EU Strategy for the Danube Region

Priority Area 1a – To improve mobility and multimodality: Inland waterways

Strategy on fleet modernisation

Author(s):

Gert-Jan Muilerman (viadonau)

Version (date):

31/12/2019

EUROPEAN UNION
European Regional Development Fund

Bundesministerium
Verkehr, Innovation
und Technologie

viadonau

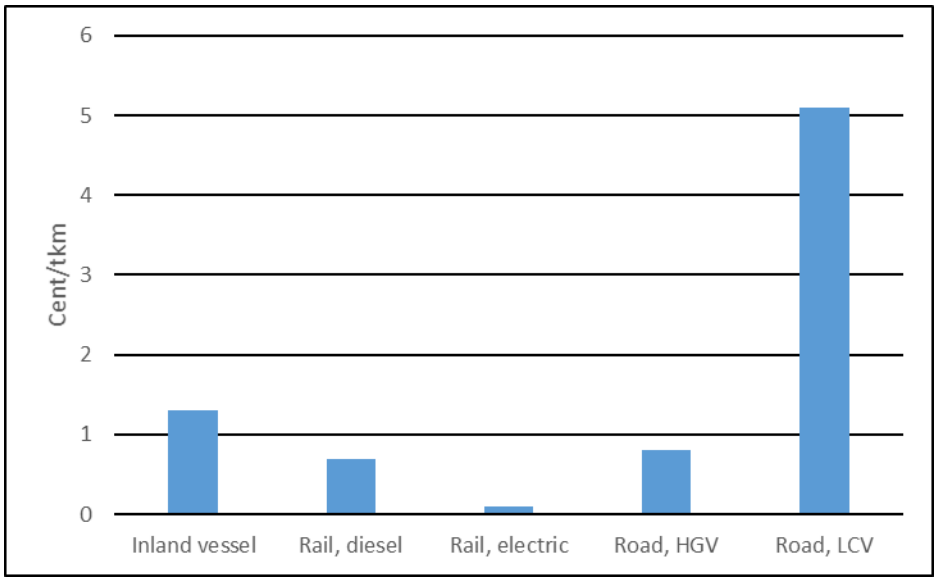
MINISTRY OF TRANSPORT,
INFRASTRUCTURE AND COMMUNICATIONS

Contents

1 Introduction

1.1 What's the problem?

Inland waterway transport has been the most environmentally friendly mode of inland transport for decades. However, this advantage has steadily been eroding due to the rapid improvement of emission levels in other transport modes and the low modernisation rate of the inland fleet.



Source: European Commission (2019), average relative external air pollution costs for freight transport for the EU28 in 2016[1] (HGV = heavy goods vehicle, LCV = light commercial vehicle)

Stricter emission regulations do not apply to the existing – the so-called legacy – fleet, and lacking these the traditional environmental and economic advantages of inland waterway transport are expected to further deteriorate in the future. This will lead to inland waterway transport losing its favourable position in comparison to road transport, resulting in reduced public support to use inland waterway transport.

The Danube inland fleet consists of about 3.500 units, which make up – compared to vessels operating on the Rhine waterway – a relatively old population. Only very few new-built vessels have been put in operation in the Danube region in the last 20 years and modernisation as well as greening measures have been implemented only to a limited extent. Some of the main drivers behind this specific problem are compulsory emission standards that are lagging behind compared to other modes, the lack of investment capital in the shipping sector, the long

[1] NH_3, NMVOC, SO_2, NO_x, $PM_{2,5}$, PM_{10}. The external costs include the ones of well-to-tank emissions which were approximated according to European Comission (2019), page 108 (well-to-tank GHG emissions 35 % and well-to-tank pollutant emissions 65 % of total well-to-tank emissions).

economic lifetime of inland vessels, as well as the small and specific market for inland vessels and their engines.

Considering these drivers, a consolidated policy is needed to facilitate and enable the transition of the conventional inland waterway fleet, and specifically the Danube inland fleet, towards an era of zero emission navigation. The need for action was all the more underlined by the recently published “European Green Deal” (COM(2019) 640).

1.2 Structure of the report

Based on a review of previous projects and analyses as well as consultations within the PA1a Working Group on Fleet Modernisation, this report shall summarise

- the state-of-play of the Danube fleet
- promising technologies to improve the status and performance of the Danube fleet
- the main drivers behind the relatively low modernisation rate of the inland fleet
- policy recommendations to overcome these drivers

In addition to the general policy recommendations that are presented at the end of this report, specific policy recommendations that are expected to be taken up by the PA1a Technical Secretariat as well as by the Steering Group members of EUSDR Priority Area 1a will be identified.

2 State-of-play of the Danube inland fleet

2.1 Size and structure of the Danube inland fleet

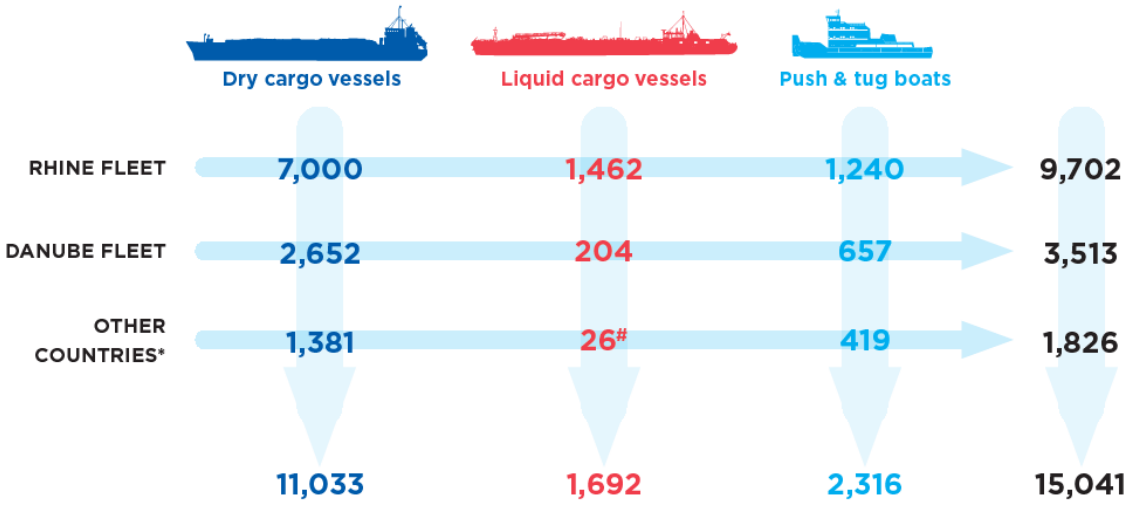
Basically, inland cargo vessels operating on the river Danube and its navigable tributaries can be divided into three types according to the combination of their propulsion systems and cargo holds:

- **Motor cargo vessels** (or self-propelled vessels) are equipped with a motor drive and cargo hold. Motor cargo vessels can be subdivided into dry cargo vessels, motor tankers, container and Ro-Ro vessels.
- **Pushed convoys** usually consist of a pusher (motorised vessel used for pushing) and one or more non-motorised pushed lighters or pushed barges. They are firmly attached to the pushing unit, and at least one unit is positioned in front of the pushing vehicle. A coupled formation means that a motor cargo vessel is used for propelling the formation or convoy instead of a pusher.
- **Tugs** are used to tow non-motorised vessel units, so-called barges. Towed convoys are rarely used on the Danube anymore because they are less cost-effective than pushed convoys.

The predominant form of cargo shipping on the Middle and Lower Danube is by means of formations (pushed convoys, coupled formations as well as pushed-coupled convoys). The majority of all transports are carried out by convoys and only a small share by individual motor cargo vessels. The situation of individual motor cargo vessels and convoys is more balanced on the Upper Danube. Individual motor cargo vessels are the principal form on the Rhine.

