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Thematic Report. An Assessment of new markt opportunities for inland waterway transport. February 2022

THEMATIC REPORT

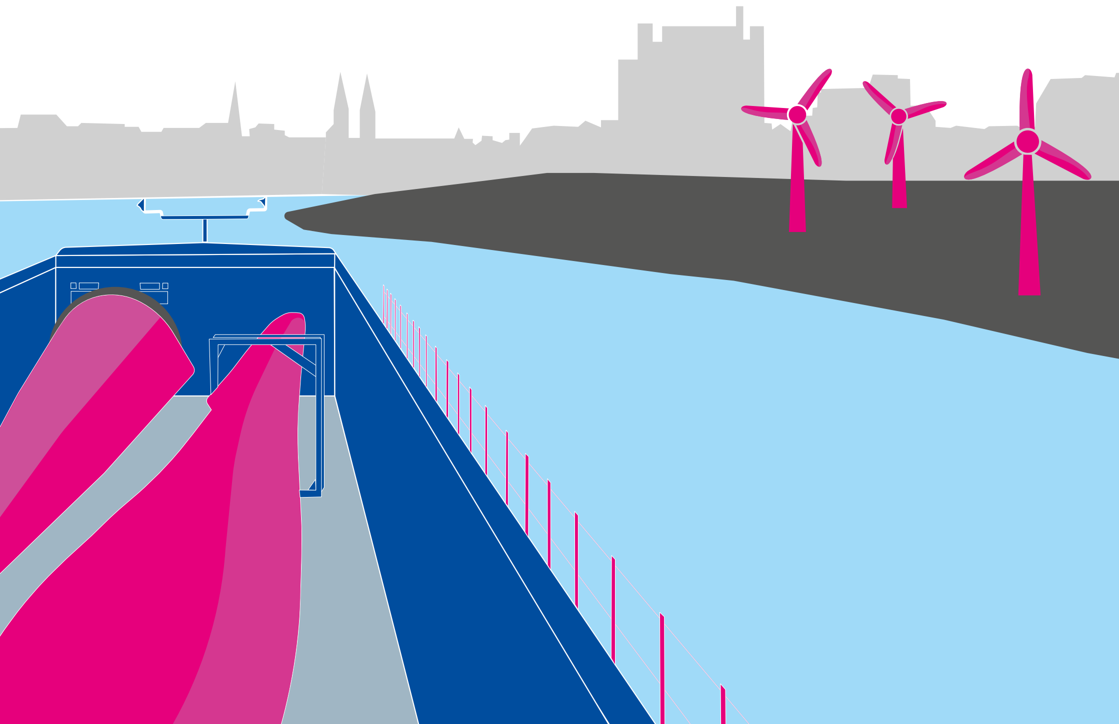
AN ASSESSMENT OF NEW MARKET OPPORTUNITIES FOR INLAND WATERWAY TRANSPORT

PUBLISHED IN

FEBRUARY 2022

European Commission

CCNR
CENTRAL COMMISSION
FOR THE NAVIGATION OF THE RHINE



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www.inland-navigation-market.org

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EXECUTIVE SUMMARY

New markets in inland navigation become essential in the framework of a transition towards a more sustainable transport sector and a climate neutral Europe. Inland navigation in the 21st century also faces several bottlenecks, including those that are structural, both on the demand and supply sides.

On the demand side, the outlook for several goods segments points to saturation or even decline (e.g. coal). A likely structural slowdown in world trade is another important challenge for inland waterway transport. While the energy transition changes the product portfolio of inland navigation, it is also expected to lead to the emergence of new markets, to which the inland navigation sector will need to adapt in order to gain market shares.

On the supply side, inland vessels will be confronted more and more with difficult navigation conditions on free-flowing rivers such as the Rhine, Danube, Elbe, and others. The underlying reason is low water periods which are expected to intensify with the ongoing climate change. The low water phenomenon and its related negative effects (loss of transport volume and of modal shares for inland waterway transport) calls for a diversification of the areas of operation of inland vessels, towards a higher participation in city or urban logistics, for instance, where water levels are less critical.

For these reasons, it is important to identify and anticipate the emergence of new markets in inland waterway transport (IWT). New markets can determine new types of products transported by inland vessels, but they often imply new types of logistics, new types of vessels and new areas of operation.

For example, one important new market, urban inland waterway transport, does not only imply a change in the type of cargo transported (e.g. parcels instead of mass cargo), but also a change in the areas of operation (city logistics instead of transport crossing borders), a different range of logistics (short-distance instead of long-distance transport), and different types of vessels (smaller vessels instead of large vessels).

Based on statistical data, literature research and expert interviews, the following new markets for IWT have been identified:

1) Urban passenger transport by inland vessels in the form of public local transport (examples are found in Antwerp, Brussels and Rotterdam).

2) Urban freight transport by inland vessels (construction material, food products, parcels, etc.) in large cities such as Amsterdam, London, Paris, Lyon.

3) New cargo flows stimulated by circular economy strategies (e.g. waste transport).

4) Transport of renewable energies or components for their generation (biomass, biofuel, hydrogen, wind turbines).

The detailed analysis of these topics reveals one common feature: new markets for IWT exist, and with high potentials. However, these markets are not yet sufficiently developed to gain easy access to the inland navigation sector. They are fraught with intermodal competition, commercial, logistical and technological challenges, risks and uncertainties to varying degrees.

The urban transport of freight, passengers and waste is an activity where inland navigation meets the need of society and governments to find solutions for existing and growing urban problems, in terms of saturation of road infrastructure, related negative externalities, and ecological problems in cities.

Similarly, the transport of alternative energies meets the need of our society to transform the energy sector from a fossil to a non-fossil form of energy generation. It is found that this new market, despite having certain potentials, is strongly dependent upon political and regulatory activities. Together with the partly unknown technological and economic trajectories of different renewable energies, these features represent certain risks for the development of this sector as a new market for IWT.

However, urban waterway logistics also face hurdles and risks. One significant hurdle is the competition for space in urban areas between the transport or logistics sector on the one hand, and the important housing and tourism sectors, on the other hand.

All in all, many transformations need to be accomplished to extend the cargo portfolio of inland navigation. The report sheds light on these necessary transformations and challenges and describes key projects in different new markets and in different cities, countries and regions, where these transformation processes are already underway and where first success stories can be told.

01

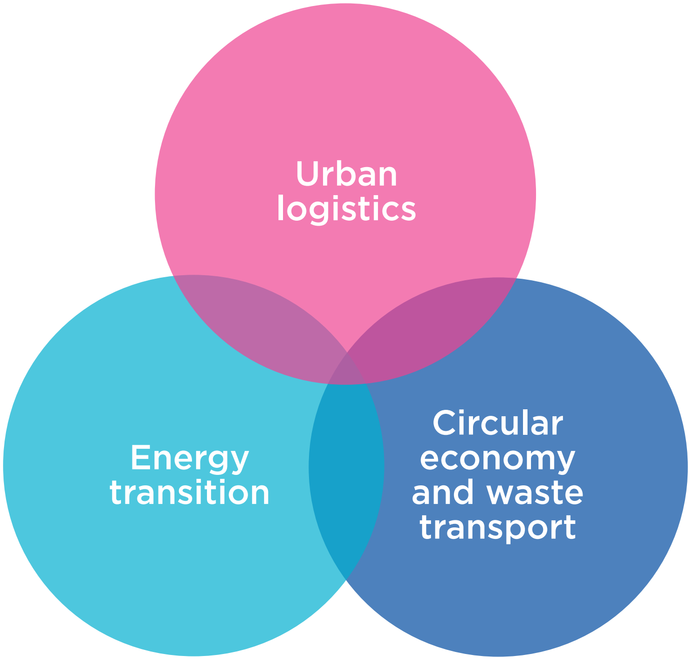
SETTING THE SCENE - WHAT IS THE SITUATION TODAY?

Inland navigation is today at a crossroads, facing several influencing factors. These embrace water levels and hydraulicity issues, difficult macroeconomic conditions, i.e. slowdown in world trade, evolving sectoral, industrial and economic trends, the structural decline of carbon-related cargo and - most recently - the Covid-19 crisis. It is therefore essential to think about the development of new markets for inland waterway transport (IWT). This report will shed light on these opportunities, and on the drivers and barriers related to them.

A new market can be described as a branch where inland navigation is either not yet present or in an early stage of development and could be considered in the coming years as a suitable transport solution. However, existing markets also see innovative changes and are showing growth potential, for instance in light of energy transition and the sustainability pressure.

To develop this report, qualitative and quantitative research was carried out. Within the more quantitative part, desk research was used to analyse new markets for IWT that show growth potentials. This part entailed also the analysis of statistical data on the development of these new markets. Within the more qualitative part, interviews with relevant experts and actors from different sectors (logistics in general, IWT, ports, science and universities) were carried out, in order to gain further insight into the suitability of these new markets for IWT. This approach has led to the identification of three main pillars for IWT development.

These include urban logistics, new cargo flows triggered by energy transition (transport of alternative energies, e.g. biomass and biofuel, hydrogen, components such as wind turbines) as well as the circular economy and transport of waste. These three fields are interrelated and partly overlap. An example would be the transport of household waste in an urban agglomeration which would then be recycled to serve as a new energy which would again be transported on an inland vessel. This case would apply to all the three fields simultaneously.



Those three pillars show promising potential for IWT development. Another market that could be a growing segment in IWT in the future is the short distance container transport.[1]

For each of the three pillars, the report will present real-world examples or projects where inland waterway transport is already involved. In addition to that, some interesting research or pilot projects that test the integration of IWT in innovative urban waterway transport will be presented. It is worth noting that the projects presented in this report should not be considered as an exhaustive list. A more detailed annex with additional relevant projects is also available. The report will also highlight the barriers and drivers for the development of new markets in IWT.

[1] *This type of container transport will however not be analysed within this report. For further information, see Bart Wiegmans and Rob Konings. 2016. Inland Waterway Transport. Challenges and Prospects.*

EXISTING MARKETS FOR INLAND WATERWAY TRANSPORT - STATE OF PLAY[2]

Before embarking on an analysis of these identified pillars and related new markets, it is necessary to summarise the current state of the most relevant markets for IWT to understand where or where not to expect more growth. This endeavour will help to understand the need for new markets. The three main cargo segments in IWT embrace dry cargo, liquid cargo as well as container transport. In its present structure, IWT rather relies on traditional market segments. The future trend developments differ within the three main categories. Passenger transport (ferry transport, other public waterway transport, day trips, river cruises) is also an important component of IWT transport which, while having suffered greatly from the Covid-19 crisis, has seen positive demand trends in the past decades.

Overall, it is seen that the energy transition will have an important effect on freight volumes in inland navigation. This concerns 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, but a gradual decline is underway. For chemicals, the outlook is far more positive. Regarding foodstuffs, it is expected that a certain reduction of emission intensive livestock activities, combined with a change in consumer habits, will influence the transport of feedstuff. The more trade-related cargo segments (in particular container transport) will be influenced by structural slowdowns in world trade. A more detailed analysis per market segment is provided in this chapter.

[2] *State of play is based on Inland navigation in European market observation reports (CCNR, European Commission), available at: https://inland-navigation-market.org/?lang=en*

DRY CARGO

The dry cargo segment accounts for 59.8% of IWT volume in EU-27 in 2020 and can be further sub-categorised into five segments:

i. Agricultural products

Agricultural and food products currently have a share of around 9% of goods transport on the Rhine and around 16% of goods transport on the Danube. Agricultural products show strong correlation with harvest results, a correlation that dominates the volumes transported each year. Bad harvest results lead to a decrease in volumes transported, good harvest results increase transport volumes. IWT seems to be a preferred mode of transport for long-distance transport of agricultural goods.

ii. Feedstuff and food products

In western Europe, densely populated areas such as the Netherlands and Belgium are experiencing problems with high nitrogen emissions, due to intensive livestock activities. Political pressure to reduce these emisisons could lead to a reduction of these activities in western Europe. Additional influencing factors for this trend stem from a change in consumer habits towards less meat consumption. In the case of a reduction of livestock activities in western Europe, a shift of these activities to other parts of Europe (eastern Europe) or to overseas countries (South America) is likely.

In both cases, food products such as meat would then need to be imported, which would create transport activities. The case whereby these products are transported by inland vessels, however, is not very likely. The feedstuff needed for feeding cattle (livestock activities) would no longer be transported in the same volumes in western Europe, which would reduce transport demand, also on inland waterways. Therefore, the current trends in this sector point to a reduction of feedstuff transport in the future in western Europe.

A completely different market is the transport of food products in cities, which is beginning to develop, and which will be dealt with in this report as a new market in IWT, and illustrated by some successful projects (e.g. in Paris and Ghent).

iii. Iron ore, steel and metals

Iron ore, steel and metals represent an important segment for inland navigation. For the Rhine their share accounts to 25% of total goods transported and for the Danube, the share reaches even around half of total goods transported.

For western Europe, the transport demand outlook for iron ore is not growth orientated, 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, as steel production reaction is very sensitive to these factors. This was once again shown during the Covid-19 crisis.

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.[3]

[3] *See also: CCNR/EC (2020), Inland Navigation in Europe – Market Observation, Annual Report 2020, chapter 8, pp. 149-152*

iv. Sand, stones, gravel and building materials

A main positive trend is captured in the segment of sands, stones, gravel and building materials, possibly more pronounced in western Europe than in eastern Europe. This consists in a growing activity in the housing market, in parallel with demographic growth. The last-mentioned factor divides western Europe, where demographic projections are positive (in particular in France, the Netherlands and Belgium) from eastern Europe, where they are more orientated towards stagnation or even a decrease.

For western Europe, a concentration on larger waterways (consolidation process) is likely to take place, in parallel with a concentration on larger production sites within the construction sector itself. In the coming years, in western Europe, large volumes of sand and gravel are expected to come on the market as a result of dredging and the great need of materials for dike reinforcement. Untapped potentials lie in the urban inland waterway transport and transport of construction materials to construction sites. This urban transport of building materials is one example of a new market in IWT. Therefore, this market segment comprises both traditional long-distance transport as well as new urban short-distance transport.

v. Coal

Coal faces an almost complete phase-out in western Europe, as far as steam coal (hard coal used in the energy sector) is concerned. The reason is the energy transition in the major IWT countries in western Europe. Indeed, among other measures, with the exit from coal, governments aim to reach the goals of the Paris Agreement of the United Nations, adopted by 196 parties on 12 December 2015 and which entered into force on 4 November 2016.[4]

[4] This Agreement aims to defend the planet against climate change, for example by "holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels […]". Source: Article 2 of the Paris Agreement of the United Nations, https://unfccc.int/sites/default/files/english_paris_agreement.pdf (last accessed on 24.8.2021).

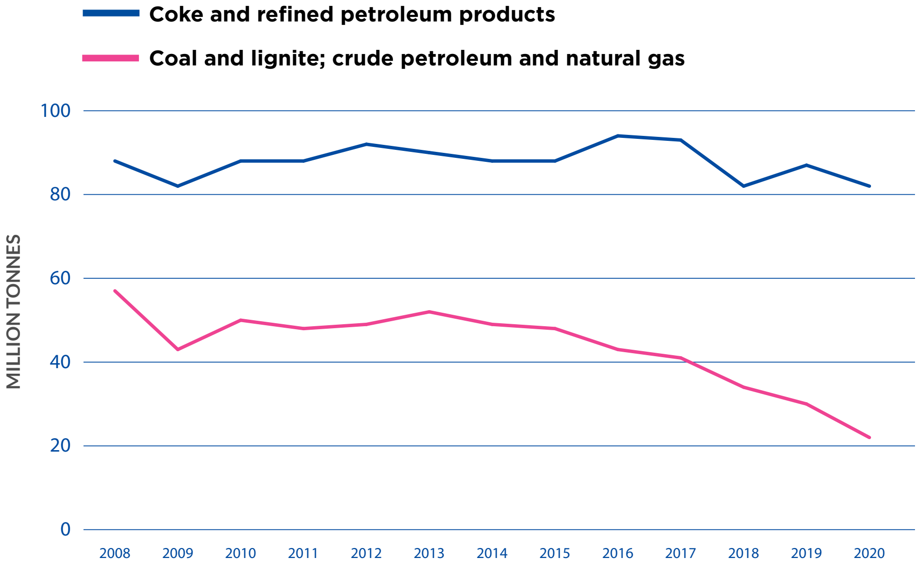
In Germany, for instance, the government decided on a gradual exit from hard coal until 2035 and lignite until 2038.[5] For coal transport in IWT, only hard coal is relevant as lignite is not transported on inland waterways.

Figure 1 shows the decrease in coal transport in the EU-27 that started in 2015. Around 90% of the series 'Coal and lignite, crude petroleum and natural gas' concerns hard coal, as neither lignite, nor crude petroleum or natural gas are transported on inland waterways in large quantities. And within this amount of hard coal barge transport in the EU (27.4 million tonnes in 2019), 84.8% was transported on German inland waterways (23.3 million tonnes). One could also mention that coal transport by inland vessel is even higher in the Netherlands (25.3 million tonnes in 2019) than in Germany, but these similarly high numbers reflect the fact that coal is transported from the Amsterdam-Rotterdam-Antwerp (ARA) seaports in the Netherlands to Germany, for providing coal fired power plants and the steel industry with raw materials.

The amount of 27.4 million tonnes of hard coal barge transport in the EU does not contain coking coal or coke (2.5 million tonnes in 2019). The entire coal volume on EU inland waterways is therefore around 30 million tonnes per year. The coal transport by inland vessels in Germany represents around 84% of total coal transport by inland vessels in the EU.

[5] *See: Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit, Fragen und Antworten zum Kohleausstieg in Deutschland, https://www.bmu.de/themen/klimaschutz-anpassung/klimaschutz/nationale-klimapolitik/fragen-und-antworten-zum-kohleausstieg-in-deutschland (last accessed on 24.8.2021)*

FIG. 1: **TRANSPORT OF FOSSIL FUELS BY IWW* IN THE EU 27 BETWEEN 2008-2020** (MILLION TONNES)

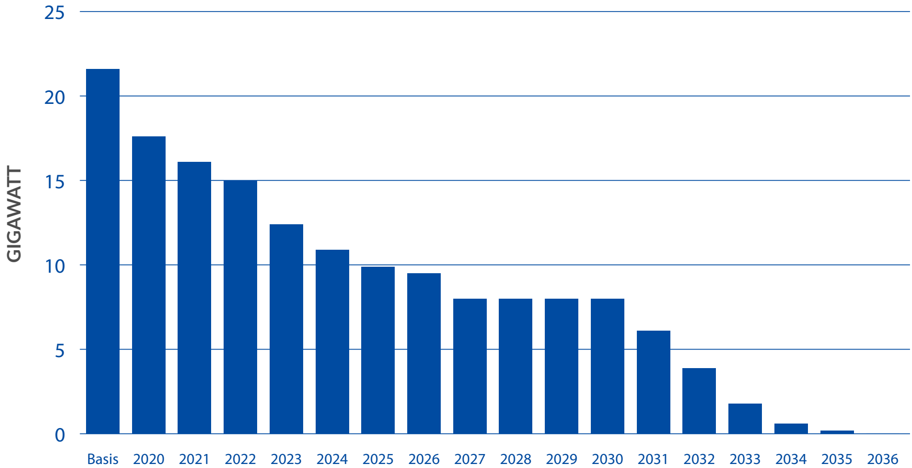


Source: Eurostat [iww_go_atygo]
** IWW: Inland Waterways*

However, hard coal is at the beginning of a phasing-out process in the energy sector in Germany. Figure 2 shows the planned reduction of power plant capacities for hard coal (in GigaWatt) in Germany. The first power plants were taken off the grid in 2020, and already by the end of 2024, the original power plant capacities will have been halved. Based on this series, a complete phase-out of steam coal transport on German inland waterways can be expected by 2036.

Steam coal is the type of coal used in the energy sector, while coking coal or coke is the type of coal used in the steel industry. Based on the Eurostat data, the large majority of hard coal transport in the EU would be steam coal (27.4 million tonnes), and only a small fraction would be coking coal (2.5 million tonnes). However, evidence about the use of coal in Germany points to a much higher share of coal used for steel manufacturing (according to coal import statistics, coal used for steel production accounts for at least 50% in Germany). The classification within the Eurostat NST 2007 system might not reflect this pattern entirely.

FIG. 2: **REDUCTION OF POWER PLANT CAPACITIES FOR HARD COAL IN GERMANY** (GIGAWATT)



Source: Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit

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 the energy transition developments in the near future.

The series 'Coke and refined petroleum products' will be discussed in the next part on liquid cargo. It has to be clarified that this NST 2007 group contains mainly refined petroleum products (share of 97%), while coking coal is represented only marginally in this series with 3%.

vi. Liquid cargo (chemicals and petroleum products)

Volumes of liquid cargo account for 28.1% of the IWW transport volume in EU-27. A main distinction must be made between chemicals and refined petroleum products. On the Rhine, the share of petroleum products is very high with 17.3% of total cargo transport in 2020, and 27.6 million tonnes in absolute numbers, forming the largest cargo segment on this most important inland waterway in Europe. Petroleum products are also very important for IWT volumes in Belgium and the Netherlands.

Although petroleum products such as gasoil/diesel, gasoline and kerosine are still expected to be part of a propulsion mix in the next decade, there are no growth prospects, and a gradual decline is assumed, possibly reaching near zero by 2050. Indeed, the long-term vision of 'a zero GHG emissions inland navigation sector by 2050' is a shared political goal at various levels.[6] Electrification of the transport sector, which makes petroleum products gradually redundant, acts as another influencing factor that puts pressure on liquid cargo volumes in IWT.

For 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.

Petroleum products have lost some transport performance in recent years (mainly due to low waters and the Covid-19 crisis), but there was no real downward trend so far in this segment (see figure 1, series 'Coke and refined petroleum products'). However, a significant drop in this segment would prevail in the case of a major electrification of road transport. The reason is that liquid fossil fuels used in the road transport sector, together with heating oil, form the backbone of the petroleum products transport in IWT.

[6] *CCNR Mannheim Declaration (2018), European Green Deal (2019), NAIADES III Action Plan (2021)*

Electrification of the European transport sector is still in an early phase, allowing the IWT sector to adapt and explore new market opportunities. For instance, in 2019, the share of electric cars within the total number of new registered cars was 1.6% in Germany, 1.0% in France, 0.8% in Belgium, 11.4% in the Netherlands and 2.1% in Switzerland.[7] For Germany, national figures for 2020 (for other countries, Eurostat figures were not yet available for 2020) point to a strong increase of this share up to 6.6%.[8]

According to these national data, a major absolute increase of newly registered electric cars can be observed in Germany in 2020 (194,163 units) representing a major uptake compared to 2019 (63,281 units). However, this number is very low compared to the stock of cars (47.716 million units in 2020) in this country, of which the vast majority is still propelled by liquid fossil fuels.

Also in Europe overall, new registrations of electric cars have shown strong increases both in absolute and relative terms. According to the European Alternative Fuels Observatory (EAFO), new registrations of electric cars in 2021 amounted to 16% of all newly registered cars, whereas the value for 2020 was far below at only 10.5% and 3.0% in 2019.[9]

Altogether, the very recent uptake in electric cars registration can explain why liquid petroleum products has not experienced any clear structural downward trend within inland waterway transport to date. However, electrification of the transport sector is currently gaining momentum, also underlined by a further rise in the share of new electric cars in the first seven months of 2021 (reaching 10.7% of all new registered cars) in Germany.[10] The trend in Germany is of high relevance, as the Rhine market represents – together with the ARA region market - the core region of the liquid cargo transport in Europe.

[7] *Source: CCNR calculation based on Eurostat data (series 'New registrations of passenger cars by type of motor energy' [ROAD_EQR_CARPDA]). A frontrunner in Europe is Norway with a share of 21% in 2019.*
[8] *Source: CCNR calculation based on data from Kraftfahrtbundesamt (https://www.kba.de/SharedDocs/Publikationen/DE/Statistik/Fahrzeuge/FZ/2020/fz14_2020.pdf?__blob=publicationFile&v=3)*
[9] *European Alternative Fuel Observatory (EAFO) website. Available at: https://www.eafo.eu/vehicles-and-fleet/m1 (last consulted on 24.11.2021)*
[10] *Source: Kraftfahrtbundesamt, CCNR calculation. Data source: https://www.kba.de/SharedDocs/Publikationen/DE/Statistik/Fahrzeuge/FZ/2021_monatlich/FZ8/fz8_202107.pdf?__blob=publicationFile&v=4*

vii. Container

Container transport accounts for 12.1% of IWW transport volumes in the EU-27. Already before the Covid pandemic in 2020, the world trade of 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:[11]

1) Shift of consumer demand away from tradeable goods to services in developed countries (dematerialisation).

2) 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.

3) Technical innovations such as 3-D printers reducing trade in goods further.

Further reasons taken from van Dorsser et al (2018)[12] for the structural change in container throughput are:

4) Declining population growth in Western Europe.

5) The fraction Labour/Population, i.e. the share of population contributing to economic output is decreasing, not only due to ageing populations but also due to the retirement of the baby boom generation. In addition to that, job losses linked to artificial intelligence put approximately 40-50% of jobs at risk.

