imported ammonia would be the first large scaled plant of its kind. Its high volumetric energy density, low production costs and good storability make ammonia one of the most attractive means of transporting hydrogen. The ability to convert ammonia back into hydrogen as well as its immediate use as a marine fuel, energy carrier or chemical feedstock predict widespread adoption and have triggered numerous export projects around the world. Commissioning of the new terminal is planned for the second half of this decade, depending on national import demand and export opportunities.

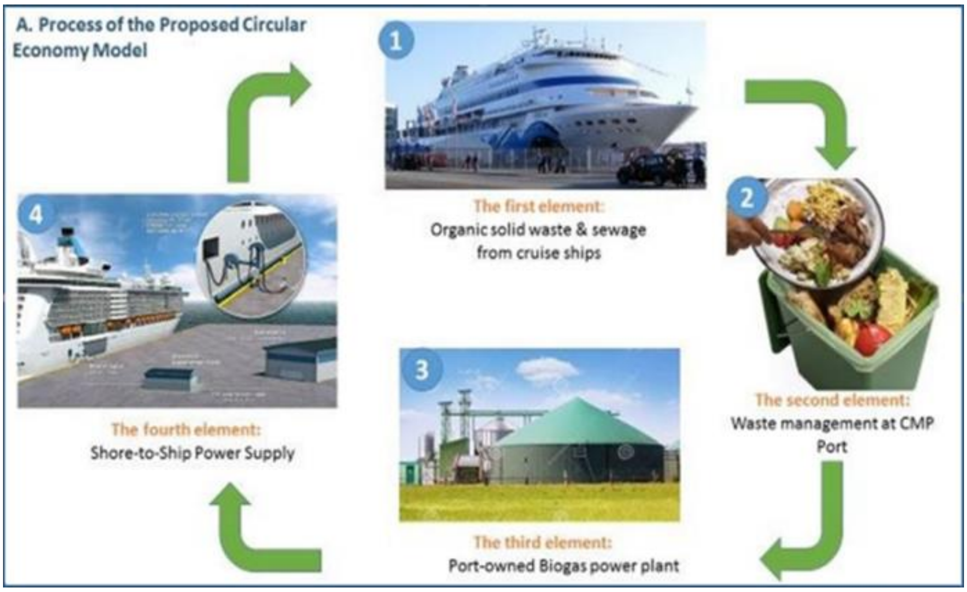
In addition, Uniper is working with its partners on a project to ascertain whether it would be feasible to build a direct reduction plant with upstream hydrogen electrolysis on the site of the existing power plant in Wilhelmshaven, as well as the required infrastructure for supplying raw materials. The aim is to produce around 2 million metric tons of "green" crude iron via an innovative process using green hydrogen generated by wind power from a 410-megawatt electrolysis plant and iron ore. Uniper is working with Salzgitter and Rhenus Logistics, the city of Wilhelmshaven and the state of Lower Saxony on this project."

105 https://www.uniper.energy/projects-and-cases/green-wilhelmshaven

Copenhagen-Malmö Port (Denmark – Sweden)

While all the aforementioned projects are based on biofuels, hydrogen and ammonia, the concept elaborated for Copenhagen – Malmo is based on circular economy ideas for energy transition. Four elements of ship-waste, port waste management, biogas plant and Shore-to-Ship power supply are used to set up the model in a closed loop. Based on the model, to the port authority will take care of waste management from cruise ships to use the waste in a port-owned biogas plant. The port-owned biogas plant produces clean electricity from ship waste while to some extent contributes to port energy security. Finally, the produced clean electricity within this model will be consumed in port for shore supply to ships or for other purposes like port buildings.

Figure 6: Process of the proposed circular economy model



Port project at Sulina

Sulina Green Port – is a new project developed by an international company together with the FREE ZONE Sulina. The project consists of a port terminal which will be in the second phase integrated in a green concept with a photovoltaic park and a hydrogen plant. The first phase of the project – direct transhipment facility from barges/coasters into Handysize and Handymax size vessels – will respond immediately to the objectives of finding new transport corridors by connecting the Ukrainian ports on the Danube as well as the port of Giurgiulesti, Reni and Galati to a deep-sea terminal able to operate vessels that make more economical sense under the present situation.

The commercial advantages and rationale of the business model include:

- Size of seagoing vessels that could be operated (Handymax);
- Acting as a hub for “feeder ports” Reni, Izmail, Galati, Braila, Giurgiulesti;
- Shorter distance compared to Constanta;
- Lower freight rates compared to Constanta;
- Faster rotation of the barges compared to Constanta;
- Higher loading/discharging rates compared to feeder ports;
- No draft restrictions for the barges calling the Sulina.

Other advantages:

- It will be the first emission free port in the region after realising phase 2;

- Will create new jobs in economically stressed Sulina area;

- Offer Sulina – an isolated town – opportunity to become a GHG emission free zone in the biosphere area of the Danube delta;

- In the second phase could deliver green energy to vessels operating in the terminal, but equally important to the local community;

- It will be a flagship project for implementing the Green Deal in the entire county of Tulcea and in Romania.

Annex 6 Interviews and questionnaires

During the research carried out for this deliverable, various interviews were conducted with experts in field and questionnaires were completed. The tables below provide an overview of the interviewed organisations and the organisations to whom questionnaire were distributed.