A pushed convoy comprising of one pusher and four non-motorised pushed lighters of the type Europe IIb, for example, can transport around 7,000 tons of goods – equivalent to the cargo carried by 280 trucks (with 25 net tons each) or 175 rail wagons (with 40 net tons each). Even more impressive is the transport capacity of a 9-unit convoy like those used on the Central and Lower Danube. A convoy of this kind can carry 15,750 tons of cargo and can therefore replace 630 trucks or 394 rail wagons (which is the equivalent of about 20 fully loaded block trains). Convoys comprising of up to 16 pushed lighters are possible on the lower reaches of the Danube due to the width of the waterway and the fact there are no limitations caused by locks.

The latest Market Observation Report by the CCNR (2019) contains an overview of the structure and size of the European inland fleet. The Danube fleet is about one-third the size of the Rhine fleet (see figure below).



Source: CCNR (2019), data on Danube fleet from Danube Commission

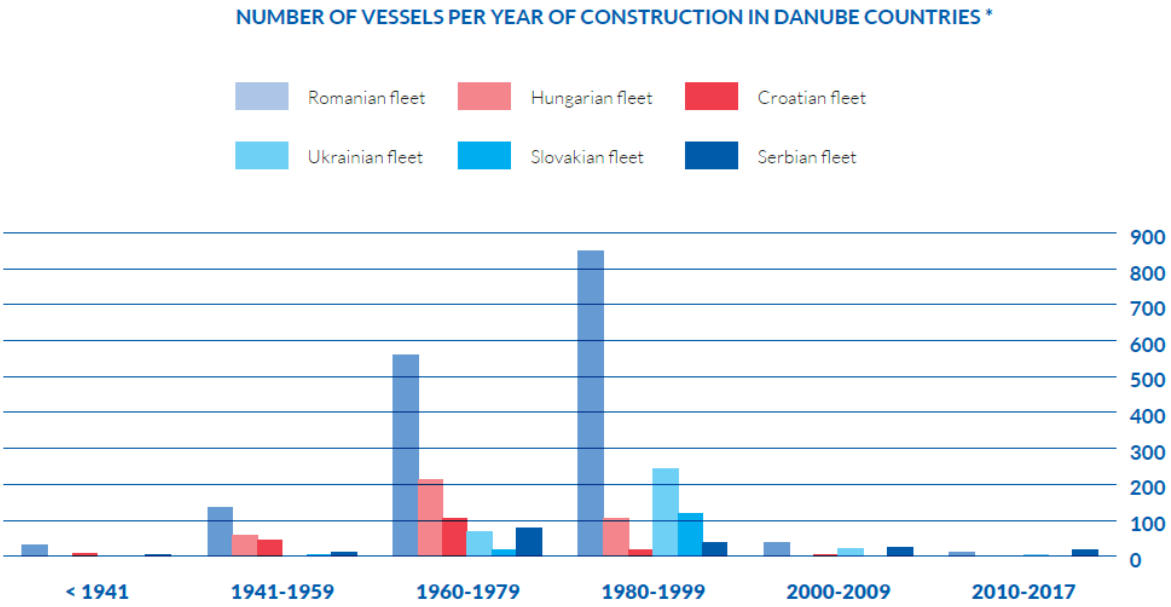
With a share of 19% (measured in number of units) and 87% (measured in loading capacity) the push boat is still relatively dominant on the Danube waterway (viadonau, 2019). The Romanian fleet thereby holds by far the largest share in the Danube inland fleet with almost 50% in terms of number of vessels and 54% in terms of loading capacity. In contrast to the shrinking fleet of for instance Hungary, Serbia and Slovakia, the Romanian fleet has also grown in the last years (GRENDEL, 2019).

2.2 Age structure of the Danube inland fleet

The Danube fleet contains a high number of vessels that were built between 1960 and 1990. A typical pushed convoy operating on the Danube was 20 years old on average in 2013 (viadonau, 2013). The pushed Danube convoys from Romania and especially the Ukraine are by far the youngest that are currently in operation.

62 percent of the Danube fleet was built between 1971 and 1990 (viadonau, 2019). The average age of all cargo units was 41 years in 2018. The picture for passenger vessels is completely different: In 2017, the average age of the 170 active cruising vessels on the Danube (capacity of 28,100 passengers) was 10 years, whereby around nine new vessels entered service every year over the last few years.

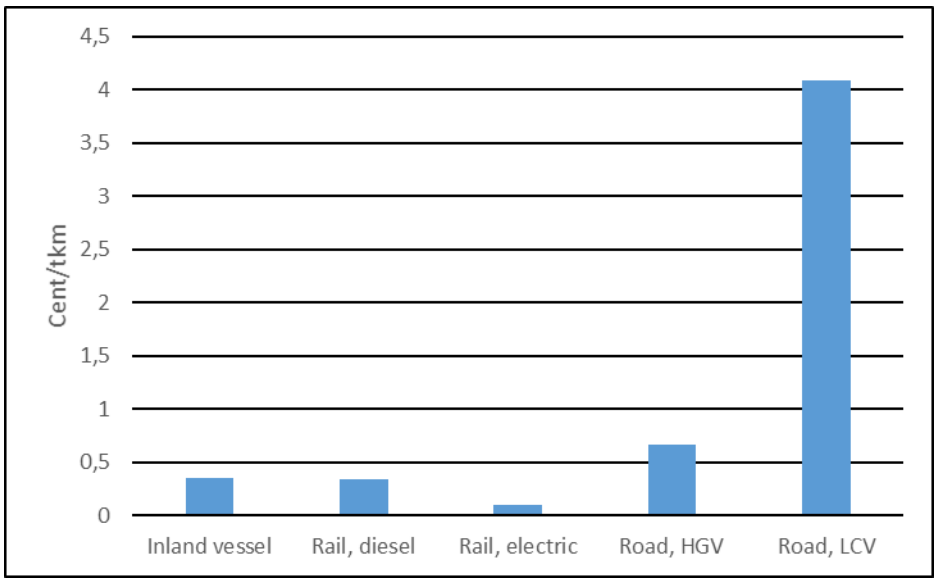
The average age of a ship's engine before its replacement is around 15 years or more. Compared to the average service life-time of truck engines, which is five to ten years, it becomes obvious that it will automatically take much longer to fulfil more stringent emission standards in inland navigation than in the road sector (viadonau, 2019).



Source: CCNR (2019), data from Danube Commission

2.3 Challenges for the Danube inland fleet

In comparison to a new engine in road haulage (Euro VI) limit values applied to conventional inland vessel engines (CCNR Stage II) are approximately 15 times higher as regards grammes NOx per kWh and 20 times higher as regards emission of PM. Although inland waterway transport has a much better fuel efficiency in terms of the amount of energy required to transport 1000 tons of goods, this gap in emission limit values leads to the conclusion that inland waterway transport is rapidly losing ground as regards its environmental performance compared to road haulage. In terms of GHG emissions, inland waterway transport still has a very favourable performance compared to road haulage (see figure below), but further reductions are possible (viadonau, 2015).



Source: European Commission (2019), average relative external climate change costs for freight transport for the EU28 in 2016[2] (HGV = heavy goods vehicle, LCV = light commercial vehicle)[3]

The UN Sustainable Development Goals and the COP21 objectives (Paris Climate Conference, December 2015) require action by all to reduce emissions of greenhouse gases and pollutants. This also includes the transport sector and more specifically the inland waterway industry.