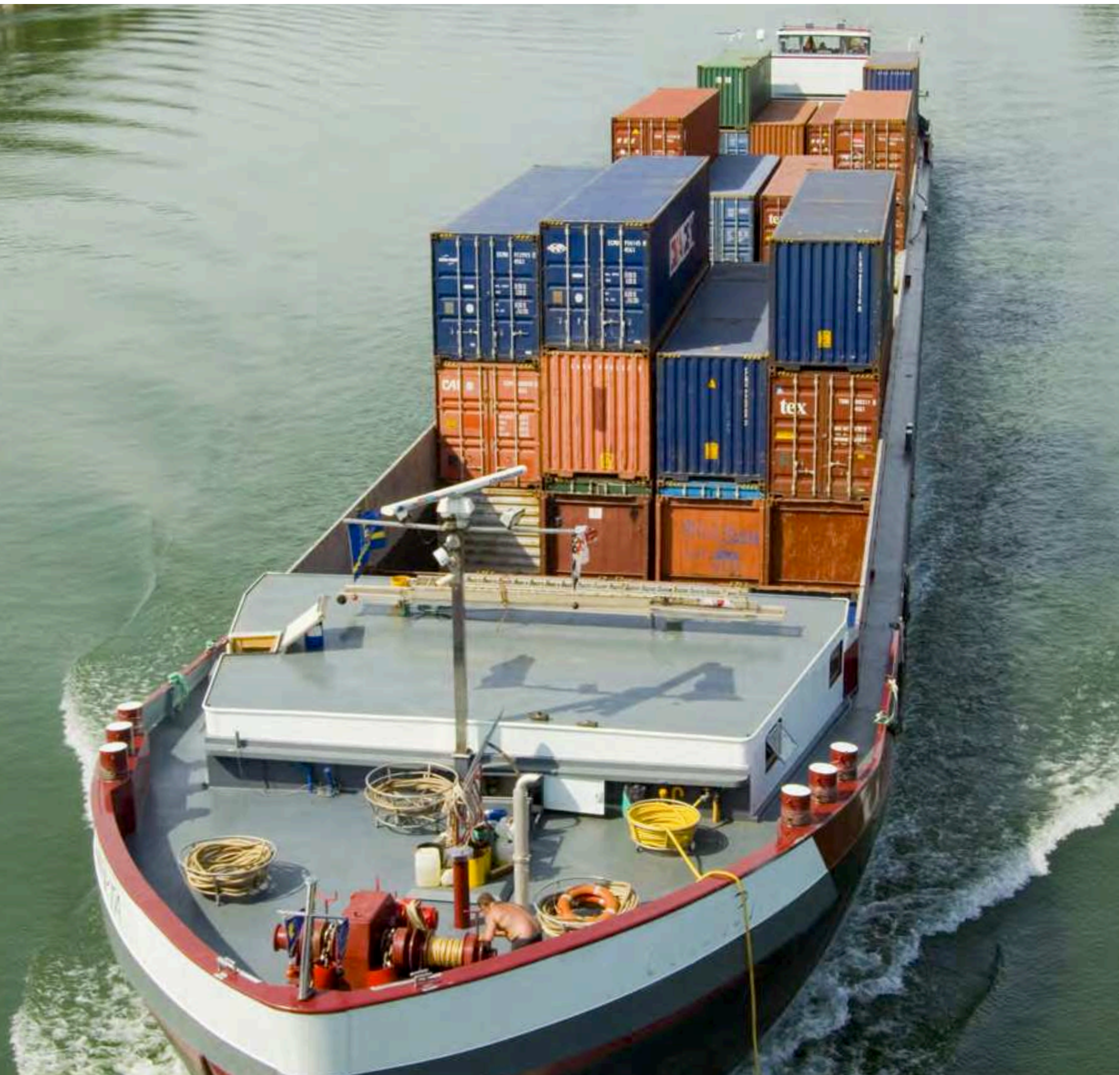
6) The growth rate of the fraction GDP/Labour decreases, which reflects a decreasing productivity growth, resulting from lower economies of scale in innovations. This trend affects technology frontier countries.

7) Reverse globalisation (decreasing ratio Trade/GDP), i.e. a higher focus on local production.

8) Containerisation coming to its saturation limits.

[11] *See the article 'Die Zukunft des globalen Handels' ('The future of global trade'), in: Schlaglichter der Wirtschaftspolitik, Monatsbericht 01/2021, (https://www.bmwi.de/Redaktion/DE/Schlaglichter-der-Wirtschaftspolitik/2021/01/kapitel-1-7-die-zukunft-des-globalen-handels.html), last consulted on 24.8.2021*
[12] *Cornelis van Dorsser et al. 2018. Port Metatrends. Impact on long term trends on business activities, spatial use and maritime infrastructure requirements in the Port of Rotterdam.*

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. Furthermore, these trends would affect seaport hinterland container transport on inland waterways. This is because inland waterway container transport is strongly linked to maritime container transport. However, if container transport would be able to integrate more in regional and urban logistics chains, and if it would be possible to build up short-distance container transport, it would keep a higher growth rate overall.



PASSENGER TRANSPORT

Passenger transport demand can be split into touristic activities and public transport activities. The latter also includes the traditional ferries, crossing waterways transversely in the form of floating bridges. This characteristic plays a crucial role in urban mobility. During the pandemic, the touristic passenger transport came to a complete halt. The relaxation of sanitary measures is expected to lead to a slow recovery in this market. It might take some years before the demand reaches its pre-crisis level.

Passenger transport in the form of public transport services, including ferries, on urban waterways can be considered as an important tool for making cities greener and more sustainable. The fact that urban passenger transport on waterways can be carried out by electric propulsion, given the limited distances in cities, is one major reason for its potential for making cities more environmentally friendly. At the same time, waterway transport reduces the overutilisation of roads and related negative effects (accidents, traffic jams in cities). Passenger transport in cities in the form of public transportation systems has huge potential, as the example of the waterbus in Brussels shows. The present report will focus only on public passenger transport in cities, not on touristic transport.

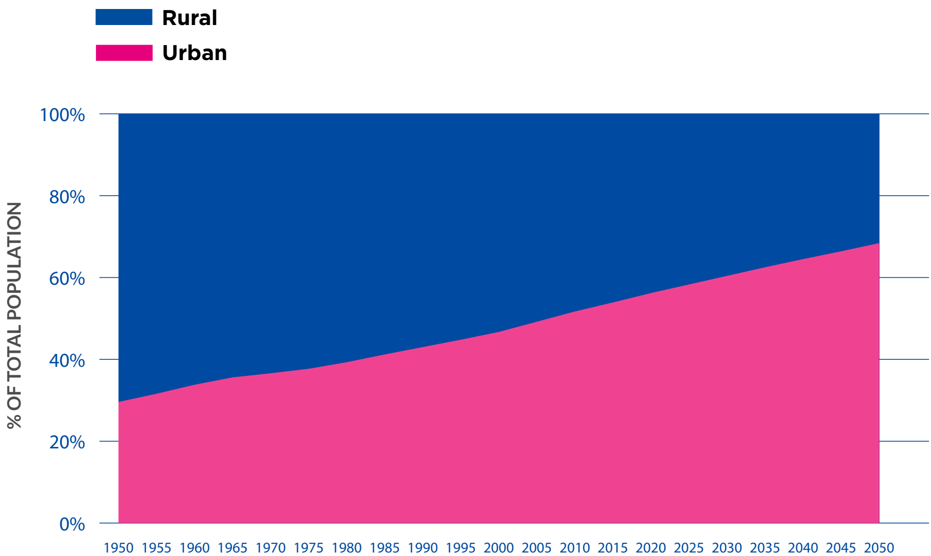
UNTAPPED POTENTIAL FOR INLAND WATERWAY TRANSPORT – MAIN DRIVERS

The following chapter will analyse the main trends that are expected to act as driving forces for urban mobility. As will be seen, the characteristics of inland navigation make it suitable as an alternative transport solution in urban areas in light of the current challenges that urban environments are facing. New markets in inland navigation can therefore emerge in light of climate policies favouring the decarbonisation of societies and insisting on more sustainable, resilient and future proof transport modes. IWT could therefore play a crucial role for making societies, in particular cities, more sustainable from an environmental and social point of view, resulting in new market opportunities. The social point of view refers to a reduction of accidents and noise by a modal shift from road to IWT, and a reduction of related negative externalities.

SATURATION OF EXISTING TRANSPORT INFRASTRUCTURE IN CITIES

Nowadays, large agglomerations are facing important challenges at the demographic, economic and environmental levels. Currently, more than half of the world population lives in urban areas and this share will increase further in the future (see figure 3). The World Urbanisation Prospects of the United Nations Department of Economic and Social Affairs projects that this percentage will increase to 68% by 2050. In the EU, urbanisation rates are among the highest in the world. Around 74% of the EU population already lives in urban areas. The share of urban population reaches for instance 98% in Belgium and 91% in the Netherlands, both countries being important for European IWT. Other relevant IWT countries such as France, Germany and Romania are projected to see a steady decrease in their rural population by 2050.

FIG. 3: **SHARE OF URBAN AND RURAL POPULATIONS IN EUROPE BETWEEN 1950 AND 2050** (% OF TOTAL POPULATION)



Source: World urbanisation prospects – United Nations, Department of Economic and Social Affairs, Population Division (2018)

The demand for goods, of which cities are net importers, rises with the size of urban population. 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. Traffic congestion in cities is the cause of substantial economic loss, estimated to account for 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.[13] According to the Staff Working Document of the Smart and Sustainable Mobility Strategy, "[t]he delay cost gives a value of the travel time lost relative to a free-flow situation. The deadweight loss costs is the part of the delay costs which is regarded as a proper basis for transport pricing."

Current transport systems are mainly based on fossil fuels and are therefore not sustainable in the long run, given the related negative

[13] *European Commission, Smart and Sustainable Mobility Strategy, Staff Working Document, 2020, available at: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12438-Sustainable-and-Smart-Mobility-Strategy_en (last consulted on 24.11.2021)*

externalities, scarcity of resources and energy dependence of the EU.[14] Road transport is by far the dominant mode of transport and represents 76.3% of total inland freight transport (excluding pipelines) in the European Union, compared to 17.6% for rail transport and 6.1% for inland waterway transport. In some countries, IWT has a higher modal share than rail transport, such as in the Netherlands and in Belgium.

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 the fragmentation of deliveries, leading to 23% of vehicles on the road travelling unloaded, according to a case study conducted in Austria.[15] 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.[16] Innovative solutions for urban freight delivery are called for to avoid the negative impacts that this framework would cause either to the economy and to the environment.

Cities located near and around waterways could take advantage of their location to make deliveries of goods in specific sectors more efficient and less polluting, through an increased use of IWT solutions. Moreover, due to historical reasons, inland waterways are often located in the heart of city centres. This feature makes them a natural infrastructure suited to deliver transport services of different types (goods for shops, restaurants, hotel and accommodation, etc.) in areas that are more and more precluded to road transport.

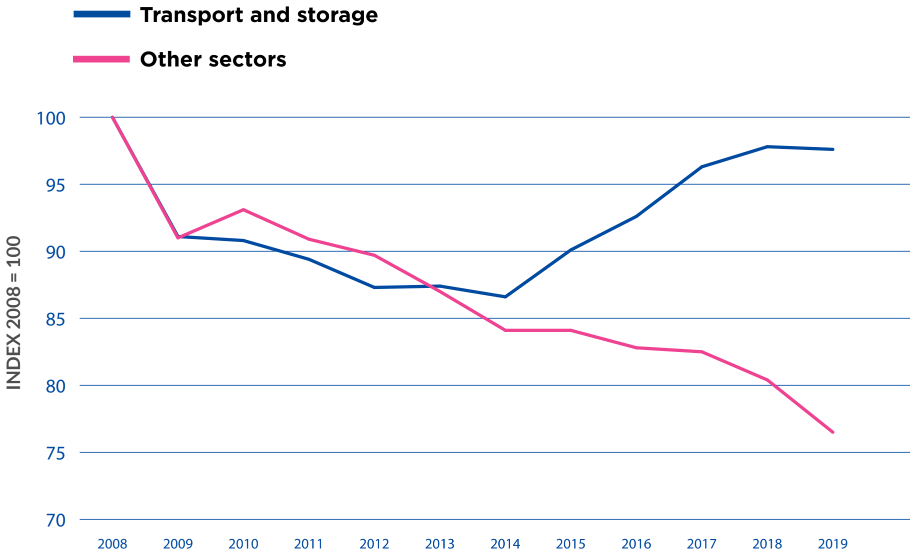
Contrary to road freight, IWT is an unsaturated mode of transport, as it uses transport infrastructure with free capacities, and a safer mode of transport. The lack of congestion facilitates on-time deliveries and the overall efficiency of urban transport flows, while generating fewer accidents and fatalities and consequently reducing the related negative external costs (health treatment costs, societal costs due to fatalities).

[14] Accompanying document to the White Paper: Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, 2011
[15] L. Simmer, S. Pfoser, M. Grabner, O. Schauer, and L. M. Putz, 'From horizontal collaboration to the physical internet – A case study from Austria', Int. J. Transp. Dev. Integr., vol. 1, no. 2, pp. 129–136, Jan. 2017
[16] L. Dablanc and D. Rakotonarivo, 'The impacts of logistics sprawl: How does the location of parcel transport terminals affect the energy efficiency of goods' movements in Paris and what can we do about it?', Procedia - Soc. Behav. Sci., vol. 2, no. 3, pp. 6087–6096, Jan. 2010

GREENHOUSE GAS AND POLLUTANT EMISSIONS OVERALL AND IN SELECTED CITIES

The transport and storage sector (NACE H) is responsible for approximately 15% of total greenhouse gas emissions in the EU and has not seen a significant decline in this respect as other polluting sectors, as shown in figures 4 and 5.[17]

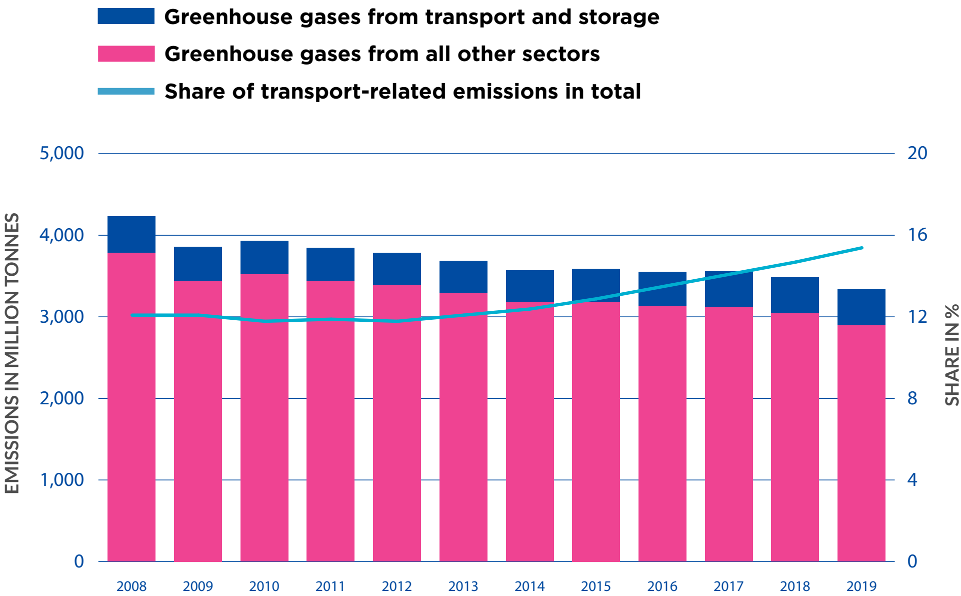
FIG. 4: **GREENHOUSE GAS EMISSIONS – DEVELOPMENT AS INDEX IN THE EU-27** (INDEX 2008 = 100)



Source: CCNR elaboration based on Eurostat data [env_ac_ainah_r2]

[17] *The European Green Deal, European Commission, 2019*

FIG. 5: **ABSOLUTE DEVELOPMENT AND STRUCTURE OF GREENHOUSE GAS EMISSIONS IN THE EU-27**

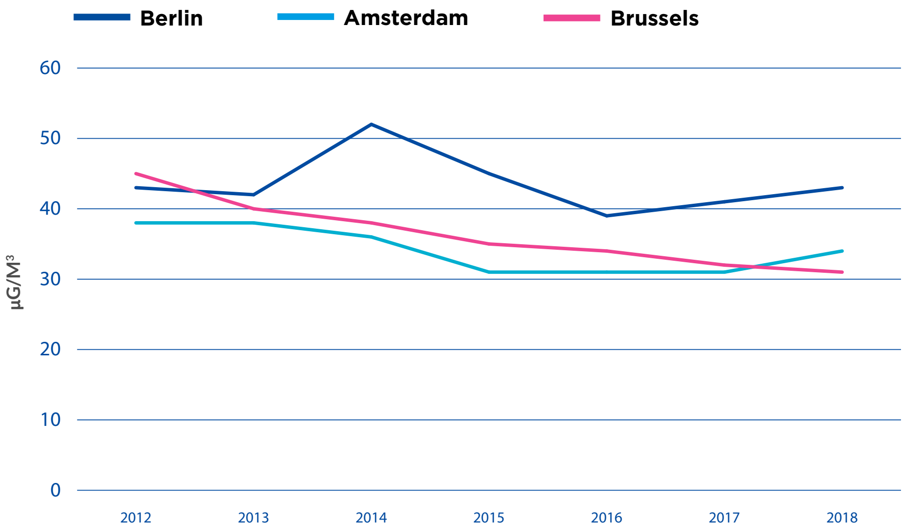


Source: CCNR elaboration on Eurostat data [env_ac_ainah_r2]

Alongside GHG emissions, air pollutant emissions are also very problematic. The very small particles, known as PM_{10}, common air pollutants, are inhalable and can cause health problems. For this reason, the EU sets the limit that PM_{10} emissions in cities must not exceed 50 µg/m³ (daily average concentration) on more than 35 days per year. Figure 6 shows the 36th highest PM_{10} emission value per year as average of a constant panel of air quality stations in each city[18] for Amsterdam, Berlin and Brussels.[19]

In order to respect the threshold or emission limits set by the EU, the values in figure 6 should not be higher than 50 µg/m³. The values are almost always below this threshold. However, for Amsterdam and Berlin, the emission trend between 2016 and 2018 was slightly upward orientated. Figure 6 shows also that Berlin exceeded the emission limit in 2014.

FIG. 6: **YEARLY DATA FOR THE 36TH HIGHEST PM_{10} EMISSION VALUE FOR PARTICULATE MATTER** (< 10 µM) **IN SELECTED EUROPEAN CITIES BETWEEN 2012 AND 2018** (µG/M³)



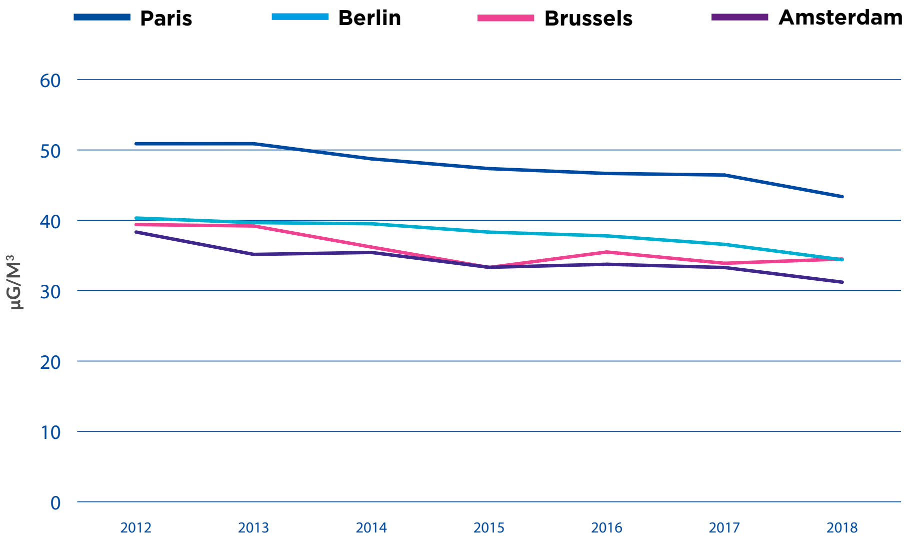
Source: European Environment Agency and CCNR analysis, average air pollutant concentrations for a panel of air quality measurement stations in each city

[18] A constant panel means that for each year, the same stations per city were chosen. Within this panel, stations near the city centre are found, as well as stations on the outskirts of the city. This helps to create an average and rather representative emission value for a city, as the city centre has higher emissions due to more traffic than stations on the outskirts.
[19] The level of emissions shown for each city in the figure shows the arithmetic average of the 36th highest daily emission level for each city. This average was calculated for a panel of air quality stations in the city (for each year, the same stations were included in the calculation of the average).

The PM_{10} data for Paris were not complete (missing values for certain measurement stations in certain years) and could not be shown on a representative basis.

NO_2 is another important pollutant, affecting health and air quality in cities. Figure 7 shows the annual average concentrations of nitrogen dioxide (NO_2) measured at the level of a panel of air quality stations in Amsterdam, Berlin, Brussels and Paris. In Paris, the average concentration of nitrogen dioxide was constantly above the limit set by the EU, which states that the annual mean concentration of NO_2 should not exceed 40 µg/m³ on more than 35 days per year. Values near the emission limit are also observed for Berlin and Brussels.

FIG. 7: **YEARLY DATA FOR THE 36TH HIGHEST EMISSION VALUE FOR NITROGEN DIOXIDE IN SELECTED EUROPEAN CITIES BETWEEN 2012 AND 2018** (µG/M³)



Source: European Environment Agency and CCNR analysis, average air pollutant concentrations for a panel of air quality measurement stations in each city

As would be expected, emission data collected by the European Environment Agency show that PM_{10} and NO_2 levels tend to be much lower in rural areas, and on the outskirts of cities. This provides an incentive to focus efforts on reducing emissions in urban areas. Inland waterway transport - in the form of electrified urban water transport or using other clean propulsion methods - could help to reduce these emissions. The further use of low-emission vessels would be a positive contribution for enhancing air quality and reducing congestion in cities. The combination of both factors could result in growing market opportunities for IWT.

RISING PRESSURE TO IMPROVE THE SUSTAINABILITY OF OUR ECONOMIES

Addressing climate change is a political priority for institutions at all levels (international, national, and local). Public policies aiming at an emission-free economy often highlight the relevance of sustainable transport solutions. Inland navigation should play a relevant role in this transition process. The European Green Deal (EGD) 2019 calls for 75% of inland freight transport to shift from road to rail and inland waterways. Main European cities are restricting access to specific areas for heavy-duty vehicles through low-emission zones. Public policies related to the energy transition are fundamental levers for the market development of IWT. While the energy transition of the IWT sector itself is out of the scope of this report, there is no doubt that the ‘greening’ of IWT could strengthen its position as a sustainable mode of transport - both from an environmental and an economic point of view.


SPLENDID

02

INLAND WATERWAY TRANSPORT EMBEDDED IN URBAN LOGISTICS

In cities situated close to waterways, inland navigation is considered increasingly in logistic supply chains. Urban logistics embraces a broad field of freight distribution comprising various interactions such as Business to Business (B2B) or Business to Customer (B2C) and the passenger transport system within urban areas.[20] Sustainable urban logistics should enable the flow of goods that enter, leave and circulate in the cities to be transported in the most environmentally friendly and sustainable way.

IWT in urban logistics has found more interest in the last decade, thanks to initiatives for more sustainable urban logistics coming from the public side (cities), and from companies active in the retail or construction sector with logistical activities in cities. However, it is still far below its reasonable potential.[21] This report will give an insight into both already operational projects and pilot or research projects. It distinguishes between urban passenger transport and urban freight transport.

[20] http://www.interregeurope.eu/fileadmin/user_upload/plp_uploads/policy_briefs/Sustainable_urban_logistics.pdf
[21] Beyer A., Debrie J., Les Métropoles Fluviales, Concilier aménagement et logistique pour un développement urbain durable, 2013

URBAN PASSENGER TRANSPORT USING WATERWAYS

Urban passenger transport using waterways can be divided into public transport services for commuter traffic and touristic transport. There is of course a certain overlap between these two categories. Within this report, the focus will be on public transport services. For touristic transport a number of examples in cities (e.g. Amsterdam, Paris, Hamburg, etc.) exist, but this is not a new market. However, public transport by inland vessel in large agglomerations is an activity that, although not entirely new, was largely abandoned over a long time. This is the reason why it is integrated in this report as a new market.

WATERBUS IN BRUSSELS – IMPLEMENTED PROJECT[22]

[22] https://www.waterbus.eu/fr/index.php
[23] https://bx1.be/communes/bruxelles-ville/transport-le-waterbus-pourrait-bientot-passer-la-vitesse-superieure/
[24] Idem
[25] https://www.dewaterbus.be/
[26] https://www.waterbus.nl

The canal shuttle waterbus navigates between Brussels and Vilvoorde, an approximate distance of 10 kilometres on the Zenne canal. It brings commuters, other passengers and tourists on a daily basis from remote locations to the city centre of Brussels. In only less than an hour, with a speed of 12-14 km/h on average,[23] the shuttle travels from Vilvoorde Centrum, Park Dire Fonteinen, Cruise Terminal, Quai de Heembeek, Pont van Braet, Quai de Peniches, all the way to Sainctelette. The stops accessed via other public transport modes or by car have free parking places.

Waterbus illustrates an extension of the public transportation system in Brussels allowing to reach out to remote areas and interconnecting the city to a better extent. Sub centres are emerging in the different areas to attract citizens. Through Waterbus, incentives to develop sub centres are reinforced.

Launched in 2013, the Waterbus project proved its economic viability and its role as a solution to urbanisation challenges such as emissions and high road congestion and related long travel hours. It transports on average 40,000 passengers per year.[24]

A similar project has been implemented in Antwerp known as 'DeWaterbus' connecting Antwerp to Lillo and Hemiksem.[25] In the Netherlands, a waterbus project has also been implemented connecting the city of Rotterdam better via the waterways.[26]

Source: Roboat project by MIT and AMS institute

[27] Interview with Roboat project manager Ynse Deinema, held on 11 March 2021

ROBOAT IN AMSTERDAM – PILOT PROJECT[27]

The Roboat project aims to develop autonomous sailing on waterways. Roboat is a concept born from the collaboration between the Massachusetts Institute of Technology (MIT) and the Amsterdam Institute of Advanced Metropolitan Solutions (AMS). Besides the main partners, Roboat also enjoys the support of the municipality of Amsterdam, Waternet, Torqeedo, Vetus and Murata.