Table 7: List of interviews

#	Organisation	Date
1	Reinplus Fiwado	26-04-2022
2	TTS (Transport Trade Services) GmbH	27-04-2022
3	Deen Shipping	12-05-2022
4	Port of Strasbourg	16-05-2022
5	NPRC	20-05-2022
6	TEN-T North Sea-Baltic Corridor	23-05-2022
7	TEN-T Rhine-Alpine Corridor	23-05-2022
8	Danser Group	23-05-2022
9	Hungarian Federation of Inland Ports	24-05-2022
10	Public Ports of Slovakia	30-05-2022
11	Port of Vienna	31-05-2022
12	ZES (Zero Emission Services)	01-06-2022
13	TEN-T North Sea- Mediterranean Corridor	03-06-2022
14	Port of Switzerland	03-06-2022
15	Maritime Ports Administration Constanta	06-06-2022
16	Port of Antwerp	14-06-2022
17	TEN-T Rhine-Danube Corridor	22-07-2022
18	Port of Rotterdam	31-08-2022

Table 8: List of organisations that completed the questionnaire on behalf of European IWT countries

#	Organisations that completed questionnaire on behalf of European IWT countries	Date of receipt
1	Ministry of Infrastructure and Water Management (Netherlands)	08-06-2022
2	Federal Ministry for Digital and Transport (Germany)	08-06-2022
3	Swiss Federal Office of Transport	08-06-2022
4	Ministry of infrastructures and transport (Italy)	10-06-2022
5	Ministry for Innovation and Technology (Hungary)	13-06-2022
6	Ministry of Infrastrucuture - Department of Water Management and Inland Navigation (Poland)	14-06-2022
7	Port Governance Agency (Serbia)	14-06-2022
8	Ministry of Mobility and Public Works (Luxembourg)	15-06-2022
9	Ministry of Transport, Information Technology and Communications (Bulgaria)	17-06-2022
10	Port of Brussels	22-06-2022
11	De Vlaamse Waterweg	22-06-2022
12	Voies navigables de France	26-06-2022
13	Viadonau	01-07-2022

Table 9: List of IWW managers that completed the questionnaire

#	Organisations that completed questionnaire on behalf of IWW managers	Date of receipt
1	Voies navigables de France	20-10-2022
2	Viadonau	21-07-2022
3	Rijkswaterstaat	09-10-2022
4	Service Public de Wallonie	16-09-2022
5	Administração dos Portos do Douro, Leixões e Viana do Castelo	01-09-2022

Most of the persons approached within the considered European IWT countries work for their respective ministries, but the list also includes a few who work for the infrastructure manager and port authority, such as Belgium (De Vlaamse Waterweg and Port of Brussels replied) and France (VNF replied).

The interviews were conducted in a semi-structured way based on an interview guide. Questions have been drafted per stakeholder group and can be found below:

Perspective of four TEN-T corridors (advisors to the coordinator within DG MOVE B1)

Interview questions:

- Research funded by the CCNR shows that the fuel mix used by IWT consisted of 1.6 MLN Tonnes of Diesel in 2015. In 2035 and 2050, this fuel mix is expected to change drastically towards more sustainable alternatives (e.g. biofuels, electricity, hydrogen, methanol)
  - What are your expectations for the future fuel mix for IWT?
  - How do you view the role of the TEN-T corridors in the transition to new sustainable alternative fuels and what complementary instruments may be needed for this transition (legislative, financial)?
  - Do you see a relevant role for others, such as the Commission, Member States or River Commissions?
- We see increasingly stringent policies and a paradigm shift in which we move away from conventional fossil fuels towards zero-emission. The European Green Deal is key in this respect. How are the European Green Deal objectives translated into the future AFIR and TEN-T regulations with regard to the alternative fuel infrastructure for IWT, and through what kind of developments will this be implemented in your corridor?
- Given the draft new versions of the corridor studies and the work plans (5th version), what are the most important implications and priorities for the clean fuel infrastructure for IWT? What are your requirements to integrate IWT in the corridor development plans in the best possible way?
- The proposed AFIR states that each MS shall prepare a draft national policy framework for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure. Do you see this as a potential barrier to the corridor approach, any alignment problems?
- What are according to your view the most important technical, legal/regulatory and economic challenges and gaps for realizing the clean energy infrastructure for IWT in the respective TEN-T corridor?

Perspective of ports

Interview questions:

- Research funded by the CCNR shows that the fuel mix used by IWT consisted of 1.6 MLN Tonnes of Diesel in 2015. In 2035 and 2050, this fuel mix is expected to change drastically towards more sustainable alternatives (e.g. biofuels, electricity, hydrogen, methanol). Are your expectations for the future on this aspect similar? - for PoV
- We see a paradigm shift in (inter)national policies. Priorly, the focus of greening policies were focusing on how to make the best use of conventional fossil fuels. We see increasingly stringent policies and a paradigm shift in which we move away from conventional fossil fuels towards zero-emission. In this respect, also given Fit-For-55 including AFIR, and the proposed TEN-T revision, what are in your view the most important current and upcoming developments for inland and seaports? - for EFIP
- What are the most important implications for the clean fuel infrastructure for IWT? - for EFIP
- Do you think ports will play an even more important role in supplying fuel for IWT even more so with sustainable alternative fuels/energy than with fossil fuels? - for EFIP
- What is the exact role assigned to ports in the realisation of this alternative energy infrastructure for inland navigation? Who are the relevant parties (e.g. port authorities, municipalities, government real estate agencies, terminal operators, etc.) for the development of this infrastructure and what are their roles in this? - DP World Constanta & MPAC, VP, PoV
- What are according to your view the most important technical, legal/regulatory and economic challenges and gaps for realizing the clean energy infrastructure for IWT in port areas? - PoV, Duisport, MPAC, TTS, DP World, VP

Perspective of energy suppliers and potential for cross sectoral synergies

Interview questions:

- Research funded by the CCNR shows that the fuel mix used by IWT consisted of 1.6 MLN Tonnes of Diesel in 2015. In 2035 and 2050, this fuel mix is expected to change drastically towards more sustainable alternatives (e.g. biofuels, electricity, hydrogen, methanol). Are your expectations for the future on this aspect similar?
- Regarding the energy transition, and the foreseen changing fuel mix in the IWT sector, how is bunkering market planning to move along with this process?
- Can the current bunkering infrastructure for IWT, which is optimized for the delivery of mainly one fuel (fossil diesel) cope with the delivery of multiple fuels to a market which is rather limited in size?
- The sustainable alternative fuels are characterised by lower energy intensity (both gravimetric and volumetric) as compared to fossil fuel. This is likely to result in a higher bunker/charging frequency compared to the status quo. What are the implications of this for the bunker/charging infrastructure?
- Can Clean Energy Hubs create the necessary scale and business case for the realisation of the clean energy infrastructure?
- With LNG, there was initially a chicken-egg dilemma, but we saw afterwards that the energy suppliers acted quite quickly by supplying LNG, first by truck-to-ship and later on with ship-

to-ship and bunkerstation-to-ship. Do you expect a similar development with the alternative sustainable fuels?

- The IWT sector is not alone in facing environmental challenges, which will probably lead to a change of the fuel mix. How do you view possible changes in the fuel mix of other sectors (trucking, personal cars, other shipping sectors, aviation)? Can the IWT sector benefit from potential synergies with other sectors?
- Do you foresee a sufficient volume of sustainable feedstocks and fuels/energy to meet the needs of IWT, given an expected growth in demand from other modes of transport as well?
- What are according to your view the most important technical, legal/regulatory and economic challenges and gaps for realizing the clean energy infrastructure for IWT from the perspective of the energy suppliers?

Perspective of barge owners and operators
Interview questions:

- What does the bunkering process in IWT look like today and what is involved in terms of administration, safety measures, the actual physical bunkering itself, etc.?
- Given that the fuel mix of IWT is expected to change from mainly diesel to a mix of sustainable alternative fuels and technologies (e.g. hydrogen, methanol, batteries, fuel cells, clean ICE's) what would be your expectation regarding infrastructure and bunkering?
- What are according to your view the most important technical, legal/regulatory and economic challenges and gaps for realizing the clean energy infrastructure for IWT?

RD&I Perspective Waterborne TP and partnership
Interview Questions:

- Research funded by the CCNR shows that the fuel mix used by IWT consisted of 1.6 MLN Tonnes of Diesel in 2015. In 2035 and 2050, this fuel mix is expected to change drastically towards more sustainable alternatives (e.g. biofuels, electricity, hydrogen, methanol). Are your expectations for the future on this aspect similar?
- How do you view the role of the Waterborne Technology Platform and of the Partnership in the transition to these new fuels in IWT and the realization of the clean energy infrastructure for IWT?
- What are according to your view the most important technical, legal/regulatory and economic challenges and gaps for realizing the clean energy infrastructure for IWT from an RD&I perspective?

Furthermore, two questionnaires have been developed, one to capture the perspective of inland waterway infrastructure managers and one to capture the view of the European IWT countries at the level of the national authority.

The **questionnaire for the inland waterway infrastructure managers** includes the following questions:

Description of organisation

- Please give a brief description of your company if applicable highlighting issues relevant to the implementation of clean energy infrastructure:

- Owner: e.g. ministry, private company, …
- Activities and responsibilities: e.g. waterway maintenance, operation of RIS, operation of locks, development of inland waterway transport, promotion, …
- Assets managed: e.g. waterway, locks, ferry landings, berths, land on waterways, …

Questions

- What is your role in relation to the development and implementation of clean energy infrastructure for IWT (e.g. electricity, hydrogen, …)?
    - Did you or will you create strategies or plans with respect to the implementation of clean energy infrastructure?
        - If yes, which ones:
    - Have you been or are you involved in the creation of policies with respect to the implementation of clean infrastructure? E.g. on national level (hydrogen strategy), master plans, …, communications on EU level, etc.
    - Have you been or are you involved in the creation of regulations with respect to the implementation of clean energy infrastructure? E.g. directives, standards, …
    - Do you see the initiation or coordination of activities relating to the implementation of clean energy infrastructure as one of your tasks?
    - Have you conducted, are you conducting or will you conduct developments, undertakings or projects relating to the implementation of clean energy infrastructure?
    - Will you be involved in the implementation of clean energy infrastructure at mooring places or berths you manage or rent?
    - Will you be involved in the implementation of clean energy infrastructure at locks or ferry landings?
- How do you see your role in general with respect to the implementation of clean energy infrastructure?

The **questionnaire for the European IWT countries**, at the level of the national authority, includes the following questions:

Questions

The fuel mix used by Inland Waterway Transport (IWT) predominantly consists of fossil diesel in the year 2015. Studies funded by the Central Commission for the Navigation of the Rhine (CCNR) made in the framework of the CCNR Roadmap[106] show by means of two different scenarios (conservative and innovative) that this fuel mix is expected to change drastically towards more sustainable alternatives (e.g. bio/e- diesel, bio/e- methanol, green electricity and hydrogen). Annex I contains the relevant figures that illustrate the expected development per scenario.