These challenging targets are also reflected by more stringent legal emission norms for the inland fleet. These include for instance the provisions of Directive 2009/30/EC, according to which sulphur-free fuel is mandatory since 2011. Other regulations relating to the usage of fuel are the Clean Fuels Directive 2014/94/EC and the Renewable Energy Directive 2009/28/EC, which foresee the deployment of (shore-side) infrastructure for alternative fuels (e.g. LNG) as well as electricity and promote the use of energy from renewable sources, respectively.

The European Parliament and the Council have adopted in 2016 the Regulation on requirements relating to pollutant emission limits for non-road mobile machinery (Regulation (EU) 2016/1628, “NRMM Regulation”). The provisions of the NRMM Regulation define stringent emission limits for engines for different power ranges and applications. They also lay down the procedures engine manufacturers have to follow in order to obtain type-approval of their engines – which is a prerequisite for placing the engines on the EU market.

The so-called Stage V emission standard of the NRMM Regulation includes limit values for emissions of carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx) and ultrafine

[2]The external costs include the ones of well-to-tank emissions which were approximated according to European Comission (2019), page 108 (well-to-tank GHG emissions 35 % and well-to-tank pollutant emissions 65 % of total well-to-tank emissions).

particulate pollutants (PM). NRMM only applies to newly built inland vessels operated in the European Union as well as to vessel engines that are exchanged. The legacy fleet as well as revised engines are not affected by the regulation. The Stage V standard has come into force for smaller engines in January 2019, whereas the larger engines have to comply with the provisions of the NRMM regulation by January 2020. The NRMM aims to gradually phase out the most polluting engines on the market.

The INTERREG project Grendel (2019) identified some of the main current and future challenges of the Danube inland fleet. On the one hand, the significant improvement of the environmental performance of inland vessels is required through a reduction of energy consumption and a reduction of greenhouse gas and air pollutant emissions. On the other hand, the further integration of inland waterway transport into logistic supply chains is to be secured through – among others – improving the logistical performance of the inland vessels and exploiting the possibilities of digitalisation.

Generally speaking, the shipping community is aware of and committed to achieving full decarbonisation or zero emission of inland waterway transport by 2050 (WATERBORNE, 2019a). The strategy of the Central Commission for the Navigation of the Rhine (CCNR) and the Mannheim Declaration also calls for a significant improvement of the ecological sustainability of inland navigation and zero emission navigation by 2050.

In summary, the challenges are clear and the long-term objectives are shared among both policy makers and the industry sector. The required actions in order to achieve the long-term objectives are however subject to discussion. The main questions that are under discussion relate to

a) *the choice of a technological development pathway that will allow zero emission navigation by 2050*: as investments in inland vessels entail long-term financial commitments and because there is no single matured technology that could guarantee zero emission by 2050 already today, more needs to be done to clarify what could be the most promising and secure technological pathway towards 2050;
b) *ways to finance the transition from conventional to zero emission navigation*: the transition of the existing European inland fleet towards significantly less polluting and more efficient inland vessels is estimated to cost at least 1 billion Euro (Ecorys, 2018). Given that existing vessels are not obliged to comply with more stringent emission limits and that the required investment capital generally seems to be lacking in the shipping industry, incentives and financing opportunities have to be developed to urge ship owners to go along with the transition.

This report will address these two questions and will come up with a set of recommendations that are specific for Danube navigation.

3 Promising greening technologies

As reported, legislation addressing the issue of emissions has become increasingly strict in recent years. The NRMM Regulation defines the thresholds for exhaust emissions in new engines. The mandatory thresholds are very strict, which will necessitate the installation of emission reduction technologies such as exhaust gas after-treatment by selective catalytic reduction (SCR) and particle filters.

It is therefore necessary to optimise engines in regard to their fuel consumption and exhaust gas emissions. The diesel engines currently in operation in inland waterway transport are emission-optimised engines and their specific fuel consumption is approximately 0.2 kg/kWh. This value has remained unchanged for several years due to the fact that nitric oxide emissions had to be reduced at the expense of fuel consumption. It seems that diesel engines will remain the most common form of propulsion for inland navigation in the medium term. In the long term, it is conceivable that gas-powered engines and fuel cells may be used as well. They have great potential to enable a significant reduction in the emissions of inland vessels (viadonau, 2019).

Possible effective measures for reducing the emission characteristics of ship engines include the following (viadonau, 2019):

- Reduction in **sulphur oxide emissions** by means of low-sulphur fuel
- Reduction in **hydrocarbon and carbon monoxide emissions** by means of diesel oxidation catalysts (low-sulphur fuel required)
- Reduction of **nitric oxide emissions**, for instance by means of exhaust gas recirculation (requires low-sulphur fuel), humidification of engine inlet air, in-cylinder water injection or use of selective catalytic reduction (i.e. injection of a reduction agent for the effective removal of nitric oxide emissions)
- Reduction of **particulate matter emissions** by means of particulate matter filters (PMF)

According to the results of international research projects and experiments, such as the PROMINENT project (2015-2018), the most effective techniques regarding the reduction of engine emissions and fuel consumption are:

- Engines for liquefied natural gas (LNG)
- Use of low-sulphur fuel
- Diesel oxidation catalysts
- Selective catalytic reduction
- Particulate matter filters
- Fuel-efficient navigation with computer-assisted decision support systems

Both the PROMINENT project (Ecorys, 2019) and the GRENDEL project (2019) have highlighted and discussed the most promising technologies that could be effective in achieving the greening objectives. Within the context of the PROMINENT project most

promising greening or best-available technologies have been selected on the basis of following criteria:

- **Effects on energy consumption and emissions**: proven emission reduction of CO2 and CH4 (climate change emissions) and/or NOx and PM (air pollutant emissions)
- **Economic feasibility**: do greening result in positive business cases or not?
- **Technical feasibility**: impact from the technical side for the main European fleet families and identified operational profiles.
- **Technological maturity**: at least Technology Readiness Level 5 should be available

A summary of the best-available greening technologies – identified on the basis of the above criteria – will be given in the remainder of this chapter.

3.1 After-treatment systems

Selective catalytic reduction (SCR) and Diesel particulate filters (DPF) are mainly an effective solution to reduce NOx and/or PM emissions for all vessels, including those with conventional diesel engines. SCR is a technology applied to diesel engines to reduce the NOx emissions, by adding a reagent (urea-water solution / AdBlue) to the exhaust gas, which is absorbed onto the catalyst, converting NOx in diatomic nitrogen (N2) and water (H2O). Cost for periodic maintenance (once a year or more) are high, in particular for the DPF (maintenance costs of 6,000-10,000 EUR per year) (GRENDEL, 2019).

SCR and DPF are often combined because then all gaseous and particulate emissions are reduced (by 70% to up to 90%) and usually the most stringent (future) emission legislation can be met. SCR and DPF general add to the operational costs of ship-owners and do not produce positive business cases per se. Investment costs (ca. 150,000 EUR) cannot be earned back, because of increased operational costs. The only way to “earn back” the investments would be through reduced port dues, that are applied by some (Western-European) ports for less polluting vessels (e.g. labelled with a Green Certificate). These port dues however usually constitute only a marginal part of the overall operational expenses of inland vessels. Additional incentives are therefore needed to increase the acceptance of SCR/DPF among ship-owners. In the meantime, efforts shall also aim at realising cost reductions by means of standardisation and development of modular systems (viadonau, 2015).

3.2 Diesel-electric propulsion

Diesel-electric propulsion combines high engine efficiency, low noise levels and environmental sustainability due to potentially lower emissions of greenhouse gases and pollutants (GRENDEL, 2019). Any type-approved diesel engine for inland ships (NRMM Stage V) or marinized Euro VI truck engine could be used for diesel-electric propulsion. Such diesel engines combined with an electric generator are known as a generator set (genset) (GRENDEL, 2019). Depending on the respective application case, diesel-electric propulsion can significantly reduce energy consumption and related emissions because of its high efficiency: propulsion needs and power are constantly adapted to actual operational conditions and the propulsive efficiency is improved by dedicated designs of the propulsion system.