Roboat aims to make use of the existing infrastructure provided by the canals of Amsterdam and is open both for freight and passenger transport. The floating platforms using self-driving technology are in fact versatile, which is a quite unique characteristic. They can be used to transport persons, collect waste, deliver goods, combine to form bridges and performance stages. According to the project's official website, the use of Roboats as floating dumpsters carrying away waste could serve 70% of the city centre's needs in terms of waste collection. The project is currently still in a pilot phase.
With a duration of five years, the partners began testing the first small scale prototypes in 2017. In the following years, research continued and in 2020, the full-scale prototypes were developed.

Concepts such as that of Roboat have the potential to improve passenger and freight transport in cities that are deeply interconnected with inland waterways, especially since it has touched a niche in the city logistics of Amsterdam. However, regulatory obstacles hamper the full implementation. Roboat's advantage is that its headquarters are located directly on the Amsterdam waterway, allowing them to perform real testing of the vessel on their own 'private' waters to allow a better and real testing of the vessel. In general, for autonomous sailing, a boatmaster needs to be on the vessel to be allowed on public waterways.

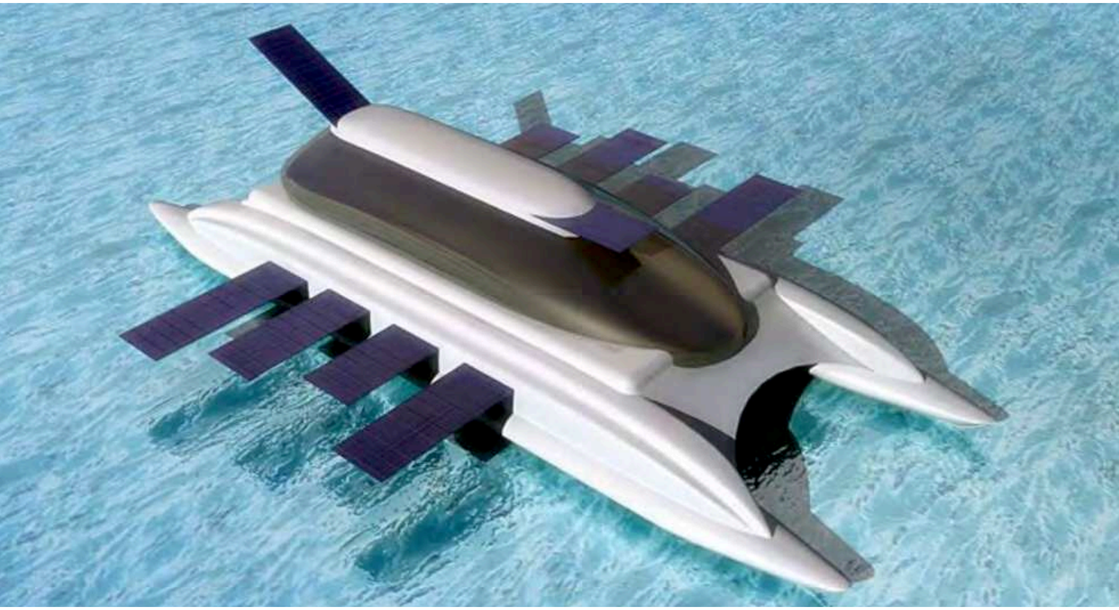
Roboat does not consider freight transport yet, as the necessity of human interaction in this field entails increased labour costs. So far, two business cases have been assessed. The Roboat for passenger transport as a taxi carrying up to five passengers and the second relates to waste collection. Both projects show increased potential. Roboat in future could also be used as an infrastructure component of a passenger bridge for example, in congested areas.

TIBER CAT IN ROME – PILOT PROJECT[28]

The city of Rome has shown interest in using the Tiber as a passenger transport infrastructure.

This further proves that IWW transport methods are attractive for their unexpressed potential in cities where they are far less developed. Tiber Cat is a project, yet to be implemented, on which architects Paolo Carlodalatri and Fabrizio Vinditti are working. Tiber Cat involves building a fully electric catamaran capable of carrying up to 50 passengers. It would be able to navigate with a water level of one metre, and would complement the existing public transport network, differentiating itself from existing tourist boats.

[28] Source: interview with architects Paolo Carlodalatri and Fabrizio Vinditti (Archigroup), held on 23 September 2021



Project of the catamaran, source: Professor Paolo Carlodalatri

The idea is part of plan of the Italian Ministry of Infrastructure and Transport, in collaboration with the city of Rome, to redevelop the area of the Tiber to make it navigable over a 60 km stretch. The use of the catamaran would be the first step towards this long-term goal, allowing navigation on the most navigable stretches of the river (from Prima Porta to Isola Tiberina, a distance of about 10 km). This initial choice would avert the challenge posed by the rapids that characterise the Tiber, improving the chances of success. Constant support from the administration represents the necessary condition for the project to get off the ground.

URBAN FREIGHT TRANSPORT USING WATERWAYS

Inland navigation allows for many different types of cargo to be transported in city centres (parcels, food products, cardboard, construction material etc.) and in varying forms (pallets, bulk, barrels, containers and so on). This is demonstrated by the large number of projects (non-exhaustive) presented in this section. For each project, it is specified whether the project is already implemented or whether it is still in the pilot stage (on its path to implementation/showing potential for sustainable urban logistics solutions).

URBAN PARCEL DELIVERY

Multimodal parcel delivery in urban areas has rooted on fruitful ground. Projects operating in various cities provide an insight into sustainable transport methods addressing urbanisation challenges.

i. Holland's Glorie – DHL in Amsterdam – implemented project[29]

In Amsterdam, Holland's Glorie, a retired passenger ferry, found its passengers replaced by parcels. Since 2017 Holland's Glorie has been operating using three modes of transport, inter alia electric trucks, a vessel and cargo bikes to bring parcels to the city centre of Amsterdam.

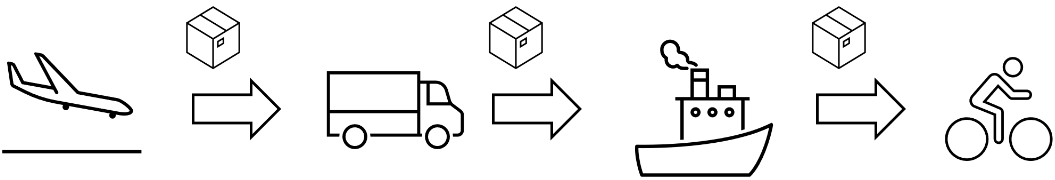
The ferry navigates twice a day from its base towards the city centre. Figure 1 captures the different steps of the delivery process. Parcels arrive at Schiphol airport and are loaded onto electric trucks which then transport the parcels to the vessel. Once in the vessel, the journey begins on Amsterdam's waterways, to reach a platform in the city centre (Koningsplein) where cargo bicycles await the parcels to be delivered. In total there are 21 bicycle messengers.

[29] *https://www.dhl.de/de/geschaeftskunden/express/infos-knowhow/newsletter/092017/schwimmend-letzte-meile.html*

The advantages of delivering by bike lie in the efficiency of deliveries by hour. One can reach up to 17 deliveries per hour, whereas by car it amounts to 5 or 6 deliveries. The reasons for this are set in the narrow streets of Amsterdam's city centre, where traffic, many bikes, motor bikes and almost no available parking places slow down the delivery process.

Source: DHL

FIG. 1: **MULTIMODAL PARCEL DELIVERY IN URBAN AREAS**



ii. ULS in Strasbourg – implemented project[30]

Another promising and operational example of successful parcel delivery using waterways is Urban Logistic Solutions (ULS) in Strasbourg. With a rental vessel from VNF, parcels are transported from the north area of the Port of Strasbourg (Quai du Bassin des Remparts, where the warehouse is situated) to a platform located in the city centre (Quai des Pêcheurs),[31] a distance of approximately five kilometres. The parcels are packed into container-like boxes, and are thereby protected from all kinds of weather conditions and from being lost.

Once arrived in the city centre, 15 available cargo bikes deliver the parcels to the final recipient in the city centre area. For the time being the vessel carries out one rotation per day but shows increasing potential in the near future. In fact, plans to invest in a larger vessel running on alternative fuel are under preparation.

A mobile crane on the platform helps transfer the loads from the vessel onto the cargo bikes. According to Thomas Castan, Director of ULS Strasbourg, cranes on the berths handle goods more efficiently and allows a better quality of transport service. In addition, an integrated crane on the boat would come with additional maintenance costs.

As well as parcel delivery, ULS transports different kinds of goods and recycles used cardboard boxes on its vessel. The capacity of the vessel amounts to 680 palettes which amount to 180 kg each. It yields a total capacity of 122 tonnes and has a width of 3.06 metres.

[30] *Interview held with Thomas Castan and Nicolas Teinturier from ULS Strasbourg on 11 June 2021*
[31] *https://www.ortl-grandest.fr/nouveau-service-logistique-urbaine-fluviale-strasbourg/*

Source: Le Monde/Frederick Florin

In addition to the environmental and efficiency reasons fostering the use of IWT in this segment, the market of parcel delivery is also booming due to increasing online trading. Hence there is potential to expand, especially as regards last mile deliveries and usage of inland waterways. During the interview, the impact of public policy actions was also highlighted. For instance, possible changes in the access routes or possible access restrictions for trucks to the city centre could encourage some economic actors into looking for alternative transport modes, including IWT.

iii. Fludis in Paris – implemented project[32]

FLUDIS

Source: Fludis

Created in 2016, Fludis is a new player in urban logistics. As it is fully electric, it provides competitive and decarbonised solutions for major players in transport, logistics and trade, handling the overall provision of the first and last kilometre. The aim is to avoid costly stock-outs in the warehouse. The company employs 11 people, including eight cyclists.

Fludis operates as follows: a semi-trailer truck transports the goods directly to the boat and the bikes deliver to the final customer:

- for the outbound journey, Fludis delivers for the company Lyreco in several districts of Paris every day;
- for the return journey, it collects electronic waste from Paprec.

[32] Sources: interviews with Gilles Manuelle (Fludis), 22 March 2021, and Emilie Mallet (HAROPA Ports), 14 April 2021

The boat makes several stops in Paris depending on the delivery addresses. Each day, approximately 700 kg of goods are delivered. The sailing time is valued by working onboard (preparation of the packages on board: breaking down the pallets and reconstituting the loads).

Despite the advantageous position of the Seine, outstanding issues remain which could impact the viability of the project. The berths available for urban logistics in Paris are multi-purpose berths and can be used for 15 minutes only. However, this is not adapted to the specific demands of urban river logistics, as Fludis deliveries require a two-hour stay at the berth to accomplish the different deliveries. To make this possible, an adaptation of the current contractual model with Haropa, the port company managing the infrastructures of the Port of Paris, would be needed.

Fludis has to pay high dock dues compared to trucks which can circulate in Paris freely without having to pay any kind of tax. This affects its competitive position compared to other transport modes. Eventually, political and economic decision-making should have an impact on the development of urban river logistics, whether negatively (i.e. limited use of berths for transshipment operations) or positively (setting up of incentives for the use of IWT solutions in urban areas).

TRANSPORT OF FOOD PRODUCTS AND BEVERAGES

i. Beerboat in Utrecht – implemented project[33]

In the historic city centre of Utrecht, the damage done by heavy duty vehicles is an ongoing concern. In 1996, the waterways came into spotlight for the delivery of various goods to the city center, more specifically to establishments located near the canals of Utrecht.

[33] *http://www.bestfact.net/wp-content/uploads/2016/01/CL1_151_QuickInfo_ZeroEmissionBoat-16Dec2015.pdf*

Source: City of Utrecht

In the historic city centre of Utrecht, the damage done by heavy duty vehicles is an ongoing concern. In 1996, the waterways came into spotlight for the delivery of various goods to the city center, more specifically to establishments located near the canals of Utrecht.

The municipality of Utrecht introduced a more innovative and economically viable way of freight transport using the waterways, the B2B beer boat. This concept is considered as an efficient last mile operation for the delivery of beer from four breweries and food products from one catering company to 65 bars and other establishments in Utrecht. It should be noted that this project benefitted from government subsidies.

By 2010, the beer boat was updated to a zero-emission electric boat thus addressing the further urbanisation issue of high emissions. Given its economic viability in the transport of food products and beverages, another electric zero emission vessel was introduced in 2012 transporting also other goods segments such as waste. The loading capacity of the electric beer boat, which is 18 metres in length and two metres in width, amounts to 18 tonnes of cargo or an equivalent of 40-48 containers.

Overall, the concept has successfully contributed to a better air quality, noise reduction, less road occupancy and less road congestion. It has made accessibility to the city centers easier and more comfortable.[34] According to a beer boat fact sheet, the boat has contributed to a yearly reduction of emissions of 17 tonnes of CO_2, NO_x by 35 kg and PM_{10} by 2kg.

ii. Franprix in Paris – implemented project[35 36 37]

franprix

Source: L'Antenne

This urban distribution concept was launched in September 2012 and is based on a multimodal chain combining river and road transport. It is the result of a partnership between XPO Logistics (transport and organisation of the chain), Haropa Ports de Paris (port infrastructure), SCAT (river transport) and Terminaux de Seine (handling). It received the support of Voies Navigables de France and the Ile-de-France region.

[34] *http://www.bestfact.net/wp-content/uploads/2016/01/CL1_151_QuickInfo_ZeroEmissionBoat-16Dec2015.pdf*
[35] *Source: https://scot.metropolegrandparis.fr/wp-content/uploads/2018/12/MGP_Labo_SCOT_fiche-HAROPA_logistiqueurbaine_181206.pdf*
[36] *Source: https://www.lantenne.com/Franprix-une-success-story-en-logistique-urbaine-fluviale_a37747.html*
[37] *Source: interview with Emilie Mallet held on 14 April 2021*

In two Franprix warehouses, approximately 20 km south of the Paris city centre, 50 containers filled with grocery goods are loaded onto inland vessels each day. The convoy leaves the warehouses at the end of the day in order to pass through two locks on the Marne before 8.30 pm. It arrives in the evening at the Port of La Bourdonnais, at the foot of the Eiffel Tower, and stays there until 5.30 am, when the first handling operations begin. The containers are then transported by truck in order to be delivered to 300 Parisian shops.

According to Franprix, the system saves 450,000 kilometres of travel by road per year, the equivalent of almost 13,000 laps of the Paris ring road, 3,800 fewer lorries on the road and almost 250 tonnes of CO_2 saved.

iii. Bioboot in Ghent – implemented project[38]

Fertile fields close to the banks of the Leie allow waterways to be integrated into the supply chain. Indeed, crops can be brought by a vessel, directly from the production site, into the city centre of Ghent. The vessel has an electric sail using solar energy from its starting point Goedinge along the Leie all the way to the Ghent city centre (approximately 8 km). The investment into the vessel was supported by subsidies, thereby reducing the investment costs to be mobilised by the Goedinge farm. Operational costs for the vessel are reported to be low. The project leaders reported to be positive about the long-term viability of the project. Once the fresh vegetables arrive in the city centre the last mile to the final recipient is concluded with bicycle trailers or the vegetables can be picked up directly at the berth. The boat sails once a week with the vegetables.

The interesting aspect of this project is the network of organic farmers. Consumers register on the platform by paying an annual share of the harvest. Three different vegetable packages can then be collected. The packages differ in the number and size of vegetables included.

[38] *https://goedinge.be/bioboot.html*

TABLE 1: **SUBSCRIPTION FEES FOR BIOBOOT**

Package type	Annual fee	Weekly fee
Small (5 vegetable portions)	410 €	10.25 €
Medium (5 large vegetable portions)	620 €	15.5 €
Large (7 vegetable portions)	810 €	20.25 €

Source: https://goedinge.be/pakketten.html

The project supports local farmers in guaranteeing a number of predefined customers.

Source: SmartShip - eu[39]

However, a number of factors regarding its economic viability remain open. The sailing of the boat and its size do not necessary allow scale effects to be present, and this factor consequently creates upward pressure on prices charged to the end consumer. In a greener set-up, such higher prices might be borne by the end consumer in the form of an add-up factor on the competitive price.

[39] *https://smartship-eu.com/*

TRANSPORT OF DIFFERENT TYPES OF GOODS

i. A-Swarm in Berlin – pilot project

The city of Berlin and its surrounding area possesses a dense inland waterway network, with the rivers Spree and Havel, and numerous canals. The capacity offered by this network for cargo transport is tremendous, but currently massively underutilised. The A-Swarm project aims to fill this gap by developing a new city logistics system according to the following main principles:[40]

a) **Small vessel size**: Development of small vessels with a length of 6 to 8 m and a width of 2.5 to 3 m, compatible for small waterways and a fine distribution of unitised cargo (goods are loaded on pallets on the vessels) within cities. The vessels are currently tested in towing tanks as well as in natural test areas.

b) **Flexibility of operation**: The system allows changing between two main operation modes, depending on logistical needs: 1) coupled-mode: coupled convoy ('swarm' of boats coupled together with a push boat) and 2) decoupled mode: self-propelled vessels operating on their own for a fine distribution of cargo.

c) **Autonomous sailing**: All vessels should be autonomous in order to achieve a business case from an economic point of view (no labour costs when sailing).

[40] *Sources: interview on 23 March 2021 with Prof. Dr. Gerd Holbach from Technical University of Berlin and Klaus-Jürgen Lichtfuß from BEHALA port company. Interview on 15 September 2021 with Prof. Dr. Torsten Jeinsch from University of Rostock. Literature: HOLBACH, G. and HOLZKI, G. (2017), 'Ver- und Entsorgung von Städten übers Wasser – Perspektiven urbaner Ver- und Entsorgung, autonome elektrische Schifffahrt, Praxisbeispiel Berlin-Brandenburg' Jahrbuch Logistik 2017, pp.27-30; Articles 'Der Zukunftshafen', 'Berlins neue Seeflotte', Berliner Morgenpost, 14 March 2021. Article in DVZ 'Selbstfahrende Binnenschiffe – Allein auf Fluss und Kanal', 6 July 2021.*

d) **Automated transshipment**: loading and unloading of cargo is carried out via ramps and roll-on/roll-off systems without hoisting cranes (no labour costs including during transshipment).

e) **Electrification**: the push boat, as well as the small boats, have electric propulsion, as is the case for the last-mile logistics for which electric trucks and/or bicycles are foreseen.

Source: University of Rostock, Institute for automation engineering

The type of goods that the project partners[41] consider to be relevant concern: parcels, food products and beverages for shops and restaurants, waste, unitised cargo (pallets).

[41] *BEHALA (port and logistics company operating ports in Berlin), Technical University of Berlin, SVA (Schiffbau-Versuchsanstalt Potsdam), University of Rostock, Infineon Technologies, Veinland GmbH*

Automated navigation must be safe and collision free, and the vessels must be capable of 'understanding' the topology of waterways, which is more complex than the environment of roads for autonomous trucks or cars. The higher complexity of waterways is due to the additional dimension represented by water depth. Furthermore, water in different areas has different physical properties such as different densities, viscosities, currents or depths, and these variables have an influence on the vessel's hydrodynamic frictional resistance and fuel consumption. This is a different situation compared to automation in road traffic, where the road surface is more a 'constant', rather than a variable such as a fluid like water.

An autonomous vessel must distinguish between ducks, human beings and carry out appropriate manoeuvres in each case. Over and above that, a vessel must measure water depth, currents and their variations to determine the optimum speed within a dynamical optimisation algorithm that should be integrated on a single-chip computer in the ship.[42]

Research in automation in inland waterway transport is ongoing, but certain scientists believe that fully autonomous vessels will not become available over the next two years.[43] Of course, this also depends on the level of automation and the size of the vessel. Semi-autonomous small vessels might be available and permitted on the market earlier. Larger vessels are less likely to be fully automated, at least such concepts might not become available in the near future.

From an economic and logistical point of view, the largest port area in Berlin (Berlin Westhafen) plays an important role as a hub, where goods for the retail sector arrive per railway hinterland transport from the Seaport of Hamburg. The fine distribution of these goods to retail shops in Berlin is currently carried out by trucks. With a full implementation of the A-SWARM concept, electrified boats could take over this role, at least partly, in the future. The Amazon company has already shown interest in the project for its parcel distribution.

[42] *Interview with Prof. Dr. Torsten Jeinsch, University of Rostock, held on 15 September 2021*
[43] *Idem*

ii. AVATAR in Hamburg and Ghent – pilot project

AVATAR aims to develop and test innovative and sustainable urban freight transport concepts with autonomous and emission-free vessels in order to achieve a shift from road to waterborne transport in the urban context on the last mile.

The project is co-financed by the European Union from the EU Interreg North Sea Region 2014-2020 programme (European Regional Development Fund). The international structure of the project is reflected by the main project partners, from Germany (Logistik Initiative Hamburg, University of Oldenburg), Belgium (University of Leuven, Development Agency East Flanders) and the Netherlands (TU Delft).[44]

The focal points of AVATAR are:

- development of prototypes of automated/autonomous ship units;
- development of remote monitoring and control concepts;
- development of use cases and business cases for deployment in an urban context;
- analysis of the political and legal framework for the deployment of autonomous ship units in the participating regions;
- implementation of pilot tests.

The project partners consider automation as a necessary tool in order to develop positive business cases for small vessels. This requires electronic tools such as remote-control systems, ship-to-ship communication and programming of fairways. A first step is to develop a small vessel with a loading capacity of 10 tonnes and to carry out pilot tests, possibly in cooperation with the Hamburg Port Authority.[45]

Regarding the potential cargo groups, four groups are identified (waste; parcels and courier; b2b retail logistics; building materials). However, the exact outcome depends on the experiences on the economic viability during the studies and should be determined via a recursive adaptation process. Hereby, vessel technology and business cases interact and are adapted in a recursive way: vessels are designed for specific market segments and tasks, and the experiences from the business case provides feedback for the vessel technology which then needs to be adapted within vessel design.

[44] *https://www.hamburg-logistik.net/unsere-aktivitaeten/projekte/avatar/*
[45] *Source: interview with Mr. Thomas Brauner from Logistik Initiative Hamburg held on 16 March 2021*

From an infrastructural point of view, the small historical canals or 'Fleete'[46] in Hamburg near the port area, that were used for cargo transport from the Middle Ages until the beginning of the 20th century, are considered as an asset which should be used again.

[46] *See the photos in this section*

TRANSPORT OF BUILDING MATERIALS – CONSTRUCTION SECTOR

i. Amsterdam Vaart! in Amsterdam – implemented project

Due to its larger capacities, enabling the transport of large batch sizes, inland waterways can prove to be an effective tool for reducing the number of trips needed to transport construction materials in urban areas. It can also ease congestion in the city, causing an improvement in air quality and reduced pressure on the city's road network. Moreover, water transport allows for additional storage capacity on the quay, because materials can be left on the vessel until they are processed.[47] This is what the Amsterdam Vaart! project has succeeded in demonstrating over the past two years.

The project is part of the Smart and Sustainable Mobility programme of the Ministry of Infrastructure and Water Management. Launched in 2018, Amsterdam Vaart! involved a consortium consisting of the Municipality of Amsterdam, the Netherlands Organisation for Applied Scientific Research (TNO), Waternet and the Port of Amsterdam. The project tested and measured the effects of this modal shift through the consortium's support of experimentation in nine living labs. The nine construction sites involved provided encouraging lessons on the potential of IWT in this logistics segment. The modal shift to inland waterways resulted in a 37% reduction in CO_2 emissions, 1,600 fewer truck trips within the city and 19,700 fewer trips outside the city in 2019.

[47] *Amsterdam Vaart! 2019, Resultaten duurzame bouwlogistiek over water*

ii. Transport of building material in Paris – implemented projects

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 building materials. In 2015, it represented 68% of total waterside traffic, and this share increased further to 77% in 2017 and to 78% in 2019. Not all of these volumes reflect urban transport, some also reflect long-distance transport, as sands, stones and gravel are transported between the Benelux region and Paris. However, the urban transport projects in the construction segment have shown particular dynamics in recent years in Paris.

Due to the Covid-19 crisis, the market experienced a rapid slowdown in March and April 2020, as reported by the Haropa ports, due to the closing of important building sites. However, despite the crisis, IWT showed a certain resilience with a drop of only 3.8% in 2020. The major Parisian construction sites are driving the BTP activity (+12% at the end of November 2020), thus confirming the essential role of river transport in the construction of Greater Paris and the 2024 Olympic Games.

Grand Paris Express

Indeed, the underlying reason for the upward trend in the construction segment on the Seine and in the Port of Paris is the project Grand Paris Express, which foresees the construction of new metro lines in Paris and in the surrounding region of the Île-de-France. As part of the work on the Grand Paris Express, a partnership has been set up between HAROPA - Ports de Paris and the Société du Grand Paris to give priority to the use of waterways for the delivery of sand and building materials for this construction work and evacuation of construction debris from the site. Around 45 million tonnes of sand, building and excavation material are expected to be transported over 15 years under this project. In 2019, one million tonnes of soil were evacuated by inland vessels, which is the equivalent volume of 50,000 loaded trucks.

