PLATINA3
IWT policy platform

D1.1 Report on technology, logistic, communication innovation for IWT market development and logistic integration

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Executive summary

The PLATINA3 project

The Horizon 2020 PLATINA3 project provides a platform for the implementation of the NAIADES III Action Plan. PLATINA3 is structured around four fields (Market, Fleet, Jobs & Skills, Infrastructure) of which Work Package 1 (WP 1) deals with various aspects of the inland navigation market, such as 1) increased modal shift and decarbonisation; 2) R&D actions to promote optimal market uptake conditions; 3) synchromodal logistic chains; 4) reducing economic and financial barriers to modal shift; and 5) policy and regulatory actions encouraging the use of IWT.

This report presents the conclusions from PLATINA3's Task 1.1 which assesses the needs for further technological, logistical and marketing and communication innovations to support modal shift, in view of attracting higher volumes and supporting decarbonisation, on the basis of identified new and growing markets. This deliverable builds upon existing studies and analyses, as well as the outcomes of the 3rd PLATINA3 Stage Event (10-11 February 2022) where experts made presentations on this topic and a draft deliverable was showcased.

Scope of the report and definitions

The scope of the report is limited to analysing the obstacles and opportunities for modal shift to IWT overall but mainly in selected new and growing markets. Marketing and communication as additional tools to strengthen modal shift are also explored. Although an important sub-market for IWT, this report does not cover passenger transport and focuses on freight transport activities only. Given the scope of other tasks in PLATINA3 Work Package 1, this report does not address the economic and financial barriers to modal shift (covered by task 1.4 of the PLATINA3 project) nor the purely regulatory actions encouraging the use of IWT (covered by task 1.5 of the PLATINA3 project). Loading units and transhipment as well as synchromodal logistics are included to some extent in this report given the synergies between them in selected new and growing markets. That being said, these two aspects are covered more broadly by Tasks 1.2 and 1.3 respectively.

Modal shift refers to relative changes in the market shares of different modes of transportation in relation to each other for specific cargo flows. A modal shift usually occurs when one mode gains a comparative advantage in a similar market over another. These shifts respond both to macro- and microeconomic factors.

The term "new and growing markets" describes, on the one hand, market segments where IWT is either not yet present or in an early stage of development and could be considered in coming years as a suitable transport solution. On the other, it refers to existing markets with strong potential for further growth. New and growing markets can determine future products transported by inland vessels, but they often imply new types of logistics, vessels, and areas of operation.

Current state of play and policy context

In June 2021, the European Commission launched the NAIADES-III Action Plan[1], which sets an "Inland Navigation Action Plan 2021-2027" aligned with the Multi-Annual Financial Framework to meet the objectives of the EGD and SSMS. One of NAIADES-III's two core objectives is shifting more freight to inland waterways from other transport modes (modal shift), thereby contributing to reducing GHG emissions and limit road congestion. Underpinning this ambition is one of eight NAIADES-III policy

[1] European Commission, "NAIADES III action plan", June 2021, [NAIADES III action plan (europa.eu)](https://transport.ec.europa.eu).

flagships dedicated to updating the EU's legal framework for intermodal transport to stimulate IWT modal share growth in the short and medium term. This flagship aims to boost modal shift to more sustainable and low-carbon transport modes such as IWT by establishing a level-playing field across transport modes when it comes to environmental performance. In this context, the PLATINA3 project provides the knowledge base for the implementation of the NAIADES III Action Plan.

On 17 October 2018, the Ministers of the five Member States of the CCNR (Belgium, Germany, France, the Netherlands, Switzerland) adopted the Mannheim declaration. Recalling the sector's high potential for development and innovation, they vowed to reinforce the role of inland navigation by promoting faster and more efficient inland vessel cargo handling in seaports and tighter integration of IWT into digital and multimodal logistic chains.

Inland navigation is today at a crossroads, facing economic as well as environmental challenges that threaten to fundamentally alter its position in the European transportation market. On the one hand, unpredictable water levels and the energy transition imperative; on the other, a slowdown in global trade, the structural decline of fossil-based cargo, and the COVID-19 crisis. At the same time, inland waterway transport (IWT) is expected to play an important role on the path towards sustainable transport in 2050, as foreseen in the European Green Deal (EGD). In fact, the EGD aims to cut 90% of emissions from transport by 2050 to reach climate neutrality and shift a substantial portion of the freight transported by road (currently accounting for circa 76% of EU inland freight) to inland navigation (circa 6%) and rail (circa 18%), namely through measures to increase the handling capacity of inland waterways and better integrate IWT into multimodal logistics chains. More specifically, the European Commission's (EC) Sustainable and Smart Mobility Strategy establishes the following milestones: "transport by inland waterways and short sea shipping will increase by 25% by 2030 and by 50% by 2050 compared to 2015".

New and growing markets for IWT

The 3rd PLATINA3 Stage Event (10-11 February 2022) featured discussions on new and growing markets which might trigger modal shift towards IWT.[2] The following options were discussed:

- Urban logistics
- Waste / biomass transport;
- Circular economy / new materials;
- New energies, including hydrogen and other alternative fuels;
- New trade routes, connections to TEN-T corridors, core and comprehensive networks;
- Container transport.

These new and growing markets are needed to respond to a decrease or saturation of existing markets (e.g. transportation of coal, ore, oil products). On the demand side, several commodity segments have reached saturation, the energy transition changes product composition, and world trade is experiencing structural slowdown. On the supply side, more difficult navigation conditions are expected to intensify due to climate change while low water events stress the need to diversify operations towards urban logistics where water levels fluctuations are much less severe.

Results of the analysis and recommendations

IWT offers clear opportunities for modal shift in urban settings and shows the viability of IWT under specific circumstances, despite the competitive pressure from road transport. An advantage of inland navigation is that it can transport such goods in different forms (pallets, barrels, containers, bulk, etc.), is able to scale easily while benefitting from alternative and renewable energy solutions. Demographic

[2] Presentations made by: Daan Schalk "New market opportunities and strategies"; Geer van Overloop "River Drones: innovation as a driving force for modal shift"; Heinrich Kerstgens "Decarbonisation of logistics and modal shift towards inland waterway transport"; Norbert Kriedel "New market opportunities in inland navigation transport"; and Thierry Vanelslander "How to increase IWT market share?".

growth, in combination with saturated and sensitive road infrastructure, vibrations, accidents, noise emissions and other negative externalities provoked by road transport in cities, are all important factors which offer potential for IWT in modern urban environments. Therefore, the current increased focus on urban mobility, including via newly established expert groups, could be a crucial opportunity for IWT to seize.

New transport flows resulting from circular economy activities are certainly an opportunity for IWT, particularly in an urban setting. IWT could serve as an ideal transport solution to spearhead the development of circular economies while enabling more efficient waste management, valorisation, and storage in urban environments.

It is expected that new transport opportunities for inland navigation will also emerge in the wake of the energy transition (e.g. biofuels, hydrogen carriers, project cargo, such as wind turbine blades and components and other infrastructure and hardware needed for energy transition). In particular, inland waterway transport can be used to distribute alternative fuels and energy sources such as biofuels, other hydrogen carriers and e-fuels, albeit requiring possible adaptations depending on the fuel distributed. Should larger volumes of such fuels be imported overseas from other continents via seagoing vessels, IWT will appear as a logical follow-up to transport them to the hinterland of European seaports (e.g. Rotterdam, Antwerp, Amsterdam, Constanta, Hamburg, Le Havre, Marseille).

For instance, there is growing interest at European level for hydrogen as a clean energy source. Its applications are manifold (industry, transport sector, power generation) and demand has been steadily growing since 1975. While it is today overwhelmingly produced from fossil fuels, hydrogen can be produced from renewables (i.e. electrolysis using green energy from wind, water or solar), meaning there is significant potential for emissions reduction from a life cycle point of view.

At European and national level, public policy is pushing for the development of hydrogen, with the adoption of hydrogen strategies. As hydrogen can be transported via maritime vessels, inland vessels, and pipelines, it is a promising cargo for IWT, especially if combined with new, innovative tanker designs, LOHC technology, and integrated into regional and global value chains through ports.

Biomass can be used to produce biofuels, heat, and electricity, and its use is on an upward trend. This versatility is undoubtedly an important factor boosting its attractiveness. The advantages of IWT for the transport of biomass are manifold: reliability, overall safety, and high carrying capacity. Transport of biomass via IWT has already been proven successful as shown by several examples for instance, in the Port of Mannheim or Straubing. In addition, unlike wind turbines, for which ports and waterways might need to adapt their infrastructure, biomass/biofuel cargo handling in inland ports does not need adaptations or special handling equipment. Furthermore, electricity and heat produced from biomass are unaffected by weather fluctuations, an important aspect compared to the fluctuations of wind and solar energy.

Uncertainty remains regarding the energy transition trajectory of our societies, an uncertainty that affects all renewable energies. Despite the need for clarity about the future shape of energy supply, technological development is characterised by uncertainties, path dependencies and by the interplay of technology and commercial successes and failures. This technological uncertainty can lead to a specific form of inertia: why invest in new production processes for alternative technologies when uncertainty is high regarding their future use and demand? This will inevitably impact the IWT sector and its micro-economic decisions to specialize or not in biomass/biofuel/e-fuel transport. Beyond these aspects, which are inherent to the energy transition and the development of new technologies, whether or not such expected new markets will develop is also strongly dependent on the regulatory and political sphere.

This report shows, firstly, that new markets exist, some with higher potential than others. Secondly, it is not a given that inland navigation will penetrate such new markets. In most cases, adaptations will be necessary in terms of logistics, vessel technology, vessel design and vessel size. Commercial, logistical and technological challenges will arise and will be affected, inter alia, by the degree of intermodal competition.

Increasing the usage of all communication and marketing possibilities will enable IWT operators to influence and inform other economic actors on the importance and advantages of IWT, namely reliability, economic efficiency, efficient use of available infrastructure capacity and sustainability. In other words, electronic communications and marketing inform and demonstrate to the wider economic operators the benefits of using IWT as a permanent business option. Efforts in favour of such communication and marketing innovations should be promoted.

Despite these promising avenues for growth, several obstacles remain to be overcome in order to enhance modal shift to inland navigation. These include tackling congestion at seaports and seaport-hinterland transport inefficiencies, combating low/high water events to ensure IWT's reliability over the long term, developing additional financing opportunities and improving communication about them as well as about the pertinent regulatory framework, and build awareness of IWT's potential as a promising modal choice for any European shipper.

Furthermore, the expected rapid development of battery electric trucks, as estimated by TNO[3] in October 2022, puts pressure on the speed of the energy transition in IWT. There is a risk that the inland fleet does not adapt to climate neutrality and low air pollutant emission performance as swiftly as the road or rail fleet if the regulatory framework remains the same and if the financial supports is not increased. The competition from road and rail might prove difficult to counteract. Consequently, without strong and rapid interventions in the IWT sector, inland navigation's environmental advantage will be quickly eroded compared thus deteriorating the rationale for a modal shift from road to IWT as envisaged in the European Green Deal.

[3] New Mobility News, "TNO study: Battery-electric truck most cost-effective option from 2030", https://newmobility.news/2022/10/13/tno-study-battery-electric-truck-most-cost-effective-option-from-2030/.

List of abbreviations

ARA	Amsterdam-Rotterdam-Antwerp
B2B	Business-to-business
B2C	Business-to-consumer
B2G	Business-to-government
BAU	Business-as-usual
CH_4	Methane
CO_2	Carbon dioxide
CSC	Container Service Charges
CSR	Corporate Social Responsibility
EC	European Commission
EFIP	European Federation of Inland Ports
EGD	European Green Deal
EU	European Union
GHG	Greenhouse gas(es)
ICE	Internal combustion engine
IEA	International Energy Agency
ILUC	Indirect Land Use Change
IPCEI	Important Projects of Common European Interest
IRENA	International Renewable Energy Agency
IWT	Inland Waterway Transport
IWW	Inland Waterways
PLATINA	Platform for the Implementation of NAIADES
RED	Renewable Energy Directive
SSMS	Sustainable and Smart Mobility Strategy
SSS	Short Sea Shipping
STU	Standardised Transport Unit
TCO	Total Cost of Ownership
TEU	Twenty-foot Equivalent Unit
THC	Terminal Handling Charges
Tkm	Tonne-kilometre
UK	United Kingdom
US	United States (of America)
VNF	Voies Navigables de France

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1. Introduction

1.1 Setting the scene

Inland navigation is today at a crossroads, facing economic as well as environmental challenges that threaten to fundamentally alter its position in the European transportation market. On the one hand, unpredictable water levels and the energy transition imperative; on the other, a slowdown in global trade, the structural decline of fossil-based cargo, and the COVID-19 crisis. At the same time, inland waterway transport (IWT) is expected to play an important role on the path towards sustainable transport in 2050, as foreseen in the European Green Deal (EGD).[4] In fact, the EGD aims to cut 90% of emissions from transport by 2050 to reach climate neutrality and shift a substantial portion of the freight transported by road (currently accounting for circa 76% of EU inland freight) to inland navigation (circa 6%) and rail (circa 18%), namely through measures to increase the handling capacity of inland waterways and better integrate IWT into multimodal logistics chains. More specifically, the European Commission's (EC) Sustainable and Smart Mobility Strategy[5] establishes the following milestones: "transport by inland waterways and short sea shipping will increase by 25% by 2030 and by 50% by 2050 compared to 2015".[6]

Today, the energy transition must be considered as both a crucial challenge and a tremendous opportunity for inland navigation. In fact, only if the IWT sector can tackle the transition to climate neutral propulsion will there be long-term political support for the sector's continued development. To achieve these ambitious objectives and trigger modal shift, it is therefore essential for IWT to become greener, more competitive, digitised, and better integrated into logistic chains. It is also critical to think about the development of new markets for IWT, as well as the barriers and drivers associated with possible new market opportunities.

This report will shed light on these two complementary aspects. To develop this report, a desk study combined with statistical data analysis was conducted. Interviews with relevant experts and actors from different sectors were also carried out to gain further insights into possible new market opportunities for IWT. To understand IWT's potential future development pathways, it is important to look into the main IWT cargo segments as they manifest themselves in the current economic and political paradigm.

1.2 Current state of play: cargo and passenger transport by IWT

Three main cargo segments currently dominate IWT: dry cargo (including agricultural products), liquid cargo, and container transport (especially on the Rhine). In addition, passenger transport is another important segment for IWT.

1.2.1 Dry cargo

The dry cargo segment accounts for 59.8% of IWT volume in EU-27 in 2020.[7] Agricultural and food products currently represent around 9% and 16% of goods transported on the Rhine and Danube respectively. The transport of agricultural products is correlated with grain harvests. In general, agricultural transport on inland waterways in one specific year is partly determined by harvest results in the previous year. IWT seems to be a preferred mode for long-distance transport of agricultural goods. Regarding feedstuff and food products specifically, in Western Europe, densely populated areas such as the Netherlands and Belgium are experiencing difficulties with high nitrogen emissions due to intensive livestock activities. Political pressure to reduce emissions combined with decreased meat consumption

[4] European Commission, "A European Green Deal", December 2019, A European Green Deal | European Commission (europa.eu).
[5] European Commission, "Sustainable and Smart Mobility Strategy – putting European transport on track for the future", COM/2020/789 final, EUR-Lex - 52020DC0789 - EN - EUR-Lex (europa.eu)
[6] Taking also into account the analysis presented in the accompanying Staff Working Document, these milestones are set out to show the European transport system's path towards achieving the objectives of a sustainable, smart, and resilient mobility, thereby indicating the necessary ambition for future policies.
[7] CCNR and EC, "Thematic Report: An assessment of new market opportunities for IWT", February 2022, Thematic report | CCNR.

could lead to a reduction in these activities and a likely shift of production to Eastern Europe or South America.

In this scenario, several food products such as meat would need to be imported, generating demand for transport. It is unlikely that such food products, which are often perishable products, will be transported by inland vessels. Feedstuff needed to feed cattle would no longer be transported in the same volumes, which would reduce transport demand, also on inland waterways (IWW). Therefore, current trends in this sector point to a reduction of food and feedstuff products transport in the future in Western Europe. However, transport of food products in cities constitute a different and promising market which will be explored in this report. The current supply chain disruptions and food shortages experienced due to the war in Ukraine must also be highlighted as they are expected to negatively impact the agricultural and food IWT segment. Indeed, the war disrupts export of agricultural products from both Ukraine and Russia, leading to a price increase of agricultural commodities. The Ukrainian export of grain is unlikely to recover quickly. At the same time, countries highly dependent on agricultural imports from Ukraine are expected to redirect their demand towards other grain exporters. It is for instance expected that harvesting regions in France and related inland waterway hinterland transport on French waterways will benefit from this situation.

Iron ore, steel and metals are another important segment for inland navigation, representing 25% and 50% of goods transported on the Rhine and Danube, respectively. For Western Europe, the transport demand outlook for iron ore is not growth oriented, due to a high environmental pressure to reduce emission-intensive steel manufacturing processes for which iron ore and coaking coal are needed as raw materials. Iron ore transport is also very vulnerable to macroeconomic fluctuations and a reduction of world trade. Apart from these environmental and cyclical factors, iron ore and steel demand seem to be more saturated in Western Europe than in Eastern Europe. This last point is related to long-term economic catch-up mechanisms in Eastern Europe. For the Danube region, these catch-up mechanisms contribute to a more growth-oriented outlook for steel and iron ore in the coming years.

A main positive trend is captured in the segment of sands, stones, gravel, and building materials, possibly more pronounced in Western than in Eastern Europe. This is due to growing activity in the housing market, in parallel with demographic growth. For Western Europe, a consolidation on larger waterways is likely to take place, in parallel to a concentration on larger production sites. Large volumes of sands are expected to enter the market due to riverbed dredging and the need for materials for dike reinforcements. Untapped potentials lie in urban IWT and transport of construction materials to construction sites, two new markets which will be explored in-depth in this report.

Meanwhile, coal faces an almost complete phase-out in Western Europe, insofar as steam coal – hard coal used in the energy sector – is concerned. This is due to the energy transition in major IWT countries in Western Europe accelerated by the Paris Agreement and the European Green Deal (EGD). At present, the Danube area is less affected by the energy transition, as it is progressing at a slower pace in this region. However, it is expected that all IWT regions will be impacted by energy transition developments in the near future.

1.2.2 Liquid cargo

Volumes of liquid cargo accounted for 28.1% of IWT transport volume in the EU-27 in 2020.[8] On the Rhine, the share of petroleum products is very high, at 17.3% of total cargo transport, with very

[8] CCNR and EC, "Thematic Report: An assessment of new market opportunities for IWT", February 2022, Thematic report | CCNR.

important volumes transported in Belgium and the Netherlands. Although petroleum products such as gasoil/diesel, gasoline and kerosine are still expected to be part of the propulsion mix in the next decade, there are no growth prospects, and a gradual decline is assumed, possibly reaching near zero by 2050. Electrification of the transport sector, which makes petroleum products gradually redundant, puts additional pressure on liquid cargo volumes in IWT.

Petroleum products have lost some transport performance in recent years (mainly due to low waters and COVID-19), but there was no real downward trend so far in this segment. However, a significant drop would only materialize in case of a major electrification of road transport, as liquid fossil fuels together with heating oil form the backbone of the petroleum products transported by inland vessels.

For liquid chemicals, a far more growth-oriented development is expected. IWT is the preferred mode of transport in the chemical industry, and chemical production itself has overall more growth prospects in Europe than mineral oil production.

1.2.3 Container transport

Container transport accounts for 12.1% of inland transport volumes in the EU-27 in 2021.[9] Prior to the COVID-19 pandemic, global trade had already experienced a slowdown. This trend is expected to continue in the post-COVID world, as the importance of global trade of goods is decreasing in trend terms compared to the soaring trade in services. This structural change in trade can be explained by a dematerialisation of tradeable goods, higher focus on local production, growing incomes in emerging markets leading to reduced cost differentials and thereby less incentives for global trade of goods, and disruptive technical innovations such as 3D printing. Additional reasons include a slowing population growth in Western Europe, a reduction of the population share contributing to economic output in ageing societies, and decreasing productivity growth.

Containerisation is also coming to its saturation limits, as shown for instance by the persistent issues of congestion in seaports, which demonstrates seaports' inability to handle more containers in an efficient manner. In addition, container vessels' carrying capacity has been continuously increasing in the last year and should eventually stabilise. More emphasis on regional logistic and production chains will certainly have negative effects on seaborne container transport, which currently carries around 90% of the world's trade in goods. Consequently, as IWT is strongly linked to maritime container transport, these trends will inevitably affect seaport-hinterland container transport on IWW. However, if container transport pivots to regional and urban logistics chains, and if short-distance container transport develops further, this segment could potentially maintain a higher-than-expected growth rate.

1.2.4 Passenger transport

Passenger transport (ferry transport, day trips, river cruises etc.) plays a key role for the future development of IWT transport. To make IWT greener and more sustainable, both passenger and freight segments must contribute. Passenger transport demand can be split into touristic activities and public transport activities.

Although it had seen positive demand trends in recent decades, touristic passenger transport has suffered greatly from the COVID-19 crisis due to an almost complete halt in operations during lockdowns and a slower-than-average recovery. It is expected that a few years of stability will be needed before demand reaches its pre-crisis levels. The war in Ukraine came as an additional blow for the river cruise industry.

[9] CCNR and EC, "Thematic Report: An assessment of new market opportunities for IWT", February 2022, Thematic report | CCNR.

Passenger transport in the form of public transport services, including ferries, can be considered as an important tool for making cities greener and more sustainable. The fact that passenger transport can be powered by electric propulsion given limited distances has the potential to make cities more environmentally friendly. At the same time, IWT reduces the overutilisation of roads and its related negative externalities (pollution, pulmonary diseases, noise, accidents, lack of space, congestion etc.). Urban passenger transport by IWT in the form of public transportation carries huge potential, as the success of the waterbus in Brussels shows.

Although an important sub-market for IWT, this report will not cover passenger transport and focus on freight transport activities only.

1.2.5 Outlook for the future

Overall, it appears that the energy transition will have a cross-cutting impact on freight volumes in inland navigation, and on coal in particular. Liquid mineral oil products will continue to be an important component of the energy sector and of inland navigation for the next decade, although a gradual decline is underway. For chemicals, the outlook is far more positive and potentially even growth oriented. Regarding foodstuffs, a reduction of emission intensive livestock activities, combined with a change in consumer habits and macroeconomic disruptions such as the war in Ukraine, will reduce transport volumes significantly. The more trade-related cargo segments – container transport in particular – will continue to be affected by the structural slowdown in world trade. Passenger transport, given its potential for sustainable urban mobility, will instead continue to expand.

