Sustainable, safe and economically feasible energy concepts and technologies for European Inland Shipping

D6.3 Business economic and financing options for greening innovations in IWT

D6.5 Financial impact of Greening IWT for Europe

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Abstract

This report presents the findings of sub work package 6.2 of the PROMINENT project and is a combined deliverable consisting of two integrated parts:

- D6.3 : "Business economic and financing options for greening innovations in IWT". This part presents costs, benefits, required investments, risks, sensitivities and further indicators for most promising innovations for various different vessel types and operating profiles;
- D6.5 : "Financial impact of Greening IWT for Europe". This part extrapolates the findings of D 6.3 for the entire European fleet and assesses the need for public funding, taking into account the financial health of vessel owners.

Building on the results of previous work packages, notably the CBAs made during the pilot preparation and the validated findings of the pilots as regards the business economics, an analysis is provided on the financing gap that needs to be bridged to enable the transition towards a greener IWT fleet. The financing gap is determined by scrutinising both the demand and supply side.

Financing supply and demand

The *financing supply* has been scrutinised through various inputs from stakeholders (governments, banks, system suppliers, ship-owners). An overview of existing financing instruments is provided. The main characteristics of the financing instruments are characterised by a:

- *Wide range of objectives*, with a partial priority for greening objectives in the funding instruments. The intentions are to stimulate lower operating costs via lowering fuel consumption, stimulating innovation or helping fleet replacement. Greening aspects are an additional benefit of other investments.
- *Different financing criteria*: eligibility, total capacity, grants, lending. The lending and funding mechanisms are based on a co-funding rate, expressed as a share of total costs with a range between 10% and 80% of the total costs. The cap for investments is non-aligned, some instruments provide max. 50,000 EUR while others can fund up to 1 million EUR.
- *Funding capacities differ*. The Member States provide rather small fund sizes, with CZ as one of the single Member States providing over 3 million EUR per year, which is still relatively small to the total market of IWT.
- *Member State specific*. The Member States have funding mechanisms for their fleets, while a majority of IWT vessels operates cross-border services.

A total of seven EU Member States (MS) offer grants to ship owners. Generally, between 30 to 50% of the eligible costs can be covered by the funds. Combined, these figures point at the availability of funds for green technologies up to 8.5 million EUR in Europe. Seen the huge demand, this governmental supply of funds and loans to IWT companies is rather limited. Moreover, it differs significantly in eligibility criteria. The fund sizes seem not to be on par with the regional size of the IWT sector across Europe. The funds seem to be connected to the registration if the vessel, while many vessel operators travel across borders on a frequent basis. Operational use and funds available seem not to align. The majority of government funds provide funds, subsidies and some governments provide in addition also provide fiscal incentives. The latter is out of scope of this deliverable.

The banking sector seems to have a limited knowledge on the specific characteristics of the IWT sector. Financing by commercial banks seems concentrated in a limited number of banks, which provide the sector a specific desk. The larger banks opt for limiting their investments in larger IWT companies of 5 and more vessels, while the specialised banks can also provide financing to the SME operators. In general, banks only regard the business case of the investment. Subsidies, grants and guarantees of governments can influence the business case positively. However, the business cases, which are positive only because of government support, are regarded to be risky for bank lending. The total bank lending capacity for the IWT sector is not known.

The EIB set up a structure Green Shipping Guarantee (GSG) where Partner Financial Institutions provide investment desk services for EIB funds. As such the market agents can find investment credits via their regular channels. EIB funds can leverage the investment budget via this cooperation with commercial banks. Lower interest rates provided via this channel can support SME uptake of investments. Some specific loans are developed under this framework, providing at first sight positive results. This GSG has a size of EUR 750 million and is supported by the EU's Connecting Europe Facility (CEF) Debt Instrument and the European Fund for Strategic investments (EFSI). But not all is directed to the IWT sector as it applies to both inland shipping and seagoing operators. Moreover, there is not yet significant experience with this instrument applied by IWT.

The technology providers are limited in providing funding or lending to their clients. Their capacity to make profit in this market segment is limited. Some provided extended payment options for new engines. But this has proven to be too risky. The leasing or renting of engines or fleets is a common practice in the rail and trucking sector, but not in the IWT sector.

The *financing demand* was assessed by extrapolating the CBAs of mature technologies to achieve the PROMINENT objectives. The objective is to reach NRMM Stage V emission levels for 70% of the IWT market in the most cost-effective way through these greening technologies.

Looking at the business cases of available and mature Stage V technologies, currently there is no significant incentive for barge owners to invest in e.g. SCR and DPF. Some ports provide discount in port dues to green vessels that can overlay a Green Award certificate, however these effects are marginal with respect to the investment (CAPEX) and/or operational costs & maintenance (OPEX).