Investment costs are currently relatively high, because electric propulsion systems are more or less custom-made, adapted to the operational profile of the specific vessel.

3.3 Gas and gas-electric propulsion

Liquefied Natural Gas (LNG) is natural gas (mainly methane) that is cooled down to -162 degrees Celsius and therefore liquified in order to ease storage and transport. LNG is mainly an opportunity for large vessels that have a high level of fuel consumption per year. In that case the high investment costs of the LNG tank and fuel system could be earned back in savings in fuel costs. LNG would allow for NOx emission reductions of at least 70% compared to conventional CCNR II diesel engine and reduction of up to 95%-100% reduction of particulate matter (PM). CO2 emissions could be reduced by 25%. Various European countries offer public support schemes for refitting inland vessels to LNG propulsion (France, Germany, Czech Republic) (GRENDEL, 2019).

Although bigger vessels with a high energy demand hold a relatively large share in the emissions of inland waterway transport in Europe, the number of vessels suitable for LNG is relatively limited. Moreover, investing in a 100% LNG engine is risky because of the current uncertainty on the price gap between LNG and diesel. In order to earn back additional investment costs for the transition to LNG engines (which can amount up 2 million EUR), it is important to have enough savings in fuel costs. This depends on the relative price advantage of LNG compared to gasoil. In the worst-case price scenario analysed in the PROMINENT project, there is even no positive business case for the application of LNG (Ecorys, 2018).

The latest development in inland shipping engine configuration is the gas-electric drive. The gas-electric drive is a system whereby an inland waterway vessel uses one or a number of gas engines that drive generators (gensets) that generate electricity. This electricity goes to electric motors that drive the ship.

3.4 Fuel cell propulsion

Fuel cells are energy converters that continuously convert the chemical energy of the fuel, (usually hydrogen, natural gas or methanol) into electrical energy. Fuel cells allow local emission-free power generation. Fuel cell propulsion causes no mechanical stress on engine components because no fuel is burned. Consequently, there is no wear and tear, vibration or generation of noise as in conventional engines (GRENDEL, 2019). Maintenance costs are low. The downsides of fuel cell propulsion are currently the high investment costs and the limited operational experiences.

The first applications using hydrogen and fuel cells in inland navigation (e.g. the ZemShip) have been released. There are also ongoing discussions on the introduction of fully electric drive systems, although this is associated with challenges in regard to the supply infrastructure, regulatory matters, storage capacity, size of the storage medium, charging time, range of the vessel and ultimately a reduction in the currently inefficient costs of the technology that need to be overcome (viadonau, 2019).

3.5 Energy efficient navigation

Computer-assisted Energy efficient navigation is considered as a promising technology, in particular when the vessel makes a lot of sailing hours such as push boats and large motor vessels, and when it is manoeuvring on free-flowing sections with dynamic waterway conditions (strongly influencing fuel consumption). The payback time of investing in equipment will strongly depend on the fuel consumption savings (viadonau, 2015).

Energy efficient navigation is considered as a promising but complex and comprehensive approach based on knowledge of interactions between vessel and engine characteristics (e.g. vessel size, hydrodynamic characteristics, …), fairway parameters (e.g. frequently changing waterway depths, current), vessel speed and the resulting fuel consumption (and following CO_2 emissions). The core approach is to reduce energy consumption by adaption of the speed (power) profile to the waterway profile, considering the following measures:

- speed (power) adaption in dependence of water depth, fairway width and counter-current
- choice of the optimum sailing track, i.e. the path with the highest water depth
- provision of the needed information to the skipper in an efficient and user-friendly way

Reduction of greenhouse gas emissions (CO_2, CH_4) of up to 25% have been observed in practical tests (on average around 14%).

3.6 Conclusion

The implementation of the NRMM Regulation and other legal requirements is expected to result in a mix of different technologies to be applied in order to reach the policy objectives, as the efficiency and effectiveness of the different greening technologies strongly depend on the operational profile and operation area of the vessels involved. In short, a one-size-fits-all technological approach will not work to attain the desired greening objectives.

4 Key issues causing a slow modernisation rate

In order to identify points of leverage for effective policy recommendations, the most important drivers behind the slow modernisation rate of the Danube inland fleet are summarised in this chapter.

4.1 Long economic life-time of inland vessels and engines

The long economic life-time of inland vessel engines (30,000 to over 200,000 hours, depending on the engine type) inherently results in a slow uptake of new engines in the fleet. The engine of a pushed convoy on the Danube has an average age of 15 to 20 years, whereas road vehicles are replaced after 5 to 10 years (NEA Panteia et al, 2013). Therefore, investments are done based on current information and long-term expectations. The ship-owner/operator needs to have certainty that the right choice is made for modernisation and greening of his/her vessel from a long-term perspective.

In general, all vessels are subject to emission requirements, meaning that if an existing vessel is equipped with a new engine, the engine has to comply with the current emission standards (NEA Panteia et al, 2013). However, as a result of the significantly higher investment and operational costs for Stage V engines and the lack of obligatory emission limits for existing engines, it is expected that many existing engines will be overhauled several times in order to avoid expensive and insecure investments (INDanube, 2019).

4.2 High investment costs and a lack of business cases

Refitting a vessel causes significant additional investment costs, mostly without clear returns on investment for the vessel owner/operator. Lacking a system of internalisation of external costs, operators of greener and cleaner vessels are generally not rewarded in economic terms. Whereas CO_2 reduction strategies usually go hand in hand with the interests of inland waterway transport operators (CO_2 reduction can usually be combined with fuel/energy reductions), operators have little or no own financial interest to invest in after-treatment devices to reduce NO_x or PM. On the contrary, operational costs usually rise through the use of these technologies. As long as external costs of transport are not somehow internalised in the transport costs. there are also little or no incentives for shippers or cargo owners to opt for more environmentally friendly vessels.

4.3 Small and specific market for inland vessels and engines

The relatively small and specific market for inland vessels causes disadvantages of scale. In the EU27 the number of companies involved in inland waterway transport does not exceed 10,000. Engine manufacturers prefer to concentrate their research and development activities

on larger and potentially more profitable markets and need to take foreign standards into account. The inland waterway transport sector lacks joint development and co-operation in the field of innovation and consequently fails to build up buying power for specific and cutting-edge applications specifically developed for inland navigation. Consequently, engine suppliers are focusing on existing technology rather than relying on innovation. Innovations that might take place in the larger maritime sector cannot – contrary to popular belief – be transferred to inland vessels, as the propulsion and engine technology is fundamentally different.

4.4 Lack of investment capital

It is being said that the most effective measure to modernise the inland fleet would be to improve the navigability conditions on the Danube and its navigable tributaries. The variable and sometimes low water conditions have a severe impact on the profitability of Danube navigation. The equity capital of ship owners is generally low, which makes them highly dependent on external finance. Combined with a lack of specialist know-how, financiers such as commercial banks are generally hesitant to invest in new technologies (especially those that still have to stand the practical test (STC-NESTRA, 2018)) and in companies with a low equity ratio and/or negative business prospects. In sum, the availability of equity and debt capital available on the market is too low to allow for the large-scale investments that would be needed for a transition to a future-proof inland fleet.

4.5 Emission regulations are not affecting legacy fleet

Existing regulations for engines have only a limited effect on fleet modernisation and innovation, since standards are only applicable to new engines. Furthermore, the number of new engines entering the market is too small to have a significant effect on the emissions of the total fleet. A large majority of more than 80% of the inland fleet is not affected by any limits with respect to emission characteristics. The ambitious policy targets of zero emission navigation will therefore not be achieved in a business-as-usual scenario or through an extrapolation of current developments. Without specific action on the legacy fleet, the traditional environmental advantages of inland waterway transport will further deteriorate in the future. This will lead to inland waterway transport losing its environmentally favourable position in comparison to road transport, resulting in reduced public support (NEA Panteia et al., 2013).