1.3 Objectives and perimeter of the report

The scope of the report will be limited to analysing the obstacles and opportunities for modal shift from road to IWT in selected new and growing markets which depend upon macro-economic factors and energy transition imperatives (as described above).

As will be detailed in Chapters 2 and 3, these new and growing markets include 1) urban logistics, 2) activities related to circular economy and waste transport, 3) transport related to the energy transition (alternative fuels and renewable energies), 4) high and heavy cargo, and 5) container transport. Each identified market will be illustrated by real-world examples, including a selection of interesting research or pilot projects that test the integration of IWT into new and growing markets in innovative ways. The report will also highlight the obstacles and opportunities facing IWT in each new market. Marketing and communication innovations, as additional tools to spur modal shift and increase awareness about inland navigation, will also be covered in Chapter 4.

Finally, given that these topics are analysed in depth by other PLATINA3 deliverables within other PLATINA3 deliverables within Work Package 1 (Market), the long-term technological innovations (in task 1.2), synchromodality (1.3), reduction of economic/financial barriers (1.4), and policy and regulatory actions (1.5), will not be addressed in this report.

2. Encouraging modal shift to IWT: barriers and opportunities

After presenting the current policy context, this Chapter reviews specialised literature on the various factors driving modal shift, then examines the barriers and opportunities to modal shift from road to inland waterways (IWW).

2.1 Policy and regulatory context

On 17 October 2018, the Ministers of the five Member States of the CCNR (Belgium, Germany, France, the Netherlands, Switzerland) adopted the Mannheim declaration.[10] Recalling the sector's high potential for development and innovation, they vowed to reinforce the role of inland navigation by promoting faster and more efficient inland vessel cargo handling in seaports and tighter integration of IWT into digital and multimodal logistic chains.

Echoing this call at EU level, the European Commission unveiled the European Green Deal[11] (EGD – December 2019) and the Sustainable and Smart Mobility Strategy[12] (SSMS – December 2020). The EGD aims to shift a substantial portion of the freight transported by road (currently accounting for circa 76% of EU inland freight) to inland navigation (circa 6%) and rail (circa 18%), namely through measures to increase the handling capacity of inland waterways and better integrate of IWT in multimodal logistics chains. On 14 July 2021, the European Commission published the "Fit for 55" legislative package[13] to deliver the EGD, a set of proposals to make the EU's climate, energy, taxation and especially transport policies fit for reducing net GHG emissions by at least 55% by 2030, compared to 1990 levels. The SSMS, on the other hand, indicated that IWT and short-sea shipping (SSS) should increase by 25% by 2030 and by 50% by 2050. Both policies recognise the importance of IWT's contribution to greening the transport sector to reach carbon neutrality by 2050.

In June 2021, the European Commission launched the NAIADES-III Action Plan[14], which sets an "Inland Navigation Action Plan 2021-2027" aligned with the Multi-Annual Financial Framework to meet the objectives of the EGD and SSMS. One of NAIADES-III's two core objectives is shifting more freight to inland waterways from other transport modes (modal shift), thereby contributing to reducing GHG emissions and limit road congestion. Underpinning this ambition is one of eight NAIADES-III policy flagships dedicated to updating the EU's legal framework for intermodal transport to stimulate IWT modal share growth in the short and medium term. This flagship aims to boost modal shift to more sustainable and low-carbon transport modes such as IWT by establishing a level-playing field across transport modes when it comes to environmental performance.

Finally, the EU Taxonomy Climate Delegated Act[15] recognises the potential of low-carbon transport modes such as inland waterways to contribute to modal shift. This observation is echoed by the

[10] CCNR, "Mannheim Declaration "150 years of the Mannheim Act – the driving force behind dynamic Rhine and inland navigation", 17 October 2018, https://www.ccr-zkr.org/files/documents/dmannheim/Mannheimer_Erklaerung_en.pdf.
[11] European Commission, "A European Green Deal", December 2019, A European Green Deal | European Commission (europa.eu).
[12] European Commission, "Sustainable and Smart Mobility Strategy", December 2020, Mobility Strategy (europa.eu).
[13] European Commission, "Fit for 55 package", July 2021, Delivering the European Green Deal | European Commission (europa.eu).
[14] European Commission, "NAIADES III action plan", June 2021, NAIADES III action plan (europa.eu).
[15] European Commission, "EU Taxonomy Climate Delegated Act", June 2021, EU taxonomy for sustainable activities | European Commission (europa.eu).

European Parliament in a resolution[16], where inland waterway transport is deemed an essential pillar in the shift towards multimodal sustainable transport, as one of the most environmentally friendly transport modes. Indeed, the resolution recognises that greening is key to ensure the IWT sector's long-term competitiveness and to enable it to play a significant, reliable, and credible role in modal shift.

2.2 Drivers of modal shift

Modal shift refers to relative changes in the market shares of different modes of transportation in relation to each other for specific transport flows. This does not preclude a simultaneous surge in absolute terms of two or more transportation modes. A modal shift usually occurs when one mode gains a comparative advantage in a similar market over another. These shifts respond both to macro- and microeconomic factors.

As shown in **Figure 1** below, Rodrigue (2020) has conceptualised the process by which modal shift occurs from one transport mode to another over time, through three distinct phases: 1) inertia, 2) modal shift, and 3) maturity.

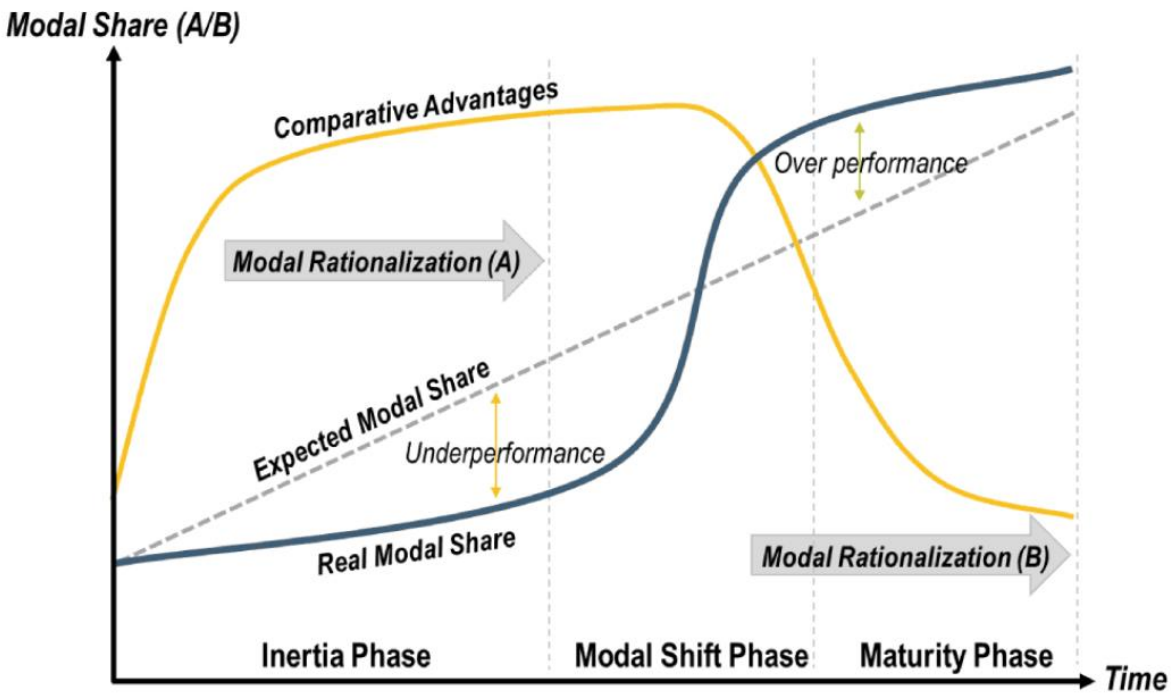

Figure 1: Schematic representation of the principles of modal shift. **Source**: Rodrigue, 2020.

From a macroeconomic standpoint, technological leaps, fuel price variations, supply chain disruptions and other structural factors linked to global trade can significantly alter the competitiveness and viability of different freight transport modes, thus leading to modal shift. From a microeconomic perspective, the modal shift decisions made by individuals and firms are caused by endogenous – users and transport providers' preferences, partly due to cultural habits, biases, path dependencies and network effects – as well as exogenous – cost perception, regulations, policies – factors. The outcome is a series of decisions to shift to another transport mode if comparative advantages are perceived to be significant enough to warrant bearing the necessary transition costs (Rodrigue, 2020). The comparative advantages

[16] European Parliament, "Towards future-proof inland waterway transport in Europe", July 2021, REPORT towards future-proof inland waterway transport in Europe (europa.eu).

mentioned in **Figure 1** could be of different types. Usually, they must become very significant before companies take steps to perform a costly and time-consuming modal shift.

In the case of modal shift to IWT, this mode is constrained by several structural factors that make it both a difficult and promising candidate for modal shift. According to an analysis conducted by Prof. Thierry Vanelslander from the University of Antwerp and presented at the 3rd PLATINA3 stage event on 10-11 February 2022[17], the eight main performance indicators taken into consideration for choosing one transport mode over another include: reliability, flexibility, loss/damage, frequency, cost, time, customer service, and environmental externalities. Among these, five are considered of superior importance: reliability, loss/damage, customer service, cost, and flexibility (in decreasing order). The results of the analysis are presented in **Figure 2** below.

	Reliability	Flexibility	Loss/Damage	Frequency	Cost	Transport time	Customer service	Environment
Importance	4,8	3,95	4,6	3,85	4,1	3,6	4,35	2,5

Performance road	reliability	flexibility	loss/damage	frequency	cost	transport time	customer service	environment
	3,85	4,35	3,75	4,40	3,45	4,10	4,00	2,30
Performance intermodal	reliability	flexibility	loss/damage	frequency	cost	transport time	customer service	environment
	3,80	3,25	4,10	3,40	3,95	3,20	3,65	3,95

Figure 2: Analysis of performance factors for modal shift from road to intermodal transport, including inland waterways. **Source**: Prof. Thierry Vanelslander (University of Antwerp).[18]

Compared to road and other land-based transport modes, IWT has advantages and disadvantages. IWT is considered as reliable as road, less flexible, less prone to loss or damage, less frequent, less costly, slower, less customer-service-friendly, and far more environmentally sustainable. Of the five most important factors, IWT is better than road on loss/damage and cost, worse on flexibility and customer service, and about equal on reliability. Therefore, it appears that IWT has a few specific niches that make it more attractive than road, but must overcome significant hurdles where road maintains an edge to spur modal shift in its favour. Even though environmental sustainability is another performance indicator where IWT greatly outclasses road (3.95 / 2.30), it is not considered of critical importance (only 2.5/5) at the moment. However, this situation is poised to change in the coming years or decades, especially due to the energy transition pressure from national and EU regulators, the role of customers and changing mindsets in terms of modal choice.

Indeed, demand for greener vessels and transport services from customers (i.e. shippers and brokers or tourists) could be a major push factor for ship owners to invest in greening technologies and sustainable alternative fuels. The influence of customers in stimulating the energy transition is different depending on whether the vessel operates in the passenger or freight transport market. In the passenger transport

[17] Thierry Vanelslander, "How to increase inland waterway transport market share?", PLATINA3 3rd Stage Event, 10 February 2022.
[18] Note: The colour green indicates the 5 most important factors; blue where IWT outperforms road; red where road outperforms IWT.

market, there is a direct relation with the customer, passenger, or tourist on board, who are more demanding regarding emissions compared to shippers in freight transport. It is found that consumers are willing to pay more for a low/zero emissions vessel. Passenger ships and especially daytrip vessels benefit from a "green" image, enabling operators to differentiate their services from the competition and thus attract more passengers. "Green" therefore acts as a powerful signalling and marketing tool. As such, a classification system for vessels informing customers of their environmental performance should be supported.

The paradigm is indeed different in the freight transport market, where the total cost of ownership (TCO) plays a more important role. Inland navigation entrepreneurs provide transport services to cargo owners/shippers for a set price. Because competition between cargo owners/shippers is also very strong, the price criterion plays a major (if not the only) role. In the current market conditions, transport should be as cheap as possible but also as reliable as possible. In practice, however, cargo owners are not yet ready to pay more to transport their goods via a low/zero-emission vessel, often because of existing bottlenecks. Nevertheless, the "green image" is becoming increasingly important for society and hence for cargo owners/shippers and brokers. Final customers, especially large multinationals, are paying more attention to their corporate social responsibility (CSR) and carbon footprint. Using a green vessel to transport goods is therefore welcomed, but in practice little or no extra payment is made for it, with a small number of exceptions.

According to the United Nations Climate Technology Centre & Network (UN-CTCN)[19], rail and water transport boast a substantially better environmental profile but are limited by longer delivery times and the necessity for pre- and post-haulage by truck, an analysis consistent with results found in the literature. Furthermore, road, rail and IWT serve different transport markets. The average distance for cargo travelling by IWT or SSS is much larger than for road and rail, while the cost per Tkm can be an order of magnitude lower. This explains why IWT and SSS are mostly used for larger quantities of bulk cargo that is relatively time-insensitive and for which demand is quite elastic.

Yet specialized literature demonstrates that structural factors and sectoral willingness to undergo modal shift are insufficient on their own to lead to large-scale modal shift. They must be complemented by targeted policies, regulations, and legislation to channel the necessary investment and stimulate innovation. Indeed, according to Pijnenburg (2021), modal shift ambitions that pre-exist within private sector stakeholders must be guided by regulations and policies, with the addition of digital tools, improved planning, and carbon footprinting to make IWT more attractive. But according to Rogerson et al. (2019), policy makers aiming to promote modal shift must understand that fees and legislation often also act as barriers in the form of administrative costs. Santén et al. (2021), on the other hand, underline the fact that realising large-scale modal shift requires multi-actor engagement, openness to emergent solutions and long-term endurance, because the investments (fleet, terminal infrastructure, technology, business case proof-of-concept etc.) needed to develop at scale are very high.

The factors described above present both barriers and avenues towards more IWT-transported freight over European inland waterways, implying both obstacles and opportunities to the realization of the CCNR's and the EU's modal shift objectives.

[19] UN-CTCN, "Modal shift in freight transport", April 2017, Modal shift in freight transport | Climate Technology Centre & Network.

2.3 Obstacles to modal shift to inland waterways

IWT faces a number of challenges to enable modal shift. Due to its nature, IWT is slower and less flexible than other transport modes, and port congestion can quickly create large backlogs and delays. These are due to persistent timetable irregularities and overbooking in maritime transport, coupled with lax application of maritime law, handling priority given to maritime over inland bound cargo, and soaring energy prices compared to the rail sector. In addition, recent events such as the COVID-19 pandemic, the Suez Canal incident (Ever Given ship), Brexit, and the Russian invasion of Ukraine led to increased congestion issues at seaports, highlighting further their vulnerability and the need to find solutions to address this challenge. Inefficient handling of inland cargo container vessels has negative impacts, both financially and in terms of image. Ultimately, this can lead to a loss of competitiveness for IWT compared to other modes. Given its important role in achieving carbon neutrality, this situation does not play in favour of modal shift to IWT. Ensuring faster and more efficient inland vessel cargo handling in seaports is essential to reinforce the role of inland navigation as an economically relevant means of transport.

Water level variations on the Rhine and the Danube are becoming more severe and the IWT sector will have to adapt to both high and low water scenarios in the future.[20] Extreme low water results in a decrease of the service quality of IWT due to increased freight rates, longer transportation times, interruptions of transport, increased administrative and financial burden with respect to organisation of more shipments, transfer of goods to other vessels, and consideration of alternative means of supply (road or rail). In the worst case, no satisfactory supply of goods and raw materials can be realised, resulting in severe losses in production, as was the case in 2018 and 2022. Consequently, cargo will be shifted from waterways to rail or road, causing a reduction of IWT's modal share, which can also become permanent as result of a loss of reliability performance (and reputation) and shippers wanting to have multiple options to mitigate risks of disruptions. This holds in particular for market segments which are in a strong multimodal competition, e.g. container transport.

The low water event in 2018 had long-lasting repercussions on a number of segments on the Rhine, including container, chemical, and mineral oil products, where rail transport took over IWT volumes (reverse modal shift).[21] The shallow water period in 2018 affected also the Upper and Middle Danube, entailing traffic stop not only for pushed convoys, but also for passenger ships. Separate local restrictions were introduced, including for single-hull ships carrying dangerous goods. More worrying is the fact that, once cargo has been moved to rail or road, it will not easily come back to IWW due to lost confidence in IWT's reliability. It is widely acknowledged within the IWT sector that there are no 'one-size-fits-all' solutions to address present and future low water challenges. A range of actions need to be taken rapidly regarding the adaptation of fleet, infrastructure, logistics and storage concepts, as well as implementation of digital tools, in order to ensure that inland navigation remains a reliable mode of transport and to avoid a permanent shift away from IWW to other modes. To support the sector, there is consensus among key IWT actors that funding and financing solutions must be made available.

Furthermore, IWT is a complex market with many intermediaries and could greatly benefit from improved forecasting. In terms of capacity and supply chain integration, demand outweighs supply at the moment and the sector remains a small player, with only 6% modal share, severely constraining its market influence. Combined with the fact that environmental externalities and taxation differ depending on the mode of transport, IWT faces difficulties due to a lack of level-playing field in this regard. However, these last two issues can be solved by policymakers to some extent, by increasing

[20] CCNR, "Act now! on low water and effects on Rhine navigation", Reflection paper, ed. 2.0, February 2021, ien20_06en.pdf (ccr-zkr.org).
[21] CCNR, "Annual report 2020", September 2020, Annual Report 2020 | CCNR.

supply or reducing demand, on the one hand, and designing more uniform charges to external costs, on the other, so that the best performing transport mode can become the most competitive.

During the 3rd PLATINA3 stage event on 10-11 February, Mr. Geert Van Overloop, project manager for River Drones at NAVAL Inland Navigation, provided insights into how innovation can be a driving force for modal shift.[22] According to him, innovation is context-specific and takes place in a competitive marketplace. It must therefore be adaptive to market demands and prices, thus maintaining both a competitive and innovative edge, with price being a key factor. Indeed, in a competitive environment, innovation cannot lead to a significant increase of TCO, pricing itself out of the market. This is especially true in a fragmented market like IWT where strong competition comes from other modes and numerous companies operating on the same waterways. To succeed, innovation in inland navigation requires making a compelling case for the client or the user to change from one mode to another, for instance by offering new benefits, such as increased flexibility, sustainability, and scalability, ideally for a comparable price.

Finally, IWT faces two more barriers of a sociological nature, namely a lack of intra-sectoral cooperation for change and a cultural preference for road transport. Compared to IWT, road is perceived as more flexible and is more familiar to operators, even if it might not be the most environmentally friendly modal choice available.

Rogerson et al. (2019) group these barriers into four distinct categories: regulatory (fees, legislation, uncertainty), financial (port charges, investment, risk), service quality (frequency, reliability, flexibility) and market characteristics (volume, last mile, ice). In the next Chapter, most of these barriers are analysed against selected new and emerging markets for IWT.

2.4 Opportunities for modal shift to inland waterways

Despite the barriers described above, the sector possesses substantial strengths that make it a promising candidate for modal shift.

First of all, as of late 2022 IWT is one of the most energy efficient means of transportation, with average CO_2 emissions only a third of their road transport equivalent per Tkm.[23] One inland (container) vessel can replace, depending on size, between 14 and 660 trucks, reduce fuel and carbon consumption by about 60-80%, noise by about 50-75%, and is more reliable due to minimal or no congestion on inland waterways. Climate change acts therefore as a push factor in light of IWT's clean transport potential and due to the role given to it by European policies such as the EGD, the SSMS and the NAIADES-III Action Plan. As all transport modes are required to reduce their emissions by 90% by 2050 to achieve the objectives of the Paris Agreement and the EGD, most transport modes will initiate their energy transition in the short to medium term. This fact, combined with future supporting policies, will have a stimulating effect on IWT, leading to fleet modernisation, clean infrastructure development, and the mainstreaming of alternative fuels.

Moreover, given that other modes such as rail and road are also initiating their transition at a fast pace and that inland navigation lags behind in its transition process, transport demand might shift to these other modes. This should be considered as an additional push factor. In this respect, a recent TNO study

[22] Geert van Overloop, "River Drones: innovation as a driving force for modal shift", PLATINA3 3rd Stage Event, 10 February 2022.
[23] European Commission, "World's cleanest vessel on inland waterway", March 2022, [World's cleanest vessel on inland waterway | Eco-innovation Action Plan (europa.eu)](https://ec.europa.eu).

made clear that by 2030 battery electric trucks may already be more competitive from a TCO standpoint compared to diesel trucks.[24] As a result, the market share of zero-emission trucks is likely to quickly increase, leading to a rapid projected reduction of CO_2 emissions by road haulage. This can eliminate the climate argument stated in the European Green Deal in support of modal shift from road to IWT. It might even trigger a reverse modal shift instead if IWT cannot keep up with this fast-paced transition in road haulage.

More generally, innovation will act as a booster for modal shift. By improving the efficiency of IWT and acting upon the factors identified by Thierry Vanelslander (mainly reliability and cost), then a substantial impact on modal shift can be expected. The IWT sector being very price sensitive, innovation will have to be either compelling or cost-effective enough to warrant modal shift. Furthermore, the large size of inland barges allows to transport much higher volumes and benefit substantially from economies of scale, thus reducing costs. In this context, technical innovations such as digitalisation and automation can certainly improve the efficiency of IWT compared to other modes. IWT is also one of the most secure and reliable means of transportation, with very few accidents and low risk of damaged payload or loss of cargo. For operators looking for long-term, sustainable and energy efficient transport solutions, IWT is an attractive option.

Another opportunity for modal shift to inland waterways resides in fostering better interconnections with maritime ports and global trade. In a case study on the freight corridor between Rotterdam and Moerdijk, Pijnenburg (2021) finds that, to achieve modal shift, SMEs must integrate IWT in their operations, seaport congestion must be tackled (see above), and both public and private parties must play an active role in steering modal shift from road to IWT. Network hubs such as the port of Rotterdam are identified as key actors who can spearhead modal shift by better linking inland waterways to seaports, and vice versa.