To this end, four river transhipment platforms are being built at the following ports, near the tunnel boring machine shafts: Île de Monsieur in Sèvres, Gennevilliers, Aubervilliers and Les Ardoines in Vitry-sur-Seine. The Gennevilliers platform was inaugurated in 2021. This platform will also overlap with the circular economy pillar. In fact, it will receive and recycle concrete from manufacturing processes, unused material from construction sites or resulting from deconstruction. Aggregates resulting from the recycling process will be sold or directly integrated into the production process of ready-to-use concrete for renovations or new constructions. Inland vessels will evacuate, where possible, the remaining non-recycled material.

The Grand Paris Express is a good example of how IWT presents further opportunities for growth in urban areas, and how public support can foster its development.

Olympic Games in Paris

The preparation for the Olympic Games in Paris in 2024 also represents such a best practice example. In this case, the French waterway administration, the Voies Navigables de France (VNF), involved in the preparation of the Olympic Games in Paris in 2024 as the contracting authority for the Olympic works delivery company (SOLIDEO), signed a protocol of commitment with HAROPA ports, SOLIDEO and the Prefect of the Île-de-France Region on 21 January 2020. The aim of this commitment is to promote river logistics in the construction of the Athletes' Village in Saint-Denis.

In total, the use of river transport could reach one million tonnes for all the Olympic construction sites along the Seine. VNF has set up a quay dedicated to the evacuation of spoil for the construction sites on the Île-Saint Denis. In total, 250,000 tonnes of spoil have been evacuated by waterway since May 2020 from the VNF and Ports of Paris facilities. In addition, VNF is working to develop partnerships to encourage the use of river transport in the logistics of the Games and for the aftermath.

03

CIRCULAR ECONOMY AND WASTE TRANSPORT

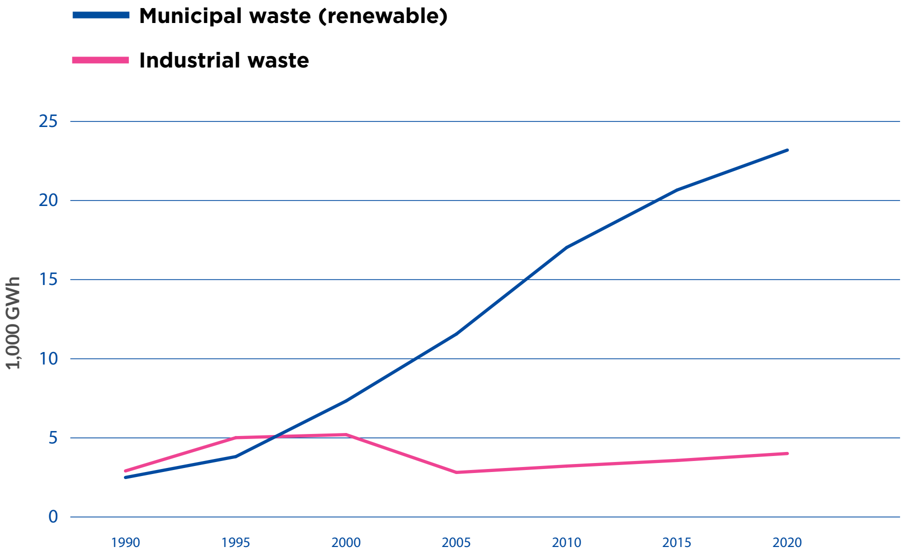
INTRODUCTION

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.[48] Three main words can be associated with this concept: reduce, reuse and recycle. In a scarce resource world, light is shed on mechanisms to recycle and re-use material that elsewhere would find its end of lifecycle in a waste disposal. Waste recycling embraces a large share in the pillar 'circular economy', not only with regard to the collection itself but also to the valorisation of waste. In March 2020, the European Commission adopted a new circular economy action plan, 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/or heating. Electricity generation from municipal renewable waste has increased more than ninefold within the last thirty years (see figure 1).

[48] *https://ec.europa.eu/eurostat/web/circular-economy*

FIG. 1: **ELECTRICITY GENERATION FROM WASTE IN THE EUROPEAN UNION 28** (1,000 GWH)



Source: International Energy Agency, Data and Statistics (https://www.iea.org/fuels-and-technologies/renewables)

Circularity as such does not always indicate an activity with no emissions. The focus lies on a reutilisation of products and resources, and by this circularity, a reduction in the consumption of rare resources is achieved.

Not only the vessels, but also inland ports, play an essential role in the circular economy on the supply side. As an example for an already existing market where inland navigation and inland ports are integrated into circular economy supply chains, the use of scrap steel, iron waste and metal waste for steel production can be mentioned.

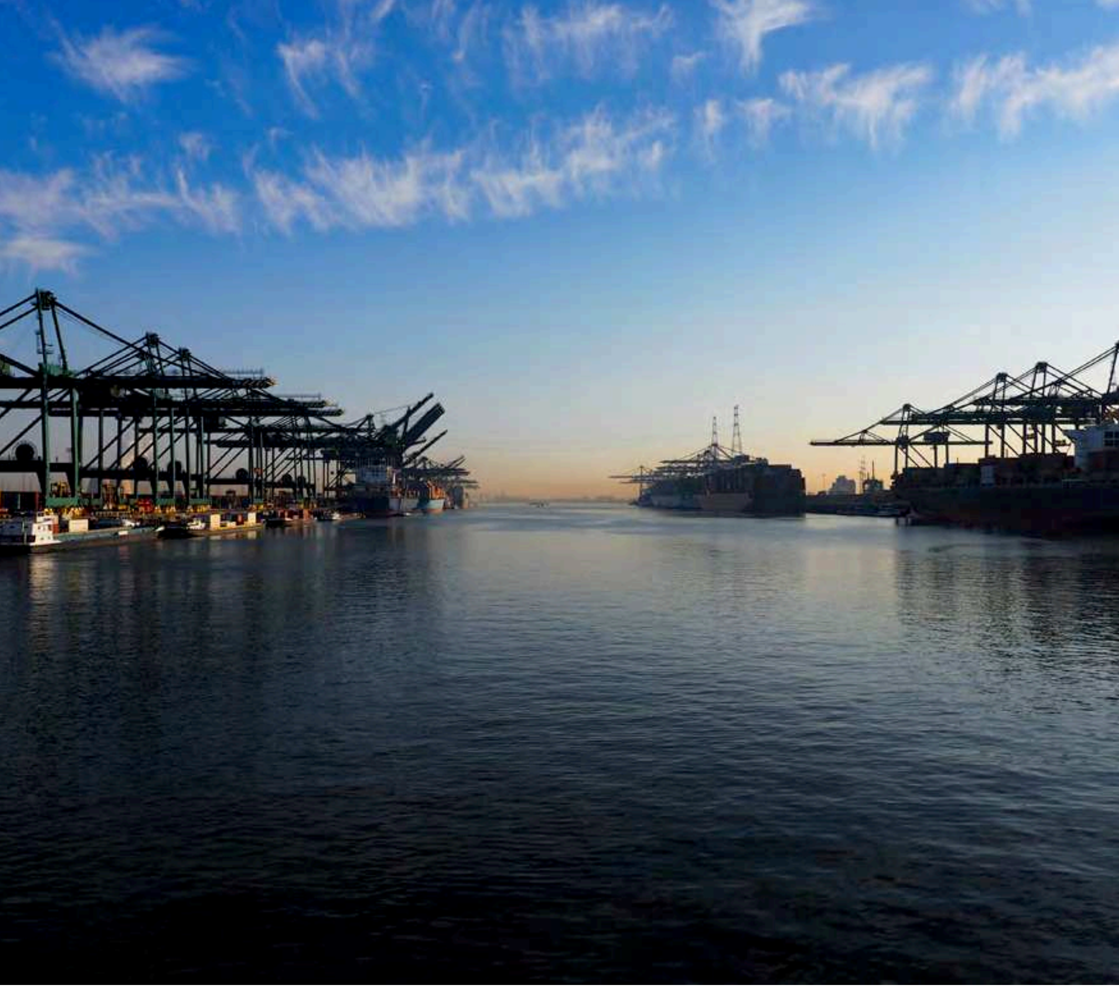
In 2019, 41.3% of crude steel production in the EU took place via electric arc furnaces, in which iron residues or metal waste are smelted with the help of electricity and converted again into new steel. Inland ports and inland navigation are heavily involved in the transport of scrap steel, metal waste and iron waste. An important example is the Rhine Port of Kehl, which will be discussed further below.

As ports are mainly located close to city centres, industries or terminals, they provide a fruitful ground for the recycling industry. 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 places for circular economy activities. The vicinity of circular economy activities near inland ports is certainly an opportunity that inland navigation transport 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.[49]

EFIP identified some barriers to the development of circular economy activities within inland ports as follows:[50]

- The lack of space for the installation of collection and treatment units
- The dependence 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 for certain waste in order to gain economic profitability
- Negative public opinion about waste and waste recycling
- Long transition process towards circular economy
- Increased cooperation between various stakeholders involved in the circular economy transition is required
- Multi-stage process of certain types of waste

[49] *EFIP, 2016, The circular economy and inland ports, available at: https://www.inlandports.eu/media/2016-04-19%20pp%20circular%20economy%20-efip%20def.pdf*
[50] *EFIP, 2016, The circular economy and inland ports, Elena Zhanzhora (2018-2019), MSc in Maritime Economics and Logistics, A circular economy strategy for inland ports*



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

WASTE RECYCLING
BY INLAND VESSELS IN CITIES

WASTE TRANSPORT ON THE THAMES AND ENERGY GENERATION IN LONDON

The recycling and energy recovery company Cory Environmental[51] collects, sorts and segregates 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, an incineration of waste takes place, and the steam resulting during this process drives a turbine that generates baseload electricity.

The company reports in its annual review, published in 2021,[52] that in 2020 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.

[51] *Source: https://www.corygroup.co.uk/about-us/what-we-do/ (last consulted on 10.9.2021)*
[52] *Source: https://www.corygroup.co.uk/application/files/1716/2213/3811/Cory_AR20_WebSpreads.pdf (last consulted on 10.9.2021)*

RIVER TRANSPORT OF WASTE IN PARIS AND LILLE[53]

In the area of Paris on the Seine, various segments of household waste (see table 1) to be recycled or reused are transported on inland waterways.

Table 1 shows the waste volumes transported by the public service company SYCTOM in Paris, as one major example of urban river transport of waste in France. SYCTOM provides a public service for the treatment and collection of household waste for 85 municipalities in the Paris region. According to their activity report in 2020, SYCTOM transported 189.7 thousand tonnes of waste on inland waterways from which they have recycled in various ways 92.4% of all waste collected. Various methods of waste recycling embrace methanisation, energy recovery (electricity and steam) or reuse of recycled material.[54]

TABLE 1: **EXAMPLE OF THE PUBLIC SERVICE COMPANY SYCTOM[55] IN THE REGION OF PARIS – TRANSPORT OF WASTE BY IWT 2019-2020**

Type of waste	Volume in tonnes 2019	Volume in tonnes 2020
Household waste	1,872,649	1,746,229
Household packing and paper	198,081	181,065
Organic waste	7,354	6,618
Landfill	30,225	43,219
Glass	128,078	121,521
Bulky items	231,422	228,046

Source: SYCTOM Activity Report 2020

[53] https://www.vnf.fr/vnf/accueil/logistique-fluviale/adopter-le-transport-fluvial/les-filieres-du-transport-fluvial/dechets/
[54] SYCTOM Rapport d'activité 2020, https://www.syctom-paris.fr/publications/rapports-dactivite.html
[55] SYCTOM provides a public service for the treatment and collection of household waste for 85 municipalities in the Paris region.

For the incineration of waste, filters are used that reduce the 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 via the Seine. The new unit in Ivry is destined for the energy recovery from household waste through an incineration process. Ivry represents the most important recycling centre for the region of Paris.[56]

In 2023, the new energy recovery unit will be commissioned and will handle an annual quantity of 350,000 tonnes of residual household waste by incineration. This amounts to the collected waste volume of around 1.4 million households from the agglomeration of Paris.[57] SYCTOM operates around ten recycling and sorting centres in the region Île de France.

It can also be observed that 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 example is the transport of waste from Gennevilliers near Paris to Rouen. On the way to Rouen professional furniture waste is transported in containers whereas on the way to Gennevilliers containers are filled with paper waste.

The waste disposal centre in Lille, in northern France, with its two recycling centres[58] in Sequedin and Halluin which are located in the northern and southern part of the city, accounts for an estimated 220,000 tonnes of household waste transported by inland vessel per year.

[56] *https://www.syctom-paris.fr/installations-et-projets/les-centres-de-traitement-de-dechets/ivryparis-xiii/centre-de-valorisation-energetique.html*
[57] *https://www.syctom-paris.fr/installations-et-projets/projets/transformation-du-centre-ip-xiii.html*
[58] *Recycling centres refer to the place where waste is recycled.*

RIVER'TRI IN LYON

Urbanisation and waste disposal is a known challenge. As populations tend to grow and space becomes scarce, waste disposal centres in densely populated areas switch to innovative solutions due to lack of space. The city of Lyon shows how waterways can help overcome space scarcity by floating boats acting as waste disposal centres.

River'Tri in Lyon is Europe's first floating waste disposal centre. Every year, an inland vessel collects 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 1.8 million euros, 37% of which was financed by the European cohesion policy (ERDF). Since that time 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 project of the circular economy, as 90% of the waste collected by inland vessel is recycled and transformed into new products (see table 2)

Source: Euronews (2021)

TABLE 2: WASTE COLLECTED BY THE RIVER'TRI INLAND VESSEL IN LYON AND NEW PRODUCTS MADE FROM THE WASTE

Waste collected by River'Tri
Bulky waste such as furniture and carpets
Paper and cardboard
Metals and wood
Electric and electronic equipment
Household hazardous waste such as paint and batteries
Textiles
Products made from the waste
Kitchens
Bathrooms
Chipboards
Wood chips (from wood of inferior quality) used as alternative fuel

Source: Euronews (2021)

The waterborne waste disposal centre in Lyon is open every Saturday from 9 am to 5 pm, when it docks along the Quai Fulchiron on the right bank of the river Saône. The city of Lyon and VNF aim to extend the availability of this inland vessel by one more day per week.

VNF reports that there is interest from private companies to introduce more river logistics services in Lyon. New services could concern the delivery of parcels or food products.[59]

Several quays are available in Lyon. On the Rhône, these quays are below the bridges, in hidden areas. On the Saône, the quays are visible and public, but the quayside on this river is often affected by floods in winter and spring. In addition, the historical architecture of the city centre limits the full implementation of urban river logistics infrastructure on the Saône.

[59] *Interview with Mr Thomas Momber, head of river services in Lyon, held on 1 April 2021*

KEY ROLE OF INLAND PORTS IN THE DEVELOPMENT OF CIRCULAR ECONOMY ACTIVITIES AND RELATED CARGO FLOWS

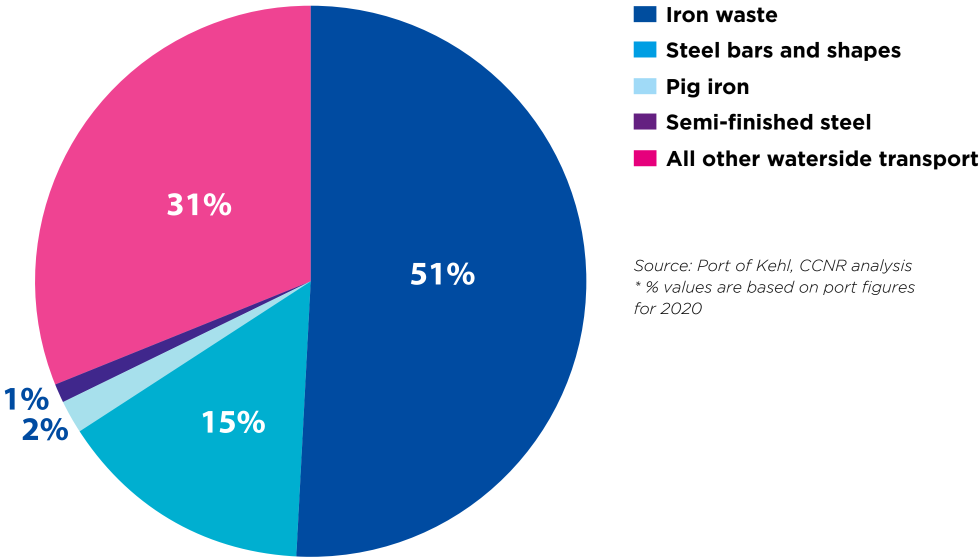
Ports are an essential player in the transition to a circular economy. They are deeply interconnected with different supply chains. Three ports will be mentioned in this section:

Port of Kehl

The Rhine Port of Kehl is one of the ten largest Rhine ports and is located near the French Port of Strasbourg, on the German side of the river Rhine. It hosts the largest German electric arc furnace steel plant. This steel production technology reutilises scrap steel and iron waste for producing new steel.

As figure 2 shows, iron waste accounted for 51% of all waterside cargo transport in the Port of Kehl (2020). The end products resulting from the circular production process of the steel plant are mainly steel bars and shapes. Total inland waterside cargo transport amounted to over 4.4 million tonnes of cargo in the Port of Kehl in 2020.

FIG. 2: **STRUCTURE OF INLAND WATERWAY TRANSPORT IN THE RHINE PORT OF KEHL** (%)*



Source: Port of Kehl, CCNR analysis
** % values are based on port figures for 2020*

Port of Moerdijk

The Port of Moerdijk focuses on embracing circularity in the port's vision.[60] One of the most important circular activities is the energy plant. It transforms animal waste into electricity and is quite unique in Europe.[61] Further, the eco park of the Port of Moerdijk attracts biobased and circular projects. One of the most advanced programmes is the testing ground for pyrolysis, i. e. heating waste to high temperatures above 400°C without the supply of oxygen to generate fuel. Pyrolysis is a chemical process to gain substances out of waste such as pallets, plastic foil or sewage sludge.[62]

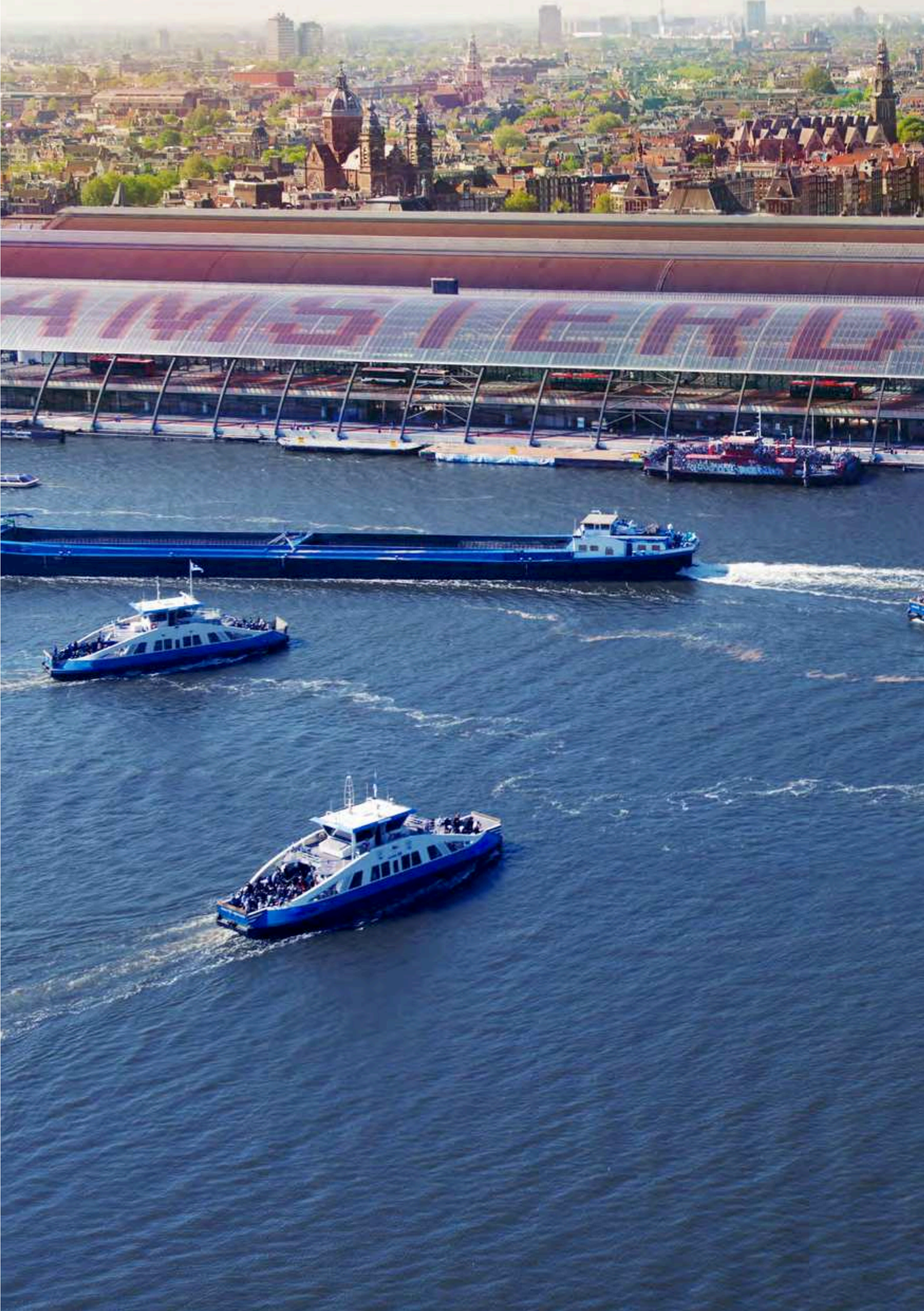
[60] Port of Moerdijk, 2014, available at: https://www.portofmoerdijk.nl/media/1243/havenstrategie-2030-eindrapport.pdf (last consulted on 8.11.2021)
[61] Peter de Langen and Henrik Sornn-Friese, 2019, Ports and the Circular Economy, available at: https://research.cbs.dk/en/publications/ports-and-the-circular-economy (last consulted on 8.11.2021)
[62] Idem

Port of Amsterdam

The Port of Amsterdam remains the frontrunner in the circular activities among all European ports. This lies within its circular economy ecosystem.[63] Three companies that are engaged in different kinds of waste recycling shall be mentioned.

- 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.[64]
- AEB Amsterdam processes residual waste to energy. With an incineration process that burns the waste, heat and electricity for up to 30,000 households in the north of Amsterdam are produced.[65]
- SUEZ Group focuses on hazardous waste. Different kinds of hazardous waste, liquid or solid, are treated to be reintroduced into the lifecycle as raw materials.[66]

[63] *Peter de Langen and Henrik Sornn-Friese, 2019, Ports and the Circular Economy, available at: https://research.cbs.dk/en/publications/ports-and-the-circular-economy (last consulted on 8.11.2021)*
[64] *Bio Energy Netherlands webpage, available at: https://bioenergynetherlands.nl/de/ (last consulted on 8.11.2021)*
[65] *AEB Netherlands webpage, available at: https://www.aebamsterdam.com/mission-and-ambition/ (last consulted on 9.11.2021)*
[66] *SUEZ Group webpage, available at: https://www.suez.com/en/suez-in-nederland/beheer-van-gevaarlijk-afval (last consulted on 9.11.2021)*



04

NEW CARGO FLOWS TRIGGERED BY THE ENERGY TRANSITION

INTRODUCTION

The early 21st century shows the downside turn of the fossil economic paradigm, in terms of climate change and natural disasters. The negative feedback of this phenomenon on human societies, including economic welfare, is more and more visible. The technical and economic transition from fossil fuels to alternative or renewable fuels is a complex process which is still ongoing. Fossil fuels are not only troublesome from an environmental point of view, but also from the viewpoint of their being finite and depleted, in combination with a growing global demand for energy.[67]

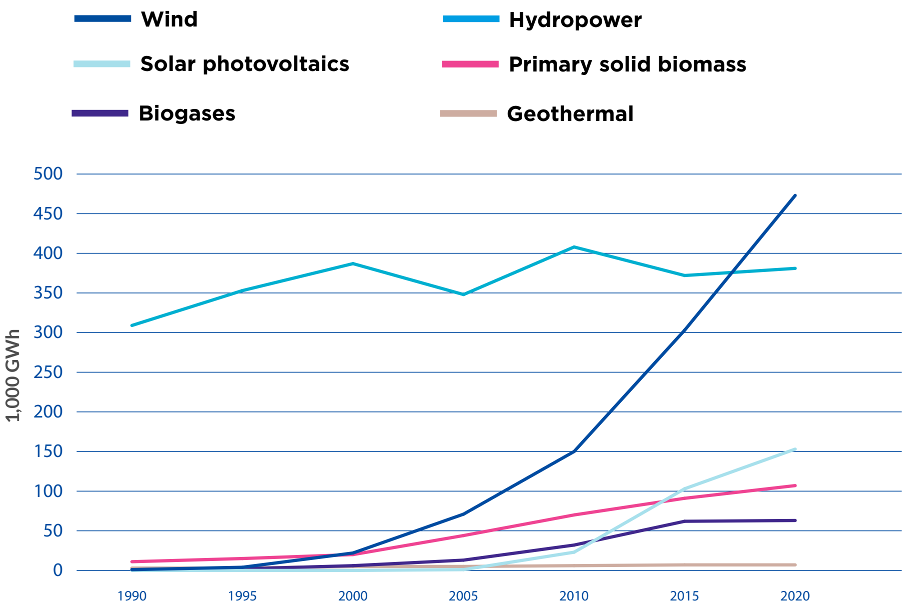
This transition implies a deep transformation for our entire economic system. This includes inland navigation, which will have to apply new technologies, transform its infrastructure, embrace social, economic and perhaps fiscal changes, and, most importantly, develop new markets. Indeed, the transition away from fossil fuels is already impacting inland navigation transport volumes.