1. Do you share the study results for your country/region? (Please select yes or no)

☐- Yes

☐- No

You can provide optional further clarification in this text field

2. Which scenario do you assess as more realistic or that should be followed, in your opinion? (Please select one scenario)

☐- Conservative Pathway

☐- Innovative Pathway

You can provide optional further clarification in this text field

3. Which alternative fuels/technological solutions do you deem to be the most prospective to produce market solutions by 2030? (You can select multiple options)

☐- HVO (hydrotreated vegetable oil and all comparable drop-in biofuels as well as synthetic diesel in an internal combustion engine which complies with the emission limits EU Stage V)

☐- LBM (Liquified Bio Methane or bio-LNG in an internal combustion engine which complies with the emission limits EU Stage V)

☐- Battery (battery electric propulsion systems)

☐- H2 FC (hydrogen stored in liquid or gaseous form and used in fuel cells)

☐- H2 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)

You can provide optional further clarification in this text field

4. Do you have a view on how the energy demand for IWT will develop in your Member State? (Please select yes or no)

☐- Yes

☐- No

5. If you answered the previous question with a "yes", how fast do you expect that the current fuel mix will change to more sustainable alternatives?
You can provide clarification in this text field

6. Do you expect that in 2030 there will be sufficient alternative fuels/energy available for IWT in your Member State which enable the sector to achieve the GHG target of 55% reduction? (Please

[106] https://www.ccr-zkr.org/files/documents/Roadmap/Roadmap_en.pdf

select yes or no)

☐- Yes

☐- No

You can provide optional further clarification in this text field

7. Concerning drop-in biofuels like biodiesel (FAME/HVO) as well as biomethane, what is your expert opinion as regards the use of these fuels in IWT? Is the use of these fuels actively being promoted or prescribed in your Member State as a possible blend (e.g. to comply with Fuel Quality Directive)?

☐- Drop-in biofuels are not promoted and/or prescribed

☐- Drop-in biofuels are being promoted and/or prescribed, this applies to (you can select multiple options):

☐- FAME

☐- HVO

☐- Biomethane

You can provide optional further clarification in this text field

8. Is there a clean energy infrastructure deployment plan for waterways and ports in your Member State? (Please select yes or no)

☐- Yes

☐- No

9. Are there foreseen feasibility studies for the deployment of clean energy infrastructure for waterways and ports in your Member State? (Please select yes or no)

☐- Yes

☐- No

10. Which financial sources will be used for the deployment of the clean energy infrastructure for waterways and ports in your Member State? (Please select one option)

☐- Public funding (national state aid program)

☐- Private financing

☐- Combination of public funding and private finance

You can provide optional further clarification in this text field

11. The proposed AFIR in the Fit for 55 package states that Member States shall develop draft national policy frameworks for the development of the market as regards alternative fuels in the transport sector and the deployment of the relevant infrastructure. Are there already concrete ideas on how the IWT sector will be included in the development of these national policy frameworks and the corresponding deployment plans for alternative fuels? (Please select yes or no)

☐- Yes

☐- No

If yes, please specify

12. If you answered the previous question with a "yes", which fuels and corresponding required infrastructure are being considered? (You can select multiple options)

☐- HVO (hydrotreated vegetable oil and all comparable drop-in biofuels as well as synthetic diesel in an internal combustion engine which complies with the emission limits EU Stage V)

☐- LBM (Liquified Bio Methane or bio-LNG in an internal combustion engine which complies with the emission limits EU Stage V)

☐- Battery (battery electric propulsion systems)

☐- H2 FC (hydrogen stored in liquid or gaseous form and used in fuel cells)

☐- H2 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)

13. Does your Member State already have (funding) instruments to stimulate the development of clean energy infrastructure for IWT? (Please select yes or no)

☐- Yes

☐- No

14. Does your Member State have plans for future (funding) instruments to stimulate the development of clean energy infrastructure for IWT? (Please select yes or no)

☐- Yes

☐- No

If yes, please specify

15. Does your Member State plan to align its national strategy with the national strategies of other Members States?

☐- Yes

☐- No

16. If you answered the previous question with a "yes", how will the exchange of information between Member States be organised?

You can provide further clarification in this text field

17. What supporting role should the new TEN-T corridor studies and work plans play in the deployment of the alternative energy infrastructure for IWT?

☐- Collecting information and monitoring role

☐- Collecting information and monitoring role & Coordinating role

☐- Other, you can provide further clarification in this text field

18. Do you foresee specific synergies for infrastructure facilities and energy production with other modes of transport, the energy sector (e.g. with electricity grid/peak shaving with modular batteries) or specific industries?

☐- Yes

☐- No

If yes, please specify relevant examples/best practices in this regard

19. If you answered question 18 with a "yes", how does your Member State aim to stimulate these potential synergies?
You can provide clarification in this text field

20. Can you identify existing local/regional/national/EU bottlenecks for the physical realization of the alternative energy infrastructure for IWT in your Member State?