It appears therefore that several niches give IWT a decisive advantage in some market segments compared to road transport. On the other hand, long-lasting modal shift is only triggered when larger distances must be covered, typically more than what can be covered by a truck in 1-2 days. It also depends on the ease with which cargo transfer to other modes of transport can be executed. Even so, new opportunities exist for IWT. For example, delivery of beverages and food supplies to bars and restaurants in city centres allows to create value while "green[ing] the last mile of city logistics".[25] Other deliveries in urban environments (construction material, bulk, voluminous goods, pallets) can help with road congestion and lack of access for large trucks to busy city centres and narrow roads. More generally, new markets in inland navigation can emerge in light of climate policies favouring the decarbonisation of societies and insisting on more sustainable, resilient and future proof transport modes. These new market opportunities are analysed in detail in Chapter 3.

[24] TNO, "Techno-economic uptake potential of zeroemission trucks in Europe", October 2022, [TNO | Report on zero-emission trucks in Europe](#).
[25] Adina Vălean, EU Commissioner for Transport, 2021, [Mobility and transport | NAIADES III action plan](#).

3. Opportunities and obstacles for inland navigation in new and growing markets

The term “new and growing markets” describes, on the one hand, market segments where IWT is either not yet present or in an early stage of development and could be considered in coming years as a suitable transport solution. On the other, it refers to existing markets with strong potential for further growth. New and growing markets can determine future products transported by inland vessels, but they often imply new types of logistics, vessels, and areas of operation.

The 3rd PLATINA3 Stage Event (10-11 February 2022) featured discussions on new and growing markets which might trigger modal shift towards IWT.[26] The following options were discussed:

- Waste / biomass transport;
- Circular economy / new materials;
- Urban logistics;
- New energies, including hydrogen and other alternative fuels;
- New trade routes, connections to TEN-T corridors, core and comprehensive networks;
- Passenger transport;
- Container transport.

These new and growing markets are needed to respond to a decrease or saturation of existing markets. On the demand side, several goods segments have reached saturation, the energy transition changes product composition, and world trade is experiencing structural slowdown. On the supply side, difficult navigation conditions are expected to intensify due to climate change while low water events stress the need to diversify operations towards urban logistics where water levels are less critical.

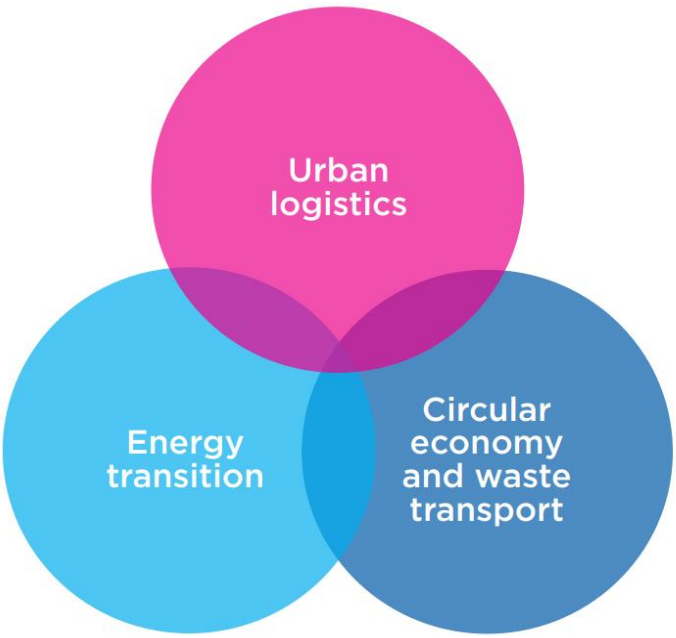

Figure 3: Abstract representation of three interrelated new markets for IWT. **Source**: CCNR.

[26] Presentations made by: Daan Schalk “New market opportunities and strategies”; Geer van Overloop “River Drones: innovation as a driving force for modal shift”; Heinrich Kerstgens “Decarbonisation of logistics and modal shift towards inland waterway transport”; Norbert Kriedel “New market opportunities in inland navigation transport”; and Thierry Vanelslander “How to increase IWT market share?”.

Building upon the stage event discussion and existing literature[27], this Chapter explores five such markets, namely: 1) urban logistics, 2) circular economy and waste transport, 3) new cargo flows triggered by the energy transition, 4) high and heavy transport, and 5) container transport. For most new and growing markets, a non-exhaustive list of concrete examples and projects is provided for illustrative purposes. It should be noted that three of these markets could be interrelated, as depicted in **Figure 3**. As a practical example: household waste could be shipped on urban waterways to be recycled into a new energy source which would then be transported again via IWT.

3.1 Urban logistics

Urban freight transport by inland vessels is viable in large cities criss-crossed by rivers and canals, such as Paris, Amsterdam, or London. Due to historical reasons, inland waterways are often located at the heart of European city centres. This feature makes them a natural infrastructure well-suited to deliver transport services in areas more and more precluded to road transport. In fact, contrary to road freight, IWT is an unsaturated and safer mode of transport, as it uses transport infrastructure with free capacities. Lack of congestion facilitates on-time deliveries and the overall efficiency of urban transport flows, while generating fewer accidents. Road traffic congestion in cities causes substantial economic loss, estimated at about EUR 180 billion per year in terms of delay costs and about EUR 32 billion per year in terms of deadweight loss at EU-27 level.[28] Furthermore, heavy trucks in historic inner cities also cause damage to the infrastructure.

Due to the large volume of goods that can be transported on a vessel unit, inland navigation vessels operating on the Danube are mainly used for the transportation of bulk goods. However, as in the case of major urban areas located directly on the Danube (e.g. Vienna, Bratislava, Budapest, and Belgrade), the availability of urban logistics services creates a reliable business environment for suppliers of scrap metal, waste plastic, waste glass and other secondary raw materials. Besides cargo transport and the emphasis being put on it, passenger transport is a booming industry (exception during the pandemic).

The demand for goods, of which cities are net importers, rises with the size of urban populations. In parallel, the production of waste increases and solutions to remove such waste must be found. This also leads to an increase in the demand for transport infrastructure. For this reason, the EU is dedicated to promoting sustainable urban transport systems. Current transport systems are mainly based on fossil fuels and are therefore not sustainable in the long run, given the related negative externalities, scarcity of resources, and energy dependence of the EU.

Changing habits among consumers places another strain on urban logistics. The rise of e-commerce and the necessity of ever faster and personalised deliveries incentivise fragmentation, leading to 23% of vehicles on the road travelling unloaded, according to a case study conducted in Austria (Simmer et al., 2017). The increase in the number of vehicles is also linked to the phenomenon of logistics sprawl, whereby, due to high land costs in the urban perimeter, logistics operators prefer to move their sorting centres further and further away from the centre. These elements put additional pressure on environmental indicators in large agglomerations, as they lead to even more road transport. Innovative solutions for urban freight delivery are called for to avoid the negative impacts that this framework would cause to the economy and the environment. Cities located near and around waterways could take

[27] CCNR and EC, "Thematic Report: An assessment of new market opportunities for IWT", February 2022, Thematic report | CCNR.

[28] European Commission, "Staff Working Document SWD(2020)331", December 2020, p.106 Sustainable and Smart Mobility Strategy (europa.eu).

advantage of their location to make deliveries of goods in specific sectors more efficient and less polluting, through an increased use of IWT solutions.

The low-water phenomenon and its related negative effects (loss of transport volume and modal shares) and the modal shift ambition call for a diversification of inland vessels' areas of operation towards higher participation in urban logistics, where water levels are less variable. Urban IWT not only implies a change in the type of cargo transported (parcels vs. mass cargo), but also a change in the areas of operation (city logistics vs. international transport), a different range of logistics (short-distance vs. long-distance transport), and smaller rather than larger vessels.

Over the past decade, IWT has sparked renewed interest for more sustainable urban logistics within the public sector (cities) and private companies. Urban logistics embrace a broad field of freight distribution comprising various interactions (B2B, B2C, public-private partnerships). Inland navigation allows for many different types of cargo to be transported to city centres (parcels, food products, construction material) and in varying forms (pallets, barrels, containers, bulk). In this context, three sub-markets for transport of urban freight by inland vessels will be studied in more detail : parcel delivery, retail logistics and the construction sector. For each, an example is provided for illustration purposes. Transport of waste and recycled goods is also a sub-market with strong potential for development in urban areas and will be addressed in a separate section related to circular economy.

3.1.1 Urban parcel delivery

With the rapid increase of e-commerce and the demand surge for fast, cheap, and reliable parcel delivery, finding more efficient, sustainable, and off-the-road transport solutions becomes essential. In Amsterdam, a retired passenger ferry found its passengers replaced by parcels. Since 2017, Holland's Glorie's[29] operations combined three transport modes to bring parcels from a logistics coordination centre to the end recipient in the heart of Amsterdam. Parcels arrive at Schiphol airport and are loaded onto electric trucks which then transport the parcels to the vessel. Once in the vessel, the journey begins on Amsterdam's waterways, to reach a platform in the city centre (Koningsplein) where 21 cargo bicycles await the parcels to be delivered. The advantages of delivering by bike lie in efficiency gains, as one can reach up to 17 deliveries per hour, compared to 5-6 deliveries per hour by car. This is due to the narrow streets of Amsterdam's city centre, where cars, many bikes, motor bikes and almost no available parking spots contribute to considerably slow down the delivery process.

In the Danube region, operators combine the Vienna Danube Canal together with cargo bike services. The solution concentrates on the delivery of parcels to end consumers in an area extending up to three kilometres from the banks of the Danube Canal. The first logistics leg is ensured by boat transport from the Port of Vienna to the transhipment warehouse on the Danube Canal, the parcels are then being collected by a fleet of cargo bikes which perform the delivery to the end customer. The combined system – inland vessels and cargo bikes – promises increased transport safety, reduced noise and emissions, less congestion and greater energy efficiency.

Channels create great opportunities for urban parcel delivery. For example, for the Danube Delta villages concentrated mostly along the Danube arms (with less than 4.000 inhabitants), with small areas of dry land and the smallest road densities in the country (Romania), the Delta provides a substantial network of local waterways (616 km). The transport of both people and goods (including parcels and other postal

[29] DHL, "Swimming the last mile", 2018, Schwimmend auf der letzten Meile (dhl.de).

services) is done by boat[30] all year round (except when the waterways are frozen, then helicopters are used).

3.1.2 Urban retail logistics

IWT can play an important role in the urban retail logistics sector, and specifically regarding the transport of food and beverages (B2B, B2C).

The retail chain Franprix developed an innovative transport solution based on a multimodal chain combining river and road transport.[31] In two Franprix warehouses, approximately 20 km south of the centre of Paris, 50 containers filled with grocery goods are loaded onto inland vessels every day. The convoy leaves the warehouses at the end of the day to pass through two locks on the Marne before 20:30. It then arrives in the evening at the Port of La Bourdonnais, at the foot of the Eiffel Tower, and remains there until 5:30, when handling operations begin. The containers are then transported by truck to be delivered to more than 300 Parisian shops. According to Franprix, the system saves 450,000 kilometres of road travel per year, the equivalent of almost 13,000 laps around the Paris ring road, 3,800 fewer lorries and almost 250 tonnes of CO_2 saved.

In Vienna, the Swedish furniture manufacturer IKEA has been also investigating the possibility of using the Danube Canal for reaching two of their warehouses located in the north and in the south of the city. Their concept involves efficient transportation of goods by inland vessels along the Danube Canal, whereas last mile logistics are performed by road transport.

3.1.3 Construction material delivery

A key urban logistics sub-market to spur modal shift is the construction material delivery sector, where IWT appears as a reliable, cheap, and efficient solution.

In preparation for the 2024 Paris Olympic Games, the French waterway administration, Voies Navigables de France (VNF), aims to promote river logistics in the construction of the Athletes' Village, in Saint-Denis.[32] In total, one million tonnes of construction material could be transported by IWT to supply all Olympic construction sites along the Seine. VNF has set up a quay dedicated to the disposal of spoil material from the construction sites on Île-Saint Denis, leading to the evacuation by IWT of 250,000 tonnes of spoil since May 2020. In addition, VNF is working to develop partnerships to encourage the use of river transport in the logistics of the Games as well as in their aftermath in the framework of smart mobility. As evidence of its viability, the construction segment on the Seine has performed very well in recent years, as its volume was 36% higher in 2019 than in 2014. In the Ports of Paris, by far the most important segment is that of sands, stones, and other building materials, representing 68% of total waterside traffic in 2015 and up to 78% in 2019. It must be noted that, on top of urban transport, these volumes also reflect long-distance transport, as sands, stones and gravel are transported between the Benelux region and Paris.

In the Austrian capital, inland navigation proved to be a reliable partner in supporting the demolition of an important bridge. To this end, a special demolition vessel was used for the first time, saving around 10 months of work. The 90-meter-long and 12-meter-wide pontoon vessel, i.e. a kind of giant raft named

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[30] Transdanube.Pearls - Network for Sustainable Mobility along the Danube, March 2018, SRTMP for the Danube Delta (interreg-danube.eu)
[31] Métropole du Grand Paris, "Logistique urbaine : Franprix, un exemple réussi", December 2018, MGP Labo SCOT fiche-HAROPA_logistiqueurbaine_181206.pdf (metropolegrandparis.fr).
[32] Actus Hauts-de-Seine, "JO 2024. Les déblais et matériaux du village olympique vont être acheminés par la Seine", January 2020, JO 2024. Les déblais et matériaux du village olympique vont être acheminés par la Seine | Actu Hauts-de-Seine.

"Kilian", was positioned in the Danube Canal directly under the Erdberger Bridge,. Pillars on the vessel supported the bridge, which was then dismantled piece by piece. The rubble conveniently fell straight onto the ship's catchment facilities and could then be taken to the port of Albern and from there by truck to the Fischamend landfill.

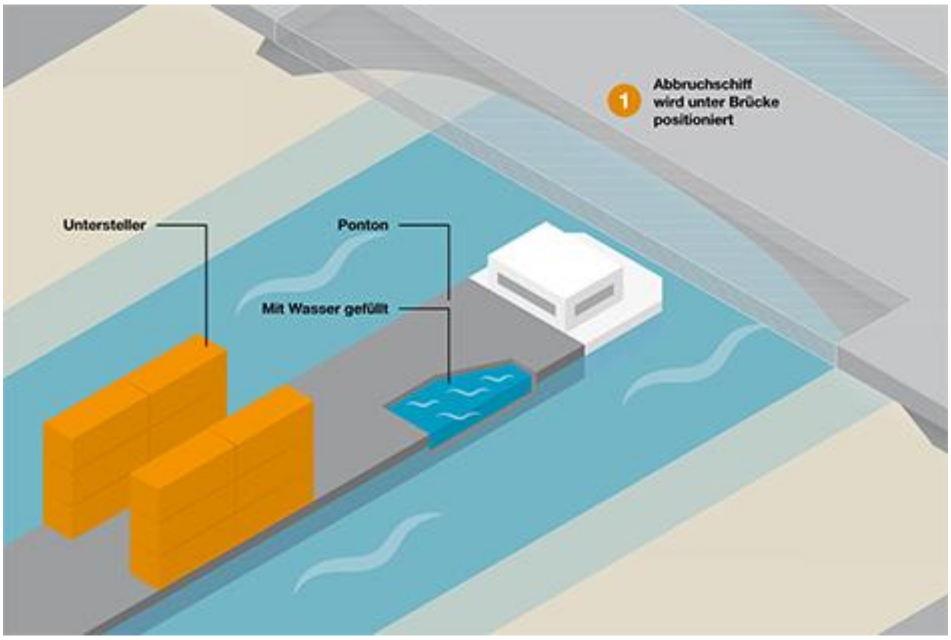

Figure 4: Drawing of the demolition vessel "Killian". **Source**: ASFINAG.

To the west of the provincial capital Linz, between the steep rocky flanks of the Danube valley, a new Danube bridge is being built which will bring numerous benefits to the city of Linz and its residents. With a total length of 300 meters and a width of 22.5 meters, the construction of the new Danube bridge[33], including the transport of all materials, has made use of the Danube in a very efficient and effective way. The transhipment point was the port of Ennshafen which provided all necessary equipment to facilitate a smooth transit.

The Danube has also been used for the transport of materials which were used in the modernization process of the southern railway Danube bridge in Budapest.[34] The new bridge (finalised in May 2022) plays a very important role in reducing the city's traffic jams, making suburban rail transport more competitive, and will allow suburbs trains to run on the section every 8-10 minutes, connecting important parts of the city, including the airport. The new bridge removed a crucial bottleneck on the Rhine-Danube Core Network Corridor caused by the Erzsébet Bridge. This bridge did not allow the circulation of freight vehicles heavier than 20 tonnes. Due to this restriction, heavy goods vehicles travelling from Hungary and Slovakia could not access the ports across the border. The new bridge clearance is 10 meters over the highest navigation water level, allowing navigation of vessels suitable for class VII waterways. The related construction material resulting from the construction works as well as important bridge parts have been successfully and efficiently been transported by inland waterways vessels.

[33] ASFINAG, "Ein Projekt der Superlative: die Donaubrücke der A 26", 20 May 2022, ASFINAG | Linz Bridge [DE].
[34] NIF, "Modernization of the Southern Railway Danube Bridge in Véghajra", May 2022, NIF | Southern railway bridge [HU].

3.1.4 Other relevant projects under development

In addition to already operational projects, new projects are currently being developed in the very dynamic urban logistics sector. These projects experiment with pioneering and innovative transport solutions to harness the benefits of digitalisation and sustainability. For example, the AVATAR pilot project[35] in Hamburg and Ghent aims to test innovative and sustainable urban freight transport concepts with autonomous and emission-free vessels in order to achieve modal shift from road to IWT to 'green the last mile of city logistics'. Four potential cargo groups are identified: waste, parcels and courier, B2B retail logistics, and building materials. This project is all the more promising as markets already exist for these cargo groups, which makes for optimistic outlooks on its business case proof-of-concept and economic viability.

3.1.5 Opportunities

As shown by the number of existing projects, IWT offers clear opportunities for modal shift in urban settings and shows the viability of IWT under specific circumstances, despite the competitive pressure from road transport. This is corroborated by Wiegmans and Konings (2016) who already shed light on IWT's potential in urban contexts. It seems that specific freight segments are suitable for IWT in cities, namely transport of parcels, retail products and building material, as well as waste (as will be seen below). An advantage of inland navigation is that it can transport such goods in different forms (pallets, barrels, containers, bulk, etc.), is able to scale easily while benefit from alternative and renewable energy solutions.

The fact that IWT enables the reduction of road congestion as well as other negative externalities, in particular accidents, thereby addressing safety and environmental challenges, is an undoubtedly essential factor for potential scale-ups. Combining low emission inland vessels – for example fully electric or hybrid propulsion vessels – with an environmentally friendly last-mile transport mode (e.g. bicycles or electric trucks) creates an efficient, clean, and sustainable urban transport system. Similarly, some European cities are restricting or planning to restrict access to specific areas for heavy-duty vehicles through weight restrictions and low or zero tailpipe emission zones[36] which can be a lever for the development of such urban logistic services using the inland waterways and local canal systems with innovative and clean vessels.

As far as urban logistics are concerned, the role of authorities and cities will become more important to direct new business models and incentives by implementing SULPs (Sustainable Urban Logistics Plans). This could help promote IWT by offering additional time windows for deliveries with greener modes of transport. Furthermore, collaboration among urban stakeholders will be key for shifting to IWT in cities. The collaboration and types of collaboration, for instance via bundling cargo, sharing infrastructure, new business models, gain sharing, and communicating benefits to a larger audience, will likely be exploited further.

Other technological developments, in particular automation and digitalisation, could also work in favour of IWT in urban centres from a cost perspective (reduced labour costs). Public policies and incentives play an important role in this regard (government tenders and projects, public financing...).

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[35] Logistics Initiative Hamburg, "AVATAR: EU Interreg NSR Project", October 2021, https://www.hamburg-logistik.net/en/our-activities/projects/avatar/.

[36] Many cities in the Netherlands will introduce zero-emission tailpipe zones from 2025 onwards for urban deliveries by road haulage. See: https://www.opwegnaarzes.nl/over-zes/zero-emissiezones.

3.1.6 Obstacles

Despite clear opportunities for IWT in urban settings, several obstacles remain to be overcome.

First, IWT faces much higher regulatory and administrative costs than its competitors (docking stations fees, port admissions, navigation permits), often linked to obtaining temporary exemptions for testing innovative solutions. As start-ups might not have the necessary resources to meet those costs, promising projects might be slowed down, halted, or even nipped in the bud. As regulations tend to favour road over IWT and do not provide equal opportunities, they significantly impact modal shift decisions.

Second, the long-term economic viability of urban IWT freight is difficult to assess, as each project is embedded in its own market environment, and most have received subsidies. It remains unknown whether publicly subsidized projects will be able to maintain a viable business case without continuous public support.

Third, IWT faces fierce competition for space in urban areas from the housing and tourism sector. Due to the demands of the housing market, little space is usually reserved for logistics. And as European city centres contain most tourist attractions, logistics and transport infrastructure must integrate well into the urban landscape to avoid degrading the sights.

Finally, IWT must overcome the dominant preference for road transport in logistics and the general lack of knowledge about inland navigation transport solutions in city centres. Compared to IWT, road is perceived as more flexible and is more familiar to operators, even if it might not be the most environmentally friendly or efficient modal choice available. This issue is cross-cutting and was also identified as an obstacle in the other three markets, as will be shown below. Potential marketing and communication innovations are examined in Chapter 4.

3.2 Circular economy and waste transport

A circular economy aims to maintain the value of products, materials, and resources for as long as possible by returning them into the product cycle at the end of their use, thereby minimising the generation of waste. Three keywords are generally associated with this concept: reduce, reuse, recycle. In a world characterized by resource scarcity, circular economy practices shed light on mechanisms to recycle and reuse materials that would otherwise end their lifecycle in a waste disposal. Circular economy also encapsulates attempts at reducing consumption for a more efficient and parsimonious use of available resources.

Waste recycling covers a large share of the circular economy pillar, not only regarding the collection of waste itself, but also the valorisation of waste. In March 2020, the European Commission adopted a new circular economy action plan[37], one of the main building blocks of the European Green Deal. The valorisation of waste is achieved by transforming waste into energy (mostly electricity and heating). Electricity generation from municipal renewable waste has increased more than ninefold within the last thirty years in the EU, jumping from 3,000 to 23,000 GWh, while electricity generation from industrial waste has remained stable over the same period, at 3-5,000 GWh.