Within this report, the use of renewables and their growing importance in the energy sector forms a framework for the analysis of potentials within transport demand in inland navigation.

Within the last 30 years, wind and solar energy have been the two segments that showed the strongest growth within renewable energies in the European Union (see figure 1).

[67] *Meadows, Donella; Meadows, Dennis; Randers, Jorgen (1992), Die neuen Grenzen des Wachstums (Beyond the limits), Deutsche Verlags-Anstalt Stuttgart 1992*

FIG. 1: **RENEWABLE ELECTRICITY GENERATION BY MOST IMPORTANT SOURCES, EUROPEAN UNION - 1990-2020** (1,000 GWH)



Source: International Energy Agency, Data and Statistics (https://www.iea.org/fuels-and-technologies/renewables)

Projections regarding the development of renewable energies in the near future are positive 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 road transport and the building sector, as well as to the maritime sector, further emissions are targeted.[68]

Electricity generation from renewables is expected to expand by almost 50% in 2025 compared to 2019. By 2025, the share of renewables in total electricity generation is expected to be 33%,

[68] *European Commission, Policy scenarios for delivering the European Green Deal, available at: https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en (last consulted on 24.11.2021)*

surpassing the coal-fired generation. Renewables are expected to meet 99% of the global electricity demand increase during 2020-25. In the European Union and the United Kingdom, the increase in renewables-based generation is expected to be more than nine times the rise in electricity demand between 2019 and 2025. Recent policy momentum is also perceived as a lever to give an extra boost to the use of renewable energy. For instance, the EU economic recovery plan foresees climate-related spending in areas such as buildings, grids, electric vehicles and low-carbon hydrogen.[69]

The aim of this chapter is to show in which fields inland navigation could benefit from these trends towards renewables, and to show also existing bottlenecks and barriers for growth in IWT 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 market that offers certain growth potentials for IWT.

This is due particularly to the large loading capacities of inland vessels, a property which is complementary to the large size and/or the large batch size of many alternative energies. Alternative energies can appear in different forms - wind, solar or hydraulic energy, solid biomass, liquid biomass (biofuel, ethanol), methanol or hydrogen.

However, there are still high uncertainties regarding energy transition pathways which our society and the different industries will follow. Such uncertainty relates in particular to prices, the availability of renewable energies, and technological development, especially zero-emission technologies.

In the context of this report, it was therefore decided to focus on three case studies, namely, transport of:

- wind turbines,
- biomass and biofuel,
- hydrogen.

[69] International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025, available at: https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 22.10.2021)

TRANSPORT OF WIND TURBINES ON INLAND VESSELS

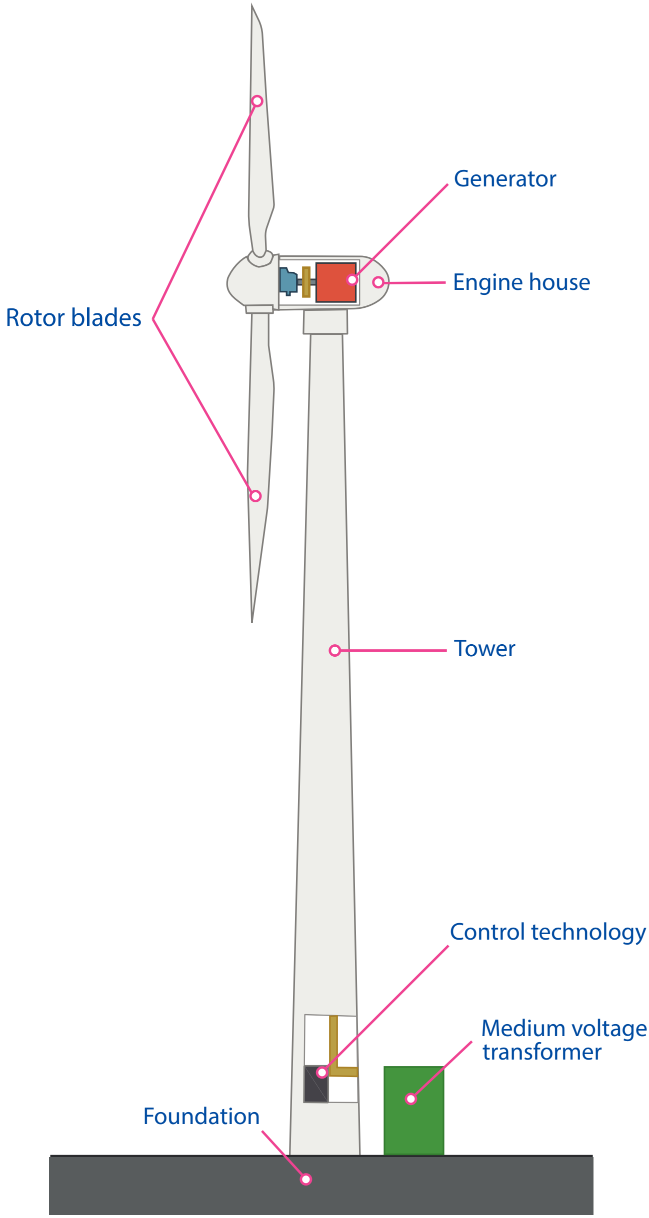
WIND ENERGY AND WIND TURBINES – OVERVIEW AND DEVELOPMENT

The growth of energy generation with wind turbines has been particularly successful in countries that offered a state-guaranteed feed-in tariff for wind power, over a period of 20 years. Due to this scheme, overall additions of capacity in the wind energy sector accelerated to meet 2030 targets. In more recent times, 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.[70] This mostly occurs when support schemes with rather fixed feed-in tariffs are turned into auction mechanisms that automatically remove the weakest players from the market. Hereby, 'weakness' is to be understood as a rather high level of production costs, meaning that such a company will not be successful within an auction procedure. This limits overall growth for wind energy capacities.

In Germany, the shift in policy design took place in 2017, when state guaranteed feed-in tariffs for wind energy were abandoned in favour of auction systems. In the system that was in operation until 2017, the compensation per KWh of wind power was guaranteed by the state, and determined on the basis of scientific studies on the average costs per KWh of wind power using state-of-the-art technology. The per kWh tariff for existing wind turbines was reduced marginally year by year by a small percentage of 1.5% in order to take into account technological progress and to give incentives for productivity growth.[71]

[70] IEA Renewables 2020, available at : https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 25.10.2021)
[71] For Germany, see: Forschungsgesellschaft Energiewirtschaft mbH. Infografik: Wie funktioniert die EEG-Umlage? https://www.ffegmbh.de/aktuelles/veroeffentlichungen-und-fachvortraege/971-infografik-wie-funktioniert-die-eeg-umlage (last consulted on 16.8.2021)

FIG. 2: **WIND TURBINE AND ITS COMPONENTS**



Source: CCNR compilation based on windwaerts

Grid operators were obliged to purchase wind power at the prices set by the state. The difference between this state price and the market price 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, as shown in table 1. Installed capacity for producing electricity from wind (both onshore and offshore) more than doubled in Rhine countries between 2010 and 2019. Between 2000 and 2010, growth had been even stronger. This last point reflects the increasing scarcity of areas for the further installation of new wind turbines. Repowering (the exchange of existing wind turbines by new, more productive ones) is one means to overcome this bottleneck.

TABLE 1: **INSTALLED NET CAPACITY*** (MEGAWATT) **FOR PRODUCING ELECTRICITY FROM WIND ENERGY – RHINE COUNTRIES**

	Installed MegaWatt in year...			Growth factor	
Country / Year	**2000**	**2010**	**2019**	**2019 vs 2010**	**2010 vs 2000**
Germany	6,095	26,903	60,721	2.3	4.4
France	38	5,912	16,427	2.8	155.6
Netherlands	447	2,237	4,484	2.0	5.0
Belgium	14	912	3,863	4.2	65.1
Luxembourg	14	44	136	3.1	3.1
TOTAL	6,608	36,008	85,631	2.4	5.4

Source: Eurostat [NRG_INF_EPCRW]
** Both onshore and offshore capacities*

Further to the already installed 60.7 GigaWatt, the German government aims to implement another 71 GigaWatt onshore and 20 GigaWatt offshore wind energy capacity by 2030, according to the new EEG policy.[72] [73]

[72] Umweltbundesamt, 2021, Erneuerbare Energien Gesetz, available at: https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-gesetz#erfolg (last consulted on 25.10.2021)
[73] International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025, available at: https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 25.10.2021)

For the same period, a similar growth (although on a lower absolute basis) is observed for Danube countries, and especially Austria. From 2000 to 2010, wind power capacity in Austria increased twentyfold, and threefold from 2010 to 2019. Croatia and Romania experienced a relevant increase in their net capacity for wind energy in the period 2010-2019 (see table 2).

TABLE 2: **INSTALLED NET CAPACITY*** (MEGAWATT) **FOR PRODUCING ELECTRICITY FROM WIND ENERGY – DANUBE COUNTRIES**

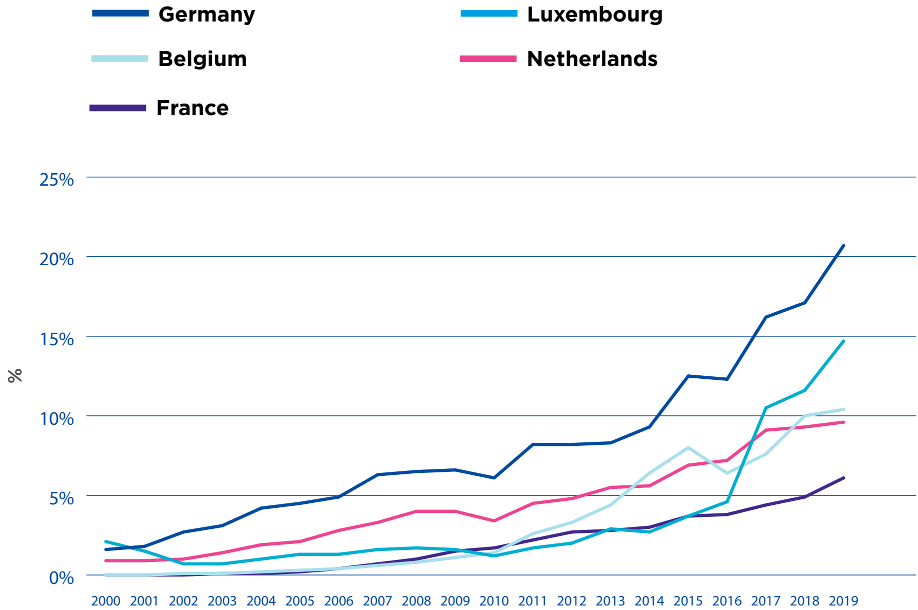
	Installed MegaWatt in year...			Growth factor	
Country / Year	2000	2010	2019	2019 vs 2010	2010 vs 2000
Austria	50	1,015	3,224	3.2	20.3
Romania	0.0	389	3,037	7.8	n.d.
Bulgaria	0.0	488	703	1.4	n.d.
Croatia	0.0	79	646	8.1	n.d.
Hungary	0.0	293	323	1.1	n.d.
Slovakia	0.0	3	4	1.3	20.3
TOTAL	50	2,267	7,937	3.5	45.3

Source: Eurostat [NRG_INF_EPCRW]
** Both onshore and offshore capacities*
n.d. = not defined due to value of zero in 2000

According to the DNV Energy Transition Outlook 2021 report, by 2050, wind is expected to account for 33% of the world's electricity output, compared to 5% in 2019.[74] 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 in the Netherlands, and 6% in France (see figure 3).

[74] *DNV Energy Transition Outlook 2021*

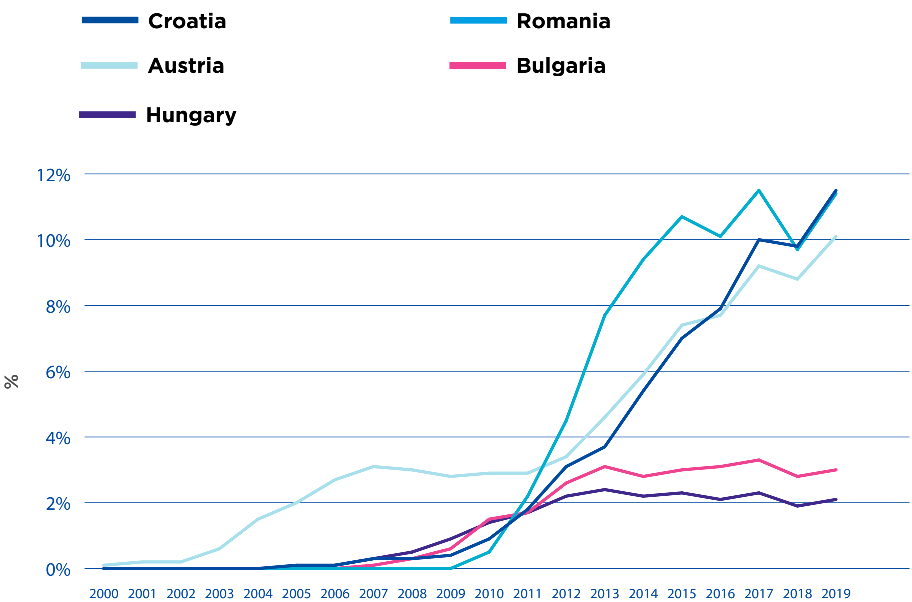
FIG. 3: **SHARE OF WIND ENERGY IN TOTAL ELECTRICITY PRODUCTION** (GWH) **IN RHINE COUNTRIES** (%)



Source: Eurostat [nrg_bal_peh]

In looking at the Danube countries of Austria, Croatia and Romania, similar growth trends can be observed. The three mentioned countries exceeded a 10% share in electricity production from wind energy in 2019 (see figure 4).

FIG. 4: **SHARE OF WIND ENERGY IN TOTAL ELECTRICITY PRODUCTION** (GWH) **IN DANUBE COUNTRIES** (%)



Source: Eurostat [nrg_bal_peh]

In 2020, a total volume of 3,860 MW new onshore wind energy capacity was put out to tender by the state in Germany. However, around 32% of the tendered volume was not awarded. In the previous year, only half of the tendered volume was awarded.[75] According to the German Ministry of Economic Affairs, only those companies with the lowest electricity generation costs would be successful in the tendering process.[76]

[75] *Source: Bundesverband Deutsche Windenergie/Deutsche Windguard (2021), Status des Windenergieausbaus an Land in Deutschland, https://www.wind-energie.de/fileadmin/redaktion/dokumente/publikationen-oeffentlich/themen/06-zahlen-und-fakten/Status_des_Windenergieausbaus_an_Land_-_Jahr_2020.pdf (last consulted on 27.8.2021)*
[76] *See the detailed description on the website of the German Ministry for Economic Affairs: https://www.erneuerbare-energien.de/EE/Redaktion/DE/Standardartikel/EEG/eeg-2017.html (last consulted on 16.8.2021)*

As a result, the investment in new capacities decreased sharply in Germany in the years 2018-2020, as table 3 shows.[77] Another of the slowing-down factors are long approval procedures, which result primarily from lawsuits filed by parts of the population against companies that want to install new wind turbines. This opposition against wind turbines among parts of society could be a major hindrance for further growth in this sector in the future in Germany. Also, in some cases, the decommissioning of the ageing fleet of wind turbines is not accompanied by repowering (installation of new turbines at the same place), which altogether reduces capacities.

In order to unlock the situation, the German government recently introduced an 'Investment Acceleration Act'. It was set in place in order to allow the construction of wind turbines to continue also during any litigation process.[78] Furthermore, in order to speed up and achieve the targets set, in 2021, a revised version of the EEG was published to generate incentives for local communities to eliminate any restrictions on newly built wind turbines in northern Germany.[79]

France is a recent market in wind energy, where there is room for accelerated increase of wind capacity. Both onshore and offshore capacity is expected to increase in France. The French Ministry of Ecological Transition's Multiannual Energy Programme (MEP) also foresees an ongoing commitment to the development of this sector. The monitoring indicators of the MEP were updated in 2021. For wind energy, the objective is to increase onshore wind capacity by 38-44% between 2020 and 2028. For offshore wind, the objective is to almost triple the capacities by 2028.[80]

[77] The total cumulated stock of installed capacity is slightly higher according to the national source for Germany, compared to Eurostat. This is due to different data collection methodologies. According to the Bundesverband Windenergie, the repowering data and the dismantling data somehow underestimate the real values slightly.
[78] International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025, available at: https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 25.10.2021)
[79] International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025, available at: https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 25.10.2021)
[80] 'Mise à jour des indicateurs de suivi de la programmation pluriannuelle de l'énergie, Octobre 2021' : https://www.ecologie.gouv.fr/sites/default/files/Indicateurs%20PPE_Mise%20%C3%A0%20jour%20Octobre%202021.pdf (last consulted on 28.10.2021)

Growth is forecast both for onshore wind, led by France, Germany and Spain, as well as offshore wind, led by the UK, the Netherlands, France and Germany.[81] Nevertheless, environmental and 'NIMBY' ('Not In My Backyard') concerns seem to grow in several parts of Europe (including France) and could hinder wind power development.

It is important to state that the transport of wind turbines or their components addresses two different markets. One is the repowering of existing wind turbines and the second the construction of new wind turbines at 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 will develop its own pace and trend, and IWW transport will be affected accordingly.

[81] International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025, available at: https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 25.10.2021)

TABLE 3: **YEARLY ADDITIONS OF NEW WIND ENERGY CAPACITY** (IN MEGAWATT) **IN GERMANY, REDUCTION THROUGH DISMANTLING OF EXISTING PLANTS, AND CUMULATED STOCKS** (ONSHORE, OFFSHORE AND ALL WIND TURBINES)

Onshore, in MW per year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gross additions	2,415	2,998	4,750	3,731	4,625	5,333	2,402	1,078	1,431
Thereof repowering	432	766	1,148	484	679	952	363	155	339
Dismantling	178	258	364	195	366	467	249	97	222
Net additions#	2,237	2,740	4,386	3,536	4,259	4,866	2,154	981	1,208
Cumulated stock*	31,028	33,730	38,116	41,651	45,911	50,777	52,931	53,912	54,938

 # Gross additions minus dismantling
** Cumulated stock at 31 December of each year*

Offshore, in MW per year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net additions	80	240	529	2,282	818	1,250	969	1,110	219
Cumulated stock*	280	520	1,049	3,295	4,108	5,387	6,382	7,516	7,770

** Cumulated stock at 31 December of each year*

Onshore and offshore, in MW per year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Net additions	2,317	2,980	4,915	5,818	5,077	6,116	3,123	2,091	1,427
Cumulated stock*	31,308	34,250	39,165	44,946	50,019	56,164	59,313	61,428	62,708

** Cumulated stock at 31 December of each year*

Source: Bundesverband Windenergie/Deutsche Windguard/VDMA Power Systems – Factsheets Windenergieausbau an Land; Windenergieausbau auf See; https://www.wind-energie.de/themen/zahlen-und-fakten/deutschland/ (last consulted on 27.8.2021)

In Austria, a similar decreasing trend in investment in new wind energy capacities has been observed since 2014, with some fluctuations, as shown in the following table. However, while the year 2020 saw a net reduction in terms of wind energy capacity, forecasts for 2021 are optimistic. Overall, the deployment of both wind and solar PV has accelerated, driven by feed-in tariffs and falling deployment costs.[82]

TABLE 4: **YEARLY ADDITIONS OF NEW WIND ENERGY CAPACITY AND REDUCTION THROUGH DISMANTLING OF EXISTING PLANTS IN AUSTRIA** (IN MEGAWATT)*

MW per year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
New capacity	279	316	409	325	228	196	232	157	25	315
Cumulated capacity	1,380	1,695	2,102	2,426	2,654	2,849	2,039	3,159	3,120	3,396
Capacity reduction from dismantling	2	2	2	1	0	1	41	37	64	40
Net additions#	277	314	407	324	228	195	191	120	-39	275

Source: IG Windkraft 2021
** For 2021, forecast*
 # New capacity minus dismantling

In light of the above, it is clear that whether transport of wind turbines will develop or not strongly depends on the decision by public authorities to, for instance, 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.

[82] *International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025, available at: https://iea.blob.core.windows.net/assets/1a24f1fe-c971-4c25-964a-57d0f31eb97b/Renewables_2020-PDF.pdf (last consulted on 25.10.2021)*

THE WIND ENERGY INDUSTRY - LOGISTICAL ASPECTS AND THE POSITION OF INLAND WATERWAY TRANSPORT

Due to the competition with other energy sources (renewable and non-renewable ones) and the public subsidies dedicated to energy transition, the economic and political pressure to reduce the production costs of renewable energies and to 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. The wind area that is covered corresponds with longer 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.[83]

From a logistical point of view, an increase in size for wind turbines makes inland vessels an appropriate mode of transport, at least in principle.

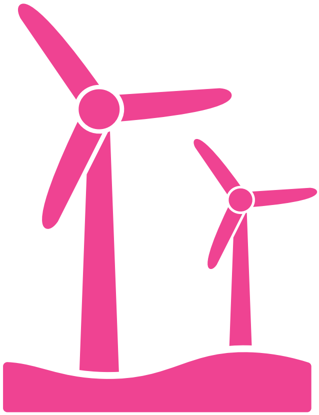
[83] SWR 2 (2020) SWR 2 Wissen – Windindustrie in der Krise, https://www.swr.de/swr2/wissen/swr2-wissen-2020-01-28-100.html, audio source (last consulted on 26 August 2021)

A publication of the Bundesverband Windenergie, the German Federation of Wind Energy[84] confirms this, by stating that “railway transport of wind turbines plays only a minor role, due to restrictions of the maximum rotor length that can be transported by rail, to 56 metres. Hence, transporting rotor blades by rail is not possible anymore, due to the increase in their size.”[85]

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. The German Federation of Wind Energy writes that it “should be objectively examined whether and when inland navigation can be more strongly integrated into transport of wind energy turbines.”[86]

With regard to road transport, authorisations by administrative authorities are generally required to transport wind turbines. In Germany for instance, each road transport of a wind turbine must be approved by the administration, and for the approval, the use of road transport must be justified with unreasonable additional costs, if the wind turbine is to be transported via inland waterways or railways. The fact that road transport is mostly approved, shows that there is still a strong tendency against the use of inland waterways, for which there are several reasons, including a certain ‘road culture’ in logistics and in the mindset of stakeholders. A further reason for citing why road might be the preferred option are the low heights of bridges limiting transport of windmills on 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.

[84] *Bundesverband WindEnergie (2020), Akzeptanz und Effizienz der Energiewende mit Windindustrie in Deutschland erreichen – Multimodaler Transport von Windenergieanlagen*
[85] *Bundesverband WindEnergie (2020), p. 3*
[86] *Idem*



While wind turbine components have long been produced in Europe, many are now produced in Asia. They are transported to Europe via seagoing vessels, IWT therefore appearing as the logical follow-up to transport them to the hinterland.[87]

The Bundesverband Windenergie identifies the following points which should be fulfilled in order to achieve a 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 of wind turbines and their components in ports;
- possibility for intermediate storage;
- minimisation of weather-related transport interruptions (high or low water);
- development of models and solutions together with the transport companies.

Such findings were also confirmed during interviews carried out with relevant actors.

[87] *L'Antenne 'Gutmann : du transport d'éoliennes à partir du port de Colmar', 20 janvier 2020*

INLAND WATERWAY TRANSPORT OF WIND TURBINES: INTERVIEWS WITH EXPERTS

i. Viewpoint of a multimodal logistics company

Interview with Rhenus Logistics

Source: Photo © Klaus Rockenbauer

Rhenus Donauhafen Krems is a company based in Austria and part of the Rhenus-Group, which develops tailor-made solutions for logistical needs worldwide.

In Austria, 74 newly built windmills are foreseen in 2021 compared to seven in 2020.[88] The total number of existing windmills amounted to 1,307 in the year 2020 producing seven billion kWh on an annual basis. This accounts for the electricity of two million households and saves three million tonnes of CO_2.[89]

The wind turbines address different specific markets. One is the repowering of wind turbines and the second the construction of new wind turbines. The first market embraces dismantled wind turbines due to the installment of new, more powerful ones, with a higher energetic productivity. Dismantled wind turbines are then exported to other countries, via the Port of Constanţa, in particular, to North Africa or to Central Asian countries such as Kazakhstan. The geographical focus for the first market lies in traditional wind energy countries (France, Germany, the Netherlands, Romania, Slovenia).

Given the size of wind turbines, inland vessels are considered to be a convenient transport mode. In addition, since trucks need an administrative permission to transport wind turbines, road transport bears the risk of a denied authorisation or potential higher administrative costs. Similarly, the lack of planning and information regarding possible works on highways, is a favourable factor for inland waterway transport. Given the size of wind turbines, there is no competition from rail transport which does not have the capacity to transport such cargo. Location of the port is another important aspect. Transport via inland vessels is for instance facilitated when the port is located next to the production site of wind turbines. This is for instance the case of the wind turbine manufacturer Enercon, which fixed its production site next to the Port of Krems, equipped with a special wind turbine handling system. This proximity allows the limiting of transshipment costs, given that no other mode of transport is required to transport the components between the port and the production sites.

Other factors influencing the potential of wind turbine transport by inland vessel are notably the availability of specialised wind turbines

[88] *IG Windkraft – Austrian Wind Energy Association. Jahresanfangspressekonferenz IG Windkraft 12. Jänner 2021*
[89] *Idem*

Source: Photo © Rhenus

handling facilities in ports as well as intermediate storage facilities. This is true for both the repowering and the newbuilding market.