☐- Yes

☐- No

If yes, please specify

Annex 7 Answers to questions raised in Wooclap

Figure 7: Answers to question 1

Figure 8: Answers to question 2

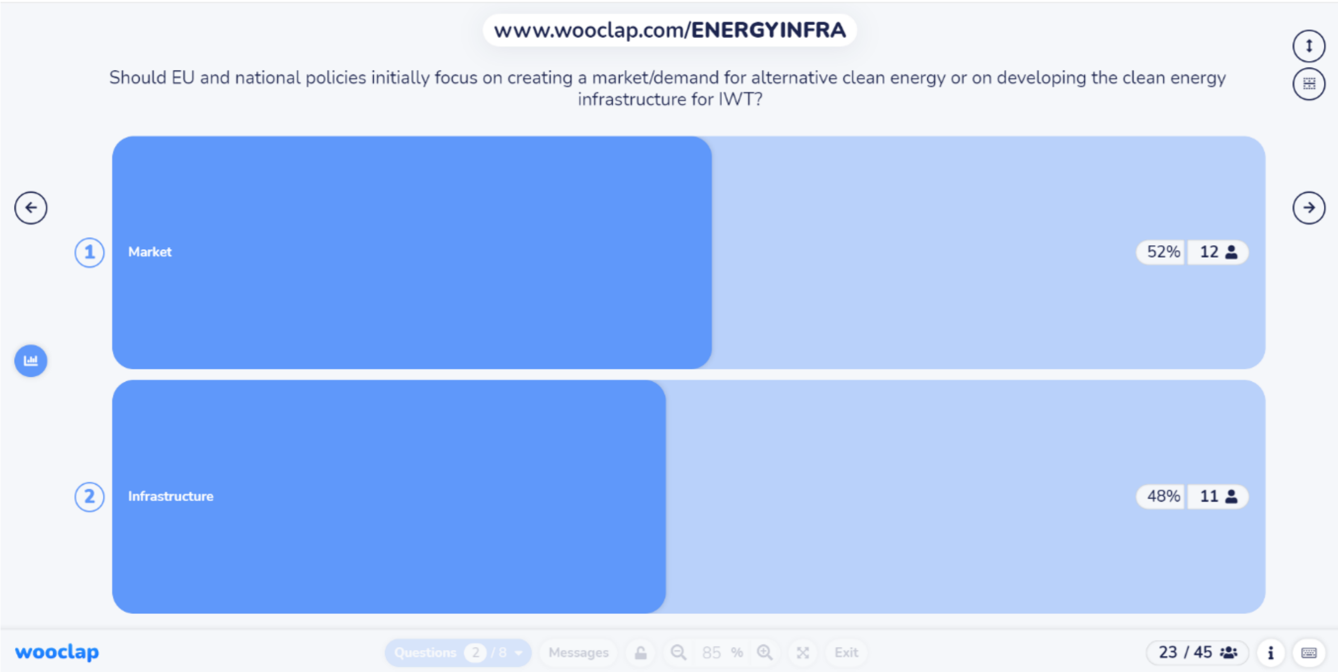


Figure 9: Answers to question 3