Circularity as such does not always indicate an activity with no GHG emissions. The focus lies on the reutilisation of products and resources, thereby achieving a reduction in the consumption of scarce

[37] European Commission, "Circular economy action plan", March 2020, Circular economy action plan (europa.eu).

resources. Vessels and inland ports play an essential role on the supply side of the circular economy. As an example, scrap steel, iron waste and metal waste for steel production are already well integrated into circular economy supply chains via inland navigation and ports. In 2019, 41.3% of crude steel production in the EU took place via electric arc furnaces, in which iron residues or metal waste are smelted with the help of electricity and converted again into new steel.[38] Indeed, the high concentration of raw materials and residual flows from numerous industrial and logistic activities which can be found in ports and the proximity to large urban agglomerations make them ideal locations for circular economy activities, an opportunity that IWT can seize.

The European Federation of Inland Ports (EFIP) expects that the implementation of the circular economy strategy by inland ports will trigger new transport flows.[39] It identified a few barriers to the development of circular economy activities within inland ports, namely:

- Lack of space for the installation of collection and treatment units;
- Dependency of inland ports on the final market uptake for circular economy activities and the initiatives of individual companies;
- Reaching critical mass in a circular economy business model to attain economic profitability;
- Negative public opinion about waste and waste recycling;
- Long transition processes towards circular economy;
- Low cooperation between various stakeholders involved in the circular economy transition;
- Multi-stage processing for certain types of waste.

So that contributing to the circular economy becomes a reality for inland ports, several levers are also described by EFIP. These include increased knowledge about the value-added applications of waste resources, standardisation, and a quality scheme for secondary raw materials, as well as a stable and long-term-oriented investment environment. A few examples of how inland navigation integrates into circular economy and waste logistics are described in this sub-chapter.

3.2.1 Circular economy and waste transport in France (Paris, Rouen, Lille, Lyon)

In Paris, multiple segments of household waste to be recycled or reused are transported along the Seine via IWT. In this context, the public service company SYCTOM collects household waste on behalf of 85 municipalities in the Paris region.[40] According to their activity report in 2020, SYCTOM transported 189,700 tonnes of waste on inland waterways, 92.4% of which were effectively recycled. Recycling methods include methanisation (fermentation of organic material to produce biomethane), energy recovery (mainly electricity and steam), or refitting and reusing recycled material. SYCTOM operates around ten recycling and sorting centres in the Île-de-France region. In the incineration of waste for energy recovery purposes, filters are used to further reduce emissions. These filters are also transported by inland vessels.

In June 2021, 24 new bag filters weighing 24 tonnes each were transported between Rouen and Ivry Paris XIII – the most important recycling centre for the Paris region – via the Seine. In 2023, a new energy recovery unit will be commissioned and handle an annual capacity of 350,000 tonnes of residual household waste by incineration. This amounts to the collected waste volume of around 1.4 million Parisian households. New types of waste transport are emerging in Île-de-France, in particular through the development of container transport, which makes it possible to collect a wider variety of waste. An

[38] CCNR and EC, “Thematic Report: An assessment of new market opportunities for IWT”, February 2022, Thematic report | CCNR.
[39] EFIP, “The circular economy and inland ports”, 2016, EFIP | Inland ports and circular economy [EN].
[40] SYCTOM, “Rapport d'activité 2021”, June 2022, SYCTOM | Rapport d'activité [FR].

example is the transport of waste from Gennevilliers near Paris to Rouen. on the way to Rouen, the vessel transports professional furniture waste in containers whereas on the way to Gennevilliers the same containers are filled with paper waste.

In Lille, two recycling centres in Sequedin and Halluin account for an estimated 220,000 tonnes of household waste transported by inland vessels every year, most of which is dedicated to energy recovery and waste valorisation.[41]

River'Tri in Lyon is Europe's first floating waste disposal centre[42], collecting 300 tonnes of waste from 5,000 people in the city centre of Lyon. River'Tri began in 2016 as an experimental project for two years with a budget of EUR 1.8 million, 37% of which was financed by the European cohesion policy (ERDF). Since then, the Lyon metropolitan area has financed this operation (approximately 500,000 euros/year) via a service provider (SITA-Suez). River'Tri is not only an urban river logistics project, but also a circular economy project, as 90% of the waste collected by inland vessels is recycled and transformed into new products, including kitchens, bathrooms, chipboards, and woodchips used as alternative fuel.

3.2.2 Waste transport and energy generation (Greater London, England)

The recycling and energy recovery company Cory Environmental[43] collects and sorts dry waste such as plastics and other types of dry mixed recyclables as well as non-recyclable waste and transforms it into electricity. Waste is collected from four riverside stations in London (Wandsworth, Battersea, City of London, Tower Hamlets). Barges pulled by tugs from these stations deliver non-recyclable waste to an 'energy from waste' (EfW) facility. In this EfW facility, incineration of waste takes place, and the steam resulting from this process drives a turbine that generates baseload electricity. The company reports in its 2020 annual review[44] that it transported 731,000 tonnes of non-recyclable waste to its EfW facility. The amount of electricity generated (501 GWh) is the equivalent of the electricity needed to supply 155,000 homes in the region of London. The EfW facility, situated in Belvedere – a district in south-east London – is located directly on the Thames. It is the only EfW facility in the UK with river infrastructure to receive waste. In total, Cory Environmental transports 1 million tonnes of waste on the Thames per year, thereby avoiding the movement of 100,000 trucks on the streets of London. It owns a fleet of 52 barges and 5 tugs and has its own repair yard for the vessels.

3.2.3 Multipurpose water logistics services in cities (Netherlands)

CityBarge provides sustainable water logistics services for municipalities, commercial and public waste collection service providers, building contractors, and retailers in the Netherlands.[45] By combining a modular and integrated system that consists of an electric push-boat, push-barge and modular floating platforms (mini-hubs), the CityBarge system facilitates various water-based logistics solutions in city centres, such as the collection, transport and disposal of waste, delivery of building materials, and retail services. CityBarge also provides its clients with transfer points outside the city and an information system updated in real time.

[41] Veolia, "Unité de valorisation énergétique d'Halluin", 2022, Unité de Valorisation Energétique d'Halluin | Veolia.
[42] Voies Navigables de France (VNF), "River'Tri, la déchetterie fluviale lyonnaise", 2022, VNF | Déchetterie fluviale lyonnaise [FR].
[43] Cory Group, "What we do", 2022, What we do | Cory Group.
[44] Cory Group, "2020 Annual Review. Providing a critical service", May 2021, Cory_AR20_WebSpreads.pdf (corygroup.co.uk).
[45] CityBarge, "How does it work?", 2022, https://citybarge.eu/en/hoe-werkt-het/.

3.2.4 Domestic waste transport (Budapest, Hungary)

Waste is being collected in an environmentally friendly way in Budapest from Danube boats and riverside entertainment venues, after the TERSUS waste collection vessel started working in September 2016. On average, the vessel can transport approximately 30-40 cubic meters of garbage per day (equivalent to approx. 16 tons), which means it can serve in one go up to seven or eight vessels.

3.2.5 Opportunities

Lack of sufficient waste management and disposal facilities in urban areas is a known challenge. As populations steadily increase and space becomes scarce, waste disposal centres in densely populated areas switch to innovative solutions due to lack of space. Demographic growth, in combination with saturated road infrastructure, high emissions and other negative externalities provoked by road transport in cities, are all important factors which offer great potential for IWT in modern urban environments.

In addition, electricity generation from municipal renewable waste has strongly increased in the last 30 years, a growth which is expected to continue with the transition towards circular economies. New transport flows are expected to emerge from such a transition, which is certainly an opportunity for inland vessels to transport products resulting from circular economy activities. IWT could serve as an ideal transport solution to spearhead the development of circular economies while enabling more efficient waste management, valorisation, and storage in urban environments.
Absolutely crucial for IWT to become a major circular economy player is a strong connection from cities to inland ports. The key role that inland ports will play in the development of circular economy activities and related cargo flows can also be considered as an opportunity. Indeed, ports are deeply integrated into global supply chains, strategically located, connected to urban areas, and often act as industrial and logistical coordination hubs. Three examples are explored here.

The port of Kehl is one of the ten largest ports on the Rhine, on the German side of the river opposite Strasbourg. It hosts the largest German electric arc furnace steel plant. This plant reuses scrap steel and iron waste to produce new steel. 51% of the port's 4.4 million tonnes transported by waterside cargo in 2020 regarded iron waste.[46] The end products resulting from the steel plant's circular production process are steel bars and rods.

In its vision, the port of Moerdijk's focuses on circularity, with one of its most important circular economy activities being its energy plant. The plant is quite unique in Europe as it transforms animal waste into electricity. Moreover, the port's eco-park attracts bio-based and circular projects. One of the eco-park's most advanced programmes is a testing ground for pyrolysis, i.e. heating waste to high temperatures above 400°C without the supply of oxygen to generate biofuel. Pyrolysis is a chemical process to gain substances out of waste such as pallets, plastic foil or sewage sludge.

Finally, the port of Amsterdam remains the frontrunner in circular economy activities among European ports. This is due to its circular economy ecosystem, where three companies are engaged in different kinds of waste recycling. Bio Energy Netherlands recycles wood chips and treats them in a gasification plant to gain syngas from which heat, electricity and hydrogen can be retrieved. AEB Amsterdam processes residual waste into energy through an incineration process, providing heat and electricity for

[46] CCNR and EC, "Thematic Report: An assessment of new market opportunities for IWT", February 2022, Thematic report | CCNR.

up to 30,000 households in the north of Amsterdam. SUEZ Group meanwhile focuses on hazardous waste, both liquid and solid, treated to be reintroduced into the product lifecycle as raw materials.

3.2.6 Obstacles

The obstacles to IWT's contribution to circular economy and waste transport are identical to those identified for urban logistics (see section 3.1.6 above). In addition, because of the specificity of this type of cargo and its potential negative externalities (smell, impact on touristic sights, safety), there might be a reluctance to allow for waste handling, storage, and/or transformation in or close to city centres. For instance, in the Netherlands, regulations on the duty of transhipping bulk goods without harming the environment states that waste containers should be handled within 48 hours of arriving at the transhipment location.[47] This is seen as hurtful to IWT as it is a slow modality and might require moving waste-related activities in rural areas up- or downstream, potentially increasing transport and/or operational costs and travel time.

3.3 Transport of alternative and renewable energies

In the early 21st century, the negative externalities of the fossil fuel-based economic paradigm, both in terms of climate change and natural disasters, became apparent. Its impacts on human societies and economic welfare became more and more visible. The technical and economic transition from fossil fuels to alternative and/or renewable fuels is a complex process which is still ongoing. Fossil fuels are not only troublesome from an environmental standpoint, but also due to their being finite and nearly depleted, in combination with a growing global demand for energy. This transition implies a deep transformation of the entire economic system, including the inland navigation sector, which will have to apply new technologies, transform its infrastructure, embrace social, economic, and perhaps fiscal changes, and, most importantly, develop new markets. This transition is already leading to a decrease in the transport of fossil fuels – expected to be replaced by new alternative energies -, which could represent new opportunities for IWT.

The transition away from fossil fuels is already impacting inland navigation transport volumes. In the last 30 years, wind and solar energy showed the strongest growth among renewable energies in the EU, reaching 475,000 and 155,000 GWh respectively in 2020 (from virtually zero in 1990). Projections regarding the development of renewable energies in the near future tend to trend upwards, especially due to the European Commission's efforts in meeting the objectives of the European Green Deal. With an extension of the carbon price signal to most sectors, further emissions will be effectively targeted, with IWT emerging as an attractive replacement option.

Furthermore, electricity generation from renewables is expected to expand by almost 50% in 2025 compared to 2019. By then, the share of renewables in total electricity generation is expected to reach 33%, surpassing coal-fired generation. Renewables are forecasted to meet 99% of the global electricity demand increase in the period 2020-25. At European level, the increase in renewables-based electricity generation is expected to be equal to more than nine times the rise in electricity demand between 2019 and 2025. The recent policy momentum is likely to act as a lever giving an extra boost to the use of renewable energies in Europe. For instance, the EU economic recovery plan foresees climate-related spending in areas such as buildings, grids, electric vehicles, and low-carbon hydrogen.[48]

[47] Rijkswaterstaat, "Discharge regulations for storage and transhipment of goods",https://www.infomil.nl/onderwerpen/lucht-water/handboek-water/activiteiten/lozen-afvloeiend/overslaan-goederen/#h1b76c624-1793-46c3-bd45-4d6c879fe735.
[48] European Commission, "Recovery plan for Europe", August 2020, Recovery plan for Europe | European Commission (europa.eu).

This sub-chapter aims to show in which sub-markets could inland navigation benefit from these trends, as well as shed light upon existing bottlenecks and barriers in this respect. Considering the growing importance of the energy transition and its long-term impact on inland navigation, transport of renewable energies and related components for the generation of alternative energies can be considered as a promising market for IWT. This is due to the large loading capacities of inland vessels leading to economies of scale, a property complementary to the large batch size of many renewables.

There are a wide variety of alternative energies: wind, solar, hydraulic, solid biomass, liquid biomass (biofuel, ethanol), methanol, hydrogen, etc. However, uncertainty abounds regarding which energy transition pathways European societies and industries will follow. Such uncertainty relates mainly to prices, the availability of renewable energies, and technological development, especially for zero-emission technologies. For the purposes of this report, two specific examples will be examined, namely the transport of hydrogen and of biomass/biofuels.

3.3.1 Hydrogen transport on inland vessels

Today, hydrogen use is dominated by the industrial sector, namely oil refining, methanol, and steel production. It can also be used in the transport sector as fuel or for power generation. Hydrogen can be extracted from fossil fuels, but also from renewables or nuclear power. The overwhelming majority of hydrogen is still produced from fossil fuels, so there is significant potential for emissions reduction in this regard. Due to its limited availability in its natural state, hydrogen must be produced on an industrial scale to be viable as an alternative fuel. Currently, there is much research on how the electrolysis process (splitting water into hydrogen and oxygen) can be made as energy-efficient and climate-neutral as possible.

Pure hydrogen can be transported as compressed gas or in liquid form. Specific safety standards and requirements must be respected as it is considered a dangerous good according to the AND regulation.[49] When transported as compressed gas, hydrogen tanks inside vessels must be able to withstand pressures reaching up to 350-700 bars. The high volume and space needed for this kind of transport is a significant hurdle for its large-scale commercialisation. When transported in its liquid form, temperatures as low as –253°C must be maintained. Furthermore, liquified hydrogen has a significantly higher weight due to its higher density per cubic meter, another aspect which must be taken into account. Finally, when transported in liquid form under the liquid organic hydrogen carrier (LOHC) technology, hydrogen is loaded onto a fluid which can be transported in double hulled tanker vessels. LOHC absorbs hydrogen then releases it through chemical reactions upon arrival. The advantages of transporting hydrogen in its gaseous and/or liquid forms lie in its overall safety, the ability to use existing vessels, and above all its high energy density (especially true in its liquid forms).

In recent years, public policy began pushing for the development of hydrogen. One such example is the ‘Hydrogen strategy’ presented by the European Commission in July 2020.[50] Within the framework of the European Green Deal, hydrogen has also been singled out as central for addressing the reduction of GHG emissions and laying the foundations of a climate-neutral economy in Europe. At national level, hydrogen plans are also being deployed, and the number of countries with policies that directly support investment in hydrogen technologies is increasing, along with the number of sectors they target.

[49] UNECE, “European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN)”, 2021/1, 2012641_E_ECE_TRANS_301 Vol I.pdf (unece.org).
[50] European Commission, “A hydrogen strategy for a climate-neutral Europe”, July 2020, EC | Hydrogen Strategy [EN].

Prominent examples include the French 'plan de déploiement de l'hydrogène'[51], foreseeing funding opportunities for the deployment of green hydrogen, or the German 'Nationale Wasserstoffstrategie'[52], exploring the possibility of establishing an international hydrogen market.

Green hydrogen programmes are also expected to raise renewable energy production capacity, although investors could also use existing wind, solar, and hydropower plants for hydrogen production. Plus, demand for hydrogen has been steadily increasing since 1975 and continues to rise. Today, clean, widespread use of hydrogen in global energy transitions faces several challenges, in particular its production cost from low-carbon energies, which remains very high. It being mainly produced from natural gas and coal means that its production is currently responsible for important GHG emissions. The slow development of hydrogen infrastructure is another important challenge.

Regarding production-related costs, the International Energy Agency (IEA) estimates that the cost of producing hydrogen from renewable electricity could fall by 30% by 2030 as a result of the declining costs of renewables and the scaling up of hydrogen production.[53] To support the deployment of hydrogen, the IEA recommends expanding hydrogen transport through fleets. Nevertheless, the development of clean hydrogen is gathering momentum, with production and demand expected to rise quickly. Transport solutions for clean hydrogen will be needed, hence representing possible new transport opportunities for inland vessels. The transition towards clean hydrogen will take several years, thereby leaving sufficient time for the inland waterway sector to develop suitable transport solutions.
Hydrogen as cargo could also be transported via pipelines in its gaseous form or by ships in its liquid form. To make the case for hydrogen transport on inland vessels, seamless access to maritime and inland ports from green hydrogen production sites is critical. Large areas dedicated to green electricity production (wind, solar, biomass) should also be available. Given the strong political momentum in the EU for the development of green hydrogen technologies, in part due to the decline in Russian gas in the European (and especially German) energy mix, pilot projects promoting strategic value chains should be publicly supported in view of creating a pan-European supply chain along the main European corridors. Such projects are currently ongoing and important insights can be gained from them. For instance, the most suitable form of storage and transportation on inland vessels must be identified, as LOHC technology, liquid hydrogen or compressed gaseous hydrogen all provide different advantages and drawbacks. For hydrogen transport via IWT to develop and gain market share, the solution should be as cost-efficient and easy to implement as possible.

Green Hydrogen @ Blue Danube: a hydrogen project of European dimensions
Within the framework of the European Commission's Important Projects of Common European Interest (IPCEIs) initiative, VERBUND – Austria's leading electricity company and one of the largest producers of electricity from hydropower in Europe – is developing the Green Hydrogen @ Blue Danube project. Jointly with technology partners and buyers of green hydrogen VERBUND is aiming at creating a trans-European green hydrogen value chain – from production to transportation to purchase by industrial and mobility customers. Wind, solar and hydropower will be converted into hydrogen directly on site to harness Europe's renewable resources that otherwise could not be utilised owing to a lack of electricity transmission capacity. This hydrogen will then be transported via the Danube River, a long-established European transport corridor (TEN-T), to hydrogen users located mainly in Austria and Germany.

[51] Ministère de la transition écologique et solidaire, "Plan de déploiement de l'hydrogène pour la transition écologique", June 2018, French hydrogen strategy [FR].
[52] Bundesministerium für Wirtschaft und Energie, "Die Nationale Wasserstoffstrategie", June 2020, German hydrogen strategy [DE].
[53] International Energy Agency, "The future of hydrogen", June 2019, The Future of Hydrogen (windows.net).

Figure 5:Map of Green Hydrogen @ Blue Danube. **Source**: VERBUND.

The current hydrogen production potential of Danube countries and their existing national initiatives and programs can provide an overview on the future of hydrogen in terms of further development of the supply chain drafted by the Green Hydrogen @ Blue Danube project. 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 2021-2030, in order to reach its 2030 renewables target of 30.7%.[54]

Ukraine joined the Green Hydrogen for the European Green Deal initiative and established in 2018 the energy association "Ukrainian hydrogen council"[55] – a first hydrogen energy association of leading energy, industrial and public companies of Ukraine. It followed up with H2U Hydrogen Valley[56] investment project of 3000 MW electrolyser plant construction with 5000 MW renewable energy source in Bessarabia, Odessa region. The project goal is to create an energy cluster in the region focused on the production of electricity from renewable energy sources, the production of green hydrogen, and its export to the countries of the EU via Danube River (through Ukrainian ports of the Danube Region: Reni, Izmail and Ust`-Dunaisk). Considering the war in Ukraine today and the intentions of the Ukrainian government to fully eliminate Russian energy supply, it can be stated that developing Ukraine's potential to produce green energy will require undertaking the necessary steps to develop this project or join similar EU-funded projects and to initiate similar projects in other Ukrainian regions with high wind and solar energy potential.

3.3.2 Transport of biomass and biofuel on inland vessels

Biomass can be differentiated into high indirect land use change (ILUC) risk (e.g. when used as feedstock) and low ILUC risk (e.g. when used for advanced biofuel or electricity production). High ILUC risk biomass includes oil plants such as rapeseed or soybean, cultivated like any other agricultural product. In this report, high ILUC risk biomass/biofuel will be referred to as first generation biomass/biofuel (1G), while

[54] Balkan Green Energy News, "Romania's NECP: 6GW of solar, wind to be installed by 2030", 21 October 2021, https://balkangreenenergynews.com/romanias-necp-6-gw-of-solar-wind-to-be-installed-by-2030/.
[55] Ukrainian Hydrogen Council, "Energy Association Ukrainian Hydrogen Council", 2022, https://hydrogen.ua/en/home-en.
[56] H2U, "Hydrogen Ukraine", 2022, https://h2u.ua/.

the low ILUC risk variant will be called advanced biomass/biofuel. From biomass, all forms of energy can be generated: electricity, heat, fuel for transport (biodiesel, bioethanol, etc). Biodiesel is blended with conventional fossil diesel according to national blending regulations and can power trucks. Rapeseed currently accounts for 80% of the raw material from which biodiesel is produced. To produce bioethanol, wheat, rye, corn, and sugar beet are the main primary raw materials. It is also blended with conventional gasoline, but upper limits exist ('blend wall') due to technical vehicle standards.

In terms of mass, rapeseed shred used as animal fodder accounts for 60% of the total output of a biomass/biofuel transition, while biodiesel and glycerine account for 40%. Glycerine is a by-product of biodiesel, which is used to produce detergents, toothpaste, and pharmaceutical products. According to a 2019 study by the International Renewable Energy Agency (IRENA)[57], production costs for 1G biofuels are largely determined by feedstock prices (e.g. rapeseed), which represent 70-90% of total production costs. This high share makes 1G biofuel production vulnerable to feedstock price variations, while advanced biofuels rely on far less expensive feedstocks such as agricultural residues and different types of waste. They also avoid any competition with food production, as they are derived from lignocellulosic feedstocks such as corn stover, straw, agricultural residues, woody residues from forestry and wood processing industries (e.g. sawdust), oilseeds produced on marginal land unsuitable for crop production, municipal solid waste, and a variety of other industrial and commercial waste types. As is the case for 1G biofuel, advanced biofuel production also generates coproducts with a commercial value – for example cellulose, used as feedstock in the paper industry.