In order to transition to LNG as a fuel, investment costs are required to replace the gasoil engines with engines suitable for LNG. In order to earn back these investment costs in twelve years (the investment is significant and can amount up to 1 to 2 mln EUR), it is important to have enough savings in fuel costs. This depends on the price advantage of LNG compared to gasoil. In the worst-case price scenario, there is no positive business case for the application of LNG. In the best-case scenario, especially larger ships can make advantage of shifting tot LNG.

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.

Selective measures (investments and funding) for high societal benefits:

- E.g. over a period of 10 years, a total of 5 billion euros in external costs (NOx and PM) can be saved by investing 508 euro in approx. 35% of the European inland fleet (vessels larger

than 80m and push boats only). The highest return on investment is achieved with large push boats, with a total installed power of ≥ 2000 kW: for every euro invested in this vessel class the benefits for society over 10 years comes to 32.4 euro.
- An additional investment of 539 million euro in passenger vessels (all sizes, small up to 135m cruise vessels) and motor vessels < 80 m length, has an added value of approx. 1.8 billion euro in 10 years, summing up to a total of 6.86 billion euro over 10 years.

Conclusively, the whole European inland waterway fleet could be compliant with Stage V emission limits for an investment of 1.05 billion euro, with a return on investment in external costs of 6.6 euro for every euro invested.

The lowest investment costs, disregarding the effect on business economic level, for the EU inland shipping fleet to reach Stage V emission levels can be achieved by means of investment in after-treatment systems (SCR and DPF). However, the after-treatment systems cause additional operational costs for urea consumption and additional maintenance. The situation for LNG is different. Although the investment is higher compared to equipment for after-treatment, Stage V levels can be reached through installing an LNG solution (engine + tank). For vessels with a high fuel consumption and with sufficient space to accommodate the tank, LNG can be a viable solution. The precondition for the business economic feasibility is that a large and stable price gap between LNG and gasoil and significant fuel consumption. Reasonably, up to 40% of the Inland fleet could be equipped with an LNG installation given that the price gap is at least € 0.35 per litre. The potential for LNG powered vessels is very small when the spread in fuel price difference is small (gap of €0.05). The total financing demand ranges between 9.5 mln euro and 929 mln euro.

Given the current mature options to reach Stage V emission levels, via SCR/DPF and LNG, the total combined financing demand ranges between approx. 1 – 2 billion euro (depending on the fuel price difference between Diesel and LNG).

Greening Fund

As mentioned earlier, except for a marginal effect in port dues, currently there are no significant incentives for barge owners to be green. At least, at this moment amongst shippers, there is no willingness-to-pay for more expensive green inland vessels. The business case is simply not there. And margins in the transport market are small. On the other hand, in order to remain **competitive to road transport**, the IWT sector will have to comply with Stage V emissions in the short to keep its “license to operate” and take responsibility in reducing emissions that cause damage to health and environment.

Importantly, the conditions of grants and loans are often so strict that they are rendered irrelevant for investments in LNG and SCR/DPF solutions. The suggested technologies are unlikely to be financed by loans, as the return on investment is negative. Considering the positive societal returns there remains a case for subsidies and blended financing instruments to enable the transition. From this perspective, the report brings together the financing supply and demand to conclude that on EU level a financing gap of EUR ca. 1 billion remains in place.

A possible solution to tackle the investment problem could be the creation of a greening fund, similar to the Norwegian NOx created for the maritime sector. Ship owners would contribute to the

fund on a regular basis. For instance, as an addition to port dues paid or a small contribution when bunkering gasoline. Once the ship owner wishes to invest in a green technology, he can apply to the fund for a financial contribution. Depending on the structure of the fund chosen, the ship owner could receive a partial or full funding of the investment.

The fund can be filled by means of grants from EU (CEF), Member States and regional governments. The sector contribution for the fund can for example be provided by means of resources from the Reserve Fund as well as introducing differentiated environmental surcharge on fuel used in IWT. This will directly address the amount of (fossil) fuel burned by inland vessels / barge owners, making the action effective, efficient and fair.

If the Greening Fund is directly related to the minimum investment need to comply with Stage V emission standard, the fund would eliminate the barrier to invest in after treatment systems (SCR-DPF) for most vessels and improves the business case for conversion to LNG to address air pollution emissions, since the application of the fund will be technology neutral. At the same time, it gives an incentive as well to CO_2 reduction and low/zero carbon drivetrains: less fuel consumed, results in less CO_2 emitted.