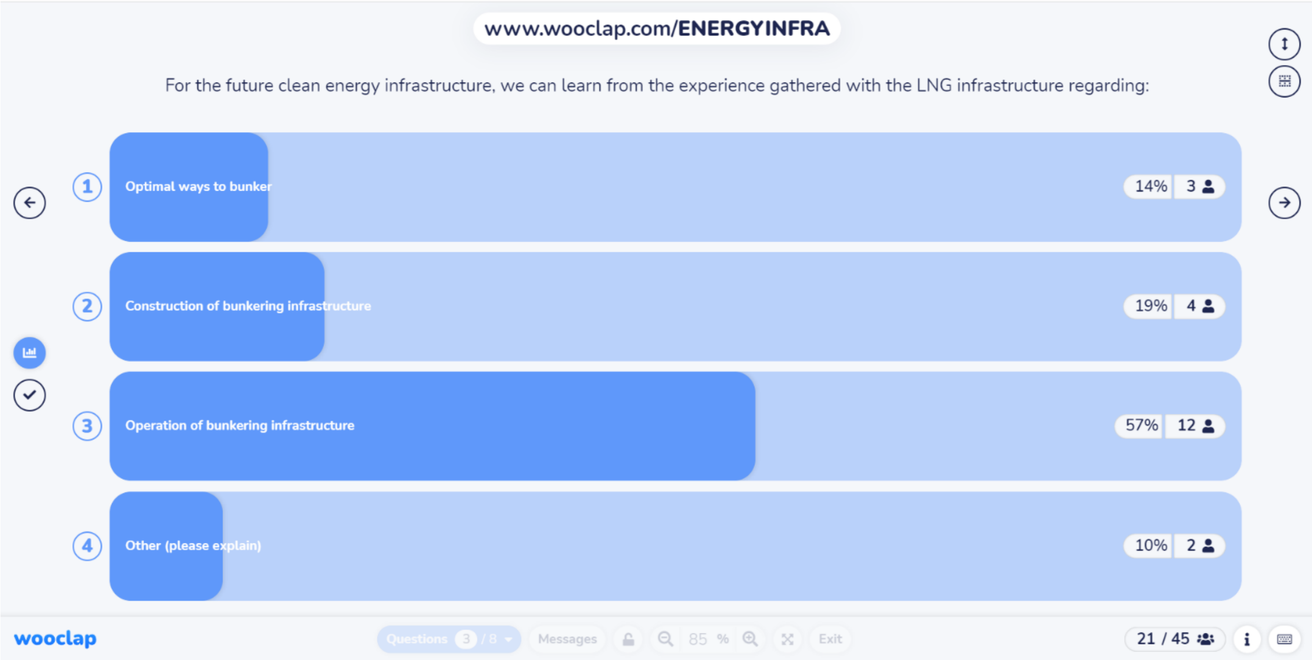


Figure 10: Answers to question 4

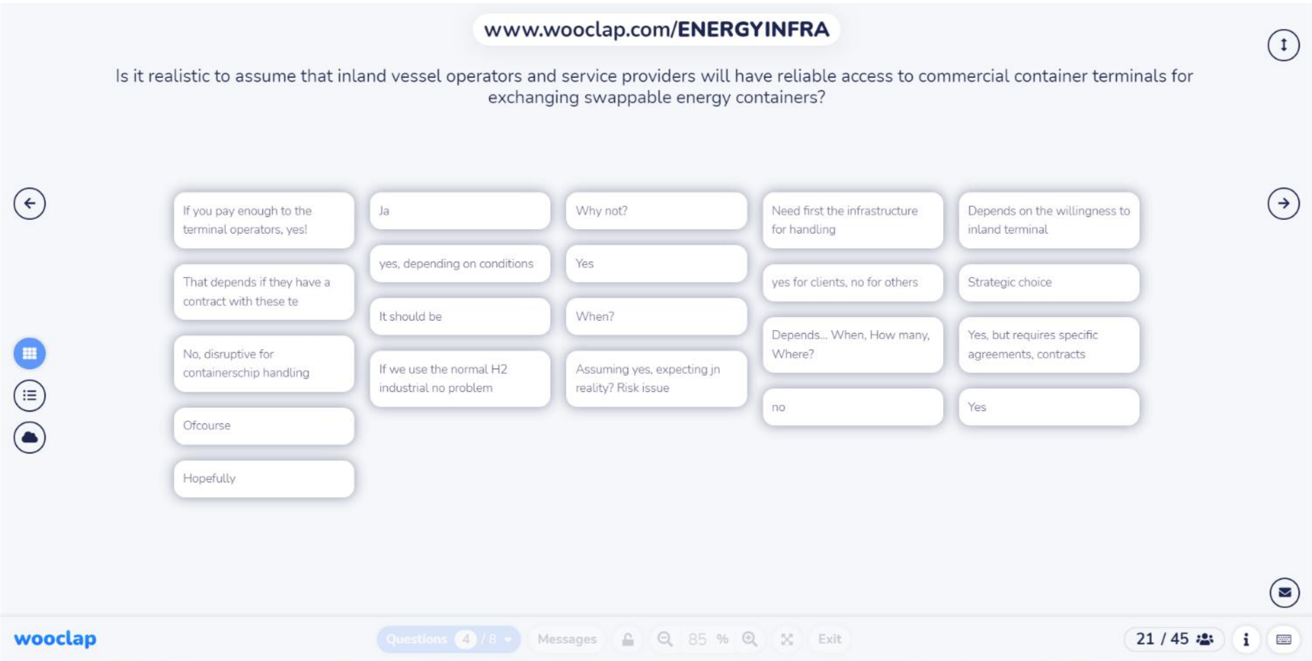


Figure 11: Answers to question 5

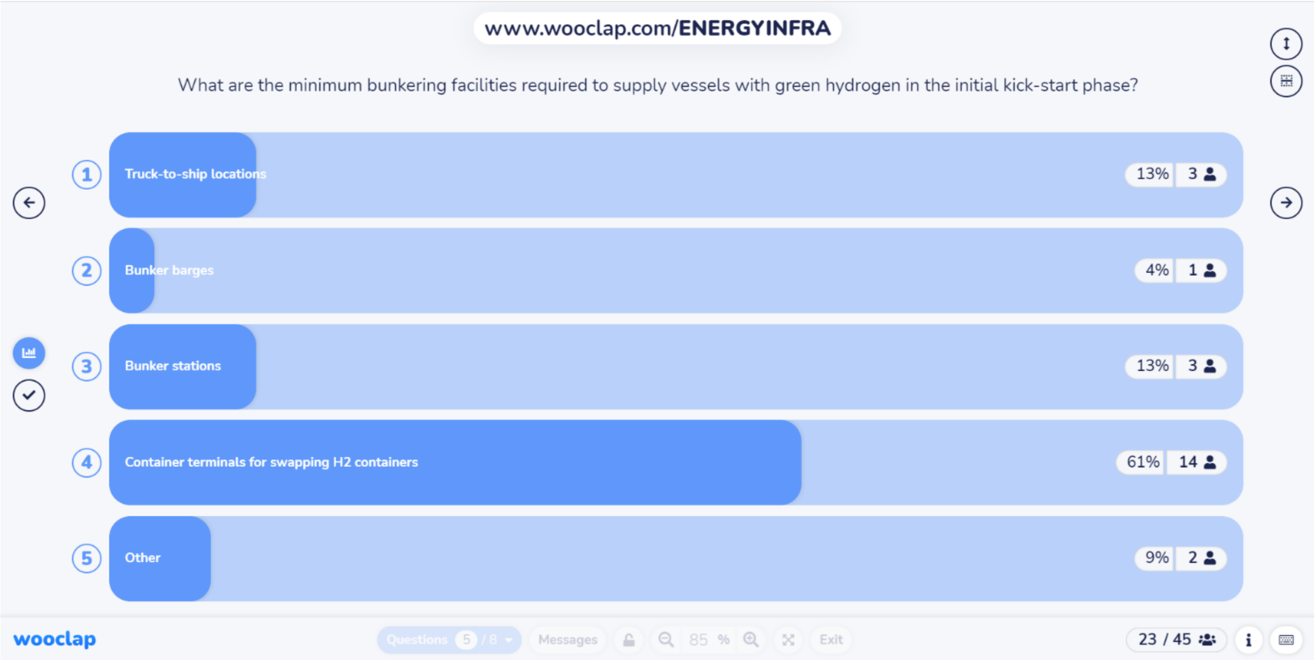


Figure 12: Answers to question 6