The production of biodiesel[58], based on 1G biomass, has followed a positive trend in the EU-27 in the last 15 years. The three biggest producers are Germany, France, and the Netherlands, which together account for 52% of all EU-27 biodiesel production in 2020. For the period 2023-2025, the IEA forecasts a biodiesel and hydrotreated vegetable oil production level 5% and 21% higher than in 2019 and 2020 respectively.[59] This growth takes place despite several regulatory changes since 2005. In Germany, for example, biodiesel was exempted from taxation until 2006, in contrast with conventional fuels. This exemption was gradually removed until 2012. At the same time, the obligation to blend a minimum proportion of biofuel with conventional petrol and diesel fuels was introduced. This policy change caused a shift from rural entrepreneur-based biodiesel production to a biodiesel market dominated by large agribusiness and oil distribution companies.

Soon afterwards, the EU's 2009 Energy & Climate Package (ECP) established a framework for EU Member States to set national renewable energy targets, leading to the enactment of the Renewable Energy Directive (RED, 2009/29/EC). This policy shift raised the question of which fuels can truly be considered sustainable. The food versus fuel concerns became the main reason why 1G biofuels were deemed only a second-best solution, bringing advanced biofuels to the forefront. Potential biomass/biofuel transport by inland vessels therefore heavily depends upon public policy decisions at national and European level, which either encourage or limit their development. For instance, RED II indicates that renewable energies shall comprise 32% of total energy consumption by 2030. A sub-target exists for the transport sector, requiring fuel suppliers to supply a minimum of 14% of the energy consumed in road and rail transport as renewable energy, also by 2030. To achieve this goal, the Directive defines a series of sustainability and GHG emission criteria that bioliquids used in transport must comply with to be counted towards the overall 14% target. For 1G biofuels, a cap was introduced, limiting their share to

[57] IRENA, "Advanced biofuels: what holds them back?", November 2019, [Advanced biofuels: What holds them back? (irena.org)](#).
[58] FAME
[59] IEA, "Renewables 2020: Analysis and forecast to 2025", November 2020, [Renewables 2020 – Analysis - IEA](#).

7% of final road and rail transport energy consumption in each Member State, allowing only for a slight increase in their production levels, while the share of advanced biofuels shall be at least 3.5% in 2030. In this directive's revision proposal presented in July 2021 by the Commission within the 'Fit for 55 Package', the use of such 1G biofuels is being discouraged. While this proposal still must go through the EU legislative process, significant impacts on the biofuel sector are expected. This will consequently affect potential 1G biomass/biofuel transport by inland vessels.

In this context, advanced biofuels should have witnessed rapid development and growth, yet this has not materialised so far. Cellulosic ethanol production has developed very slowly and was accompanied by multiple technical and commercial setbacks in the US and Europe. By 2018, on a worldwide scale, only 12 refineries produced cellulosic ethanol at commercial level, with modest production volumes. Five of them are in Europe, two in Brazil, three in China, and two in the US. Most of them can be categorised as demonstration projects. A prudent approach is therefore preferrable. Advanced biofuels will be one element within the decarbonisation process of the transport sector, in parallel with electrification. It will be better suited to heavy freight vehicles, large ships, and aviation, which require high amounts of energy. At the same time, 1G fuels' reliance upon food or feed crops represents a serious barrier for their future growth, especially in the current food insecurity paradigm borne out of the war in Ukraine. Given the lack of large-scale deployment of advanced biofuels, relevant real-world examples for biomass logistics are mostly found among 1G biofuel cases.

Biomass/biofuels' potential can be studied via the activity of ports, which are well integrated into biomass production and transport logistics value chains. This offers great prospects for future development in the context of modal shift to IWT. Five examples are presented. In the first two (Mannheim, Straubing), rapeseed is transformed into rapeseed oil, from which biodiesel[60] is produced (1G biofuel). In the third case (Ghent), wood waste is used to produce electricity, avoiding food-fuel competition (advanced biomass). Finally, two examples of biomass (Pischelsdorf) and biofuel (Dunaföldvár)production utilising local value chains in the Danube region.

1G biomass and biofuel waterside handling in the Rhine region - port of Mannheim

The Port of Mannheim is the third largest Rhine port in Germany. In the port area, an oil mill receives rapeseed from ships, stores it, and produces rapeseed oil and shredded rapeseed, the by-product used in the foodstuff segment. Most of the rapeseed oil is transported to the port's company Mannheim BioFuel GmbH by pipeline to manufacture biodiesel, which is then delivered by ships and trucks to customers (mineral oil companies, petrol stations, haulage companies, etc.). The nominal capacity of the production site reaches around 120,000 tonnes of biofuel per year.

According to port authorities, inland navigation offers several advantages for biomass/biofuel logistics:

- Large capacity;
- High efficiency and reliability;
- No operational restrictions during the weekends;
- Few accidents.

1G biomass and biofuel waterside handling in the Danube region - port of Straubing

The Danube port of Straubing is the second largest Bavarian inland port after Regensburg. Since its creation in 1996, the port has specialized in handling agricultural products and biomass, with several

[60] FAME

companies active in the bioeconomy market making use of surrounding inland waterways. Companies active in different fields of agribusiness (trade and storage of grain), oilseeds crushing, and animal feedstuff production have manufacturing and logistical capacities in the port area. The most important company is ADM, a US food-processing and commodities trading company, operating internationally.

Raw materials – especially rapeseed and soybeans - are transported on the Danube, mainly from Hungary, Austria, and Serbia. In Straubing, they are converted into rapeseed oil, soybean oil, and meal. The rapeseed oil is transported mainly by rail (tank wagons) to Mainz (where another ADM manufacturing unit is located) and other customers, to be processed into biofuel. The meal is transported to other destinations in Germany, mainly to feed manufacturers. This transport is carried out by ships (50%) and trucks (50%). Soybean oil, as well as soybean shred, is exported from Straubing via the Danube, the Main-Danube canal, and the Rhine to Basel, given that Switzerland only allows non-genetically modified soybean products to be used on its soil. As biomass products handled in the Port of Straubing fulfil this sustainability requirement, they can be exported to Switzerland.

Transhipment of dry biomass is carried out with cranes and gripper arms present in most ports for dry cargo operations, meaning additional infrastructure is not necessary. Thanks to its bioeconomy orientation, the port's overall waterside handling figures have developed more positively than at regional (Bavaria), national (Germany), and EU level. Overall, IWT activities in Straubing increased by 9.2% between 2010 and 2020, compared to a decrease at every other level. This example shows that a rather high modal split share and an overall positive development can be achieved when IWT is integrated into 1G biomass/biofuel supply chains and ports.

Advanced biomass used for electricity generation - Gentse Warmte Centrale (Ghent, Belgium)

Biomass is not only transformed into liquid biofuels but is also used to generate heat and electricity directly, namely via wood pellets and chips combustion. In Western Europe, biomass (including solid biomass, liquid biofuel, and biogas) accounted for 12% of total electricity production in France, 8% in Germany, 5% in Belgium, 3% in the Netherlands, and 1% in Luxembourg in 2019. In the Danube region, constant growth of biomass in electricity production is observed in Croatia (7%), Hungary (6%), Austria (6%), Bulgaria (4%, up from 1% in 2017), and Romania (1%). In general, all Rhine countries have increased their capacity, except for Belgium. On the Danube, there was an overall decrease in installed net capacity for producing electricity from biomass between 2010-2019. In particular, Austria halved its capacity in that time period, while Croatia increased it by more than ten times in this timespan. Overall, the potential of biomass is still not being fully exploited, particularly on the Danube.

The 'Gentse Warmte Central', a combined heat and electricity biomass power plant, began construction in January 2020 and aims to produce green energy (heat and electricity) using wood waste that cannot be otherwise recycled. The wood waste comes from the demolition of old houses and from businesses. The volumes of feedstock (wood residues) transformed annually will amount to 160,000 tonnes. The plant will produce 156 GWh of green electricity annually (the annual consumption of about 50,000 households) and supply green heating energy to industrial customers in the area around Ghent. The biomass power plant is equipped with advanced air purification technologies and meets strict emission standards. Located in the North Sea Port area, it allows for the predominant use of inland vessels to transport materials to the power plant. The company foresees using inland vessels to carry around 75% of the wood waste.

Agrana operations in Pischelsdorf, Austria - a logistics hub for biomass

The AGRANA Group is a leading international enterprise for the production and processing of fruit, starch products and bioethanol, as well as sugar and isoglucose. The AGRANA plant in Pischelsdorf, Austria was constructed in 2007 as a bioethanol refinery and expanded in 2013 as a facility for the processing of wheat starch. This bio-refinery, which belongs to the starch products business unit, implements the sustainable refinement of agrarian raw materials. The facility uses around 840,000 tons of raw materials each year to manufacture over 100,000 tons of wheat starch, 23,500 tons of wheat protein, 240,000 m^3 of bioethanol, 120,000 tons of biogenic CO2, 190,000 tons of protein feed and 55,000 tons of clay. Most of the biomass required for this process is sourced in the Danube region. Around half of the bioethanol output is exported to Germany. During the Corona crisis the produced bioethanol was also used to produce germicide. At present, up to 40% of the raw materials and products are transported by inland vessels. The vessels are loaded and unloaded at a transhipment site with a length of 649m. Inland vessels are principally used to transport bulk goods. However, the current transhipment volume is 600,000 tons per year. For the upcoming years an increase is planned due to the expansion of the wheat starch facility.[61]

Pannonia Bio's biorefinery plant in Dunaföldvár, Hungary

The Hungarian company Pannonia Bio[62], a subsidiary of the Irish ClonBio Group Ltd, which is owned by the Irish brand Turley, invested 250 million euros into construction of a biorefinery plant on the Danube coast, near Dunaföldvár, in the Hungarian Tolna district. Built on a more than 40ha site located on the west bank of the Danube River, the refinery processes more than 1 million tons of grain annually. The plant operates all necessary facilities to provide low-cost barge transportation on the Danube. It is Europe's largest biorefineries and has almost tripled its capacity since 2012, producing 500 million litres of bioethanol from wheat each year. According to experts, in coming years, the market for bioprocessing products will grow by almost 10% annually, which forecasts good growth prospects for the region.

3.3.3 Opportunities

The growing pressure to extend capacities for renewable energies at the expense of fossil fuels presents a potential market in which IWT can be advantageous. Research was carried out by means of face-to-face semi-structured interviews and analysis of available data focused on the transport of hydrogen, biomass, and biofuel. The results of the analysis lead to diverging conclusions.

Hydrogen

There is growing interest at European level for hydrogen as a clean energy source. Its applications are manifold (industry, transport sector, power generation) and demand has been steadily growing since 1975. While it is today overwhelmingly produced from fossil fuels, hydrogen can be produced from renewables (i.e. electrolysis using green energy), meaning there is significant potential for emissions reduction. At European and national level, public policy is pushing for the development of hydrogen, with the adoption of hydrogen strategies. As hydrogen can be transported via maritime vessels, inland vessels, and pipelines, it is a promising cargo for IWT, especially if combined with new, innovative tanker designs, LOHC technology, and integrated into regional and global value chains through ports.

Biomass and biofuel

Biomass can be used to produce biofuels, heat, and electricity, and its use is on an upward trend. This versatility is undoubtedly an important factor boosting its attractiveness. The advantages of IWT are manifold: reliability, overall safety, and the possibility of transporting large quantities of mass cargo. In

[61] Viadonau and Binnenschifffahrt, "Manual of Danube Navigation 2019", 05/2020, Viadonau | Manual of Danube navigation.

[62] Pannonia Bio, "Dunaföldvár refinery", 2022, https://pannoniabio.com/impacts/dunafoldvar_refinery.

addition, unlike the transport of wind turbines, for which ports and waterways might need to adapt their infrastructure (see 3.4 below), biomass/biofuel cargo handling in inland ports does not need adaptations or special handling equipment. Furthermore, electricity and heat produced from biomass are unaffected by weather fluctuations, an important aspect compared to the fluctuations of wind and solar energy.

While dry cargo transport in general has tended to decline in recent years in German ports, the examples of Mannheim and Straubing show that biomass has enabled IWT and inland ports to grow within segments that embrace biomass, such as agricultural products and foodstuff. Furthermore, bioenergy demand projections from 2018 to 2030 - made in the framework of the Interreg Energy Barge project[63] - suggest the market still has untapped potential. Among the three biomass types considered, demand for bioheat remains constant in both the BAU and worst-case scenarios, while in the best-case scenario a surge in demand is expected.

3.3.4 Obstacles

Hydrogen

Fundamentally, hydrogen as fuel remains an immature technology still in its infancy and fraught with high production costs. This is reflected by a lack of large-scale infrastructure for electrolysis anywhere on the continent. It remains unclear how hydrogen can truly emerge as a new market when compared to other renewable energies which are more reliable, for which there is more demand, and whose technological maturity status is higher. Furthermore, it is yet the question what will be the dominant hydrogen carriers in terms of safety and efficiency from the total production and supply chain perspective (pure hydrogen compressed? Liquified? LOHC? Methanol?).

In addition, IWT faces fierce competition from pipelines. Given that hydrogen transport infrastructure still needs to be built and further developed, the sector could very easily choose to focus its development efforts on pipelines rather than IWT. This trend is compounded by additional technical hurdles that remain to be overcome for the safe transportation of hydrogen by IWT (pressure, weight, LOHC technology, etc). Finally, price might be the deciding factor. Lanphen (2019) assessed the costs of importing hydrogen to the port of Rotterdam via different carriers and concluded that hydrogen imported via pipelines, i.e. in its gaseous form, is the least costly option for the importer.

Biofuel and biomass transport

Biofuel markets are heavily influenced by regulations, interest groups, and public opinions. Long-term investments, however, require stable framework conditions. A biorefinery takes five to ten years to develop. In addition to that, pre-project stages also must be taken into account (business planning, feasibility analysis, engineering design, permissions regarding the contracting of feedstock, setting up supply chains, etc). Regulatory uncertainty can be very problematic for long-term projects and their financing, in particular for small start-up firms. Despite being a well-performing sector, there are concrete risks of stricter regulations being enacted on the production and use of 1G biomass/biofuels. It is possible that advanced biomass will have better growth prospects in the future, as it avoids competition with food production, which underlines a shift towards more sustainable feedstock. Restrictive regulations might reduce innovation potential and make biomass/biofuels not competitive enough to constitute a reliable and long-term new and growing market for IWT.

[63] Interreg, "Transnational scenarios for biomass demand in the bioenergy sector", June 2018, c18f78683df4c2dfee7afd2b5a001576f2cedbe2.pdf (interreg-danube.eu).

The deployment of advanced biomass and biofuels is currently at a very early stage, and it can be expected that it will take considerable time until widespread deployment is achieved. This is problematic as this nascent industry faces competition from traditional petro-fuels, who currently benefit from high-demand and low-price trends (2011-2020). With the technologies for advanced biofuels being immature and suffering from high learning costs, new biorefineries based on advanced biomass need to be developed, and the necessary pre-project studies need to be carried out. This is a time-consuming process which can take more than ten years in total. One could expect inland vessels to play a role in future biofuels supply chains, but there will be competition from other modes of transport such as rail or pipelines.

Finally, there is uncertainty regarding the energy transition trajectory of our societies, an uncertainty that affects all renewable energies. Despite the need for clarity about the future shape of energy supply, technological development is characterised by uncertainties, path dependencies and by the interplay of technology and commercial successes and failures. This technological uncertainty can lead to a specific form of inertia: why invest in new production processes for alternative technologies when uncertainty is high regarding their future use and demand? This will inevitably impact the IWT sector and its micro-economic decisions to specialize or not in biomass/biofuel transport.

3.4 High and heavy transport

High and heavy cargo refers to payload that is voluminous and/or heavy. It is characterised by peculiarly shaped, very long and/or bulky items which are not the usual, day-to-day payload transported by IWT vessels. On both the Rhine and the Danube, IWT offers a significant comparative advantage for short, medium, and even large distance transport of high and heavy cargo.[64] Indeed, waterborne transport is more energy efficient, safer, and potentially faster (in case of special convoys) than road, offering the possibility to bundle large cargos together (Wenzel, 2020). Some exceptionally high and heavy cargo can only be transported via waterborne options, either inland or maritime, as in the case of large machinery equipment and factory parts.

Generally speaking, IWT offers concrete advantages for high and heavy cargo transport due to inland vessels' large dimensions and heavy load carrying capacity, reaching up to 100m in length and 10m in width. Road options cannot match these features in such a price-competitive way in most cases. Furthermore, locks along the Rhine and Danube work at night and during weekends (24/7), enabling high transportation flexibility. High and heavy cargo transport on inland waterways is usually considered standard transport and therefore does not require any special permits or supervision. Therefore, usage of inland waterways is free of charge, although transhipment at ports is subject to fees. In addition, IWT offers numerous ecological advantages over trucks as emission values per ton are comparatively low, especially for oversized goods. Dry cargo ships can be multifunctionally used for the transportation of high and heavy cargo, but also for many other products, thus avoiding empty journeys to or from loading zones.

3.4.1 High and heavy cargo: an increasing market in Austria with potential for modal shift

The steadily increasing number of special transports (SOTRA) on Austria's roads, i.e. the transport of large and heavy general cargo beyond the normal road dimensions, was increasingly causing headaches for the responsible authorities and road operators. A project initiated by the waterway operator viadonau and the Austrian Ministry of Climate Action aims at improving the current situation and reduce

[64] Via Donau, "High & Heavy – Transports on Inland Waterways", February 2022, Via Donau | High and heavy cargo.

the number of road transports of high and heavy cargo. Thus, since 1 January 2022, inland waterway vessels must be used for particularly heavy, wide and high transports that follow the Danube corridor across borders. This shift is an important first step towards reducing climate-damaging emissions, easing the burden on road infrastructure and increasing road safety. For the regular transport of high and heavy cargo on inland waterways, which does not constitute a special transport (meaning: the cargo hold of the vessel is sufficient for the transported freight), inland vessels can very easily be used.

That being said, IWT also has its drawbacks for high and heavy cargo. Due to its massive size and weight, high and heavy cargo transport requires significant draught and fairway depth, meaning it is more sensitive to low water events. As these events become more frequent, high and heavy cargo transport by IWT might become more difficult to sustain in the long run. Vessels could be ballasted to counteract this phenomenon. In some specific instances where cargo parts stick out of the cargo hold, bridge clearance levels at critical chokepoints must also be considered in the journey planning phase. Another issue to consider is extreme weather and ice, as official bans can be imposed by authorities and regulatory bodies in case of extreme weather conditions, such as floods or during severe ice formations. Finally, in most cases the source and destination of the cargo, as well as the locations of the interim storage facility and final assembly, are not situated directly along the waterway. Therefore, cargo transhipment is usually necessary. This requires special port infra- and superstructures, such as quay walls and platforms, that can carry high ground pressures for mobile transhipment facilities, heavy cargo cranes or ramps for rolling cargo. In the best case, this equipment is available on a stationary basis.

Along the Danube, there are numerous ports and terminals where different variants of heavy-lift transhipment can be carried out.[65] Heavy lift ports with a stationary lifting capacity of more than 200 tons are located in Linz (AT), Bratislava (SK), Constanța (RO) and Reni (UA). Ramps are mainly located on the Upper Danube and on the joint Bulgarian-Romanian section of the Danube. Detailed information on high & heavy transportation along the entire Danube which is available to all interested parties is also provided by viadonau.[66]

3.4.2 Example of modal shift of high & heavy cargo in Hungary – construction of a polyol complex

MOL Petrolkémia expanded its operations with the construction of a polyol complex that is unique in the entire Danube region. The EUR 1.3 billion development in Tiszaújváros will use advanced technologies to produce a widely usable product, polyol. Polyol is an innovative and extremely sought-after chemical raw material, the demand for which will only increase in the coming decades. Polyol is the raw material for polyurethane, which is used almost everywhere, from the construction industry to thermal insulation and furniture production to the automotive industry and the textile industry. MOL will be the first company in the Central and Eastern European region to control the entire value chain of plastics production, from the extraction of crude oil to the production of polyol.

The equipment and modules of the polyol complex were manufactured in several parts of the world. Most of the parts could not be transported by road due to their weight and size, so they chose to transport them by water. When planning the transport, it was considered that - based on the data of the last 15 years - the water level of the Tisza is only suitable for carrying out such transports for a short period of the year. Since November 2019, a total of 65 parts have "sailed" on the Tisza, weighing

[65] A current list of transhipment possibilities starting from 35 tonnes is available here: https://www.viadonau.org/en/economy/danube-logistics/high-heavy-transports-on-inland-waterways.
[66] High & Heavy Transports on Inland Waterways: High & Heavy-Transporte mit dem Binnenschiff (viadonau.org)

between 10 and 400 tonnes, and ranging in size from a few meters to 45 meters in length. The last part of the device arrived in Tiszaújváros on the Tisza in May 2020. During the six-month period, the water level of the Tisza fell 3 times to such a level that transport had to be temporarily stopped.

Pre-assembled units arrived from Thailand and other equipment from many countries around the world, from Spain to China. The sea shipments arrived at Constanța on the Black Sea, from where the equipment was shipped by river barges on the Danube and the Tisza to Tiszaújváros. The other part of the shipments started from Genk in Belgium, sailing through the Rhine, Main, Rhine-Main-Danube canal, the Danube and the Tisza. A new temporary port had to be built on the bank of the Tisza, where a heavy-duty crawler crane lifted the cargo onto special transport vehicles. The shipments made their way from the port to the construction site on the road built especially for this purpose. Due to the fact that the Tisza is not navigable all year round, certain pieces of equipment were transported by road from the Danube harbor in Budapest to the Tiszaújváros site, including a 72 m long propane-propylene splitting column, which in itself is a significant logistical achievement.

3.4.3 Electricity generation from wind turbines and transport via inland vessels

This section will focus on one specific type of high and heavy cargo borne out of the energy transition: the transport of wind turbines by inland waterways.