Regulatory aspects also play an important role. In particular, one bottleneck is the lengthy administrative process required for the building of new wind turbine parks. Another obstacle is rather a 'cultural' one. Indeed, the mindset of shippers prefers road transport, and this is often detrimental towards IWT. This is generally due to a lack of knowledge about inland waterway transport. In addition, while this issue is not specific to the transport of wind turbines, IWT is also often perceived as a mode which is vulnerable to high and low water periods.

The evolving size of wind turbines' components is a double-edged sword. It could be a further opportunity for IWT but also a bottleneck in case inland vessels are unable to adapt for instance, to the constantly growing size of wind blades (from 45 to 65 metres while the next generation could reach 80 metres) which is previously mentioned.

Last but not least, the high value of the wind blades (amounting up to USD 170,000) requires a great deal of caution during transport, which can be offered by inland waterway transport.[90] According to Mr. Gerhard Gussmag, similar considerations are also true for the transport of hydropower plant components.

[90] *https://www.skuld.com/topics/cargo/project-cargo/transportation-of-wind-turbines-as-cargo/*

ii. Viewpoint of two logistics companies

Interview with Bolk specialised in project cargo

Bolk is a transport company based in the Netherlands with branches in several European countries (Germany, Austria, Romania and France). The company also manages exceptional project logistics, including inland shipping where required. In the context of wind turbine transport, several factors influence the choice of mode of transport. One of the main decisive economic criteria considered by the clients is that of costs. The mode of transport that provides the service at the lowest costs is usually chosen. However, aspects such as proximity to production sites for wind turbines favour the inland waterway transport due to well-equipped inland ports.

Nevertheless, when choosing IWT, additional costs such as transshipment charges need to be considered. These costs arise if the construction sites or final destinations are not located near the port and therefore require a further mode of transport. Given the construction site not being directly located at the port, a truck would need to first bring the components to the vessel. This includes handling costs that might, when comparing the whole logistics chain of different transport modes, favour road transport. In addition, the risk of low water and the associated service irregularities discourage the adoption of IWT as the first choice.

Road transport appears to be the more flexible and faster choice compared to IWT. Flexibility means that the company that is producing the wind turbine does not have to complete all the components at once, as trucks can pick up one component each week. However, this higher flexibility comes with higher transport costs compared to IWT. Indeed, the high loading capacities of IWT allows carrying all the components within one single journey. A factor in favour of road transport that is often relevant for logistical choices is the shorter transport time of trucks, compared to river vessels.

Because of its high loading capacities, when transporting heavy cargo, IWT is also the preferred (or even the only) choice from an environmental point of view, unless - when departing from the same point - the number of kilometres to be covered by waterway is significantly higher than the number of kilometres to be covered by road to reach the same destination. The growth in size of wind turbines is - in principle - another argument for a waterborne transport of these components. The interview partner, Mr Gerhard Wagner, confirms this trend, but adds that ports and shipowners sometimes lack the equipment to handle this growing size. On the other hand, this trend will complicate road transport probably far more (need for ultralong trucks, new axles) thereby increasing journey times, which could be comparable to those of inland vessels.

According to his assessment, there is a difficulty to innovate in inland waterway transport, in contrast with road transport which strives to remain competitive and adaptive. Stricter regulations may lead to the choice of inland waterways. In some countries, it is difficult to obtain permits for road transport, and this can produce sufficient pressure to favour inland waterway transport. However, there is resistance to this modal shift within the transport sector. This resistance seems to come from several sides which were mentioned by the interview partner:

1) Additional costs due to transshipment if the place of loading is far from an inland port

2) Less flexibility of IWT compared to road transport, due to large batch sizes in IWT

3) Embedded 'road culture' among logistical companies and lack of knowledge about IWT

According to the interview partner, road transport dominates the market of wind turbine transport.

Source: Photo © Gutmann

Interview with Gutmann France, a logistics company specialised in heavy cargo logistics

Gutmann Sarl is a medium sized family enterprise created in 1963 in Karlsruhe. It is specialised in national and international transport of heavy cargo (100 – 200 tonnes). Around 50% of its transport activity in Germany and France is dedicated to transport of wind turbines.

Within the wind turbines transport activity of this company, 90% of transport is related to newly built turbines and 10% to repowering activities. Regarding the modal share of IWT in the total wind turbines transport market, the director of Gutmann France Sarl, Mr Paul Schmitt, emphasised that only 10% of the total transport of wind turbines are transported by inland vessels and the remaining 90% by trucks via road transport.

This results from several factors:

- The cost factor: it is often lower for road transport as it does not involve transshipment costs and storage costs. The cost of transport is always assessed on a case-by-case basis, and such costs can play in favour of inland vessels when space on board is optimised, but it cannot always be the case.

- Bridges on inland waterways can have a strong impact on the transport capacities of inland vessels.
- Flexibility and adaptability: road transport is considered more flexible compared to inland waterway transport.
- Availability of road infrastructure to exit the port: when transported by inland vessel to a port close to the windmill park, the last mile needs to be done by road transport. As blades are becoming longer and longer by up to 85 metres, ports lack the necessary infrastructure for heavy duty vehicles to be capable of driving out of the port area. The availability of road infrastructure from and to the port is an important obstacle. Such infrastructure should be developed to increase the modal share of IWT in this segment.
- Technical aspects: it is not always technically possible to accommodate for the transport of wind turbine on an inland vessel. However, this is also true for road transport.

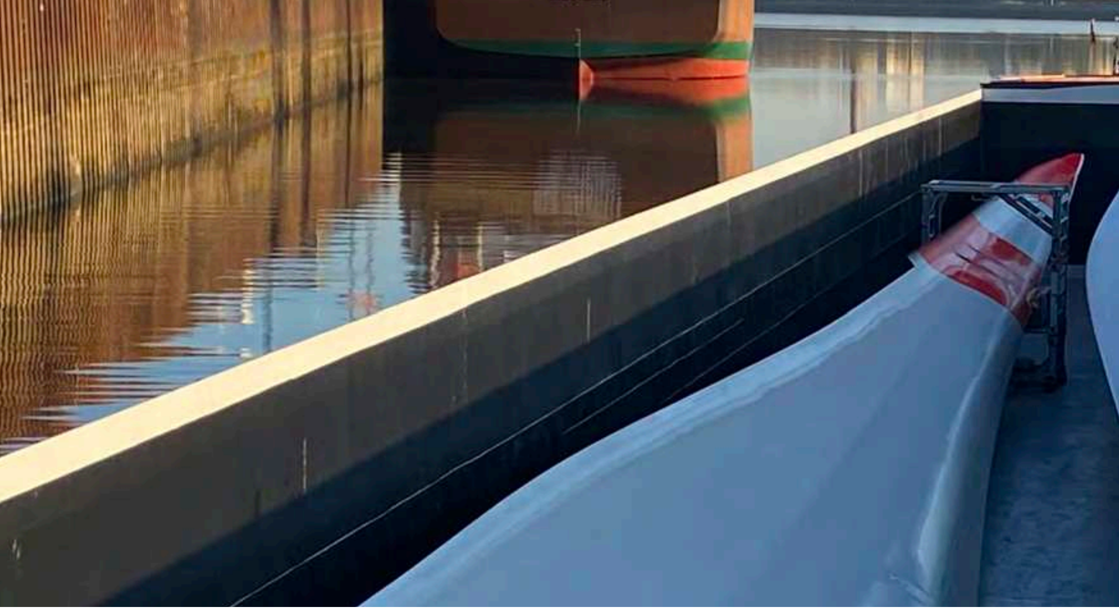
There are also several opportunities for transport of wind turbines on inland vessels:

- Economies of scale exist when the space on board is optimised. Such optimisation exists in particular when wind turbines are transshipped from a maritime vessel to an inland vessel. Indeed, all the components necessary to build entire wind turbines can generally be carried by maritime vessels and then transshipped on board of inland vessels, thereby avoiding storage costs and creating economies of scale.
- The fact that windmills are produced less and less in Europe and more often imported from countries such as Brazil, China, Vietnam or Poland, is an opportunity for inland waterway transport since the initial leg of the transport chain takes place on a maritime vessel.

According to the interviewer, there is untapped potential for transport of wind turbines by inland vessels. At the level of Gutmann, he sees the modal share of wind turbine transport on waterways possibly increasing to 20% compared to the 10% at present. He also sees potential for IWT in the development of new logistics concepts.

Nevertheless, according to Paul Schmitt, the market for transport of wind turbines is also very evolutive. Despite the observed decrease in investments in the last three years in particular, this market is expected to follow a positive evolution in the coming years, both in France and Germany, particularly driven by the ambitious public policy objectives with regard to the development of renewable energies and their role in the energy mix. In Germany, the 2021 Renewable Energy Act notably plans to increase solar, biomass, onshore and offshore wind capacity, to reach higher expansion goals and to raise public acceptance of their expansion. In France, the development of wind energy is more recent than in Germany and important capacities are still available, leaving further room for the development of wind energy. According to Paul Schmitt, France lags 15 years behind compared to Germany. However, there is hope for a brighter increase in this sector.

Source: Photo © Port Rhénan Colmar Neuf-Brisach, 2021



ii. Viewpoint of an inland vessel owner-operator

Interview with owner of MS CATHARINA

The transport of wind turbine components represents a considerable part of the company activity. In order to be acknowledged by shippers in this market segment, respect for deadlines and punctuality is very important. Mr. Hohenbild confirms that trucks are the main competitors for inland vessels for the transportation of wind turbines, while railways play a minor role. The average length of the rotor blades is around 65 metres, and the weight 20 tonnes, so that by transporting two rotor blades, the total loaded weight is only 40 tonnes. The length and loading capacity of inland vessels are largely sufficient for transporting rotor blades.

When transporting engine houses, several units (each weighing 90-100 tonnes) are often transported in one batch (up to five engine houses), resulting in a total loaded weight of 500 tonnes. Given these limited loaded weights, low waters are not problematic for the transport of wind energy components. It can therefore be a profitable market segment for rivers such as the Elbe or Danube, where low waters are relatively frequent. The limited height of bridges,

Source: Photo © MS CATHARINA

on the other hand, can represent obstacles in some cases, although alternative routes are mostly feasible.

Mr. Hohenbild identifies the decrease in newbuilding activity of wind turbines in Germany as the main barrier for growth in the near future, mentioning as a main cause the paradigm shift from guaranteed state prices for wind electricity towards tender and auction procedures. This has resulted in a strong reduction of newbuilding activity (which is confirmed by figures in table 3) and even in a transfer of production capacities from Germany to other European countries such as Portugal or Turkey. According to his market experience and observations, several companies within the wind industry have gone bankrupt in the last three years or have shifted their production sites to other countries.

The growing opposition against the installation of wind turbines amongst parts of the German population is also a major drawback regarding the further growth in this sector. Each newbuilding project is endangered by long approval procedures.

TRANSPORT OF BIOMASS AND BIOFUELS ON INLAND VESSELS

STRUCTURE AND DEVELOPMENT

Biomass used as feedstock in the energy sector can be split into biomass with high ILUC[91] risk (food and feed crops) and biomass used for advanced biofuel or electricity production with low ILUC risk.[92] The high ILUC risk biomass includes mainly oil plants such as rapeseed or soybean, which need to be planted in the same way as any other agricultural product. Within this report, high ILUC risk biomass/biofuel will also be called first generation biomass and biofuel (1G), while low ILUC risk biomass and biofuel will be called advanced biomass/biofuel.

From biomass, all forms of energy can be generated – electricity, heat, fuel for transport (biodiesel, bioethanol, etc.). Rapeseed currently accounts for 80% of the raw materials from which biodiesel is produced.[93] Biodiesel is blended with conventional fossil diesel, according to national blending regulations. Trucks can also use pure biodiesel. For the production of bioethanol, wheat, rye, corn and sugar beet are the primary raw materials. Bioethanol substitutes fossil gasoline and is also blended with conventional gasoline. For these blends, technical upper limits exist ('blend wall'), due to technical vehicle standards.

[91] ILUC stands for indirect land use change, i.e. "[...] the extension of agriculture land into non-cropland, possibly including areas with high carbon stock such as forests, wetlands and peatlands." (RED II)

[92] Revision of the Renewable Energy Directive II, Annex IX Part A, available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN (last consulted on 11.2.2021).

[93] Source: www.biokraftstoffverband.de

In terms of the mass, rapeseed shred used as animal fodder accounts for 60% of the total output of a biomass-biofuel transition, while biodiesel and glycerin account for 40%.[94] Glycerin is a by-product of biodiesel, which is used for producing detergents, tooth paste and products for the pharmaceutical industry.

As the study of the International Renewable Energy Agency (IRENA) from November 2019 points out, "practical experience in transporting and storing ethanol and biodiesel is already abundant, as these commodities are traded globally, and in the main markets (Europe, the US, Latin America) storage and handling facilities are located near major ports."[95] This statement is confirmed by two case studies presented in this chapter of the present report, regarding biomass and biofuel logistics in the ports of Mannheim and Straubing.

According to the IRENA study, the production costs for 1G biofuels are largely determined by the costs of feedstock (e.g. rapeseed), which represent 70-90% of total production costs.[96] This high share makes 1G biofuel production vulnerable towards an increase in feedstock prices.

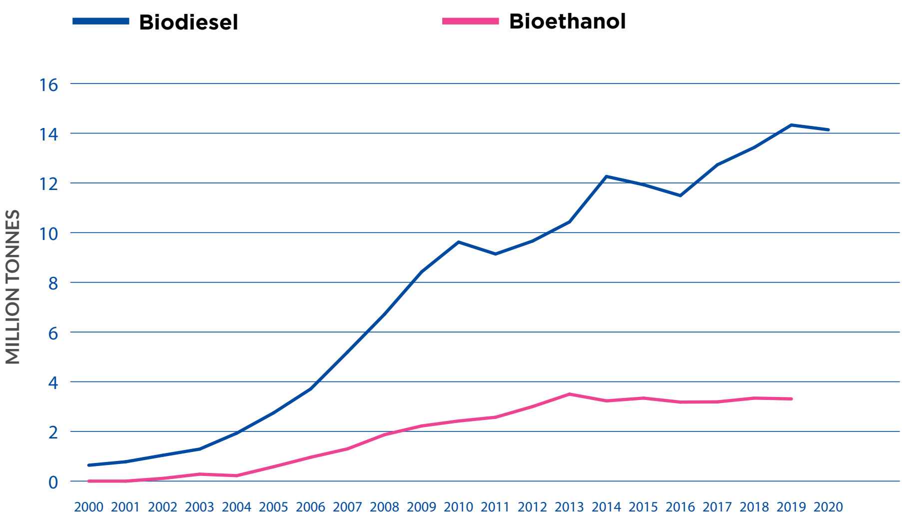
Advanced biofuels avoid any competition with food production: they are produced from lignocellulosic feedstocks such as corn stover, straw, agricultural residues, woody residues from forestry and wood processing industries (e.g. sawdust), oilseeds produced on marginal land that is unsuited for crop production, municipal solid waste and a variety of other industrial and commercial waste types.

[94] *Agentur für Erneuerbare Energien (2020), Renews kompakt – Klimaschutz im Verkehr mit Biokraftstoffen. To take the example of Germany: The country produced 1.8 million tonnes of biofuel in 2018, and as a by-product, 2.4 million tonnes of animal fodder.*
[95] *Source: IRENA (2019), Advanced biofuels, What holds them back?, International Renewable Energy Agency, Abu Dhabi, page 34*
[96] *Source: IRENA (2019), Advanced biofuels, What holds them back?, International Renewable Energy Agency, Abu Dhabi*

Apart from the sustainability concerns about 1G biofuels, another advantage of advanced biofuels is that they rely on far less expensive feedstocks such as agricultural residues, and different types of waste. Waste products are low-value products by nature. However, the quality of advanced feedstocks may be more variable than for 1G feedstocks, due to their waste-type nature.[97] As it is the case for 1G biofuel production, advanced biofuel production also generates coproducts with a commercial value - for example cellulose, which is used as feedstock in the paper industry.

Up until now, the commercial development of 1G and advanced biomass follows very different pathways. The production of biodiesel, based on 1G biomass, has followed a positive trend in the EU-27 during the last 15 years. The three countries with the highest production level in Europe are Germany, France and the Netherlands, which together had a share of 52% of all biodiesel production of the EU-27 in 2020 (see figure 5).

FIG. 5: **INDIGENOUS PRODUCTION OF LIQUID BIOFUELS IN THE EU-27** (MILLION TONNES)



Source: Eurostat [NRG_CB_RW]

[97] Source: IRENA (2019), Advanced biofuels, What holds them back?, International Renewable Energy Agency, Abu Dhabi, page 30

According to the International Energy Agency (IEA), a decrease of biodiesel production of 13.6% is estimated for 2020, due to the reduction of fuel demand during the Covid-19 pandemic. The rebound in diesel demand in 2021 should lead the volumes back to the 2019 level. For the time span 2023-2025, the IEA projects a production level for biodiesel and hydrotreated vegetable oil (HVO)[98] in the European Union that is 5% higher than the level in 2019, and 21% higher than the level in the Covid-19 crisis year 2020.

The European Union represents the region with the highest production level of biodiesel on a worldwide scale, in front of the US, Indonesia, Brazil and Argentina.[99] Data from IEA are in line with Eurostat data, by stating that France, Germany, the Netherlands and Spain are the most important biodiesel producing countries, accounting for two-thirds of EU production.

The growth process for biodiesel should not hide the fact that there have been several regulatory changes since 2005. In Germany, for example, biodiesel was exempted from taxation until 2006, in contrast to conventional fuels. This exemption was gradually removed until 2012, but 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 oil distribution and agribusiness companies.[100]

[98] Hydrotreated Vegetable Oils (HVO) are biofuels made by hydrocracking or hydrogenation of vegetable oil. Hydrocracking breaks big molecules into smaller ones using hydrogen while hydrogenation adds hydrogen to molecules. These methods can be used to create substitutes for gasoline, diesel, propane, kerosene and other chemical feedstock. Diesel fuel produced from these sources is known as green diesel or renewable diesel.
[99] International Energy Agency (2020), Renewables 2020 – Analysis and forecast to 2025
[100] IRENA (2019), p. 39

Soon afterwards, the EU Energy & Climate Package (ECP) of 2009 established a framework for EU member countries to set national renewable energy targets, leading to the enactment of the Renewable Energy Directive (RED, 2009/29/EC). The focus then turned to sustainability concerns and to the question, 'which renewable fuels are really sustainable?' Food versus fuel concerns became the main reason why 1G biofuels were considered only as a second-best solution and brought advanced biofuels onto the agenda.[101]

It is therefore important to note that the potential of biomass/biofuel transport on inland vessels is heavily dependent upon the public policy decisions at national and European level, which either encourage or limit their development. For instance, the European Renewable Energy Directive II fixes the target according to which renewable energies should reach a share of 32% within 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 by 2030 as renewable energy. 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 7% of the final consumption of energy in the road and rail transport sectors in each member state, and allowing therefore only for a slight increase in their production levels. The share of first-generation biofuels cannot exceed 7% by 2030 while the share of advanced biofuels shall be at least 3.5% in 2030. In the proposal to revise this directive, which was presented in July 2021 by the European Commission within the 'Fit for 55 Package', the use of such 1G biofuels is being discouraged. While this proposal still has to undergo the EU legislative process, non-negligeable impacts on the biofuel sector are expected. This will consequently affect the potential for 1G biomass/biofuel production and transport by inland vessels. This is only one example of how public policy affects the development of biofuels, but other examples of this kind exist.

[101] *IRENA (2019), p. 39*

Given the fact that further growth of 1G biofuel is discouraged, it could be the aim to develop advanced biofuels as soon as possible, and to unchain the growth process for these fuels. However, any kind of rapid growth of advanced biofuels and related production capacities have not materialised so far.

Cellulosic ethanol production has developed very slowly and was accompanied by many failures, both technically and commercially, in the US as well as in Europe. By 2018, on a worldwide scale, only 12 refineries produced cellulosic ethanol at commercial level, and with very modest production volumes. Five of them were found in Europe, two in Brazil, three in China, and two in the US. Most of them can be categorised as demonstration projects.

The main reasons for this situation can be summarised as follows:[102]

- Regulatory and political uncertainties and related high risks: Biofuel markets are heavily influenced by politics, regulations, interest groups, and public opinions. Long-term investments, however, require rather stable framework conditions. It should be noted that a biorefinery takes five to ten years to develop. In addition to that, pre-project stages also have to be taken into account (business planning, feasibility analysis, engineering design, permissions regarding the contracting of feedstock, setting up supply chains, financing). Regulatory uncertainty can be very problematic for long-term projects and their financing, in particular for small start-up firms.
- High competition with conventional petro-fuels: With the technologies for advanced biofuels being immature, high learning costs and therefore high production costs must be taken into account by start-up firms. This does not make it easy to reach break-even points, and to outperform conventional petro-fuels, in particular in times when the oil price followed a downward trend, as was the case between 2011 and 2020.
- Lack of technological readiness/too high costs: In many cases, technical problems during the early production process of advanced biofuels can occur, in the start-up phase. Solutions can mostly be found, but they are so expensive that the production costs are becoming too high, resulting in a price level for the end product that the relevant market is not able to tolerate.

A prudent approach to be considered is that in the long run, advanced biofuels will be one element within the decarbonisation process of the transport sector, in parallel with electrification, but as an element which is more appropriate for heavy freight vehicles, ships and aviation which require high amounts of energy.

[102] *IRENA (2019)*

At the same time, regarding 1G fuels, their reliance upon food or feed crops represents a serious barrier for their further growth in the future.

Given the lack of large-scale deployment of advanced biofuels, relevant real-world examples for biomass logistics are mostly found among 1G biofuel cases. The case studies presented in this report show ports where IWT is integrated in biomass production and logistical chains. In two of three cases, the solid biomass or natural feedstock is rapeseed, which is transformed into rapeseed oil and rapeseed shred. In a further step, biodiesel is produced from rapeseed oil. In the third case, the feedstock used is wood waste, so that this third example could be considered as one that avoids any food-fuel competition (advanced biomass).

BIOMASS AND BIOFUEL WATERSIDE HANDLING IN THE RHINE REGION (PORT OF MANNHEIM)[103]

The Port of Mannheim is the third largest Rhine port in Germany. In the port area, an oil mill (Ölmühle Bunge) receives rapeseed mainly by ship from different regions in western Europe, 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 ship and trucks to customers (mineral oil companies, petrol stations, haulage companies). The nominal capacity of the production site of Mannheim is 120,000 tonnes of biofuel per year.[104]

Photo: Port of Mannheim © Axel Heiter Fotodesign

[103] *Interview with Ms Melanie von Castell, head of department of Port of Mannheim, held on 12 July 2021*
[104] *CCNR/EC Annual Market Observation Report 2018*

According to the Port of Mannheim, inland navigation offers several advantages within the biomass and biofuel logistics:[105]

- large capacities;
- high efficiency and reliability, no restrictions at the weekend;
- few accidents.

Data have been available since the year 2005 (biomass) and 2007 (biodiesel) respectively. For all forms of biomass, higher values were recorded in 2020 compared to 2005/2007 and also when comparing the data with 2010. However, rapeseed and rapeseed shred showed high fluctuations, although this was partly caused by an accident in 2010 (fire in the oil press) (see figure 6).

For rapeseed oil, a more constant growth trend can be seen from the long-term time series. The biodiesel volumes developed again differently. Although they were much higher in 2020 than in the first year of data recording for biodiesel (2007), the trend has been less positive in the last years, and the value in 2020 was indeed lower than in 2010.

[105] *Interview with Ms Melanie von Castell*

TABLE 5: **WATERBORNE HANDLING OF BIOMASS AND BIODIESEL IN THE PORT OF MANNHEIM** (IN 1,000 TONNES)

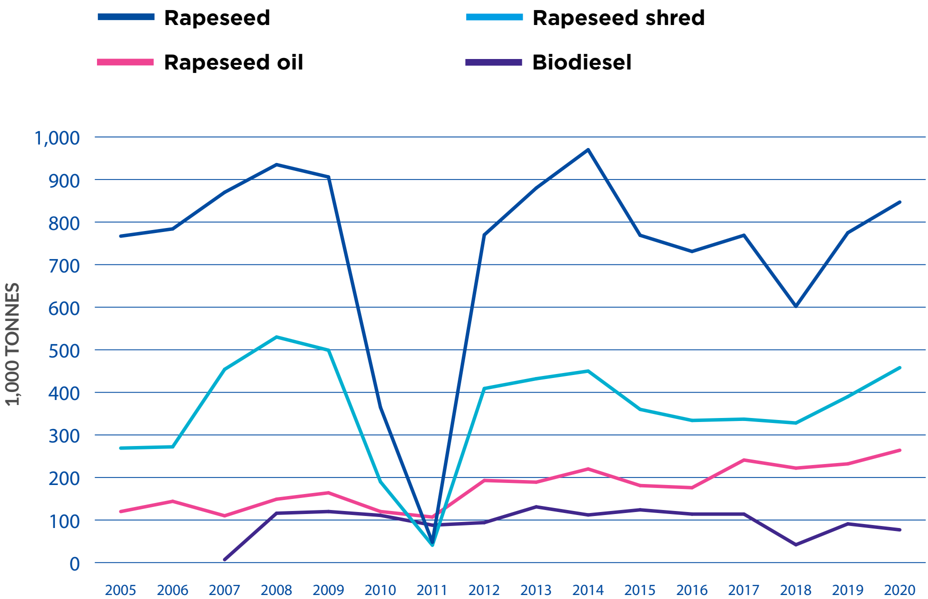
	Volumes				Growth factor	
Product	**2005**	**2010**	**2015**	**2020**	**2020/2010**	**2020/2005**
Rapeseed	767	365	769	847	2.3	1.1
Rapeseed shred	269	190	360	458	2.4	1.7
Rapeseed oil	119	120	181	264	2.1	2.2
TOTAL	**1,156**	**675**	**1,310**	**1,568**	**2.3**	**1.4**

	Volumes				Growth factor	
Product	**2007**	**2010**	**2015**	**2020**	**2020/2010**	**2020/2007**
Biodiesel	7	111	123	77	0.7	10.9

Source: Port of Mannheim

Figure 6 shows the data since 2005. The fire in the oil press in 2010 accounts for the strong drop in 2011. The share of rapeseed shred within the sum of rapeseed oil and rapeseed shred was 65% on average in the period from 2005 until 2020. This confirms approximately the share that is given in the literature about rapeseed and rapeseed oil manufacturing. The trend for rapeseed oil is upward orientated, while biodiesel follows a constant trend.