The impact of an environmental surcharge on operational costs has been estimated. For this a few typical vessels and average operational characteristics have been selected, with varying total operational costs. Assuming a surcharge of 2, 4 and 8 eurocents, the impact on the total annual costs varies between the 0.3 and 4.1 %. In a situation with energy efficient navigation or other techniques/solutions, compared to the current situation, the fuel consumption can be reduced with 10%, the total annual effect would be between the 1.6 and -1.5% (so costs saving).

Legal barriers for Greening Fund

It will require legal actions to provide the framework for the Greening Fund and the EU-wide environmental surcharge on fuel dedicated to feeding the Greening Fund. The study assesses whether such a fund could potentially be linked to the CDNI-Convention on the disposal of ship-generated waste on a selection of waterways[1]. Ships operating on the parts covered by the Convention are obliged to deliver their ship waste and are obliged to pay for the disposal thereof.

The idea has been raised to piggyback on the already existing CDNI-Convention, for which one of the waste types, oily and greasy ship waste, the levy is linked to the bunkering gasoil (7.50 euro to be paid on each 1000 litres of fuel plus VAT). Although, the CDNI Convention is not considered as the most efficient way to implement a Greening Fund (mostly due to the limited geographical scope), it does illustrate that it is feasible to implement a surcharge / disposal charge on the consumption of fuel without being in conflict with the Mannheim Convention.

The way forward would be to introduce legislation (regulation or directive) on European level. The EU has competence both in the field of transport and environment (Article 4 TFEU). A solution path would be to develop dedicated legislation for the inland shipping sector that imposes emission limits for the entire inland shipping fleet, targeting also existing vessels/engines to reach emission limits. The implementation of a Greening Fund and related contribution by the inland shipping sector, could form an integrative part of this initiative and related targets, under the condition to earmark

[1] The Convention applies to all waterways in Germany, Belgium and the Netherlands, the Moselle in Luxembourg, parts of the Rhine in Switzerland and parts of the French waterways.

the fund exclusively for greening technologies in the inland shipping sector. Furthermore, it provides also an opportunity to set targets to reduce greenhouse gas emissions and to set the course towards (almost) zero-emission.

The main advantages of using EU legislation as a legal basis for a greening fund are:

- The inclusion of the entire EU fleet and EU waterway network initiative
- The possibility to widen the scope of the fund to all emissions
- The opportunity to manage the fund and the pay out at EU level
- The option to earmark the fund exclusively for greening technologies

It would not be the first time the EU would set-up a (temporary) fund to support specific goals in the inland navigation sector. During the 1990's the Commission introduced the scrapping fund, which aimed to reduce the overcapacity in the market (Council Regulation (EEC) No 1101/89). Examples of combining environmental targets with a financial instrument in EU legislation can be found in other sectors as well, see for instance Regulation (EU) No 1257/2013 on safe and sound ship recycling, where a financial instrument has been proposed as well.

Short-term recommendations

At the same time, it is noted that the existing financing instruments provided by among others Member states and Regional Governments leave room for improvements. Typically, popular innovation grants rarely lead to investment in the "most green" technologies and less popular instruments are indeed too stringent to catalyse a greener fleet. The recommendations are therefore to:

- Stimulate investments in providing assistance to the needed own-capital of SMEs looking for financing, in addition to lower interest rates.
- Stimulating banks to again increase the pay-back periods, making that loans by SMEs can be better absorbed.
- Better align government expectations with SME capabilities and banking risk profiling.
- Stimulate the market to promote the use of (greener) vessels via regarding the greener IWT alternative as the part of a larger supply chain, and not a point-to-point service.

Following up on these recommendations should enable a swifter transition to a greener IWT fleet. At the same time the technological progress should be closely monitored, as future efficiency gains may enable a comparatively greater shift towards market-based financing.

Moreover, also the implementation of a Greening Fund seems to be a necessary instrument to close the gap between financing demand and supply. It is recommended to carry out more research to assess economic, environmental, legal, political and societal impacts of various implementation options. On European level, an impact assessment is typically considered as a dedicated tool to provide guidance to policy makers and industry representatives to assess the implementation of new policies and legislation.

Long-term recommendations

ZERO emission IWT solutions are under-researched. The current PROMINENT goals are ambitious in terms of lowering the emissions of the current fleet. Though, after obtaining this objective. The fleet can still be made greener by implementing different techniques, e.g. hybrids, battery-electric, Hydrogen solutions.

Financial technology is another under-researched topic. Given the LNG investment, market uptake will largely depend on the price gap between diesel and LNG fuel. Future hedging of the LNG fuel price might be a solution to stimulate further uptake. The price gap can be insured by fixing the LNG price or securing a minimum discount with reference to diesel fuel. This is a common technique used in large fuel consuming companies, such as in the aviation sector (airlines), maritime sector (cruise lines) and road sector (trucking companies). Such solutions could be researched to provide a more secure business case for investments in LNG in the IWT sector.