According to the DNV Energy Transition Outlook 2021 report, wind is expected to account for 33% of the world's electricity output by 2050, compared to 5% in 2019.[67] In Rhine countries, the share of electricity produced from wind energy lies above the world's average. By 2019, it reached 20% in Germany, 15% in Luxembourg, 10% in Belgium and the Netherlands, and 6% in France. From 2000 to 2010, wind power capacity in Austria increased twentyfold, and threefold from 2010 to 2019. Croatia and Romania also experienced a substantial increase in their net capacity for wind energy over the period 2010-2019.

The growth of energy generation by wind turbines has been particularly successful in countries that offered state-guaranteed feed-in tariffs for wind power over a period of 20 years. Due to this scheme, overall capacity additions in the wind energy sector accelerated to meet 2030 targets. Grid operators were obliged to purchase wind power at the prices set by the state. The difference between this state price and market prices for electricity was paid by the end consumer in the form of a submission to the grid operator. Following this subsidy scheme, the wind industry experienced considerable growth for 20 years: installed wind-based electricity production capacity (both on- and offshore) more than doubled in Rhine countries between 2010 and 2019, while between 2000 and 2010 growth was even stronger. For the same period, a similar growth (although on a lower absolute basis) was observed in Danube countries, and especially in Austria.

Recently, however, permitting challenges and grid constraints started to limit growth. It was also observed that changes in policy design - from state guaranteed feed-in tariffs towards auction systems - had negative effects on capacity growth. In France, Germany and Italy, such changes in policy design led to a sharp decline in newly built capacity. This mostly occurs when support schemes with rather fixed feed-in tariffs are turned into auction mechanisms that automatically remove players with high production costs from the market. This last point reflects the increasing scarcity of areas for further installation of new wind turbines. Repowering (the exchange of existing wind turbines for new, more productive ones) is one means to overcome this bottleneck. As a result, investment in new capacities

[67] DNV, "Outlook 2021", November 2021, https://eto.dnv.com/2021/about-energy-transition-outlook.

decreased sharply in Germany in the years 2018-2020. These also suffer from long approval procedures, primarily due to lawsuits filed by parts of the population against companies wishing to install new wind turbines. In some cases, decommissioning parts of the ageing wind turbine fleet is not accompanied by repowering, which further reduces overall capacity.

Growth is forecasted both for onshore wind, led by France, Germany, and Spain, as well as offshore wind, led by the UK, the Netherlands, France, and Germany. Nevertheless, environmental and 'NIMBY' ('Not In My Back Yard') concerns seem to grow in several parts of Europe (including France) and could hinder wind power development in the medium to long term. In this context, transport of wind turbines or their components addresses two different markets. The first is repowering existing wind turbines and the second is construction in new locations. Both cases represent a possible market for inland navigation. It is worth noting that in the case of repowering, replaced wind turbines can be dismantled and recycled as well as moved to another geographic area. In both cases, transportation of wind turbine components takes place. Depending upon regulations in the wind energy market, each of the three cases (repowering, newbuilds, dismantling wind turbine components) will develop its own pace and trend, and IWW transport will be affected accordingly.

In light of the above, it is clear that the extent to which transport of wind turbines will develop strongly depends on public authorities' decisions to build new wind turbine parks and their acceptance by citizens. Another aspect is the availability of space for building such parks. Indeed, once such space is saturated, it is no longer possible to build new wind turbines.

The wind energy industry - logistical aspects and the position of the IWT sector

Due to competition with other energy sources (renewables and non-renewables) and public subsidies dedicated to the energy transition, economic and political pressure to reduce production costs and increase their energetic productivity over time is high. Hence, over the years, wind turbines have grown in size and height. Regarding size, the length of rotor blades is an important factor. Turbines with longer blades have enabled more electricity to be produced with one unit, because the efficiency of the propeller increases with longer rotor blades. Secondly, the height of the tower also increases productivity, as wind speed increases in higher areas. Between wind speed and energy generation, an exponential relation exists: if wind speed is doubled (growth by factor 2), energy production increases by factor 8, due to physical laws. From a logistical point of view, an increase in wind turbines' size makes inland vessels an even more appropriate mode of transport, at least in principle.

The German Federation of Wind Energy[68] confirms this, stating that "railway transport of wind turbines plays only a minor role, due to restrictions of the maximum rotor length (56m) that can be transported by rail. Hence, transporting rotor blades by rail is not possible anymore, due to the increase in their size". Railways are only capable of transporting parts of the tower of a wind turbine, or components of the engine house when these are divisible. Despite its suitability for the transport of wind turbines, inland navigation accounts only for a rather small share of all logistical activities of the wind industry. With regard to road transport, authorisations by administrative authorities are generally required to transport wind turbines. In Germany for instance, each wind turbine transport by road must be approved by the administration, justifiable only by invoking unreasonable additional costs if the wind turbine were to be transported via IWT or railways.[69] The fact that these approvals are almost always given is evidence for

[68] Bundesverband WindEnergie, "Akzeptanz und Effizienz der Energiewende mit Windindustrie in Deutschland erreichen – Multimodaler Transport von Windenergieanlagen", 2020, BWE | Akzeptanz und lokale Teilhabe in der Energiewende.
[69] Note : in Germany, all very large and/or heavy cargo transport by road must be authorised.

the lingering tendency against the use of inland waterways, for which there are several reasons, including a 'road culture' in logistics and stakeholders' mindsets. Furthermore, low bridges can limit wind turbine transport by inland vessels, in certain cases. However, should the administrative requirements to obtain an authorisation to transport wind turbines by road become stricter, additional opportunities for inland waterway transport would arise.

While wind turbine components have long been produced in Europe, most are now produced in Asia. They are transported to Europe via seagoing vessels, IWT appearing therefore as the logical follow-up to transport them to the hinterland. Bundesverband WindEnergie identifies the following points to achieve higher modal split share of IWT within the logistics of wind energy components:

- Availability of a sufficiently high number of large inland vessels for the transport of wind turbines;
- Quality requirements for waterways, locks and ports regarding size and technical conditions;
- Possibility for loading and unloading wind turbines and their components in ports;
- Possibility for intermediate and temporary storage;
- Minimisation of weather-related transport interruptions (high or low water, ice);
- Development of models and solutions together with transport companies.

Such findings were corroborated during interviews carried out with experts and relevant stakeholders.

3.4.4 Opportunities

For transport of wind energy components, IWT appears to be advantageous for many reasons:

- No competition from rail, only from road;
- Inland vessels can cope with the increasing size of the turbines (inland vessels offer enormous loading capacities with loading spaces of up to 100m in length and 10m in width);
- Fewer size restrictions or administrative barriers for inland vessels compared to road, and their capacity makes them suitable for this market (high and heavy cargo transports on the inland waterways are usually standard transports and therefore do not require any permits or supervision);
- The relatively large bridge clearance heights offer an extensive loading gauge;
- Dry cargo ships can be multifunctionally used for the transportation of heavy and oversized goods, but also for many other products, thus avoiding empty journeys;
- The locks along the Danube work at night and during weekends, enabling a high transportation flexibility.

A key success factor for IWT to be a preferred mode of transport over road lies in the proximity of the inland port to wind turbines production sites or the end site where they are to be delivered. Indeed, it is an essential element to limit transhipment costs. Other trends, in particular increased production of wind turbines outside Europe, act in favour of IWT. This trend leads to more wind turbines being imported into Europe via maritime transport and seaports. Hence, IWT is becoming the logical follow-up mode of transport towards the hinterland in these cases.
Wind turbine components transport is linked with the continued development of the wind energy industry itself. In the last 20 years, considerable growth in this sector has taken place, in particular in Germany. With the exception of repowering, the outlook is somehow less growth oriented due to space scarcity and saturation, social opposition against new wind turbines, and a shift from subsidy to auction systems. In this respect, the role of public policy, acting in favour or not for the development of this renewable energy, or pushing for certain renewable energies only, is paramount. Indeed, the availability

of funding and financing solutions to support investment in wind parks as well as technological development is crucial. Should they materialize, IWT would be a clear beneficiary.

3.4.5 Obstacles

As has been shown, wind turbines are growing in size. While this is an advantage for IWT in general terms, the absence of vessels and infrastructure in ports equipped for handling ever larger components could be an obstacle for further modal shift to inland waterways. In addition, lack of adequate waterway infrastructure, and availability of road access to and from inland ports, is a barrier to the further development of IWT in this market.

Moreover, there are natural limits to the expansion of wind parks. The actual potential of wind turbines as a new market for IWT depends on the level of geographical saturation of this market, especially for onshore wind energy. Indeed, once available space for building wind parks becomes saturated, further growth will then only depend on repowering existing turbines. Repowering can create a high volume of investment (and transport of turbines) on its own, but this presupposes favourable and growth-oriented regulations and schemes in wind energy policy.

Another limit lies in public acceptance of this market. As observed, growing public opposition to wind turbines is prompting governments to be more cautious about funding the sector further. This uncertainty about future wind energy developments casts a shadow of caution over the potential of this renewable energy as a new market for IWT. At the same time, governments are more and more focused to reduce emissions and decarbonise the energy and transport sector. It is therefore very likely that wind energy and turbines will continue to play a role in the future, but the actual conditions for growth will be different from one country to another. For offshore wind energy, different challenges exist which relate to environmental and habitat protection in maritime waters. Technical challenges are also observed (costly installation of cables and transport of electricity underwater, etc.).

In addition, regulatory change can also have a major impact on the development of the wind energy market, as the German example shows. The shift within the German energy sector from a subsidy scheme towards an auction system caused some wind energy companies to disappear and led to a general slowdown in the construction of new wind turbines. Such changes affecting the wind market itself can potentially hinder the transport of wind energy components by inland waterways. This is confirmed by expert interviews. In reaction to this, the German government introduced a new regulation allowing the construction of wind turbines to continue also during a long litigation process. This example proves once more the important role of government and public policy in the development of this market. Regulation can therefore be either an obstacle or an opportunity.

Finally, as observed in other sub-markets road culture in logistics and lack of knowledge about IWT is a major issue. The interviews with logistical players active in the wind turbine market showed this phenomenon quite clearly. It is indeed very difficult to overcome this obstacle, as it often concerns a cognitive bias fuelled by lack of information about IWT on behalf of logistical companies.

3.5 Inland waterway container transport[70]

A container is a sealed, rigid, reusable metal box used to hold goods that require transport by vessel, truck, or rail. Data are expressed in tonnes and twenty-foot equivalent units (TEU). TEU is based on a container measuring 20 feet in length (6.10 m) and provides a standardised measure for containers of various capacities. The two most common international standardised container types are the twenty- and the forty-foot-long containers. These must be built for repeated use, easy to fill or empty, and specially designed to facilitate the carriage of goods without intermediate reloading. All containers must have construction fittings able to withstand transport pressure.

Container transport refers to the transportation of goods in standardised containers via rail and waterborne transport. The flexibility of container transport makes a significant contribution to the reduction of transport costs. It is the most economical form of cargo transportation, especially when moving bulk and consumer goods via multimodal logistic chains. In this context, container load is a shipment that fills a container by bulk or with the maximum allowed weight. In essence, it is the volume of shipments that can be transported using a standardised shipping container. When containers get to port, they are subject to Container Service Charges (CSC) or Terminal Handling Charges (THC), fees charged by the shipping terminals for the storage and positioning of containers before they are loaded onto a vessel. These charges usually consist of goods handling, unloading, stacking, and crane service.

Container transport has gained enormous importance in inland shipping. In the EU-27, it amounted to 6.8 million TEUs and 56.5 million tonnes in 2020, which was an increase of 2% (based on TEU) but a decrease of 3% (based on tonnes) compared to 2019 levels. This amount represents a share of 11.3% of total IWT in the EU. The share of container transport followed an upward trend in recent years: 9.0% (2015), 9.9% (2018), 10.4% (2019), 11.3% (2020).[71] The main reason for this trend is that almost all ships that can handle bulk are also suitable for container transport. Vessels can carry containers with several appliances, clothing, but also frozen foods loaded into freezer containers. In addition to that, there are also more specialized inland waterway vessels constructed specifically for container transport.

Container transport on European inland waterways takes place mainly in Rhine riparian countries (as well as Belgium and Luxembourg), with over 99% of IWT container transport in Europe. Experiments are currently underway to make it a significant market segment on the Danube as well, mainly to replace the predicted decline of bulk cargo transport on this waterway.

3.5.1 Container transport on the Rhine

Container transport on the Rhine has been an important sub-market since the early 2000s. In 2020, 1.21 million containers were transported on the Rhine, the equivalent of 15 million tonnes of cargo (3.54 million TEUs). The bulk of the container transport market (1.92 million TEUs) takes place on the Lower Rhine, i.e. between Rotterdam and Bonn. The intensity decreases when moving upstream. Upstream transport (924,000 TEUs) is loaded mainly in the Netherlands and Belgium and services Germany, France, and Switzerland. About 50% of upstream containers are empty. Downstream-bound cargo is loaded

[70] Note: This chapter focuses only on the transport of ISO maritime containers (20ft/40ft TEU) and does not address the other types of non-maritime standardised containers filled with Europapallets that are mainly transported by road. Despite IWT's suitability for the transport of containers in the hinterland, no development exists at the moment for these non-maritime containers, partly because of the nature of the goods they contain, but also because the continental containers are of different dimensions than maritime containers and thus less suited to be transported together on a vessel. If a new standard container for maritime and continental transport can be made, the continental container flows might prove a significant opportunity for IWT. As they are outside the scope of this report, intermodal loading units are addressed in PLATINA3 Task 1.2.

[71] CCNR, "Annual report 2020", September 2020, Annual Report 2020 | CCNR.

mainly in Germany and unloaded in Belgium and the Netherlands. More than 90% of those containers are filled.[72]

Recently however, container transport's growth path has been curbed, but was not halted or reversed. This is due to a combination of factors: fierce competition from road and rail, low waters in 2018, trade slowdown and supply chain disruptions as a result of the COVID-19 crisis, and traffic congestion in seaports. Recent econometric analysis shows that:

- Container transport on the Rhine is intensely connected to hinterland transport from ARA seaports. Rotterdam is hereby the most important seaport.
- Container transport is vulnerable to low waters, due to high competition with railways.
- Macroeconomic factors (growth, inflation and especially energy prices, exchange rates, etc.) also play an important role.
- The Rhine forms, in particular, an export artery for German containerised goods.
- Longer-term outlook points to a structural slowdown in world trade growth, which would affect container transport on the Rhine.

Container transport by IWT along the Rhine is the natural continuation of containers' sea journey from maritime ports (mainly Rotterdam and Antwerp) on their way to the hinterland. For an inbound TEU, the main unloading regions are Antwerp (BE), Rotterdam (NL), Noord-Brabant (NL), and Düsseldorf (DE). Realising the sharp increase in inland container shipping volumes in recent years, the port of Rotterdam published its "inland container shipping guidelines"[73] to accommodate this growth in a reliable, sustainable, and cost-efficient way. The port wishes to foster improvements in the logistic chain, including bundling concepts, integrated planning (Nextlogic), digitalisation processes for information exchange (Portbase), and expansion of capacity. At present, 38% of the containers that move between Maasvlakte and the hinterland are transported by inland vessels. The Port Authority of Rotterdam aims to increase this share to 45% by 2030.

Although container transport does not constitute a new market on the Rhine and its affluents, it may be considered a new and growing market on the Danube.

3.5.2 Container transport on the Danube

As detailed above, container transport is already widespread on the Rhine but remains virtually non-existent on the Danube. Current cargo on the Danube consists of bulk cargo with a very little number of (mostly empty) containers being transported on its waters. The predicted decline of bulk cargo calls for new market opportunities to be developed which could be found in the development of container transport. Several companies tried to stimulate the establishment of container services on the Danube in the past by opening liaisons along the Giurgiu-Constanța, the Belgrade- Constanța, and the Budapest-Belgrade-Constanța routes. These ventures did not prove economically successful and were terminated relatively quickly.

Two projects, aiming amongst other goals, at developing container transport on the Danube are however ongoing: Dionysus[74] and IW-NET[75]. Despite previous unsuccessful attempts at developing container transport on the Danube, recent public policy developments such as the EGD and the

[72] Norbert Kriedel, "Container transportation on the Rhine and its main characteristics", 2nd Workshop on Container Liner Services, DIONYSUS – Integrating Danube Region into Smart & Sustainable Multi-modal & Intermodal Transport Chains, 7 December 2021.
[73] Port of Rotterdam, "Inland container shipping guidelines", August 2019, inland-container-shipping-guidelines.pdf (portofrotterdam.com).
[74] Interreg Danube, "Dionysus project", 2020-2022, https://www.interreg-danube.eu/approved-projects/dionysus.
[75] IW-Net, "IW-Net project", 2020-2023, https://www.iw-net.eu.

availability of public subsidies might have a positive impact on the development of this new market on the Danube.[76]

In addition, the Danube is utilised far below its capacity. Free capacity is therefore available on the Danube for the development of container transport. Connections with strong industrial regions in South-eastern Europe can also be considered as favourable conditions for the development of this market. For instance, the Ennshafen port in Austria has a capacity upwards of 450 000 TEUs at the heart of its strongest industrial region. Its connection to other river basins (via the Danube-Main-Rhine and Rhine-Moselle/Rhine-Meuse confluences) could allow for good enough conditions to successfully develop container transport.[77] According to an upcoming PIANC WG-237 report on "Bottlenecks and Best Practices of Transport of Containers on Inland Waterways"[78], container transport on the Danube could constitute both a success factor and a threat.

Many obstacles must however still be overcome for container transport to take up on the Danube. For instance, transit times between the port of Constanța and Serbian or Hungarian ports are significantly higher than containers delivery times from the ports of Rijeka, Koper, or Bar, using road or rail transport (7 to 11 days, or 4 to 8 days compared to 1 day). Furthermore, available infrastructure and equipment in most Danube ports is not suitable to the needs of transhipment and transport of containers on the Danube. Other unfavourable conditions can be cited such as need for vessels to be adapted to navigate in low water periods or the lack of information among shippers regarding inland navigation container transport. With regards to the latter an observatory of key IWT enablers was developed in the context of the IW-NET project to act an information platform for IWT.[79] Finally, as the Danube flows through both EU and non-EU countries, it may generate higher administrative and political obstacles, which can significantly reduce the competitiveness of container barge transport compared to its rail and road alternatives.

Serbia - Container terminal construction in the port of Novi Sad

The Port of Novi Sad-DP World's 800-metre quay can accommodate up to 5 vessels in one row of berths. DP World Novi Sad owns and operates 44,000 m^2 of closed warehouses and 100,000 m^2 of open storage area, consisting of public and bonded warehouses. West on the Danube there are connections with international ports upstream of Novi Sad: in Hungary (Dunaujvaros, Budapest, Komar), Slovakia (Komarno, Bratislava), Austria (Vienna, Linz, Enns), Germany (Deggendorf, Regensburg, Kelheim) and, through the Rhine-Main-Danube Canal, there are river connections with Germany, Switzerland and the Netherlands. The reconstruction and modernization of the Port of Novi Sad on the Danube, started in May 2022, where the owner "DP World" undertook to invest 30 million euros, began with the construction of a new vertical quay, an intermodal container terminal[80]. In two years, the first container terminal will be built on this part of the Danube, which will be of great importance for the development of Danubian logistics and economy.

Ukraine - Establishment of Container Liner Services in the Lower Danube

As mentioned in previous chapters, the Russian invasion in Ukraine, which began in February 2022, led to the emergence of additional risks in the Danube shipping market. At the same time, due to the blockade of Ukraine's seaports, the logistics of cargo flows to/from Ukrainian ports on the Danube has changed dramatically. Accordingly, the organization of transportation in the Lower Danube and the

[76] Lisa-Maria Putz, "Containerized Transport on the Danube", 3rd PLATINA3 stage event, 10 February 2022.
[77] Vladislav Maraš, "Container transport, a possible new market for the Danube", 3rd PLATINA3 stage event, 10 February 2022.
[78] PIANC, "Upcoming publications", 2022, https://www.pianc.org/upcoming-publications.
[79] REWWAY, "Research and Innovation", 2020-2023, https://www.rewway.at/en/research-and-innovation/.
[80] Port Technology, "DP World breaks ground on new Serbia container terminal", 18 May 2022, Port Technology | DP World.

need to build a special logistics regime for the ports of Ukraine, Moldova and Romania have become of particular importance, primarily to facilitate Ukrainian agricultural exports and import necessary goods into Ukraine.

In support of EU solidarity measures and according to the Action plan for EU-Ukraine Solidarity Lanes to facilitate Ukraine's agricultural export and bilateral trade with EU[81], the Danube Commission undertakes a number of initiatives to contribute to solving this problem related to proper functioning of the Lower Danube corridor and facilitation/improvement of existing IWT logistics. One of the solutions in this regard, considering significant bottlenecks and capacity constraints for rail and road transport between UA-MD-RO which emerged due to distorted logistics routes from Ukraine, was the establishment of container liner services operating on the line Izmail, Reni (UA) – Giurgiulesti (MD) - Constanța (RO). Due to the present freight market affecting the cost of transportation from Giurgiulesti, the project is currently on hold. The port of Giurgiulesti tried to solve the problem by sharing a solution of moving containers from Reni to Giurgiulesti by platforms. There is still a gap, which will have to be covered due to high freight rates for river transport.

Additionally, to the existing traffic, there are plans to develop container liner service operating from the port of Reni (Ukraine) to port of Constanta (Romania). One of the partners in this project is Maersk, which - besides the traffic commitments - intends to bring the necessary equipment for operations, such as: cranes, reach stacker, spreaders, etc. The other partner, responsible for the sea transport will position in the first phase one vessel (400 TEUs capacity), which will feed Constanta Port – DP World terminal on a round trip weekly basis. A second vessel will follow as soon as the liner will start operation. This line will be serving for humanitarian aid and general cargo transportations from Constanta to Reni and for mostly grain and general cargo transportations from Reni to Constanta. The main limitation for this new traffic, was obtaining the status of "liner" for this new project. This status was obtained by Maersk, which allows vessels to operate round the clock and get priority at entrance/exit of Sulina canal. The line is planned to be operated by Romanian fleet operator – Trading Line, once established and proved itself as a reliable and sustainable, it might become a solution not only as a temporary measure to unblock Ukrainian cargo flow in a war situation, but as a fixed operating line for the whole region.

Another trial shipment has started in October 2022, Izmail – Constanta also transporting humanitarian cargo, grains and general cargoes. The shipowner is Trading Line, with vessel Bolero (5300 mts intake at 3 m draft/abt 200 TEUs capacity). If this proves to work, then the second vessel will be positioned on the line, connecting first Reni to Constanta, and at the second stage Giurgiulest as well. It has to be mentioned that container transportations are also provided by Ukrainian Danube Shipping Company, yet in rather small quantities (50 containers per barge) and not as a regular liner service.