FIG. 6: **WATERBORNE HANDLING OF BIOMASS AND BIODIESEL IN THE PORT OF MANNHEIM** (1,000 TONNES)



Source: Port of Mannheim

Photo: Port of Mannheim © Axel Heiter Fotodesign

The following table shows key figures for the Port of Mannheim, including a comparison with the regional,[106] national and EU level with respect to inland waterway transport. The agri-food segment, of which rapeseed is a major part in Mannheim, has developed better than the average inland waterway transport between 2010 and 2020.

Waterside transport of rapeseed, rapeseed shred and rapeseed oil amounted to 1.57 million tonnes in Mannheim in 2020. These materials are counted as food products (NST 2007 group 04) and have a share of 78.4% in total waterside handling of agribulk and food products (NST 2007 groups 01 and 04 taken together) in the Port of Mannheim. Biodiesel is counted under chemical products (NST group 08).

NST 2007 product groups 01 and 04 registered a strong increase in the Port of Mannheim between 2010 and 2020, thanks to the positive evolution of rapeseed, its dominating core component.

TABLE 6: **DEVELOPMENT OF TOTAL IWT AND OF TRANSPORT OF AGRICULTURAL AND FOOD PRODUCTS IN THE EU, IN GERMANY, IN BADEN-WÜRTTEMBERG, AND IN THE PORT OF MANNHEIM BETWEEN 2010 AND 2020***

	Port of Mannheim	IWT in Baden-Württemberg	IWT in Germany	IWT in the EU
Comparison IWT volume 2020 vs 2010	-9.8%	-9.5%	-18.1%	-4.8%
Comparison transport volume of agricultural products, foodstuff and food products by IWT 2020 vs 2010	+78.0%	+44.1%	-14.3%	+10.4%
Share of agricultural products, foodstuff and food products within IWT volume in 2020	29.0%	10.9%	12.4%	12.0%
Modal split share IWT (actual)	n.d.	n.d.	8.0%	6.1%

Sources: Port of Mannheim, Landesamt für Statistik Baden-Württemberg, Eurostat [iww_go_atygo] and [tran_hv_frmod], CCNR analysis
** The figures in the table are based on transport volumes (tonnes)*
n.d. = no data available

[106] The regional level is represented by data for the Federal state of Baden-Württemberg of which the city and the Port of Mannheim are part.

BIOMASS AND BIOFUEL WATERSIDE HANDLING IN THE DANUBE REGION (PORT OF STRAUBING)[107]

Another example is the Danube Port of Straubing in Bavaria, the second largest Bavarian inland port after Regensburg. In Straubing, several companies active in the bioeconomy make use of inland waterways, in this particular case of the Danube.

Since its creation in 1996 the port has focused on agricultural products and biomass. Related raw materials and products represented 91% of all waterside handling in 2020. 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.

Source: Port of Straubing

[107] *Interview with port director Mr Andreas Löffert, held on 1 September 2021, and with Mr Rene van der Poel from the company ADM, held on 17 September 2021*

Within incoming logistics, raw materials – especially rapeseed and soybeans[108] - are transported on the Danube, coming mainly from Hungary, Austria and Serbia. In the Port of Straubing they are processed to rapeseed oil, soybean oil and meal.

With regard to outgoing logistics, the rapeseed oil is transported mainly by rail (tank wagons) to Mainz (where another manufacturing unit of ADM is located) and to other customers, in order to be processed to biofuel. The rapeseed meal is transported to different destinations in Germany, mainly to feed manufacturers. This transport is carried out partly by ship (50%) and partly by 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/ Switzerland. The background of this export is that Switzerland allows only soybean products without any genetical modification to be used in its country. As biomass products handled in the Port of Straubing fulfill this sustainability requirement, they can be exported to Switzerland.

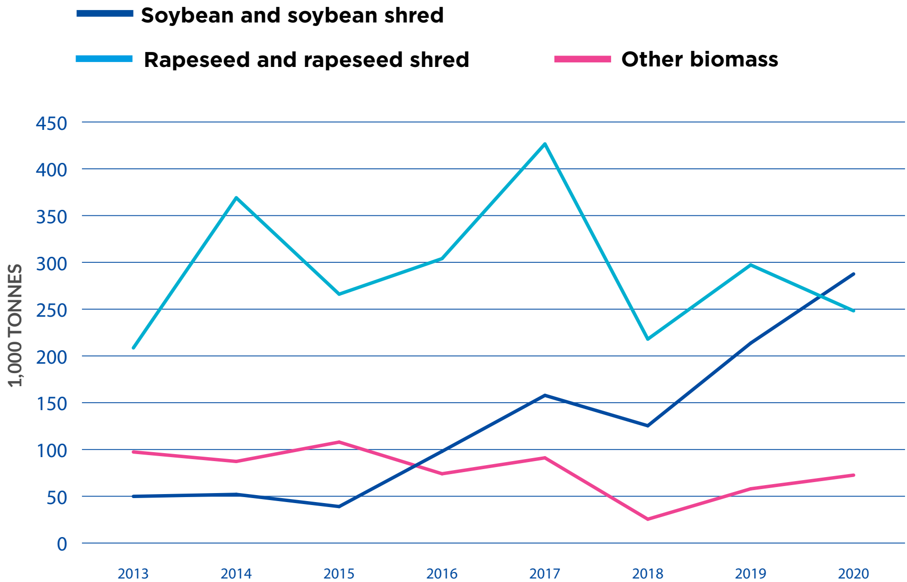
According to Mr Rene van der Poel, General Manager of the ADM company, low water levels on the Danube can cause significant additional transport costs for the agribusiness company. As a rule of thumb, each 10 cm reduction of the water level on the Danube near Straubing causes freight rates and freight costs to increase by 10%.

However, according to the port director, Mr Andreas Löffert, the infrastructure works that have started on the local Danube stretch in 2021, after several years of preparatory studies, and which aim to deepen the fairway depth, navigating conditions are expected to be much better in the future. From 2023 onwards, vessels coming from the Rhine-Main region will be able to reach the Port of Straubing with

[108] Both rapeseed and soybeans are not from genetically modified cultivation, according to the port's information.

a draught of 2.50 metres on 300 days per year. This represents a major breakthrough in terms of available draught and a more efficient connection of the port with the Rhine-Main and the ARA region.[109]

FIG. 7: **WATERBORNE HANDLING OF BIOMASS IN THE PORT OF STRAUBING*** (1,000 TONNES)



Source: Port of Straubing
** Other biomass = mainly grain*

According to the port director, Mr Andreas Löffert, the transshipment of dry biomass is carried out with the usual cranes and gripper arms that are present in most ports for dry cargo operations, so that additional infrastructure is not necessary.

[109] Regarding the infrastructure works on the Danube stretch around Straubing, see: https://www.lebensader-donau.de/das-gesamtprojekt/news/spatenstich-fuer-den-wasserstrassenausbau-arbeiten-in-der-bundeswasserstrasse-donau-beginnen/ (last consulted on 1 October 2021)

Source: Port of Straubing, Fotoatelier am Hafen – German Popp

Thanks to its orientation towards the bioeconomy, the port's overall figures of waterside handling have developed more positively than at regional (Bavaria), national (Germany) and international (EU) level. Overall IWT in Straubing increased by 9.2% between 2010 and 2020, compared to a decrease on the regional, national and international level. The example of the Port of Straubing shows that a rather high modal split share and an overall positive development of IWT figures can be created for IWT when it is integrated into biomass supply chains.

TABLE 7: **DEVELOPMENT OF TOTAL IWT AND OF TRANSPORT OF AGRICULTURAL AND FOOD PRODUCTS IN THE EU, IN GERMANY, IN BAVARIA, AND IN THE PORT OF STRAUBING BETWEEN 2010 AND 2020***

	Port of Straubing	IWT in Bavaria	IWT in Germany	IWT in the EU
Comparison IWT volume 2020 vs 2010	+9.2%	-14.2%	-18.1%	-4.8%
Comparison transport volume of agricultural products, foodstuff and food products by IWT 2020 vs 2010	+28.0%	-3.9%	-14.3%	+10.4%
Share of agricultural products, foodstuff and food products within IWT volume in 2020	91.2%	33.8%	12.4%	12.0%
Modal split share IWT (actual)	15.7%	n.d.	8.0%	6.1%

Source: Port of Straubing, Bayerisches Landesamt für Statistik, Eurostat [iww_go_atygo] and [tran_hv_frmod], CCNR analysis
** The figures in the table are based on transport volumes (tonnes)*

BIOMASS USED FOR ELECTRICITY GENERATION

Biomass is not only used for the transformation into liquid biofuels, but also for generating heat and electricity from solid biomass. This is often done in the form of combined heat and power generation. Raw materials often used for combustion are wood pellets/wood chips.

In Rhine countries in 2019, biomass (including solid biomass, liquid biofuel and biogas) accounted for 12% of electricity production in France, 8% in Germany, 5% in Belgium, 3% in the Netherlands and 1% in Luxembourg. Regarding Danube countries, we observe a constant growth of biomass in electricity production in Croatia, reaching a share of 7% in 2019. Hungary and Austria have both a share of 6%, Bulgaria 4% and Romania 1%. The share of biomass in Bulgaria is not impressive, but it is interesting that this share was below 1% until 2017, and it has since seen a sudden growth.

Installed capacity for producing electricity from biomass grew by one and a half times between 2010 and 2019. In general, all Rhine countries have increased their capacity, with the exception of Belgium, that has seen a decrease from 2010 to 2019. As the figures in table 8 also show, the growth rates of installed capacity have been reduced in the decade from 2010 to 2019, compared to the decade from 2000 to 2010.

TABLE 8: **INSTALLED NET CAPACITY** (MEGAWATT) **FOR PRODUCING ELECTRICITY FROM BIOMASS* – RHINE COUNTRIES**

	Installed MegaWatt in year			Growth factor	
	2000	2010	2019	2019 vs 2010	2010 vs 2000
Germany	474	5,460	8,904	1.6	11.5
France	216	524	1,374	2.6	2.4
Belgium	67	889	781	0.9	13.3
Netherlands	93	375	431	2.0	5.0
Luxembourg	0	9	47	5.1	n.d.
TOTAL	850	7,257	11,537	1.6	8.5

Source: Eurostat [NRG_INF_EPCRW]
** Biomass includes solid biofuels, pure biogasoline, pure biodiesels, other liquid biofuels, and biogases.*

Data for Danube countries tell a different story. From 2010 to 2019, there was an overall decrease in installed net capacity for producing electricity from biomass. In particular, Austria halved its capacity in that time period. The exception is Croatia, which increased it by more than ten times in this timespan. Overall, it can be concluded that the potential of biomass is still not made use of in Danube countries.

TABLE 9: **INSTALLED NET CAPACITY** (MEGAWATT) **FOR PRODUCING ELECTRICITY FROM BIOMASS* – DANUBE COUNTRIES**

	Installed MegaWatt in year			Growth factor	
	2000	2010	2019	2019 vs 2010	2010 vs 2000
Austria	804	1,933	978	0.5	2.4
Hungary	6	493	453	0.9	82.2
Slovakia	0	178	220	1.2	n.d.
Romania	251	20	139	6.9	0.1
Croatia	0	9	127	13.4	n.d.
Bulgaria	52	10	57	5.7	0.2
Serbia	0	0	24	n.d.	n.d.
TOTAL	1,206	3,018	2,428	0.8	2.5

Source: Eurostat [NRG_INF_EPCRW]
** Biomass includes solid biofuels, pure biogasoline, pure biodiesels, other liquid biofuels, and biogases.*

Gentse Warmte Centrale (Ghent, Belgium)[110]

A good example of a project where biomass is used for producing electricity is the 'Gentse Warmte Central' (a combined heat and electricity biomass power plant) of the Belgian Eco Energy (BEE) company. The project started its construction phase in January 2020 and aims to produce green energy (heat and electricity) using wood waste that cannot otherwise be recycled. The wood waste comes from the demolition of old houses and from businesses.

The volumes of feedstock (wood residues) transformed on an annual basis amount to 160,000 tonnes. The plant is located in the North Sea Port area in Ghent. This location will allow the predominant use of inland vessels to transport the materials to the power plant. The use of inland vessels for at least 75% of the 160,000 tonnes of wood waste is foreseen according to company information. 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.

[110] *https://www.bee.eu/en/projects/warmte-centrale-gent and company information by e-mail, 23 November 2021*

TRANSPORT OF HYDROGEN ON INLAND VESSELS

INTRODUCTION

Today hydrogen use is dominated by industry, namely oil refining, ammonia production, methanol production and steel production. It can also be used in the transport sector, as a 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 that there is significant potential for emission reduction.[111]

Due to its limited availability in its natural state, hydrogen must be produced on an industrial scale to be used, for instance, as an alternative fuel. Currently, there is much research on how the electrolysis process, which is needed to split hydrogen from 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 requirements for the transport of hydrogen need to be respected as it is considered to be a dangerous good according to ADN regulation.

When transported as compressed gas, standards such as the pressure of up to 350 bars or 700 bars need to be respected. The hydrogen tanks inside the vessel need to withstand this pressure. The high volume and space that is needed for this kind of transport is a significant hurdle for its commercialisation.

[111] *International Energy Agency (2019), The future of hydrogen: https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf*

When in liquid form, temperatures as low as – 253°C need to be created. The higher weight of liquefied hydrogen due to a higher density per cubic metre is another aspect that needs to be taken into account.

Finally, when transported in liquid form under the liquid organic hydrogen carrier (LOHC)[112] technology, hydrogen is loaded on a fluid which can be transported in double hulled tanker vessels. LOHC absorbs hydrogen and releases it through chemical reactions. Advantages of this kind of transport lie in the safety, use of existing vessels and above all the high energy density in the liquid case. Furthermore, the amount carried amounts to 17 million kg H_2 in a tanker vessel. To indicate a better understanding of this vast amount: a 35-wagon railway could carry up to 50 thousand kg H_2 whereas a truck would carry 1.5 thousand kg H_2.

The most advanced processes for the production of hydrogen are reforming from fossil sources and water electrolysis. The second option (so-called 'green hydrogen') is more favourable from a climate neutrality perspective, in particular when the electricity that is used for the electrolysis is of renewable origin.

There are two main possibilities of using hydrogen for the propulsion of vehicles: the use of a fuel cell and the direct combustion of hydrogen in an internal combustion engine. In a future hydrogen economy, vessels propelled by hydrogen could transport hydrogen using the LOHC technology.

With regard to the development of hydrogen, it can be seen that recent public policy pushes for the development of hydrogen, such as the 'Hydrogen strategy' presented by the European Commission in 2020.[113] Within the framework of the European Green Deal, hydrogen has also been singled out as central for addressing the reduction of greenhouse gas emission, preparing a climate-neutral

[112] *Interview with Hydrogenious, held on 17 March 2021*
[113] *https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf*

economy and for evolving energy systems 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. Named examples are the French 'plan de déploiement de l'hydrogène', foreseeing funding opportunities for the deployment of green hydrogen[114] or the German 'Nationale Wasserstoffstrategie'[115]. Green hydrogen programmes are also expected to raise renewable capacity, although investors could also use existing wind, solar PV and hydropower plants for hydrogen production.

As regards demand, it is interesting to note that demand for hydrogen has been increasing since 1975 and continues to rise. Today, clean, widespread use of hydrogen in global energy transitions faces several challenges, in particular, its cost of production from low-carbon energy, which remains very high. The fact that it is currently mainly produced from natural gas and coal, means that its production is responsible - under current conditions - for important GHG emissions. The slow development of hydrogen infrastructure is an important challenge.[116] Regarding the production costs, the International Energy Agency (IEA) estimated that the cost of producing hydrogen from renewable electricity could fall by 30% by 2030 as a result of declining costs of renewables and the scaling up of hydrogen production. Among the recommendations from the IEA to support the deployment of hydrogen, one of these relates to the expansion of hydrogen in transport through fleets.

Nevertheless, the momentum towards the development of clean hydrogen is high and production of clean hydrogen, as well as the demand for clean hydrogen, is expected to rise. Transport solutions for clean hydrogen will be needed, hence representing possibly a new transport opportunity 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.

[114] *https://www.ecologie.gouv.fr/sites/default/files/Plan_deploiement_hydrogene.pdf*
[115] *https://www.bmwi.de/Redaktion/DE/Publikationen/Energie/die-nationale-wasserstoffstrategie.pdf?__blob=publicationFile&v=20*
[116] *International Energy Agency (2019), The future of hydrogen*

TRANSPORT OF HYDROGEN ON INLAND VESSELS

Hydrogen as a cargo could be transported by pipelines in gaseous form or by ships in liquid form.

Green hydrogen – as mentioned earlier - is emission-free because it is generated by using renewable or low-carbon energies to split water via electrolysis and it is storable in the long term. This makes it a useful resource to decarbonise the industries and reach the emission targets at European level. The production of green hydrogen requires a high amount of green electricity that can be generated from several sources (wind, photovoltaics, hydropower).

In order to create a positive case for the transport of hydrogen on inland vessel, good access to maritime and inland waterways and ports from the green hydrogen production site is an important element. Large areas for producing green electricity (wind onshore, photovoltaics and biomass), should also be available.

Given the strong political aim in the European Union to develop green hydrogen technologies, there is momentum to support pilot projects promoting strategic value chains, such as creating a pan-European supply chain along main European corridors. Such projects are currently ongoing and important insights can be gained from them.

For instance, the most suitable form for storing and transporting hydrogen on inland vessels has to be identified, with the use of LOHC (liquid organic hydrogen carrier) technology, ammonia, liquid hydrogen or compressed gaseous hydrogen all providing different advantages and drawbacks. In order for transport of hydrogen on inland vessels to develop, the solution should be cost-efficient and easy to implement.

In light of the anticipated future needs in terms of transport of hydrogen, some inland shipping companies are already investing in a fleet adapted for the transport of green hydrogen, this is for instance the case of Chemgas Shipping BV.[117]

[117] *Binnenschifffahrt 11/21, Chemgas plant Flotte für die Wasserstoff-Transporte auf der Donau*

05

LESSONS LEARNT, OPPORTUNITIES AND OBSTACLES

CONSIDERATIONS REGARDING URBAN WATERWAY TRANSPORT

Potentials

IWT offers potential for urban logistics as shown by the number of existing projects and those under development. Several projects are operational, showing that inland waterway transport in urban areas can be an economically viable activity under specific circumstances, despite the competitive pressure from road transport. Wiegmans and Konings (2016) had already shed light on the potential of IWT in urban contexts.[118] Of course, one of the main pre-conditions for IWT to be considered as part of the urban logistics/passenger transport chain is the location of the waterway, which must be close/flowing through urban centres. This might be the case in most cities, but not in all.

It seems that specific market segments are suitable for IWW transport in cities, namely, transport of passengers (touristic and commuting activities), parcels, building material, food and retail products as well as waste.[119] France, Belgium and the Netherlands appear as the countries where urban transport using waterways has developed the most. Another interesting element is that such transport solutions seem to be viable in very large cities (as shown by projects in Paris or Amsterdam) but also in medium-size cities such as Lyon or Lille. An advantage of inland navigation is that it can transport such goods in different forms (pallets, bulk, barrels, containers).

The fact that IWT enables the reduction of congestion on roads as well as other negative externalities, in particular accidents, thereby addressing safety and environmental challenges, are without doubt essential factors for a potential scale-up.

[118] *Bart Wiegmans and Rob Konings, 2016, Inland Waterway Transport, Challenges and Prospects*
[119] *For the waste related aspects, see chapter 4 on circular economy*

Combining low emission inland vessels – for example fully electric or vessels with hybrid propulsion - with an environmentally friendly last-mile transport mode (e.g. bicycles or electric trucks) creates an efficient, clean, and sustainable urban transport system. Several projects already in operation demonstrate that this can be possible.

Other technological developments, in particular automation and digitalisation, could also play in favour of IWT in urban centres, in particular from a cost perspective (reduced labour costs when sailing during transshipment).

Public policy plays an important role for the development of IWT in urban centres. For instance, with regard to the transport of building material, IWT can be encouraged by integrating specific clauses in government tenders relating to the construction of important public projects as is the case with the Grand Paris Express project. Similarly, some European cities are restricting access to specific areas for heavy-duty vehicles through low-emission zones which can be a lever for the development of IWT.

However, there are remaining obstacles to be overcome to allow the full potential to unfold. The following paragraphs aim to shed light on these aspects. Obstacles range from regulatory barriers up to a traditionally biased mindset of stakeholders without excluding stricto sensu economic factors.

Obstacle 1: Regulation and administrative costs

Regulation tends to lag behind innovative solutions. An example lies within the autonomous sailing on waterways in city centres. No regulation has yet given the green light even on trials on public waterways without at least one skipper onboard. In Belgium, a decree was passed in 2019 that can give temporary exemptions in testing innovative solutions in this regard.[120]

Competences and processes for permission often go hand in hand with immense administrative costs and time. As start-ups might not have those capacities in terms of time and human resources, promising projects might be slowed down or even halted. For this issue, the platform Interlud in France helps to consult and harmonise agreements between various stakeholders and institutions from cities to agglomerations or counties.

Vessels face costs for docking stations, ports' admissions and other permissions for navigation from which road transport is mainly relieved. Hence, regulations in this regard are not favourable to IWT compared to road transport, and thus do not provide equal opportunities for the different modes of transports.

[120] *De Vlaamse Waterweg, 2019, available at: https://www.vlaamsewaterweg.be/smart-shipping-english-version (last consulted on 26.11.2021)*

Obstacle 2: Economic viability

The economic viability of urban freight transport is difficult to assess in a global or even quantitative way, as each project is embedded in its own market environment and has its own specific conditions, operational areas, vessel capacities, turnaround times, competitors and other framework conditions.

It can be observed that many pilot projects or even projects that are already in operation received public subsidies, in particular in the event of investing in a vessel with better emission performance (i.e. in the case of urban transport, generally operating with batteries). It will 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.

In general, it is observed that many existing and economically viable projects are operating with personnel. However, when it comes to pilot and research projects, stakeholder interviews often revealed the aim of developing urban freight projects with no personnel onboard (automation). As a reason, high staff costs were put forward.

However, automation still requires in certain cases some kind of human interaction in the sense of loading, unloading or monitoring and remote control. Apart from that, automation creates challenges on the technological level for ship design and ship technology, challenges which are currently difficult to overcome. The economic viability of such projects can be out of reach if research and development costs cannot be lowered in the near future.

Automised vessels need to be developed, designed and tested in towing tanks and in natural test areas. The technology required for autonomous sailing is ambitious and requires high costs in research and development. The uncertainty of achieving a positive return on investment after a number of years of successful operation might deter many actors from such a project right from the start.

Obstacle 3: Competition for space with other economic sectors in cities

The continuous demand for space that comes from the housing market in particular defines another barrier for inland navigation in an urban setting. Within this competitive setting, it is often the case that not enough space can be granted for logistical purposes.

In cities, competition exists also between tourism and logistics. Indeed, transport infrastructure needs to integrate well in the urban landscape. A significant example can be seen in Lyon, where the development of city logistics on the Saône is hampered, as platforms for loading and unloading of freight in the heart of the historical city centre of Lyon would probably not be well seen. On the Rhône, quaysides and logistics infrastructure are often hidden under bridges, which support their development. Another example is Strasbourg, where pioneer companies, willing to develop inland waterway transport solutions in the city center are criticised for placing an industrial set-up in one of the most visited areas and thus ‘reducing’ the beauty of the sight itself.

To address this, it is important 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.

Obstacle 4: Road transport culture in logistics and lack of knowledge about IWT

Another obstacle that emerged on many occasions during the interviews relates to a cultural preference for road transport. 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.

CONSIDERATIONS REGARDING CIRCULAR ECONOMY AND WASTE TRANSPORT

Potentials

Demographic growth, in combination with saturated road infrastructure and high emissions and other negative external effects provoked by road transport in cities, are important factors which offer great potential for inland waterway transport of waste in urban agglomerations.

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.

Inland ports are also ideal locations for the development of circular economy activities, which is certainly an opportunity for the transport of products resulting from circular economy activities by inland vessels.

Obstacles

Obstacles identified are merely identical to those obstacles put forward for urban freight transport (see 5.1). Because of the specificity of this type of cargo, there might be a reluctance to allow for waste handling in city centres.

CONSIDERATIONS REGARDING TRANSPORT OF CARGO FLOWS TRIGGERED BY THE ENERGY TRANSITION

The growing pressure to extend capacities for renewable energies at the expense of fossil fuels presents a potential market in which inland waterway transport can be advantageous. The research carried out within this report by means of face-to-face semi-structured interviews and analysis of available data focused on the transport of wind turbines, biomass, biofuel and hydrogen. The results of this qualitative-quantitative analysis lead to different considerations for the three sectors considered.

TRANSPORT OF WIND TURBINES

Potentials

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

- No competition from rail, only from road;
- Inland vessels can cope with increasing size of the turbines;
- Fewer size restrictions or administrative barriers for inland vessels compared to road, and their capacity makes them suitable for this market.