As the European Commission (2013) stated in its Staff Working Document COM(2013) 324, the circumstance of emission standards being applicable only to new engines entering the market is also valid for other sectors. But for inland waterway transport this limitation has a much larger impact due to the longevity of the engines. It is expected that rules applying only to new engines cause vessel owners to revise existing engines rather than buying new engines that comply with emission limits. In principle, the regulative framework should be adapted so the vessel operators who invest in fleet modernisation are not confronted with competition disadvantages.

4.6 Incomplete alternative fuelling infrastructure

If alternative fuels such as LNG were to be used in modernised vessels, the bunkering infrastructure should obviously also be in place in order not to reduce the cruising range of inland vessels. Shortages of bunkering facilities can temporarily be overcome by flexible solutions (e.g. tanker trucks), but are not efficient in the long run. The currently limited penetration rate of alternative fuels in inland waterway transport conversely also undermine the business case for investments in an alternative fuelling infrastructure. Policy initiatives in the framework of the Trans-European Network for Transport are aimed at breaking this deadlock (European Commission, 2013).

4.7 Conclusion

The estimated minimum investment costs to bring the European inland fleet (passenger and cargo vessels) to Stage V emission levels comes to 1.05 billion euro. SCR and DFP do not result in business economic costs savings, though, societal benefits are high. Analyses of the PROMINENT project (Ecorys, 2018) demonstrated that the whole European inland waterway fleet could be compliant with Stage V emission limits for an investment of 1.05 billion euro. This investment sum is currently clearly not available in terms of equity or debt capital. The PROMINENT scenario however also showed that the return on investment in terms of external cost benefits would be 6,6 EUR for every euro invested. This clear positive cost/benefit ratio demonstrates that one of the keys towards a greener inland fleet lies in the internalisation of external costs.

5 Instruments for the modernisation of the inland fleet

The transition to a significantly greener Danube fleet requires the application of a combination of different instruments. This chapter provides an overview of different instruments and measures that been put in practice already as well as of instruments that are under development.

5.1 Policy and regulatory instruments

Clear and ambitious emission target setting

Both the studies of STC-NESTRA (2018) and NEA-Panteia (2013) call for setting clear and ambitious targets in the field of emission limits which apply to both new vessels and the existing fleet and their engines. By providing clear medium/long term transition pathways and targets for achieving zero emission, the risks and insecurities connected to required large scale investments by commercial parties can be reduced. The current deadlock in investments is caused by the fact that existing vessels/engines are not affected by stringent emission limits. Moreover, the lack of a clear and long-term policy perspective does not provide the security required for entrepreneurs to raise their willingness-to-invest, especially in greening measures that do not produce a positive business case in themselves.

Regulations and rules that keep pace with technological development

The definition of rules and regulations should be coherent with the development of new technologies (Waterborne, 2019). Regulations and rules should thereby keep pace with technological development in order to speed up modernisation on European waterways. Currently, cutting edge technologies are being approved on a case-by-case basis in a relatively long and costly process. The approval procedures for inland vessels do foresee individual and temporal exemptions but the technical proof of compliance has to be delivered at the cost of the investing party. This adds to the investment risks of entrepreneurs. Faster, cheaper and more standardised type approval procedures could induce faster modernisation in inland navigation.

Environmental zones

Several port authorities in Western Europe have already developed local schemes to promote greener shipping in the last years. For instance, the port of Rotterdam has announced to ban polluting vessels with so called CCNR 1 engines in future. An environmental zone can however also contain rewards or rebates for greener vessels, which comply with standards of a certificate or green label. This trend can especially be observed in the bigger Western

European ports, with densely populated areas around them. Ports along the Danube usually lack the business power to be selective and no concrete steps towards environmental zoning are being observed. Zoning can be a supporting instrument, but given the relatively small amounts involved, it is not expected to have a significant impact on the modernisation rate of inland vessels (Ecorys, 2018).

Internalisation of external costs

A major pre-condition for a level-playing field between land modes is fair pricing, that also includes the external costs of transport. Given the mass transportation character of inland navigation this could have a beneficial effect on the modal share of inland navigation. With external costs being internalised, new business cases could emerge for investments in green inland navigation technologies. In the current situation, entrepreneurs are not rewarded for doing greening investments by means of higher freight rates for their services. A higher level of internalisation of external costs could lead to accelerated and higher investments by private parties.

A cost-benefit analysis study by NEA-Panteia et al. (2013) demonstrated that all conventional greening options will generally produce negative net present values for most vessel classes. These negative financial impacts are however clearly outweighed by the positive net present values of the external cost gains. Based on these analyses, it can be assumed that a more radical transition towards zero emission navigation will not materialise on the basis of market forces only and especially not in the segment of small and medium sized vessels and the existing push boats. Internalisation of external costs could be an essential element to create a more balanced level playing field between transport modes.

Voluntary covenants between public and private parties

The Dutch „Green Deal Zeevaart, Binnenvaart en Havens“ is an example of a broad covenant closed between public and private parties, with the aim of reducing greenhouse gas and pollutant emissions. The covenant is a voluntary agreement that has the aim to strengthen the joint commitment towards a faster transition to a greener fleet. The Dutch Green Deal acknowledges that a further greening of the fleet is dependent on financial feasibility, in combination with a set of additional measures. A covenant like this can help define a more reliable pathway towards zero emission, which in turn could raise investment security for private parties.

5.2 Financial instruments

National grant schemes

About seven EU Member States offer public grants or subsidies to ship owners. Generally, between 30 to 50% of the eligible costs can be covered by these funds. The Czech IWT fund, which in turn is financed by the Cohesion Fund, is the exception as it allows financing up to 85% of eligible costs. The available funding schemes would amount to 8.5 million EUR in

Europe, with the Danube countries being underrepresented. Moreover, eligible items are not always focused on direct investments aimed at greening or modernisation. Sometimes studies without an immediate impact on emission levels are for instance funded as well (Ecorys (2018). Given the large scope of possible funding items in the current funding programmes (especially compared to the policy objectives), overall effectiveness could be blurred.

Moreover, national grants are still often used to finance the purchase of new diesel engines, which are still relatively polluting whilst new technologies such as LNG, navigation systems and hydrodynamic improvements (which are also eligible) are largely underrepresented, as the funding rates are apparently seen as insufficient to compensate for the investments and risks involved. The available grants are in some cases not significant enough to convince ship owners or banks to make substantial investments.

Another major issue with the national funding schemes is their connection to the registration of the vessel. The given unclear delimitation between European and national funding schemes leads to the potential risk of doubling of efforts. This phenomenon could also potentially lead to selective “subsidy shopping”, whereas a coordinated European approach would be more effective. Given the international market and the existing fragmentation, it would make more sense to bundle the regional and national funds into an overall European financing scheme (NEA-Panteia, 2013). For this purpose, the GRENDEL project will develop a model State Aid Scheme and innovative financial instruments in order to design coordinated public support measures for Danube fleet modernisation (GRENDEL, 2019).

National grant schemes supported by Cohesion Fund

Within the Danube region public financial means are even more scarce than in Western-Europe. Joint efforts to modernise the Danube fleet should be manageable with the help of EU funding, for instance from the Cohesion Fund, like was applied successfully in the Czech Republic in the previous period. The operational programmes could be exploited better – especially in the new financial period after 2021 – in order to co-finance part of the required national public financing of the fleet modernisation programmes in cohesion countries. The combined greening measures for inland vessels would require only trivial amounts compared to many infrastructure projects contained in these operational programmes. In order to raise the absorption rate of national funding programmes by a main part of the inland navigation sector, such programmes shall also be accessible to small inland shipping companies and the application process should be kept as straightforward and accessible as possible.