Another initiative was proposed for establishment of an alternative logistics corridor between Ukraine and Greece for transportation of agricultural cargo. Currently there are ongoing discussions on possible connectivity routes. Amongst others, there is an option for containerized transport: transshipment in containers from the Ukrainian ports on the Danube, e.g., port of Reni or Ismail or the Moldovan Danube port of Giurgiulesti (considering that all of them could handle containerized for short sea shipping) to Constanza (RO) or Ruse (BG) and then by rail to the port of Alexandroupoli (GR). It was also considered to use containers and ship the grain in bags which would also help and facilitate the handling in Alexandroupoli port because of the possibility of storing them in the piers.

[81] European Commission, "An action plan for EU-Ukraine Solidarity Lanes to facilitate Ukraine's agricultural export and bilateral trade with the EU", 12 May 2022, EC | EU Solidarity Lanes.

3.5.3 Opportunities

Currently, the Danube is utilized far below its container transport capacity while on the Rhine daily container services take place. Danube operators have an opportunity to take advantage of this free capacity and shift more containerized multimodal cargo on the Danube. As environmental awareness is constantly increasing and forcing companies to make use of more sustainable modes of transport, Rhine and Danube shippers could make use of available European funding to spur more modal shift initiatives on IWW. As in recent years the number of containers transported along European IWW grew enormously, a further increase of this type of transport is generally expected.

In addition, transporting a container on inland waterways instead of roads can decrease GHG emissions by up to 75%.[82] Thus, making container transport by inland waterways more competitive can contribute to the achievement of the Paris Agreement, given the fact that close to a quarter of energy related global GHG emissions come from transport and that they are expected to grow substantially in years to come.

Carrying containers on inland navigation vessels is also much safer than on trucks.[83] At the same time, road and rail are strong competitors to container transport via inland navigation, often having the advantage of being faster and requiring fewer transhipments.

Thus, inland navigation must become more efficient, more reliable, and more customer oriented to increase its market share or just defend the status quo. For this increasing trend to continue, it is certainly important that container transport integrates better into regional and urban logistic chains and that short-distance container transport develops as well.

3.5.4 Obstacles

Beyond strong competition from other modes, other emerging factors could have a negative impact on inland container transport. As was already the case before the Covid-19 crisis, international trade has stopped accelerating and even started shrinking. The drivers of this development might be profound structural forces, including an increasing shift of global consumer demand away from tradeable goods to services, but also towards more locally produced goods. Other factors such as technical innovations such as 3-D printers reducing trade in goods further or even containerisation coming to its saturation limits will also play a role[84],[85]. These tendencies would create more regional logistic and production chains and would certainly have negative effects on seaborne container transport, as around 90% of world trade in goods is carried out by seaborne trade.

Already before the COVID-19 pandemic in 2020, world trade in goods slowed down, and this trend is expected to continue. The importance of global trade in goods is decreasing in trend terms, while trade in services is increasing. This structural change in trade can be explained by the following factors:

- Shift of consumer demand away from tradeable goods to services in developed countries (dematerialisation);
- Growing incomes and wages in emerging market countries leading to less wage and cost differentials worldwide, and therefore to less incentives for worldwide trade of goods;
- Technical innovations such as 3-D printers reducing trade in goods further;
- Declining population growth in Western Europe;
- The labour/population ratio, i.e. the share of population contributing to economic output, is decreasing, not only due to ageing populations but also due to the baby boom generation

[82] Preliminary work of PIANC WG 237 on "Bottlenecks and Best Practices of Transport of Containers on Inland Waterways (InCom)".
[83] *Ibid*.
[84] See: BMWI, "The future of global trade", January 2021, https://www.bmwi.de/Redaktion/DE/Schlaglichter-der-Wirtschaftspolitik/2021/01/kapitel-1-7-die-zukunft-des-globalen-handels.html.
[85] See: Cornelis van Dorsser et al., "Port Metatrends. Impact on long term trends on business activities, spatial use and maritime infrastructure requirements in the Port of Rotterdam", 2018.

retiring *en masse*. In addition to that, job losses linked to automation and artificial intelligence put approximately 40-50% of jobs at risk.
- The growth rate of the GDP/labour ratio decreases, which reflects a decreasing productivity growth, resulting from lower economies of scale in innovations. This trend affects technology frontier countries.
- Reverse globalisation (decreasing trade/GDP ratio), i.e. a higher focus on local production.
- Containerisation coming to its saturation limits.

Environmental aspects could also play a role. An increase in maritime transport costs due to stricter environmental regulations could impact maritime freight transport. Given that a common feature of large-scale container transport on inland waterways is its interdependence with seaports, the described trends affecting maritime container transport are expected to affect inland waterway container transport in return.

On the Danube, container transport remains dominated by empty containers (reverse logistics). The main hindrances for container transport to take off on the Danube remain local conditions such as water levels and navigability. Most companies need at least three levels of containers stacked up to be profitable, which in high water level periods makes it challenging to navigate below bridges.

4. Marketing and communication innovations as additional tools to strengthen modal shift

In light of the EU's ambitious plan to significantly reduce emissions by 2030 and become climate neutral by 2050, and considering that the Rhine and the Danube are the economic backbones of their respective transnational regions – whilst forming a vital part of the wider, complex European Inland Waterway Network – both the effective promotion of IWT in the EU's policy framework as well as towards new transport and logistic markets is an essential prerequisite to orient IWT towards the needs and requirements of a future-oriented, more competitive global transport system.

National transport development plans recognize the strategic role of transport in providing the inter-sectoral linkages of the economy. Nevertheless, IWT is not used at its full capacity even though transportation of goods by water from a seaport or an inland port directly to the customer (e.g.: transporting iron ore from Rotterdam to the steel mills on the lower Rhine by IWT) is extremely competitive in terms of costs per tonne-kilometre. Often, additional costs occur only during transhipment operations when the cargo is moved in and out of vessels. Among other factors, the final cost is thus directly related to the amount of transhipments necessary for a shipment.

Promotion of IWT in the context of intermodal competition and multimodal cooperation may start by showing "problems-that-are-not", enabling a complete rethinking and consequently, laying the ground for adequate communication with the public, new markets, and emerging industries. At the same, with the adoption of the European Green Deal and the subsequent legislation to support its implementation, environmental sustainability has become one of the most important challenges of modern-day Europe. The challenge is to incorporate sustainability and climate neutrality in the business context. This is even more so for the transport sector. Indeed, it is widely known that the transportation sector is a major source for greenhouse gas emissions and is characterised by steadily increasing energy prices. Moreover, it is a large consumer of non-renewable energy resources with negative environmental impacts. Awareness and promotion of the obvious advantages of IWT compared to other modes of transport must, thus, be continuously highlighted and disseminated: comparatively low energy consumption, reduced noise pollution, superior level of safety, good reliability, and high versatility. Customers, shippers, freight forwarders must be convinced that IWT is an essential part of the supply chain.

A valuable example of how communications and marketing may foster the development of IWT comes from the Netherlands, where communication to shippers aimed at fostering a modal shift in favour of IWT has been conducted in the past by the Bureau Voorlichting Binnenvaart.[86]

Their communication strategy centres around the search for shippers that might potentially support modal shift, which is done by desk research. Once identified, shippers were contacted directly, and a free modal shift scan was offered. Here, the logistical process was mapped and opportunities for modal shift evaluated. After an initial analysis, shippers that would benefit from a modal shift and demonstrated interest would go into the pilot phase of the project. In this phase, the role of BVB lessens as the shipper enters into contact with suitable IWT operators or Logistic Service Providers. When successful, these pilots tended to lead directly to the adoption of IWT. This strategy has been in use by BVB since the early 2000's with the some of the initial actions even before that date. Although personal

[86] https://www.bureauvoorlichtingbinnenvaart.nl/wat-wij-doen/wie-is-het-bvb/

attention certainly bore its fruits, most shippers initially contacted had relatively small interest in modal shift or IWT. Overcoming this hurdle remains difficult. Communication on the short-term benefits of IWT is thus vital.

In addition to the communication strategy detailed above, BVB has noted that the so-called "werkbezoeken" (literally: working visits) on board of IWT vessels where the IWT operation is shown can really make people enthusiastic about the sector. This type of communication, however, is very time intensive to set up, and can only be used with small groups at a time, brought in a vessel to learn about IWT. Therefore, they have mostly been used by politicians, and high-ranking civil servants. To increase the added value of a "werkbezoek" to the broadest group of shippers, a short video, animations, and factsheets can be used. BVB has had some success with factsheets, whilst the EICB has seen successful with animations reaching the broader public for non-modal shift projects.

4.1 Campaigning for the adoption of IWT – a modus operandi

Based on the research done in projects like LASTING[87] and DYONISUS[88], it is clear that developing a dedicated IWT Awareness and Promotion Strategy has a beneficial impact on the development of IWT across regions and transport corridors by attracting new markets and emerging industries. Such campaigns must be developed towards achieving the ambitious goal of the European Union to become climate neutral by 2050, with IWT's vital contribution in reaching this objective being at the heart of the strategy.

4.1.1 Identify the target audience

Generally speaking, as a first step, the starting point is identifying **who** shall receive the message. Identifying the targets for promotion therefore is the point where a promotion strategy starts. All subsequent steps of a strategy must take the specific characteristics of the target audience into consideration. It is also of utmost importance to think of the needs of the specific audience or market segment and recipients of the core message. The more precise the identification of the audience or target group is, the more accurate the campaign will be. In this case, the identification of the target group can be made quite precisely since it directly concerns the IWT sector as such, but also potential new unexploited markets and industries that might benefit from the advantages IWT has to offer.

Once the core recipient of the message is identified, one must establish concrete communication goals. The most influential messages are persuasive. Persuasion campaign messages are generally accompanied by corresponding positive or negative incentive appeals. In such strategies, positive incentives that highlight the concrete advantages of IWT as compared to other transport modes must be used. The preparation process of a promotion strategy and, moreover, its actual implementation, require a well thought reflection on the promotional mix components relevant to the IWT industry and potential new markets. The right mix of components allows to efficiently raise awareness and become more visible. Communication often uses advertising and public relations as tools to efficiently reach out to new markets. Advertising and public relations may be defined as the practices to manage and disseminate information whilst influencing. Both tools must be used as key tools to keep the IWT sector informed and influence all other economic sectors on the benefits of the IWT sector. Characterised by a high level of geographic dispersion – the use of digital and interactive advertising is one of the most appropriate approaches to keep costs low and efficiently reach out to target groups, as analysed in detail later in this chapter.

[87] LASTING project, https://www.waterborne.eu/projects/coordination-projects/lasting/about-lasting.
[88] DYONISUS project, https://www.interreg-danube.eu/approved-projects/dionysus.

4.1.2 Fine-tuned and targeted messaging

The next step in a successful communication campaign is the **development of a core message**. What do we want to say? How do we want to say it and promote our message? It is commonly agreed that developing an impactful message is the quintessence of any promotion and awareness strategy. The message should be developed in such a way as to motivate recipients to think about its content – for instance by emphasizing the positive climate benefits associated with IWT.

The development of an impactful message relies on **rational appeals**, **emotional appeals,** and **moral appeals**. Rational appeal refers to the use of logic - for instance by comparing the benefits of IWT in relation to other modes of transport such as low congestion, economic viability, and minimum climate footprint. The message should ideally also include an emotional component with moral appeals reinforcing the importance of "doing the right thing" for "what is best for society". These components of the message can, for instance, be linked to the obvious advantages of IWT in terms of lower emissions. It is therefore of utmost importance to refer to positive "emotional" appeals by highlighting the different advantages of IWT – both in terms of Europe's ambitious pathway towards climate neutrality as well as considering IWT as an economically viable and reliable mode of transport.

Rational and emotional appeals, to be effective, depend heavily on the **selection of specific media** used in a promotion campaign. At this stage we define "specific media" as the vehicles carrying messages to the receiver. Since the combination of advertising, public relations as well as digital and interactive marketing is the most adequate "promotional mix" tool for the successful awareness and promotion strategy of IWT – necessary to increase visibility, dissemination and communication – digital/online channels are the best suited for the strategy's objective. Therefore, executing campaigns via diverse social media platforms appears be a worthy pathway to choose. Equally important is the distribution of various types of relevant information via newsletters. This complementary approach allows to effectively persuade and remind the target audience of the multitude of benefits IWT has to offer.

Channelling messages capable of increasing the uptake of IWT requires an adequate **budget** to cover the costs of a tailored communication campaign. This is a key aspect in the preparation process of a promotion strategy. The budget depends on the use of communication channels that end must be used in such a way as to effectively reach out to the target audience. If the Internet is chosen as the most suited communication channel, overall costs can be kept at a low level.

Finally, the results of the campaign must be **measured**. This implies going back to goals and objectives to ascertain whether such a campaign has effectively reached its target audience and, equally important, with what results.

4.2 The impact of the digital communications

Effective communication can be defined as a process of exchanging information and reaching mutual understanding which allows for the flow of key information through different networks and channels. The spread of complete and proper information is instrumental in achieving goals and becomes a powerful means of persuasion. Communication therefore helps to create connections with a target audience by raising awareness, building trust, and influencing customers through a variety of communication channels. Accordingly, communication is paramount to build trust and maintain long-term relationships between stakeholders. Moreover, it fosters the uptake of innovation, enhances transparency, disseminates innovative solutions, and generates revenue and employment. As we navigate through a technologically advanced era and humanity is confronted with key environmental challenges, marketing, public relations and more generally, communications are, thus, vital for all businesses, irrespective of the sector.

In line with the two major policy initiatives of the European Commission, namely the European Green Deal[89] and the Digital Strategy[90] increased attention is paid to the ways in which the transport sector can achieve the green and digital transformations and become more resilient to future crises. Accordingly, digitalisation is instrumental to improve the sustainability, resilience and competitiveness of the IWT sector. Online tools and platforms therefore serve a dual purpose: on one hand, they strengthen the modal shift by matching supply and demand more efficiently and transparently; on the other hand, they contribute to achieving the EU´s objectives of decarbonising the sector and ensuring an inclusive digital transition by making transactions more seamless. More widely, digital tools also inform stakeholders in a supply chain of all the multi-modal possibilities available, including the IWT.

Although road transport often remains the initial and final part of the transport chain, data shows that operators increasingly resort to rail, inland waterways, or short sea shipping (SSS) as alternatives or in complement to road transport only. However, intermodal transport (and more so, synchro-modal transport) is intrinsically complex and only preferred if it allows operators to reap the benefits of economies of scale, namely reduced costs, increased economic gains and transactional speeds, that in turn bring in new business opportunities. In the case of IWT, these benefits are supported by IWT´s known high reliability, lower costs and reduced negative externalities (pollution, noise, congestion, safety, etc.), the latter, nowadays are getting more attention in view of regulatory compliance as well as corporate responsibility. However, there is certainly no full internalisation of external costs yet, resulting in a lack of incentives for using inland waterway vessels instead of trucks to perform the main haul of the transport.

The benefits referred are compounded by innovation, which in turn acts as an enabler of modal shift. Innovation requires access to quality and reliable data, often lacking. More so, freight forwarders or shippers are not sufficiently informed about the advantages and solutions offered by intermodal transport and IWT, as stated in contacts by members of the European Shippers' Council. An expedient to improve this situation might therefore consist in enhancing the sector´s digitalisation, improving information flows and supporting the creation of ad hoc platforms supportive of IWT and modal shift, that also create awareness on innovation, best practise, and new business concepts.

In 2016, DG MOVE investigated possibilities for digitalization of the IWT sector and defined the so-called Digital Inland Waterway Area (DINA)[91], a concept to interconnect information on infrastructure, people, operations, fleet, and cargo in IWT to other transport modes. The study emphasised the need for IWT to adapt to and navigate the trends in digitalisation. To meet the challenges, a number of developments are underway. As regards business developments, Smart Shipping needs a digitalized infrastructure that facilitates autonomous vessels for a safe and efficient navigation. In addition to this, multimodal and synchromodal transport and logistics will bring in new requirements to IWT and, at the same time, lead to an overall improvement in the quality and efficiency of the sector supported by technology. As regards technological developments, key will be the use of the Internet of Things/Physical Internet, Artificial Intelligence and Big Data, as well as greater interconnectivity between platforms (e.g.: via federated platforms) and automated data exchanges, propelled by a new need for faster and more accurate exchange of data, be it in the transport and logistics sector, for e-commerce or with public authorities.

[89] European Commission, "A European Green Deal", December 2019, A European Green Deal | European Commission (europa.eu).
[90] European Commission, "Digital Strategy", 30 June 2022, EC | Digital Strategy.
[91] See: https://www.inlandwaterwaytransport.eu/digital-inland-waterway-area-towards-a-digital-inland-waterway-area-and-digital-multimodal-nodes/; https://www.inlandwaterwaytransport.eu/digital-inland-waterway-area-towards-a-digital-inland-waterway-area-and-digital-multimodal-nodes/.

These technological developments could benefit from re-usability of public sector data under strict conditions - in line with the Open Data Directive[92] or the recently approved Data Governance Act[93] - and current practices in other sectors, such as road transportation, where private operators access selected public traffic and travel data. For the future, it is imperative to guarantee the continuous flow of "public to private" data (under strict conditions), but also "private to private" data and "private to public" data, on which the above-mentioned technologies are sustained upon.

Given the importance of IWT and its benefits, new technology, digital communications and the digital transformation will make IWT more accessible and easier to coordinate (e.g.: by means of data exchange and enhanced navigation) and should give it a more prominent place within the European transport sector. In line with the above, five EU Member States´ authorities in Austria, Belgium, France, Germany and the Netherlands, are working on a joint project aimed at the creation of a new Masterplan on Digitalisation of Inland Waterways (DIWA)[94] for the period 2022-2032. The project will promote the development of a basic digital infrastructure of the IWT network, which will facilitate the transformation of the sector.

In the document "Towards a Strategic Research Agenda: Inland waterways transport and ports in Horizon Europe" (EBU et al., 2019)[95], the European Inland Waterway Transport sector formulated a digitalisation vision towards 2050 based on the general principle "Easy to use and reliable mobility and logistics". According to the document, "digitalization connects smart vessels and ships as well as smart ports and smart infrastructure. It enhances data flows, self-diagnosis, and swift machine interaction, allowing a progressive and safe increase in automation and autonomy, automated and autonomous systems, vessels and ships operations and remote controls from the shore. […]". Digitalisation also allows for the establishment of digital corridors composed of information and communication systems sustained on standardized and secured access to automated data exchanges between networks of shippers, transporters and public institutions. EU projects FENIX[96] or FENIX 2.0[97] are good examples of this.

Communication is, thus, directly intertwined with full connectivity. Similarly, communication between actors in the supply chain is relevant for the choice of transport modality, since the manner in which transport operators communicate with their customers (shippers), terminal operators, agents, freight forwarders, port authorities and other relevant parties co-determines their efficiency and usability for potential customers. Several freight forwarders, agents and shippers make use of supply chain systems that require very specific input to operate smoothly. In the past, IWT mainly communicated with these actors by relatively old-fashioned ways such as phone or e-mail, less suited than automated digital communication requiring reduced human intervention.

Today, given the increasing importance of modal shift, private companies, and governmental bodies in and around IWT have brought a degree of digitalisation (and electronic communications) to the sector. IWT is becoming more and more able to communicate in such a way as to attract and answer the needs of new and existing customers. By investing in marketing and communication – including machine-to-

[92] Directive (EU) 2019/1024 of the European Parliament and of the Council of 20 June 2019 on open data and the re-use of public sector information (recast).

[93] Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act). (Text with EEA relevance).

[94] See: https://www.masterplandiwa.eu/.

[95] See: https://www.inlandnavigation.eu/a-strategic-research-agenda-for-inland-waterways-transport/ https://www.inlandnavigation.eu/a-strategic-research-agenda-for-inland-waterways-transport/.

[96] See: https://fenix-network.eu/.

[97] See: https://fenix-network.eu/ready-for-fenix2-0/.

machine electronic communications – and by recognising their importance as additional tools to strengthen modal shift, it becomes possible to overcome the operational challenges linked to the choice of transport modes and increase the uptake of modal transport, thereby also making IWT more attractive. Many are the opportunities offered by marketing and communications in this sense, among which are specific online tools and platforms that can match user expectations with supply and wider demand needs, by approximating and contrasting them in real time, but also by marketing different modes of transport working together. This elevates the quality (and quantity) of services rendered and allows for bespoke solutions targeting very specific customer needs whilst increasing adoption of IWT options.

As larger IWT companies and cooperatives develop their own supply chain systems to match the need of their customers, smaller companies are still lacking the resources to do this. This can be partly remedied by governmental bodies currently building port community systems (PCS), allowing PCS actors in and around the port to exchange data witch each other more efficiently.

In the Port of Rotterdam, the local PCS (called PortBase[98]), is augmented by a specific online tool for IWT container transport, Nextlogic.[99] Nextlogic offers an integral planning system (IPS) fed by data that is delivered by barge operators, terminal and empty depots, and consists of crane and quay capacity, call sizes, positions of vessels etc. The system then delivers and integral planning for all partaking terminals and barges. Due to the delivered data by the parties, each party's planning is suitable for itself and all the other parties. Cranes and quay's availability is optimally matched to the rotation of each barge between different terminals in the port. This, in turn, decreases waiting times and increases efficiency. Nextlogic will work optimally when all barges calling at local terminals, and all local terminals make use of the tool. Currently, this is not yet the case, but pilots are being held to test and improve the system and to showcase it to interested parties.

A PCS allows for the exchange of data in a faster way than it is normally done between all parties active in the port, while an IPS (like Nextlogic) offers an integral planning for different actors to maximise their efficiency. By joining these developments, IWT operators make themselves more suitable for the needs of customers. To reach new potential customers, the sector might rely on further innovations on the path to holistic, integral planning and port wide communication.

Fostering port wide communication will also enhance the integration of ports into intermodal transport chains, the harmonisation and automation of administrative procedures, ICT tools and services to simplify the exchange of data between different partners. For shippers, this means increased reliability, and tracking of the right KPI's to assist in the choice of the transport mode. For the IWT, port wide communication adds supports wider communication efforts, by improving the image of the sector that is dependent on all its stakeholders (ports included) as it more effectively responds to consumer demands.