A key success factor for IWT to be a preferred mode of transport over road, lies in the proximity of the wind turbines production site or the end site where the wind turbines are delivered to the inland port. Indeed, it is an essential element to limit transshipment costs.

Other trends, in particular the increased production of wind turbines outside Europe, acts in favour of IWT. This trend leads to more wind turbines being imported to Europe via maritime transport and seaports. Hence, IWT is becoming the logical follow-up mode of transport towards the hinterland in these cases.

The further potential of transporting components of wind turbines is of course intensively linked with the further development of the wind energy industry itself. In the last 20 years, a considerable growth in this sector has taken place, in particular in Germany. But the outlook is somehow less growth orientated, due to a certain saturation (scarcity of space for new turbines), social opposition against the further installation of new wind turbines, and a shift from subsidy to auction systems.

In this respect, the role of public policy, pushing or not for the development of this renewable energy, or pushing for the development of 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.

Obstacle 1: Need for adequate infrastructure, facilities and vessels

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 a modal shift to inland waterways.

In addition, the lack of adequate waterway infrastructure, and availability of road access from and to inland ports, is a barrier to the further development of IWT in this market.

Obstacle 2: Natural and social limits for further expansion of wind turbines

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 the available space for building wind parks is more or less saturated, further growth will then only depend on repowering of existing turbines. Repowering can create a high volume of investment (and transport of turbines) on its own, but this presupposes favourable and growth orientated regulations and schemes in wind energy policy.

Another limit lies in the social or public and political acceptance of this market. As observed, growing public opposition to wind turbines is prompting governments to be more cautious about further funding of the sector. 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 to decarbonise the energy and transport sector. It is therefore very likely that wind energy and wind 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 in particular to environmental and habitat protection in maritime waters. Technical challenges can also be observed (costly installation of cables and transport of electricity underwater, etc.)

Obstacle 3: Change in regulation of the wind energy market

Regulatory change can 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 has caused some wind energy companies to float into troubled waters and lead 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 any 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.

Obstacle 4: Road culture in logistics and lack of knowledge about IWT

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.

BIOMASS AND BIOFUEL TRANSPORT

Potentials

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 in its attractiveness. The advantages of inland waterway transport are linked to the reliability of this mode of transport, its safety and the possibility of transporting large quantities of mass cargo. In addition, unlike wind turbines, for which ports and waterways might need to adapt their infrastructure, cargo handling in inland ports does not need special adaptations of handling equipment.

It should also be mentioned that electricity and heat from biomass is independent from weather fluctuations, an important aspect when thinking of the fluctuations of wind and solar energy.

While dry cargo transport in general has tended to decline in the last years in German ports, the examples of the Port of Mannheim and the Port of Straubing show that biomass has enabled inland waterway transport and inland ports to grow within segments that embrace biomass, such as agricultural products and foodstuff. Furthermore, projections of bioenergy demand from 2018 to 2030 - made in the framework of the Interreg Energy Barge project[121] - suggest that the market still has untapped potential. Among the three types of biomass considered by this research project, the demand for bioheat should stay at constant levels in both the BAU and worst-case scenario, while in the best case there will be a surge in demand.

[121] *D 3.2.2 Transnational Scenarios for Biomass Demand in the Bioenergy Sector, http://www.interreg-danube.eu/uploads/media/approved_project_public/0001/22/c18f78683df4c2dfee7afd2b5a001576f2cedbe2.pdf*

Obstacle 1: Future regulation of biomass and biofuel of the first generation

We have seen that despite being a well-performing sector in different ports and in different regions, there is a concrete risk of stricter regulations on the production and use of biomass and biofuels of the first generation. This is something that is already being discussed at European and at national level and it should be taken into account when looking at future potentials for biomass. It is possible that advanced biomass will have better growth prospects in the future, as a competition with food production will hereby be avoided. The industry, more precisely Cargill in Ghent, has shown efforts in constructing a new plant for advanced biomass underlining the shift towards more sustainable feedstock.

Obstacle 2: Early phase of deployment of advanced biofuels

The deployment of advanced biomass and biofuels is currently still at a very early stage, and it can be expected that it will take considerable time until such a deployment is reached. 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. Regarding the supply chains for these advanced biofuels, it can be supposed that inland vessels will play a role, but there can be competition from other modes of transport such as rail or pipelines.

Obstacle 3: Uncertainty regarding the energy transition trajectory of our societies

Despite the comprehensible 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 success or failure. The energy transition trajectory which our societies will follow, and in particular the type of energy that will be used in the future, remains to some degree uncertain. This technological uncertainty can lead to a specific form of inertia. Why invest in new production processes for alternative technologies, when uncertainty remains regarding their future use and demand?

HYDROGEN TRANSPORT

Potentials

There is a growing interest at European level for hydrogen as a clean energy source. We have also seen how it can be transported in different forms and have observed that maritime vessels, inland vessels, pipelines and electricity as such are possible modes of transport.

In addition, applications of hydrogen are manifold (industrial sector, transport sector, power generation) and demand has been growing since 1975.

While it is today overwhelmingly produced from fossil fuels, hydrogen can be produced from renewables (i.e. electrolysis is carried out by using green energy). There is still a significant potential for emission reduction.

Last but not least, it is clear that both at European and national level, public policy is pushing for the development of hydrogen, with the adoption of hydrogen strategies.

These different factors make it a promising cargo for the future, since it is in its early stage of development.

Obstacle 1: Immature sector and high production costs

The fact that hydrogen is still in an early development phase is reflected by the lack of infrastructure for electrolysis on a large scale as well as by its very high production costs.

Obstacle 2: Competition with pipelines

A risk for IWT is that the transport infrastructure for hydrogen that needs to be built up, could be focused on pipelines rather than ships. Indeed, some technical hurdles still need to be overcome with regard to transporting hydrogen on inland vessels. Additionally, the cost factor might be the final decision maker. Lanphen (2019) assessed the costs of importing hydrogen to the Port of Rotterdam via different carriers and concluded that hydrogen via pipelines, i.e. in gaseous form, is less costly.[122]

[122] Stephanie Lanphen, 2019, Hydrogen Import Terminal, Providing insights in the cost of supply chain elements of various hydrogen carriers for the import of hydrogen, available at: https://repository.tudelft.nl/islandora/object/uuid%3Ad2429b05-1881-4e42-9bb3-ed604bc15255 (last consulted on 9.11.2021)


ALEXANDER GRIN

06

CONCLUSIONS

The detailed analysis of several different new markets revealed one common feature: new markets for IWT exist, with high potentials. But these markets do not fall into the hands of inland navigation similar to 'ripe fruits'. They are fraught with intermodal competition, commercial and technical challenges, risks and uncertainties to varying degrees. Some of these new markets might require clear deviations from the previous state-of-the-art model in terms of vessel technology (including automation), vessel design (how to integrate batteries or hydrogen tanks on board) and size of vessels, as well as logistical concepts.

The urban transport of freight, passengers and waste is an activity where inland navigation meets the need of society and governments to find solutions for existing and growing urban problems, in terms of saturation of road infrastructure, related negative externalities, and ecological problems in cities. The greater these problems become, the more inland navigation can position itself as an adequate solution. However, this presupposes a 'greening' of inland vessels themselves in order to meet the demands placed on new city logistics and in order to be 'credible'.

But even if a complete greening of vessels that are active in urban freight, passenger and waste transport has not yet been achieved, these new market activities are important for making experiences in city logistics, to find suitable logistical concepts, and to gain more understanding about the needs of the demand side in urban logistics (supermarkets, construction industry, parcel delivery, waste transport, etc.)

Apart from urban transport of freight, passengers and waste, the transport of alternative energies was identified as a new market. Within this field, three different submarkets (wind turbines, biomass/ biofuel, hydrogen) were analysed. A common feature is a rather high degree of risk coming from the regulatory and political sphere and from partly unknown transition pathways in the future.

The logistical activities in the energy sector represent a derived transport demand, dependent upon the generation of a certain type of energy in certain volumes per year, which itself depends upon political and regulatory incentives and technological developments. The food-fuel debate in the biomass/biofuel market is a good example of how market conditions can change over time.

While this is not in the scope of the report, it is worth mentioning that beyond the use of IWT as a transport mode for specific types of cargo in urban areas, new logistics and new usage concepts involving inland vessels could also emerge in the future. Such new concepts could further strengthen the use of inland vessels, notably in urban areas, and could also be considered as new opportunities for inland vessels. For instance, such new concepts could be self-unloading vessels with on-board handling equipment or shared barges (several users for the same barge). Similarly, new usage for barges could consist in logistical chains where the clients collect their goods directly from the barge (no last mile). For instance, the users would receive their parcels directly from the barge, which would require designing barges in such a way that receiving the public, withdrawals of parcels for individuals, shipping and returns management, preparation of orders, departure start of delivery rounds can be made on board. Barges could also be used as floating stocks. Goods, such as clothes, could be stored on barges in the immediate vicinity of sales areas and be made available at short notice in case of a peak in demand. All in all, it seems that the abovementioned urban transport of freight, passengers, alternative energies and waste represents a promising but, at the same time, challenging array of new opportunities, which should be conquered by inland navigation companies with the necessary help from public authorities, aiming to achieve more sustainable logistics in the future.

ANNEX 1
Further projects related to new markets and not mentioned in the main text

Urban passenger transport

Country	Market pillar	Project	Status	Source
Antwerp, Belgium	**Urban logistics passenger**	**DeWaterbus** – Bus service on Scheldt river connecting Antwerp with Hemiksem and Lillo. Launched in 2017 by the Port of Antwerp. Since 2021 the Flemish government (agency MDK) is running the service that uses 7 vessels.	Fully operating	https://www.dewaterbus.be/
Rotterdam, Netherlands	**Urban logistics passenger**	**Waterbus** - Extension of the public transport system connecting Rotterdam and the region.	Fully operating	https://www.waterbus.nl
Copenhagen, Denmark	**Urban logistics passenger**	**Movia (Danish public transport agency)** – 5 electric passenger vessels for public passenger transport in Copenhagen (ferry).	Pilot	https://www.damen.com/en/news/2018/07/damen_embarks_on_danish_full_electric_public_transport_project_for_arriva
Stavanger, Norway	**Urban logistics passenger**	**Urban Water Shuttle** – This ferry is a pilot project for passenger transport on waterways which would be fully electric and would come with auto-mooring terminal systems, allowing for quick passenger loading and immediate charging.	Pilot	https://maritimecleantech.no/project/urban-water-shuttle/

Urban freight and waste transport

Country	Market pillar	Project	Status	Source
Amsterdam, Netherlands	Urban logistics/ circular economy	**Plastic Whale** – Waste collection project. Plastic Whale is a social enterprise that was launched in 2014. Its boats, which are built entirely from canal plastic, fish out plastic waste from Amsterdam's canals. Current size of the Plastic Whale fleet: 10 vessels.	Fully operating	https://www.amsterdam.nl/en/news/new-plastic-whale-boat/
Leiden, Netherlands	Urban logistics/ circular economy	**City Barge Waste collection** – An electric push boat in combination with small barges collects company waste, transports it over urban waterways in Leiden and brings it to stations outside the city where it can be transformed/ recycled further.	Fully operating	https://citybarge.eu/en/2020/09/09/citybarge-video-bringing-back-the-boats-into-the-city-2/ Article «Afvalvervoer over Leidse grachten», in: Binnenvaartkrant, 16 february 2021
Amsterdam, Netherlands	Urban logistics/ construction	**Amsterdam Vaart!** – Shift logistics transport for construction sites from roads onto waterways. "37% less CO_2 emissions, 1,600 fewer truck trips in the city and a reduction of 19,700 trips outside the city" were achieved in the last two years. Construction logistics for over nine projects in and around the city.	Fully operating	https://amsterdamlogistics.nl/amsterdam-vaart-minder-uitstoot-en-congestie-in-de-stad/
Amsterdam, Netherlands	Urban logistics/ construction	**City Barging** – Innovative and sustainable solution for the transport of (building) materials. Close collaboration with Mokum Mariteam.	Fully operating	https://citybarging.nl/
Brussels, Belgium	Urban logistics/ construction	**Brussels Construction Consolidation Center** – Vessel with integrated crane. Decrease truck and heavy-duty vehicles in urban context. Decongestion by moving building material on the waterway.	Fully operating	https://bccc.brussels/fr/accueil/ https://www.youtube.com/watch?v=Fci1sxkYcug&t=15s
Amsterdam, Netherlands	Urban logistics/ different type of goods	**Mokum Mariteam** – Makes use of the canals of Amsterdam to deliver goods and services and remove waste. The company operates a fully electric vessel and has started performing three full sailing days for the partner Icova transporting waste containers.	Fully operating	https://mokummariteam.nl/ https://www.parool.nl/nieuws/proef-vuilnis-negen-straatjes-via-de-gracht-afgevoerd~-b611a9cb/
Ghent, Belgium	Urban logistics/ different type of goods	**Green Wave** – Emission free barge for urban transport. Constructed by The European Shipment Company (TESCO) BV, in collaboration with partners from the EU funded Interreg-project #Inland Waterway Transport Solutions 2.0 (#IWTS 2.0).	Fully operating	https://project-iwts20.eu/wp-content/uploads/2020/10/201030_CaseStudy_GreenWave.pdf
Kapellen, Belgium (also active in Paris, France)	Urban logistics/ different type of goods	**Blue line logistics ZULU** – Principle of the 'self-unloading' ship with a crane on board, Zulu Barge (300t load).	Fully operating	http://www.bluelinelogistics.eu/news; https://www.zulu-associates.com/

Country	Market pillar	Project	Status	Source
Willebroek, Belgium	Urban logistics/ different type of goods	**Watertruck+** – "Watertruck+" is a European project that introduces an innovative concept for the transport of goods on small waterways (CEMT I-IV) by using small, self-propelled or unpropelled, standardised barges, combined with environmentally friendly push boats.	Fully operating	https://watertruck-plus.eu/fr https://www.lydiapeeters.be/nieuws/3-miljoen-ton-goederen-minder-op-de-weg-dankzij-watertruck/
Vlaams Brabant, Belgium	Urban logistics/ waste recycling	**Afval Vlaams Brabant** – Household waste is collected from 2 intermunicipals (Ecowerf en Haviland) and transported via waterborne transport from 2 quays (Leuven/Vilvoorde) to the end destination in Antwerp (Indaver – specialised in waste management and solutions). On an annual basis, about 60,000T are transported by the Intercommunales involved via inland navigation. An equivalent of 8,000 trucks are taken off the Flemish roads in this way. At the beginning of 2021, a return shipment from Doel to Grimbergen of bottom ash was also set up. This volume amounts to 30,000T and in terms of truck equivalent this means 2,400 fewer trucks on the road.	Fully operating	https://www.ecowerf.be/over-ecowerf/wat-is-ecowerf (last consulted on 26.11.2021)
Bordeaux, France	Urban logistics/ food products	**La Garonne Fertile** – The "Garonne Fertile" is a food transport chain in the region of Bordeaux with different stakeholders, using the existing infrastructure of waterways to bring food products close to the city center. The pilot trip took place from Damazan to Bordeaux beginning of May 2021.	Pilot	https://www.garonnefertile.org/
Gothenburg, Sweden	Urban logistics/ waste recycling	**Recycling barge** – The project was tested as a pilot in 2019 and has since found fruitful grounds. A barge in five different berths along the Göte River serves people to dispose of bulky waste.	Pilot	https://dencity.se/berattelser/atervinningspra-men-ett-test-som-blev-verklighet https://dencity.se/index.php/transportlosningar/transport-pa-de-urbana-vat-ten vagarna
Amsterdam, Netherlands	Urban logistics	**Amsterdam Logistics Cityhub** – Ready in 2022. Multimodal and sustainable. Space for 1,680 covered parking spaces, 200 loading docks and a 180-metre private quay.	In progress	https://www.amsterdamlogisticcityhub.nl/en/the-site/

Renewable energies

Country	Market pillar	Project	Status	Source
Rotterdam, Netherlands	**Renewable energies, biodiesel**	**Biofuel Nord Ester in France** – The company Oleovia, belonging to the Nord Ester (Daudruy) group is specialised in the collection and recycling of edible oils for the production of biodiesel. Edible oils are transported on barges from Rotterdam to Dunkerque where the waste oils are recycled by methanisation. The produce is then used as fuel in road transport.	Fully operating	http://www.nord-ester.fr/

ANNEX 2
List of interview partners

Interview partner	Project/topic	Organisation	Role/function	Date of interview
Bas Joormann	Hydrogen transport in general	Lloyd's Register	Inland Waterway Product Manager	11/03/2021
Stephan van Dijk Debby Dröge Ynse Deinema	Roboat	AMS Institute	Director of Innovation Head of Communications Programme Developer	11/03/2021
Antoon Van Coillie	ZULU	Blue Line Logistics	Director	15/03/2021
Klaas van Staalduine	Hydrogen transport general	RH2INE Project	Programme Manager	15/03/2021
Thomas Brauner	AVATAR	Logistik Initiative Hamburg	Project Manager	16/03/2021
Cyril Alias Joachim Zöllner	DeConTrans	DST	Department Head Logitics and Transportation Project Coordinator	17/03/2021
Stefan Reif Rafael Schmidt	Hydrogenious	Hydrogenious LOHC technologies	Business Developer Head of Business Develop-ment	17/03/2021
Gilles Manuelle	Fludis	Fludis	President	22/03/2021
Prof. Dr. Gerd Holbach Klaus-Jürgen Lichtfuß	A-Swarm	Technical University of Berlin BEHALA port company	Professor and Head of Depart-ment of Design and Operation of Maritime Systems at Techni-cal University of Berlin Logistics Manager at BEHALA	23/03/2021
Lionel Rouillon	Urban river transport	VNF	Development Director	23/03/2021
Emilie Gravier	Urban river transport	Port of Strasbourg	Director of Port Development and Promotion	24/03/2021
Didier Baudry	Urban river transport	CEREMA	Managing Director Urban Logistics	24/03/2021
Céline Oppenhauser-Ohresser	Urban river transport	VNF	Head of Port Strategy and Prospective Studies	26/03/2021
Peter Geirnaert	AVATAR	IWTS 2.0	Consultant and Project Coordinator of Green Wave in Ghent	30/03/2021
Dr Tom Pauwels	AVATAR	POM East-Flanders	Project Coordinator	30/03/2021
Senne Van Baelen	AVATAR	KU Leuven	Engineer in Robotics, Automa-tion and Mechatronics (RAM)	30/03/2021
Ton van Meegen	Urban river transport	Port Liner	President	31/03/2021
Thomas Momber	River'Tri in Lyon	Voies navigables de France	Head of River Services VNF Lyon	01/04/2021
Ankie Janssen Maaike Dalhuisen	Hydrogen Transport	Port of Rotterdam	Programme Manager Alternative Fuels Advisor Business Strategy	13/04/2021
Emilie Mallet	Fludis, Franprix	HAROPA Ports Paris	Urban Logistics Project Manager	14/04/2021

Interview partner	Project/topic	Organisation	Role/function	Date of interview
Gilles Vandenborre	Urban logistics	De Vlaamse Waterweg	Responsible for Mobility and Land Management Deve-lopment Inland Shipping & Knowledge Centre Innovation	16/04/2021
Gunther Jaegers	Hydrogenious/ general information on hydrogen	Reederei Jaegers	Managing Director	22/04/2021
Philippe Boisdron	Urban river transport	UFMO	President	25/05/2021
Gerhard Gussmag	Transport of wind turbines	Rhenus Logistics	Managing Director Rhenus Donauhafen Krems	08/06/2021
Thomas Castan Nicolas Teinturier	ULS Strasbourg	ULS Strasbourg	President Development Manager	11/06/2021
Thomas Delvalle	Circular Economy	VNF Nord-Pas de Calais	Development Agency Manager	18/06/2021
Steve Labeylie Benoît Mugnier Pierre-Yves Girardet	Urban river transport	SOGESTRAN	Head of Institutional Relations Multimodal and Urban Logis-tics Business Line Director Assignment Manager	24/06/2021
Melanie von Castell	Biomass in the Port of Mannheim	Port of Mannheim	Head of Department	12/07/2021
Gerhard Wagner	Transport of wind turbines	Bolk transport	CEO and Co-Owner	03/08/2021
Frank Andreesen	Hydrogen and Circular Economy	Covestro	Vice President	06/08/2021
Klaus Hohenbild	Transport of wind turbines	Inland vessel MS Catharina	Barge Owner-Operator of the Inland Vessel MS CATHARINA	26/08/2021
Andreas Löffert	Biomass in the Port of Straubing	Port of Straubing	Managing Director	01/09/2021
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GLOSSARY

ARA REGION: Amsterdam-Rotterdam-Antwerp

AVAILABLE OR POSSIBLE DRAUGHT OF A VESSEL: minimum navigation channel depth + (actual water level – equivalent water level) – under-keel clearance

B2B: Business to business

B2C: Business to consumer

BN: Billion

CIRCULAR ECONOMY: according to Eurostat, a circular economy aims to maintain the value of products, materials and resources for as long as possible by returning them to the product cycle at the end of their use and while minimising the generation of waste.

CONSTANT PANEL: this means that for each year, the same stations per city were chosen. Within this panel, stations near the city centre are found, as well as stations on the outskirts of the city. This helps to create an average and a more representative emission value for a city, as the city centre has higher emissions due to more traffic than stations on the outskirts.

DANUBE COUNTRIES: Austria, Bulgaria, Croatia, Hungary, Romania, Serbia, Slovakia

DRAUGHT OF A VESSEL: distance between the vessel's keel and the waterline of the vessel

EFIP: European Federation of Inland Ports

EFW: Energy from waste

EU: European Union

EU ENERGY & CLIMATE PACKAGE (ECP) OF 2009: established a framework for EU member countries to set national renewable energy targets, leading to the enactment of the Renewable Energy Directive (RED, 2009/29/EC).

EUROPE: European inland navigation in this report includes two countries not belonging to the European Union, Switzerland and Serbia

EUROPEAN GREEN DEAL (EGD): a set of policy initiatives by the European Commission with the overarching aim of making the European Union (EU) climate neutral in 2050. An impact assessed plan will also be presented to increase the EU's greenhouse gas emission reductions target for 2030 to at least 50% and towards 55% compared with 1990 levels. The plan is to review each existing law on its climate merits, and also to introduce new legislation on the circular economy, building renovation, biodiversity, farming and innovation.

FIT FOR 55 PACKAGE: a package of legislative measures that will support Europe's climate policy framework and put the EU on track for a 55% reduction in carbon emissions by 2030, and net-zero emissions by 2050. The interconnected proposals cover areas of climate, land use, energy, transport and taxation, to bring them into line with the targets agreed in the European Climate Law.

FREIGHT RATE: price at which a cargo is delivered from one point to another

GDP: Gross Domestic Product (basic measure of the overall size of a country's economy)

HYDROTREATED VEGETABLE OILS (HVO): biofuels made by hydrocracking or hydrogenation of vegetable oil. Hydrocracking breaks big molecules into smaller ones using hydrogen while hydrogenation adds hydrogen to molecules. These methods can be used to create substitutes for gasoline, diesel, propane, kerosene and other chemical feedstock. Diesel fuel produced from these sources is known as green diesel or renewable diesel.

ILUC: this stands for indirect land use change, i.e. "[...] the extension of agriculture land into non-cropland, possibly including areas with high carbon stock such as forests, wetlands and peatlands." (RED II).

IPCEI: Important Project of Common European Interest

IWT: Inland Waterways Transport

IWW: Inland Waterways

LOHC: Liquid Organic Hydrogen Carrier

MIO: Million

MODAL SPLIT SHARE: the percentage of inland waterway freight transport performance (in TKM) within total land-based transport performance. Land-based freight transport modes include road, rail and inland waterways.

NEW MARKET (IN INLAND NAVIGATION): a branch where inland navigation transport solutions are either not yet present or in an early stage of development and could be considered in the coming years as a suitable transport solution.

NORTH SEA PORT: the name of the port formed by the cross-border merger between Zeeland Seaports (Flushing, Borsele and Terneuzen) in the Netherlands and Ghent Port Company in Belgium

RECYCLING CENTRES: refer to the place where waste is recycled.

RHINE COUNTRIES: Belgium, France, Germany, Luxembourg, the Netherlands, Switzerland

SYCTOM: a public service company which provides a public service for the treatment and collection of household waste for 85 municipalities in the Paris region in France.

URBAN LOGISTICS: according to Interreg Europe, urban logistics is a wide field, comprising both business-to-business (B2B) and business-to-customer (B2C) interactions, and involving a very large number of stakeholders and economic operators. It is essential for the operation of modern cities, delivering post and parcels, taking stock to retailers, collecting waste and refuse, transporting construction materials and machinery, and connecting value chains.

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INTERVIEW PARTNERS

A list of all interview partners can be found in Annex 2 of the report.

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Bundesministerium für Wirtschaft und Energie	German Ministry for Economic Affairs	Germany
Bundesministerium für Wirtschaft und Klimaschutz	Federal Ministry of Economics and Climate Protection	Germany
Bundesverband Windenergie	Federal Association for Wind Energy	Germany
CCNR/ZKR/CCR	Central Commission for the Navigation of the Rhine (CCNR)	Europe
CORY Group	CORY Group	UK
De Vlaamse Waterweg	Waterways in Flanders	Belgium
European Alternative Fuels Observatory (EAFO)	European Alternative Fuels Observatory (EAFO)	EU
European Commission	European Commission	EU
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EUROSTAT	EUROSTAT	EU
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Infineon Technologies, Veinland GmbH	Infineon Technologies, Veinland GmbH	Germany
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Lebensader Donau	Danube Lifeline	Germany
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Umweltbundesamt	German Environment Agency	Germany
Universität Rostock	University of Rostock	Germany
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