The Structural Funds and the Cohesion Fund are financial tools set up to implement the regional policy of the European Union. The Structural Funds are made up the European Regional Development Fund (ERDF) and the European Social Fund (ESF). The Structural Funds and the Cohesion Fund are one of the biggest positions in the EU budget.

Cohesion policy is included in the Country Report (part of the European Semester). The European Semester is the annual cycle of macro-economic, budgetary and structural policy coordination. It comprises recommendations for investment priorities and boosting cooperation among member states with reference to the EUSDR. The Country Reports are being converted

into the new Partnership Agreements and Operational Programmes. The Partnership Agreements on European structural and investment funds are agreements that set out the national authories' plans on how to use the structural and cohesion funds.

For the territorial cooperation programmes, the EC is issuing Orientation Papers for transnational programmes. The contents of the legislative package for the Cohesion Policy 2021-2027 have been tabled by the Council of the EU in June 2019. It contains five investment priorities:

- Smarter Europe, through innovation, digitisation, economic transformation and support to small and medium-sized businesses
- a Greener, carbon free Europe, implementing the Paris Agreement and investing in energy transition, renewables and the fight against climate change
- a more Connected Europe, with strategic transport and digital networks
- a more Social Europe, delivering on the European Pillar of Social Rights and supporting quality employment, education, skills, social inclusion and equal access to healthcare
- a Europe closer to citizens, by supporting locally-led development strategies and sustainable urban development across the EU.

Budget decisions on the Cohesion Policy are dependent on the Multi-Annual Financial Framework. This will be no earlier than in the course of 2020.

The principles and priorities of the cohesion policy are developed by the European Commission in a consultation process with the Member States. Each Member State thereby develops a draft Partnership Agreement that includes the country's strategy and a list of programmes. This is then elaborated into draft Operational Programmes for specific themes/regions – e.g. Operational Programme for Transport. Partnership agreements and operational programmes are negotiated between MS and EC. The programmes are then implemented on a national level, led by the designated managing authorities.

InvestEU

The EFSI Fund ("Juncker Plan") shall be followed up by "InvestEU" in the period 2021-2027. It shall support investments in sustainable infrastructure, research and development and digitalisation, small and medium sized enterprises and social investments. InvestEU is planned to mobilize public and private investments up to 38 billion EUR. The investments are done via financial partners, of which the EIB will be most important. In case InvestEU resources are combined with HorizonEurope or CEF2, solely the rules of InvestEU shall be applicable to the entire project, which shall be a relief of administrative burden for the applicant. 11 billion Euro is reserved for sustainable infrastructure.

Loans by private banks

Only a few commercial banks with dedicated inland waterway experts (concentrated in Western Europe) seem to have knowledge of the particular financing challenges of the inland waterway sector. Market knowledge is limited, the risk perception is high (Ecorys, 2018). It seems that the bigger companies have easier access to finance by commercial banks, whereas SMEs have more difficulties in providing sufficient financial securities to balance the risks. The volatile and fragmented market apparently limits financing opportunities for smaller companies. These SMEs generally also lack the knowledge and experience to apply for larger grant instruments, which could contribute to more financial security. This dilemma could be overcome by additional instruments, such as public guarantees, soft loans or loans with longer pay-back periods. Such preferential conditions are for instance offered by a back-up instrument of the European Investment Bank.

Green Shipping Guarantee programme of European Investment Bank (EIB)

The so-called Green Shipping Guarantee of the EIB is financially supported by the Connecting Europe Facility (CEF) and the European Fund for Strategic Investments (EFSI). The Green Shipping Guarantee is a lending facility of the EIB that allows commercial banks to take higher risks. It is a financial instrument that supports investments in greener shipping. The GSG has a size of EUR 750 million and can leverage the investment budget via a cooperation with commercial banks (Ecorys, 2018). The co-financing rate is up to 50 of debt financing on new vessels and 100% of additional costs for green components of retrofitting operations. The fund is primarily aimed at and used by the maritime sector, but would also be open for inland waterway transport. Lower interest rates provided via this channel can support SME uptake of investments. No significant experience with this instrument applied in inland navigation has been made as yet. Ecorys (2018) stresses that the GSG programme concerns loans for business plans that have a positive business case. The bank will not be interested in providing loans to initiatives or greening technologies with a negative business case, such as SCR-DPF, unless the company will get better paid or a long-term contract as a reward for applying the greening technology (Ecorys, 2018).

Fiscal incentives

In addition to grants and loans, some governments provide fiscal incentives to promote investments in energy efficient technologies. These incentives are usually not specific for inland waterway transport technologies, but may also be used by inland navigation operators. In the Netherlands, for instance, a list of greening technologies is published, the costs of which are eligible for deduction of their operational profit. Such a rebate is especially deemed interesting in case of greening technologies with a negative return on investment, such as after-treatment systems. It seems however, that these tax reliefs for inland waterway operators are relatively insignificant in relation to the investments costs and risks involved. Fiscal incentives also only work in case the company involved is making profits, which is not always the case.

Innovation Fund of DG CLIMA

As a successor to the NER300 programme, the recently launched Innovation Fund is a large funding programme for demonstration of innovative low-carbon technologies. Among others it focuses on low-carbon technologies in energy-intensive industries, carbon capture and utilisation as well as innovative renewable energy generation. The financial means of the fund are being generated through the EU Emissions Trading System (EU ETS). Depending on the carbon price, the fund might amount to 10 billion Euro between 2020-2030. The grants of the fund will cover up to 60% of the incremental costs of capital and operations needed for carbon reduction innovations. The Innovation Fund can be combined with other grants, such as HorizonEurope, InvestEU, Connecting Europe Facility and the Cohesion Fund.

The Innovation Fund has a focus on highly innovative technologies with significant emission reductions and aims to finance a varied project portfolio, in order for different industries and Member States to reap the benefits of it. The Fund would also be open for small scale projects, defined as projects with capital costs below 7.5 million Euro. Project applicants should first submit an expression of interest, which should explain the effectiveness, as well as its innovation and maturity level. The second-stage full application is then assessed according to criteria of scalability and cost efficiency. An Innovation Fund Expert Group assists the Commission with the preparation of the calls for proposals. First calls are planned for 2020, with regular calls up to 2030.

European Greening Fund

A European Greening Fund for inland waterway transport does not exist as yet. The idea for such a fund has been raised in several studies (NEA-Panteia, 2013 and Ecorys, 2018) and has moreover been referred to in the Dutch Green Deal of 2019, as the creation of a level playing field for funding in the international inland navigation business would be crucial. During 2019 the Dutch government and the Central Commission for the Navigation of the Rhine (CCNR) have issued studies to investigate and develop the basic elements of such an instrument. The results of these investigations are expected to presented in the year 2020.

A European-wide Greening Fund would need to finance a large-scale uptake of proven solutions, dedicated to reducing air pollutant and greenhouse gas emissions. NEA-Panteia et al. (2013) suggest that the fund could be filled in several ways, namely by grants from EU, Member States and regional governments on the one hand and by sector contributions on the other. The sector contribution could be generated by a differentiated environmental surcharge on fuel and by making use of the Reserve Fund.

Ecorys (2018) suggests the creation of a greening fund, similar to the Norwegian NOx Fund created for the maritime sector. Ship owners would thereby contribute to the fund through payment of differentiated environmental port dues or surcharges on gasoil. This would directly impact the amount of fossil fuel burned by inland vessels, making the action effective, efficient and fair. The impact of an environmental surcharge on operational costs has been estimated

in the study by Ecorys (2018): Assuming a surcharge of 2, 4 and 8 eurocents, the impact on the total annual costs for several vessel and operational profiles varies between 0.3 and 4.1%.