One innovation targeting improved exchanges between operators is the so-called Online Matching Platform (OMP), as proposed in a paper by Guo et. al. in 2020[100] entitled "A dynamic shipment matching problem in hinterland synchromodal transportation". Here the authors search for possibilities for a centralised platform that matches shipment requests and transport services on offer. The paper focuses

[98] See: https://www.portbase.com/.
[99] See: https://www.nextlogic.nl/.
[100] See: https://repository.tudelft.nl/islandora/object/uuid%3Af480db0d-243d-40d7-9207-3d28d2c87a1e.

on possible algorithms and approaches that such a platform could use to make efficient matches and offer efficient solutions.

The key point for barge operators is that an OMP can in theory service all transportation requests and all transport services on offer in a certain location. This means that goods to be transported should be matched with the most efficient transport service. In other words, the decision between transport modes is taken out of the hands of shippers, agents and freight forwarders and put in the hands of the OMP. Such an OMP would not suffer from previously held preconceptions (often unfounded) about IWT capabilities, and instead would weight each transportation demand all relevant indicators to see which transport service (and mode) is best suited to fulfil a specific need, in a given moment. Such a system, which could easily be seen as the next step for ports that offer PCS and IPS, offers a chance to attract more cargo for barge operators that are prepared to meet the necessary digitalisation needs that come with it. It also serves to communicate to users, the real benefits of IWT.

Among B2B platforms, SpotVessels[101] serves as an example of the positive power of communications and marketing in IWT. SpotVessels is an online cargo booking and fleet management platform for inland waterway shippers, carriers, and freight forwarders. While the underlying aim is to tip the benefits of a smart IWT marketplace and make IWT more accessible and cost-efficient, the platform indirectly contributes to reducing road traffic and emissions, thereby enhancing transport´s sustainability. By providing for the possibility to instantaneously book an inland ship suited to cargo, Spotvessels entails a number of benefits for both ship and cargo owners. Overall, it contributes to shaping a more transparent shipping market as it provides a comprehensive view of the market and enables tracing selected ships. It also allows direct exchanges with ship operators, frequent updates on the actual situation of the inland waterways and easier access to IWT-documents complemented by access to hydrological, GPS, and market data that eventually optimises a fleets' performance. Accordingly, the information provided helps to reduce costs and waiting time by increasing overall efficiency and reducing the levels of risk and uncertainty. While this will end up increasing IWT´s share in the overall transport mix, it will also contribute to reducing the degree of environmental harm caused by the transport sector as a whole.

As previously mentioned, communication fosters IWT uptake. Part of such communication and marketing efforts involve disseminating innovative solutions and approximating potential buyers. European projects such as the ENTRANCE portal[102], provide for an online European Matchmaking Platform and off-line support services aimed at accelerating market access and scale up of innovative sustainable transport solutions. ENTRANCE focuses on the so-called "supply-demand-finance" triangle which applies to all transport and mobility modes. On the supply side, organisations provide near-to-market transport and mobility solutions. On the demand side, potential buyers can acquire innovative solutions. On the finance side, public and private organisations can provide funding programmes to enhance the transport sector.

Overall, ENTRANCE identifies potential solution providers and matches them with the uptake and upscaling of innovative transport and mobility solutions, including in the IWT sector. It also shapes and implements communication activities to support the general goals of the project in advancing "innovative (sustainable) transport solutions" and facilitates the dissemination of information, data exchange and the exchange of best practices on the implementation of sustainable transport solutions.

[101] See: https://www.spotvessels.com/about.
[102] See: https://www.entrance-platform.eu/.

This, in turn, helps transport reduce its environmental footprint and meet the mobility needs of people and freight in the 21st century.

As seen, the importance of electronic tools, communication, and marketing in fostering a modal shift favourable to the IWT is of paramount importance, as they support and enhance planning, port wide communication and data exchange.

All these tools require continuous data flows, transformed thereafter into information accessible (and comprehensible) by humans. Hence, efforts must focus on how to further improve current information flows that are at the basis of all electronic tools. This may well require new thinking on accessibility of public information by private economic operators, under strict conditions, the exchange of economically sensitive information of superior interest (e.g.: specific location of goods in a given time) and the implementation of current regulation such as the Data Governance Act[103] or the eFTI Regulation[104], which introduces (in law) the obligation for Member-States authorities to accept and recognise electronic freight transport information (e.g.: e-CMR), in equal manner as they do with paper-based freight transport information.

4.3 Example from viadonau in Austria: Information platforms and initiatives for promising cargo groups

Viadonau has developed various online services and publications which are made available free-of-charge to the cargo and passenger shipping industry and are intended to facilitate transport and voyage planning for shipping companies. Since 2008, viadonau has been operating the online directory "Danube Logistics Portal", which contains profiles of numerous ports along the Danube, from Kelheim to Sulina. The "Danube Logistics Portal", with its four subpages "The Blue Pages", "Danube Ports", "Travel Time Calculator" and "Transport Planner", provides comprehensive information on service providers related to Danube navigation and logistics.[105]

"The Blue Pages" is a comprehensive directory of shipping companies and brokers operating on the Danube. Since 2009, it is an indispensable reference tool for industry and commercial companies in the Danube region. Shipping companies and brokers can create an extensive company profile for free and can be contacted directly for transport requests. The "Danube Ports" is a platform providing information on more than 60 ports and transhipment sites along the Danube, between Kelheim in Germany and the Black Sea, as well as adjacent rivers and canals. In addition to general information about the ports, the extensive port profiles contain further details such as contact details of port operators, port authorities, important data on infrastructure and superstructure for storage and handling facilities, as well as an overview of local logistics service providers.

The "Travel Time Calculator" offers the possibility to calculate a realistic travel time estimation between ports on the Rhine-Main-Danube axis. Finally, the "Transport Planner" is an interactive tool for planning transport between two ports along the Rhine-Main-Danube axis, including information on data on the selected ports, on the possible logistics providers and on the calculated travel time.

[103] Regulation (EU) 2022/868 of the European Parliament and of the Council of 30 May 2022 on European data governance and amending Regulation (EU) 2018/1724 (Data Governance Act).
[104] Regulation (EU) 2020/1056 of the European Parliament and of the Council of 15 July 2020 on electronic freight transport information.
[105] See : https://www.danube-logistics.info/.

Since 2010, it viadonau has also been carrying out focus initiatives in the field of transport development, that aim at evaluating the potential for transport by inland vessel for promising cargo types, discussing possible transport solutions and enabling cooperation between the stakeholders from the Danube logistics sector and the industry (cargo owner) sector. Within a two years' duration, these initiatives offer a neutral platform for knowledge and information exchange between the Danube logistics sector and the selected business branch. The great advantages are the national focus, namely the direct focus on the regional target group, and the thematic focus, based on regular market observations and in close cooperation with the Danube logistics sector. Although this might lead to a relatively small target group, in the course of the workshops a strong interaction between these target group is developed between the shipping sectors.

Thanks to such initiatives, new contacts were generated, cooperation between the participants was enhanced and new transport solutions were, in many instances, implemented in the mid-term. At the same time, findings and best practices resulting from national initiatives are also implemented in international workshops and events, such as the inland navigation conference "Danube Business Talks", which provides a platform to discuss pressing issues with representatives from the European Commission, national authorities, and other relevant decision-makers. This event format is very welcomed by the shipping sector, thus providing the opportunity to directly address the challenges and needs of the sector and help it grow and comply with European strategies (e.g., Greening inland navigation within the framework of the European Green Deal).

Overall, viadonau places great emphasis on the collection, preparation and sharing of expert knowledge relating to Danube navigation. With the publication of the Manual on Danube Navigation, it has made an important contribution to the dissemination of knowledge regarding inland navigation on the Danube.[106] The Manual offers a concise and easy-to-read overview on 45 control points at EU and Schengen borders in seven Danube riparian countries. It contains general information on control modalities in each country, including steps to be followed by captains and crew members, as well as the forms to be filled. Furthermore, locations of control points, contact details and opening hours of all involved control authorities are listed. Besides providing valuable information, the manual will serve as a basis for discussion between control authorities and is considered as a step towards harmonised and efficient control procedures. The manual's main objectives are the following: to ensure time-efficient controls for involved skippers and control authorities; to raise awareness on the steps skippers must undergo at control points; to reduce disadvantages caused by lack of information and facilitate market entry for newcomers; to provide a basis for harmonising control procedures along the whole Danube River.

Finally, viadonau has been involved in a lively exchange of information and knowledge with educational institutions for many years now. For instance, remarkable is the collaboration with the University for Applied Sciences - Logistikum Steyr in the context of the on-line platform REWWay[107], whose goal is to integrate inland navigation (with a focus on Danube navigation) into logistics education and training to raise acceptance of the Danube as environmentally friendly way of transport. In addition, viadonau is also active beyond the traditional educational methods, resorting to e-learning tools such as INeS Danube, an e-learning platform providing education on IWT and intermodality in the Danube region.[108]

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[106] See: https://www.viadonau.org/en/newsroom/publications/manual-on-danube-navigation/.
[107] See: https://www.rewway.at/en/.
[108] See : http://www.ines-danube.info/ilias.php?.

4.4 Conclusion

From the above, it follows that increasing the usage of all communication and marketing possibilities (including electronic communications) will enable IWT operators to influence other economic operators on the importance and advantages of IWT, namely reliability, economic efficiency, efficacy in the use of available infrastructure capacity and sustainability. These benefits should then become as obvious to users as the many (unfortunate, unfounded, and rather unrealistic) stereotypes associated with IWTs. In other words, electronic communications and marketing inform and demonstrate to the wider economic operators, the exceptional benefits of using inland waterways transport as permanent business option.

5. Conclusion and recommendations

In conclusion, it appears that IWT possesses both advantages and disadvantages in the face of new and growing markets. On the one hand, its large carrying capacity, the high energy efficiency performance and relatively low cost make it an attractive option for some specific markets. On the other, low reliability, high and low water events made more frequent by climate change, and a rapid adaptation to climate and air pollutant objectives by other transport modes (especially road) hinder IWT's development and modal shift. Indeed, IWT's modal share in European transport networks hovers around the 6% mark and has stagnated for the last few years, despite policymakers' best efforts at increasing it.

That being said, IWT's modal share has also not decreased during this period, which could be attributed to actions taken during this time. In the near future, some clear trends can be identified that could potentially trigger modal shift, if decisive and concrete action is taken urgently with the appropriate political support. The following recommendations attempt to capture the main levers that policymakers and industry representatives alike can pull to achieve the EGD's and SSMS' objectives. Although these solutions have been known for the past decade, they remain the most promising avenues to increase IWT's modal share in the coming years.

5.1 Capture new markets as a stimulus to modal shift and integrate IWT into urban logistics

Increased participation of IWT into urban logistics (deliveries, transhipment of urban waste) has a number of environmental and societal benefits, including, *inter alia*, reduced CO_2 emissions, accidents, road congestion and cost of transport. Regulators should strive to promote IWT development in urban environments to reap these benefits. This could be achieved through:

- Increased public procurement – especially for transport of building materials. IWT could be encouraged by integrating specific clauses in such government tenders relating to the construction of important public projects.
- Financial support from public authorities to support the experimentation of IWT in urban areas (for instance by supporting possible additional costs linked to the use of IWT compared to road transport). Indeed, while several pilot projects have emerged in the last years and some proved to be economically viable solutions, at least in very large cities, almost all projects in operation today received public subsidies. It will certainly be relevant to assess in a few years whether such public supported projects have been able to maintain a viable business case even without public support.
- More urban deliveries (pallets, food, beverages).
- Denser passenger transport on urban waterways.

However, increased loading capacity and construction of ever greater inland navigation vessels is inconsistent with the development of the IWT sector in urban environments due to the narrowness of urban waterways. Developing smaller builds adapted to urban operations and local conditions is key to gaining a solid foothold in this new and growing market and appears as a necessary step to be taken.
In addition, it will be important that regulators enable innovative solutions to be deployed (such as those relating to automation, for instance) in order to be competitive compared to other modes of transport. To address the issues related to the competition for space in cities (particularly with the housing market), it will be important for cities to anticipate the integration of transport logistics in cities, for instance in the context of the multiannual urban planning of relevant cities, and to 'reserve' some space for logistics activities. Regarding the transport of waste in urban settings, this issue is even greater given the specificity of this type of cargo.

5.2 No modal shift without the energy transition

The energy transition will make it imperative that the IWT sector becomes, as a transport mode, more sustainable and energy efficient. Indeed, the European Green Deal (EGD) called upon the EU Transport system to reduce its GHG emissions by at least 90% by 2050 compared to 1990, while also working towards a zero-pollution ambition. In this context, there is no doubt that all modes of transport shall realise their transition towards zero-emission and the road sector has already made significant leaps towards a zero-emissions future. The IWT sector must not fall behind if it wants to preserve and strengthen its position as a competitive, sustainable and environmentally friendly mode of transport. Greening the sector by integrating alternative energy carriers (such as biofuels, e-fuels, hydrogen and battery-electric) and more sustainable practices will be key to fostering modal shift in the medium to long term. However, this must be done while preserving the affordability and economic viability of the IWT sector as a transport mode able to adequately compete with road and rail.

The IWT sector could also benefit from contributing to the energy transition as a reliable and cost-effective transport mode for renewable energies and related components for the generation of alternative energies such as biofuels, wind turbines and hydrogen. Indeed, the energy transition will lead to new alternative fuels and energy sources (hydrogen, biofuels, CO2 …), which will need to be transported. Transport of new cargo flows however implies a change in the type of cargo transported, but in some instances also changes in the areas of operation and the type of vessels. Overall, capturing new markets requires an adaptation of the logistics chains which must be anticipated sufficiently in advance in order to be successful.

In order to stimulate opportunities linked to the transport of alternative fuels, the framework conditions should continue to be regularly adapted to enable inland waterway vessels to transport alternative fuels along European waterways.

In the same vein, CO2 capture and storage also contribute to fighting climate change. After capture, CO_2 must be directed to its place of storage or use. Given the volumes involved, the only possible large-scale solutions are to use pipelines or vessels (both maritime, SSS and inland). Over large distances, transporting CO_2 via IWT is attractive not only because it is already mature and technologically feasible, but also because it is cheaper than pipelines, more flexible, scalable, less sensitive to fluctuations in capture profile than piping, and does not require fixed infrastructure.[109] However, transporting gases requires constant research into its reliability and possible risks, as it can corrode the inside of tanker vessels.[110] That being said, transporting CO_2 in gaseous form towards its injection site could become a new market for inland navigation and could be considered as an additional catalyst for modal shift to inland waterways if it is supported by outstanding feasibility studies and pilot projects along the main IWW axes to test the commercial reliability of CO_2 transport.

5.3 Continue funding pilot projects

To achieve the ambitious goals outlined above, continued financial support must be provided to fund studies and pilot projects testing the impact and economic viability of transport, technological and logistic innovations. In general, supporting pilot projects is in fact paramount. For example, before choosing to operate modal shift to IWT, many shippers first check if IWT fits their shipping needs in an affordable way. In the case of CO2 transport, significant experimentation and studies would have to be performed at scale prior to its full implementation to determine its feasibility in real conditions. Similarly, testing trials will have to be organized to ascertain the viability and reliability of inland navigation vessels for the transport of new cargo. With regards to the energy transition, pilot projects are also essential to

[109] CCUS Project Network, "CO_2 ship transport: Benefits for early movers and aspects to consider", December 2021, https://www.ccusnetwork.eu/sites/default/files/TG3_Briefing-CO2-ship-transport-Benefits-for-early-movers-and-aspects-to-consider.pdf.
[110] Club CO_2, "Transporter le CO_2", 2022, https://www.club-co2.fr/fr/content/transporter-le-co2.

gain knowledge of new technologies, identify and address economic, financial, technical and regulatory obstacles to their deployment.

5.4 Improve seaport operations and interconnections to global trade

In order to stimulate modal shift to IWT, improving the handling of inland waterway cargo in seaports and the performance of the container logistics chain overall must also be addressed.

Many seaports' strategy to maximise volume and traffic led to an increasing number of megaships which have a disrupting effect on the overall quality of the local port operations as they have priority. Thus, many European seaports suffer from congestion which affects the reliability of seaport-hinterland transport via IWT operations and therefore negatively impacts their image.

Inefficient slot management also creates bottlenecks and delays, with negative consequences in terms of predictability and costs for IWT. This situation could be improved by mainstreaming slot times across seaports. A slot time provides each involved actor with the opportunity to plan ahead and coordinate their activities towards achieving the common goal of a predictable and timely delivery. At the same time, supply chain visibility is being improved, particularly thanks to digitalisation and improved information sharing. Consultation platforms are also in place at the level of seaports to enable discussions between all actors along the container supply chain to find solutions which are suitable to all actors. The purpose of such a platform would be to enable all affected actors to share a common situational awareness which is particularly important when plans and forecasts begin to change.

Overall, it would be necessary to achieve a higher degree of predictability for arrival and departure times, for example via the use of interconnected digital platforms and standardized data exchange between all actors involved. Cooperation and exchange of information between the different actors in the transport chains must continue and be improved. This is particularly relevant when contractual agreements are being arranged. When it comes to demurrage and detention for instance, establishing appropriate parameters with the deep-sea shipping company could reduce time pressure on the delivery and collection of containers.

Finding the right equilibrium certainly requires shared efforts on the side of all actors involved in the supply chain and at institutional level: port authorities (maritime and inland), Member States, EU, local/regional authorities, maritime shipping companies, inland waterway companies, shippers/forwarders, and terminal operators must all contribute to this shared goal.

In addition, to better connect inland flows and global trade, IWT should take advantage of new trading routes – Short Sea Shipping (SSS), intra-European trade, Artic routes – and market itself as an attractive modal option that must not be discarded. To do so, awareness-building activities targeting shippers should be pursued.

5.5 Better adapt IWT to low water events

As a result of rapid climate change, the probability that Europe will face longer and more severe droughts will increase in the coming decades. This will likely raise the frequency and severity of low water events along European waterways. IWT therefore needs to be better adapted to low water events to avoid efficiency losses and blows to its reputation and reliability which could cause reverse modal shift.

To do so, several actors will have to work together. Manufacturers will develop modern newbuilds optimized to reduce draught as much as possible. Vessel owners will have to adapt and refit their vessels,

while infrastructure managers will add the necessary upgrades to existing infrastructure[111], and take low waters into consideration for future infrastructure development projects. Shippers and operators will have to adapt their logistical organisation to face these low water events. Finally, public authorities will provide important subsidies to coordinate and support these endeavours in an organic manner.
As identified in the "Act Now!" for low waters report in the case of the Rhine, there is no one-size-fits-all solution to face this challenge.[112] Yet, a few key general recommendations can be made:

- Improve water management along European waterways;
- Improve the accuracy, speed and availability of low water forecasts, including via digital tools, to provide up-to-the-minute depth information to boatmasters and shippers;
- Adapt transport concepts and logistical chains to take increase probability of low water scenarios into account, including, but not limited to, the use of smaller vessels in platoons or coupled formations;
- Expand the handling and storage capacity of ports next to industrial sites;
- Reduce administrative costs and red tape related to lengthy authorisation procedures;
- Foster dialogue between regulators, industry, logistics providers and environmental associations.

5.6 Bring more awareness to the advantages of IWT as an alternative mode of transport

Another obstacle facing IWT relates to a preference for road transport in the past decades. Compared to IWT, road is perceived as more flexible and is more familiar to the operators, even if it might not be the most environmentally friendly modal choice. This issue was also identified as an obstacle in the other pillars. Road culture in logistics and lack of knowledge about IWT therefore act as barriers to modal shift to inland waterways.

The interviews with logistical players active in the wind turbine market showed this phenomenon quite clearly. It is indeed very difficult to overcome this obstacle, as it often concerns a lack of information about IWT on behalf of logistical companies. Therefore, increased communication and marketing activities are needed to remedy this problem (see the communication modus operandi under section 4.1).

IWT would also strongly benefit from a centralised and up-to-date webpage containing all of the relevant and available funding opportunities at European, national, regional and local levels. A similar webpage for all relevant IWT regulations would also be desirable. Finally, policymakers should facilitate the setting up of national aid schemes for spurring modal shift, in line with the EU exemption regulation.

Finally, IWT's fundamental and intrinsic advantage is its excellent energy efficiency, which is a key asset in view of a possible shortage of green energy sources. This element can be marketed much more prominently to spur modal shift.

[111] The Good Navigation Status (GNS) regulation enjoins that at least 2.5 meters of fairway depth must be provided within major European waterways. Furthermore, the AGN international agreement includes similar provisions.
[112] CCNR, "Act now! on low water and effects on Rhine navigation", Reflection paper, ed. 2.0, February 2021, ien20_06en.pdf (ccr-zkr.org).

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Annex 1: List of additional relevant projects

Projects/ best practices	AEB Netherlands webpage: https://www.aebamsterdam.com/mission-and-ambition/	The Netherlands
	Amsterdam Vaart!: https://www.portofamsterdam.com/en/business/cargo-flows/local-construction-logistics-water	The Netherlands
	BEE: https://www.bee.eu/en/projects/warmte-centrale-gent	The Netherlands
	Beerboat: http://www.bestfact.net/wp-content/uploads/2016/01/CL1_151_QuickInfo_ZeroEmissionBoat-16Dec2015.pdf	The Netherlands
	Bioboot: https://goedinge.be/bioboot.html	The Netherlands
	Bioenergy Netherlands: https://bioenergynetherlands.nl/de/	The Netherlands
	DeWaterbus: https://www.dewaterbus.be/	Belgium
	Franprix: https://scot.metropolegrandparis.fr/wp-content/uploads/2018/12/MGP_Labo_SCOT_fiche-HAROPA_logistiqueurbaine_181206.pdf	France
	Holland's Glorie: https://www.dhl.de/de/geschaeftskunden/express/infos-knowhow/newsletter/092017/schwimmend-letzte-meile.html	The Netherlands
	Le Waterbus: https://www.waterbus.eu/fr/index.php	Belgium
	Roboat: Interview with Roboat project manager Ynse Deinema	The Netherlands
	Smartship: https://smartship-eu.com/	EU
	SUEZ Group: https://www.suez.com/en/suez-in-nederland/beheer-van-gevaarlijk-afval	The Netherlands
	ULS: https://www.ortl-grandest.fr/nouveau-service-logistique-urbaine-fluviale-strasbourg/	France
	Waterbus: https://www.waterbus.nl	The Netherlands

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