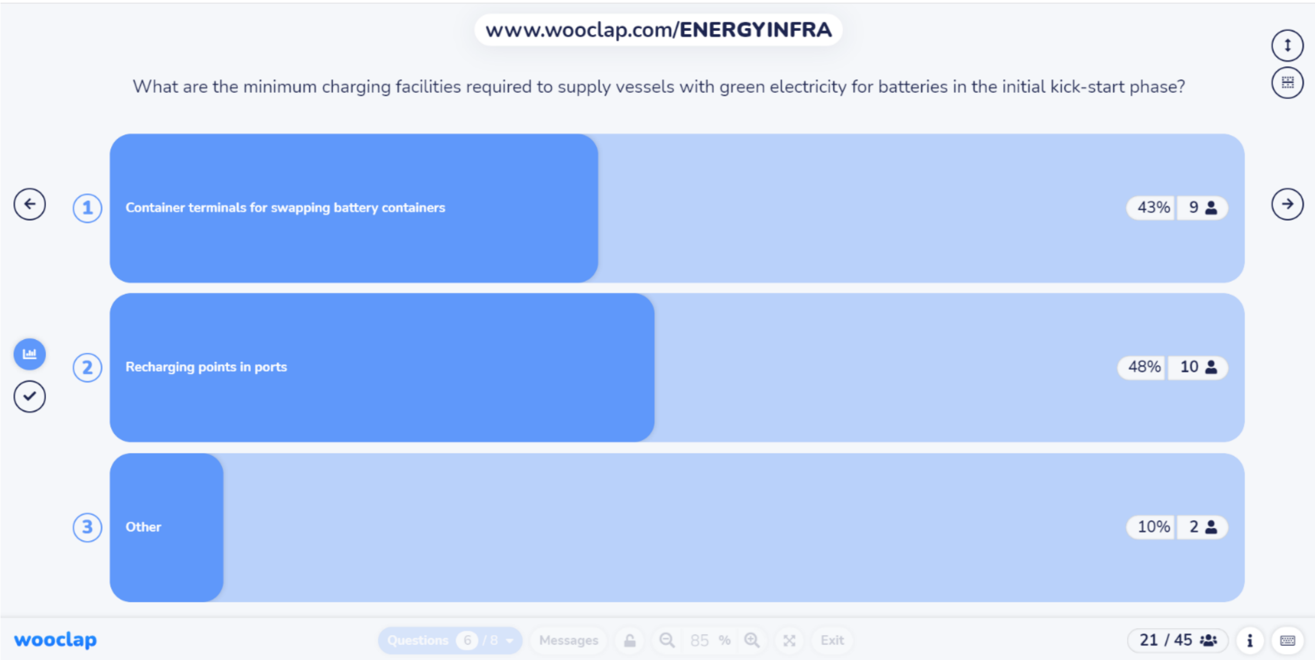
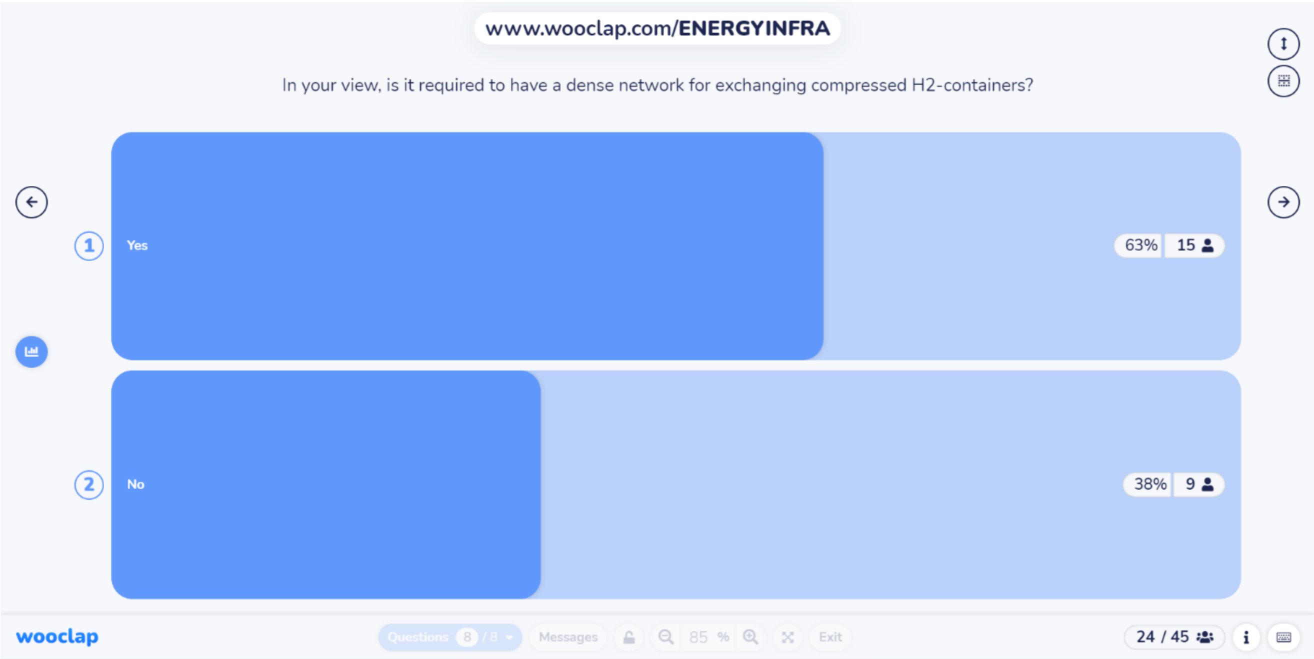


Figure 13: Answers to question 7

Figure 14: Answers to question 8



Annex 8 Source list

The consulted online sources for this study are as follows[107]:

- https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12438-Sustainable-and-Smart-Mobility-Strategy_en
- https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en#policy-areas
- https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/package-fit-for-55
- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0550&from=EN
- https://www.europarl.europa.eu/legislative-train/theme-a-european-green-deal/file-revision-of-the-directive-on-deployment-of-alternative-fuels-infrastructure#:~:text=The%202014%20Alternative%20Fuels%20Infrastructure,alternative%20fuel%20vehicles%20and%20vessels.
- https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52021PC0812
- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021PC0812&from=EN)
- https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_6725
- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1745&from=EN
- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R0182&from=EN
- https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A52021PC0559)
- CCNR, "Mannheim Declaration", 17 October 2018, CCNR | Mannheim Declaration [EN]
- CCNR, "CCNR roadmap for reducing inland navigation emissions", March 2022, CCNR | Roadmap on emissions reduction [EN].
- CCNR, "Study on energy transition towards a zero-emission inland navigation sector", October 2020, CCNR | Study [EN].
- https://www.cdni-iwt.org/dashboard/?lang=en
- https://heijmen.nl/bunkerstation-millingen-aan-de-rijn/
- https://www.reinplusfiwado.com/nl/bunkerlocaties/zwijndrecht/
- https://www.slurink.nl/netwerk/dordrecht/
- https://titan-cleanfuels.com/
- https://unece.org/sites/default/files/2021-01/ADN%202021%20English.pdf
- https://wetten.overheid.nl/BWBR0022762/2021-07-01
- https://www.infomil.nl/onderwerpen/veiligheid/activiteitenbesluit/afleveren-brandstof/afleveren-brandstof/#hb52a6126-16ab-4a6e-8127-a64729ec70b8
- https://www.portofamsterdam.com/nl/nieuws/eerste-waterstof-bunkervergunning-van-nederland
- https://www.ccr-zkr.org/13020500-en.html
- https://lngbinnenvaart.eu/wp-content/uploads/2020/02/Pilot-test-report-Werkendam-external.pdf
- https://www.rh2ine.eu/
- https://www.ebu-uenf.org/wp-content/uploads/AFIR-Statement-press-release-2022-01-06.pdf and https://www.inlandwaterwaytransport.eu/wp-content/uploads/Press-release-IWT-sector-on-the-TEN-T-revision.pdf
- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019D1118&from=EN

[107] This list excludes the list of IWT clean energy infrastructure initiatives in Annex 4

- https://theses.ubn.ru.nl/bitstream/handle/123456789/3856/Wursten%2C_Robert_1.pdf?sequence=1
- https://lngbinnenvaart.eu/first-permanent-lng-bunker-station-in-germany/
- www.interreg-danube.eu/daphne
- https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdfhttps://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf
- https://www.eba250.com/about-eba250/ https://www.eba250.com/about-eba250/
- https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/alternative-fuels-sustainable-mobility-europe/renewable-and-low-carbon-fuels-value-chain-industrial-alliance_en#:~:text=The%20Renewable%20and%20Low%2DCarbon,Maritime%20and%20RefuelEU%20Aviation%20initiatives.https://transport.ec.europa.eu/transport-themes/clean-transport-urban-transport/alternative-fuels-sustainable-mobility-europe/renewable-and-low-carbon-fuels-value-chain-industrial-alliance_en#:~:text=The%20Renewable%20and%20Low%2DCarbon,Maritime%20and%20RefuelEU%20Aviation%20initiatives.
- https://www.rh2ine.eu/rh2ine-kickstart-study/ https://www.rh2ine.eu/rh2ine-kickstart-study/
- https://www.gdws.wsv.bund.de/DE/gdws/01_ueber-uns/aufgaben/aufgaben-node.html;jsessionid=55F27281B1D39B1306B80D4BAF42432C.live21321 https://www.gdws.wsv.bund.de/DE/gdws/01_ueber-uns/aufgaben/aufgaben-node.html;jsessionid=55F27281B1D39B1306B80D4BAF42432C.live21321
- https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2004_I_177/BGBLA_2004_I_177.pdfsig https://www.ris.bka.gv.at/Dokumente/BgblAuth/BGBLA_2004_I_177/BGBLA_2004_I_177.pdfsig
- https://www.rijkswaterstaat.nl/en
- https://www.inlandnavigation.eu/
- https://www.inlandnavigation.eu/wp-content/uploads/2022/01/AFIR-Statement-220125.pdfhttps://www.inlandnavigation.eu/wp-content/uploads/2022/01/AFIR-Statement-220125.pdf
- https://www.inlandports.eu/news/press-releases/position-efip-ine-iwt-afir https://www.inlandports.eu/news/press-releases/position-efip-ine-iwt-afir
- https://www.wallonie.be/fr
- https://www.vnf.fr/vnf/https://www.vnf.fr/vnf/
- https://www.viadonau.org/en/home https://www.viadonau.org/en/home
- https://www.bmk.gv.at/dam/jcr:eaf9808b-b7f9-43d0-9faf-df28c202ce31/BMK_Mobilitaetsmasterplan2030_EN_UA.pdfhttps://www.bmk.gv.at/dam/jcr:eaf9808b-b7f9-43d0-9faf-df28c202ce31/BMK_Mobilitaetsmasterplan2030_EN_UA.pdf
- http://www.apdl.pt/header
- https://www.ccr-zkr.org/files/documents/reglementRP/rp1nl_01062022.pdf https://www.ccr-zkr.org/files/documents/reglementRP/rp1nl_01062022.pdf
- https://www.arbo-binnenvaart.nl/userfiles/file/validatie%20bunkeren/BPR%20RPR%20bunkeren.pdfhttps://www.arbo-binnenvaart.nl/userfiles/file/validatie%20bunkeren/BPR%20RPR%20bunkeren.pdf
- https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1745&from=EN https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1745&from=EN

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101006364. The opinions expressed in this document reflect only the author's view and in no way reflect the European Commission's opinions. The European Commission is not responsible for any use that may be made of the information it contains.

Project coordination	Stichting Projecten Binnenvaart
Contact	info@platina3.eu

PLATINA3
IWT policy platform
- FLEET -

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