A comparable International Maritime Research Fund (IMRF) to accelerate the introduction of low-carbon and zero-emission technologies in the maritime industry was proposed to IMO on 18th December 2019 by the representatives of the largest maritime shipping operators. The main funding should thereby be provided via a mandatory R&D contribution per tonne of marine fuel oil purchased for consumption. This should maintain an appropriate level of funding and maintain fair competition between shipping companies (Marine Environment Protection Committee, 2019).

Legal provisions for the implementation of a Greening Fund would obviously need to be elaborated, but ideas range from linking up to existing conventions such as CDNI (surcharge for waste) to the setup of a European fund, like in the case of the scrapping fund that was introduced by the Commission to reduce overcapacity in the inland navigation sector.

5.3 Research and development

Strategic Research Agenda

One of the main aims of any research and development activity should be to create cost-efficient and effective technologies and processes in terms of greenhouse and pollutant emissions. Greening technologies themselves are under steady development. Given the relatively small size of the inland waterway market, these developments are not being taken care of by market forces alone. Therefore, in order to create a critical mass, it is important to seek cooperation and coordination in all research and development activities dedicated to inland waterway transport. One way of coordinating R&D efforts is to set up a joint strategic research agenda for inland waterway transport in Europe.

In January 2019, the Inland Waterway Transport Sector released its Strategic Research Agenda to the European Commission and the European Parliament (INE et al., 2019). This Strategic Research Agenda was released during a discussion at the EP Intergroup Seas, Rivers, Islands & Coastal Areas on the overall Waterborne Strategic Research Agenda. This SRA it aimed at meeting the COP21 objectives and societal needs by adopting emerging technologies towards 2050. Priority is therefore given to healthy and easy-to-reach cities, zero-emission and resource efficient economy, easy-to-use and reliable mobility and logistics, as well as climate resilient, thriving and sustainable waterfront.

These objectives require investments in research & development activities, both by the sector as well as by the European Commission. A proper inclusion of the Inland Waterway Transport and Port sector in Horizon Europe, is therefore essential. Equally important is the need to support research and deployment activities in inland waterway transport through the Connecting Europe Facility 2021–2027 so as to enable the sector to further integrate in a zero-emission logistics chain.

The development of this Strategic Research Agenda is the result of a close cooperation between the Inland Waterway Transport and Port Organisations (European Barge Union and European Skippers' Organisation), European Inland Barging Innovation Platform (EIBIP), Inland Navigation Europe (INE), European Federation of Inland Ports (EFIP), with the support of the European Association of Shipyards and Maritime Equipment Manufacturers (SEA Europe).

HorizonEU

The Horizon2020 project "PROMINENT" already suggested to concentrate on further technological research on promising greening engine room techniques with a low technological readiness level (TRL), such as the further development of Stage V engines. Possibly this could be realised by a combination of techniques that are currently still considered experimental. A few options could be selected in order to further research and develop to see if stage 5 performance would be within reach. As an example, following techniques should be developed, possibly in combination with SCR/DPF:

- Cooled exhaust gas recirculation (EGR)
- Gas to liquid fuel (GTL)
- Fuel-Water Emulsion (FWE)
- Hydrogen emulsification/injection
- Combinations of marinised Euro VI truck engines in diesel electric mode
- Further research on the combination of LNG with SCR/DPF
- Optimisation of retrofitting of existing and new engines
- Creating standard modules for certain SCR and DPF combinations

The inland waterway sector lacks the critical mass and investment power to develop these technologies towards a higher TRL on its own. The most suitable programme for these themes to be taken up is the future Horizon Europe programme of the European Union: The European Parliament and the Council reached a political agreement on Horizon Europe in March/April 2019. Subject to the agreement on the next EU long-term budget (2021-2027), the Council and European Parliament will negotiate and subsequently adopt the programme, whereas Horizon Europe shall be launched on 1st January 2021.

The first Horizon Europe survey, which ran during 2019, dealt with key strategic orientations for research and innovation support for the programme's first four years. These surveys followed a so-called co-design approach. The respondents stressed the importance of research and innovation to contribute to sustainable solutions, especially for climate related challenges (https://ec.europa.eu/info/horizon-europe-next-research-and-innovation-framework-programme_en).

The European Commission and Member States are currently in the process of Strategic Programming for Horizon Europe. Strategic Programming is the process that will pave the way for the design of the working programmes in a later stage. The European Commission and Member States thereby approved in principle the establishment of a co-programmed partnership zero-emission waterborne transport in the framework of Horizon Europe. This

partnership is key as it will allow the strategic European waterborne transport sector to develop knowledge, technologies and solutions that will enable zero-emission shipping for all ship types and ship services, in line with the Green Deal for Europe (WATERBORNE, 2019b). The European Commission and Member States are expected to start to discuss the objectives for the call topics in 2021 and 2022 in early 2020.

6 Recommendations for actions by EUSDR stakeholders

As the causes for a slow modernisation rate for the Danube inland fleet are manifold, any strategy to accelerate its modernisation necessarily consists of a mix of measures. The following scheme connects the key issues related to slow fleet modernisation with a set of measures and their expected impacts. The strategy will not work if single measures are selected only, as not all grounds for slow modernisation will addressed by choosing individual measures from the below scheme.

Measures to counter lack of business cases and investment capital

Measure	**Explanation**	**Main addressee(s)**
Contribute to European solution for internalisation of external costs of transport	The business case for many greening technologies is not positive as the reduction of external costs is not priced via markets. Introducing internalisation of external costs would reward greener entrepreneurs.	Member States European Union
Engage in programming for ESI Funds in favour of fleet modernisation and greening measures	Strategic contents for European Structural and Investment funds in the period 2021-2027 are in the process of being defined during the course of 2020. Fleet modernisation should be included during this time window.	Member States
Set up coordinated national grant schemes aimed at tangible modernisation measures	Taking into account the lessons learned from previous national fleet modernisation schemes, national grant schemes should be developed in close coordination with other member states. The project GRENDEL provides an opportunity to coordinate contents of funding programmes, avoiding undesired side-effects (e.g. selective subsidy applications).	Member States
Engage in investigations for a European Innovation and Greening Fund	Analogous to the proposal of maritime fleet operators, an innovation and greening fund could be set up and financed by means of surcharges on fossil fuel consumption	Member States IWT industry

	(polluters pay for greening). Member States and the IWT industry should get involved in relevant studies initiated by The Netherlands and the CCNR in 2019-2020.	
Consider public guarantee instruments to raise bankability of SME investment projects	State support can also take the form of creating more favourable conditions for bank loans, by providing guarantees for entrepreneurs.	Member States
Investigate opportunities offered by Green Shipping Guarantee programme (EIB)	The Green Shipping Guarantee programme of the European Investment Bank is being carried out together with commercial banks. The opportunities offered by this programme for inland waterway transport entrepreneurs is not completely clear at time. The experiences in the shipping sector should be used and future opportunities explored.	IWT industry
Engage in Innovation Fund Expert Groups (DG CLIMA) to promote greening measures	DG CLIMA announced to first calls for projects for the Innovation Fund in 2020. Innovation Fund Expert Group will prepare call topics. Both the IWT industry and Member States should engage in preparations of these calls, in order to anchor IWT-specific topics in future calls.	IWT industry Member States
Support discounts for cleaner vessels in environmental zones	A possibly effective regulatory measure to reduce further exploitation of polluting vessels could be the creation of environmental zones (especially in urban areas) that can only be accessed by vessels meeting certain emission standards. Sufficient transitional periods would be required. Moreover international coordination of such regulatory measures would be required in order to avoid negative side effects (e.g. “escape routes”).	Port authorities Member States

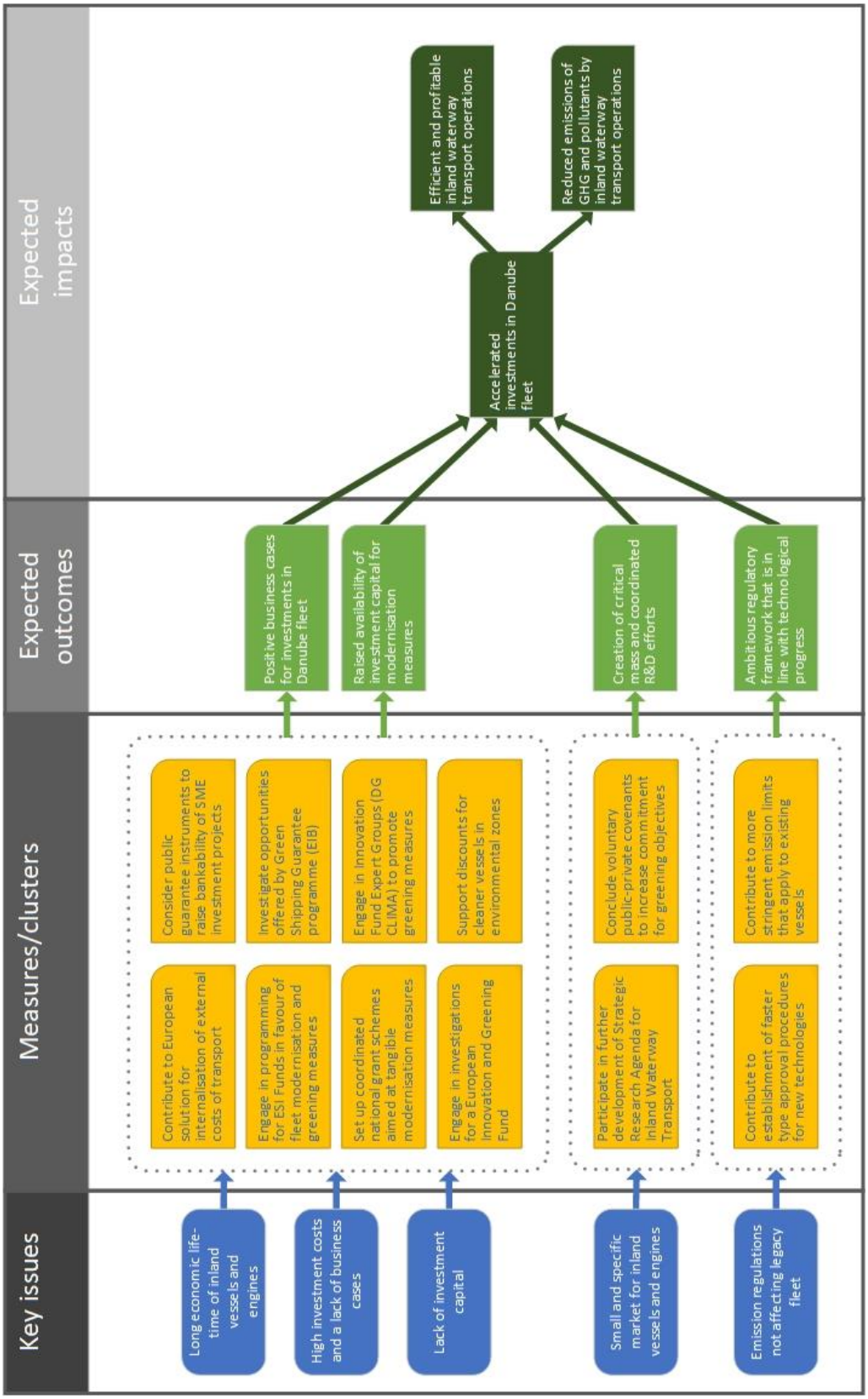
Small and specific market for inland vessels and engines

Measure	Explanation	Main addressee(s)
Participate in further development of Strategic Research Agenda for Inland Waterway Transport	The IWT industry is characterised by relatively small companies and the size of the IWT market is relatively small as well. Larger original equipment manufacturers are therefore usually reluctant to develop highly innovative technologies and services just for this market segment. One way to overcome this deadlock is to bundle future research demands in a coordinated Strategic Research Agenda.	IWT industry
Conclude voluntary public-private covenants to increase commitment for greening objectives	Reluctance of entrepreneurs to invest in greening technologies is also caused by the fact that strategic policy goals and technology pathways for a typical investment time horizon are not clear to individual entrepreneurs. Joint covenants defining the strategic objectives and the roadmap to arrive there can provide more investment security for entrepreneurs.	Member States IWT industry

Emission regulations not affecting legacy fleet

Measure	Explanation	Main addressee(s)
Contribute to establishment of faster type approval procedures for new technologies	Regulatory standards should keep pace with technological advancements. Early adopters of effective break-through innovations should not be victims of slow type approval procedures and take over responsibility for additional administration burden and costs on top of that.	Member States

Contribute to more stringent emission limits that apply to existing vessels	The legacy fleet is hardly affected by any emission limit. As long as investment costs for new vessels and engines are relatively high and do not produce positive business cases by definition, individual entrepreneurs are likely to continue to sail older – and more polluting – vessels. More stringent emission limits also applicable to the legacy fleet, with sufficient transition periods and combined with other incentives (as described above), will be an effective means to overcome this condition.	Member States IWT industry



Strategy for fleet modernisation

7 References

CCNR (2019), Annual Report 2019: Inland navigation in Europe/Market observation, Strasbourg.

Ecorys (2018), D6.3 Business economic and financing options for greening innovations in IWT and D6.5 Financial impact of Greening IWT for Europe, PROMINENT project, Grant Agreement: 633929.

European Commission (2013), NAIADES II Commission Staff Working Document: Greening the fleet: reducing pollutant emissions in inland waterway transport, COM(2013) 324 final, Brussels, 10.9.2013.

European Commission (2019), Handbook on the external costs of transport, January 2019.

GRENDEL (2019), Fact sheet: Why to modernise inland vessels, INTERREG GRENDEL project.

INDanube (2019), Know-how transfer event: Modernisation of Danube fleet: Summary of outcomes, 7-8 March 2019, Vienna.

INE, EBU, EFIP, EIBIP, ESO, WATERBORNE (2019), Towards a Strategic Research Agenda for Inland Waterways Transport: Inland Waterways Transport and Ports in Horizon Europe, Brussels.

Marine Environment Protection Committee (2019), Reduction of GHG emissions from ships: proposal to establish an International Maritime Research and Development Board, 18 December 2019.

NEA-PANTEIA, Planco, viadonau, SPB and CCNR (2013), Contribution to impact assessment of measures for reducing emissions of inland navigation, financed by the European Commission Reference R20130023/C0019200/RLE/LJO, Zoetermeer.

STC-NESTRA (2018), D 6.7 Assessment, Recommendation and Roadmap, PROMINENT project, Grant Agreement: 633929.

viadonau (2013), Handbuch der Donauschifffahrt, Vienna.

viadonau (2015), D 1.2 List of best available greening technologies and concepts, PROMINENT project, Grant Agreement: 633929.

viadonau (2019), Handbuch der Donauschifffahrt, Vienna.

WATERBORNE (2019a), Strategic Research Agenda for the European Waterborne Sector, Brussels, January 2019.

WATERBORNE (2019b), WATERBORNE Newsletter November 2019, https://www.waterborne.eu/media/100184/waterborne-newsletter-november-2019.pdf.