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1 Background and position in the project

Background
The PROMINENT project advanced a comprehensive approach to test and advance technologies that can contribute substantially to the greening of the European IWT fleet. Beyond fleet and technology analyses, as well as real-life pilot deployments, the project also focus on analysing the conditions that need to be put in place to enable the uptake of these technologies. This report constitutes one of the final parts of the project and covers the financial analysis for the most promising technological solutions, both on business level and on macro level for the European fleet.

PROMINENT goals
PROMINENT project aims at introducing various technological innovation to the vessels operating on river and canal network within the EU, with the aim of reducing Nitrogen Oxides (NOx) and Particulate Matter (PM) emissions down to the 1.8 gram per kWh and 0.015 gram per kWh of engine energy respectively.

While another goal, of a maximum emission Particulate Number (PN) of 1x10E12 per kWh has also been set, this will be ignored in the scenario, as no information regarding PN emission reduction of greening technologies was provided in the Cost Benefit Analyses (CBA) [3], [5], [6]. Furthermore, no specific goals regarding the CO_2 emissions were given either, thus this pollutant will also be ignored by the scenarios. It was assumed that with every installation of a given technology the emission levels for the updated vessel become equal to the desired average emission levels of 1.8 gram per kWh and 0.015 gram per kWh of engine energy for PM and NOx respectively. An important conclusion can be drawn from this: if the desired emission levels are to be achieved on average, the entirety of the fleet needs to be equipped with decarbonisation technologies.

Position in the project
The report builds mainly on the CBA studies made in WP2 and the pilot studies as performed in Work Package 5. The focus for the extrapolation is notably put on two of the selected technologies that were deemed most relevant in light of the project's objective to enable the short-term greening of the IWT fleet. These technologies are LNG and SCR/DPF installations. D1.3 reports on a total list of innovations, also those not analysed via a CBA, ranked on their barriers for uptake and short or long-term potential to contribute to the greening objectives of PROMINENT.

Methodology
The report presents a short overview on earlier CBA outcomes, including investments, likely cost-savings and other benefits for ship-owners. It then present funding needs for the relevant vessel types per operating profile (on business level). A list of innovations analyses already in 2015 in the D1.2 report is updated. This concerns for example the assessment of application of Euro VI truck engines and recent developments regarding full electric vessels (batteries).

Subsequently, linked to the updated and validated knowledge base on the business economics of the innovations, an analysis was made of the EU financing supply, and EU-wide demand for the implementation and financing of these innovations, the gap between the supply and demand and barriers related thereto. Then we add recommendations to close the gap in terms of promising financing approaches. These conclusions and recommendations build on a range of interviews with

industry stakeholders (See Annex I), desk research, and an extrapolation of the CBA results for the European fleet.

Via an extrapolation of the CBA outcomes for various vessel types, we conclude the report with an approximation of the EU-wide uptake of these technologies. The total funding need is large. And to finance the uptake, a creative supply of funding is suggested provided that business cases for the three technologies are challenging. Uptake without funding of vessel owners is expected to be low, and consequently the IWT market will not reach PROMINENT's sustainability increase objectives. Barriers for uptake are numerous, aside funding this includes legal barriers. These are discussed. Funding options and impacts are provided in Chapter 3 and 4.

2 Financing supply

This chapter provides an overview on the current and anticipated availability of funding sources to finance innovative green technologies in the IWT sector. Notably, comments will be provided on the effectiveness of the instruments for which we draw upon interviews and documents by various stakeholders' groups. Financing supply is therefore discussed sequentially from the different perspectives of governments, banks, system suppliers and ship owners.

2.1 Governments

Governments are the primary providers of grants to ship owners in order to promote the modernisation of the fleet. Typically, national or regional governments manage the biggest funds. But also port authorities are involved in providing incentives for greener IWT. The sections below discuss the grants and loan instruments as applied by different levels of governments. Fiscal instruments such as the possibility to earmark certain investments as tax deductible, fall outside the scope of this exercise but could provide an additional support locally. These are not the primary investment support, but can further stimulate the business case of investments, in addition to the initial funding thereof.

Grants

Through an analysis of various sources an overview was created of recent and open funding sources to promote the greening of the IWT sector. A total of seven EU Member States (MS) offer grants to ship owners. An overview of the instruments is provided in Annex 1. This information was gathered in 2017 and beginning of 2018. The research on the funding opportunities was closed end of February 2018.

Figure 1 shows the share of total costs that can be covered by the funding instruments of the respective countries. In addition, the size of the yearly available funds is indicated. All funding mechanisms are based on a co-funding rate (expressed as a share of total costs in the figure below; between 10% and 80%).

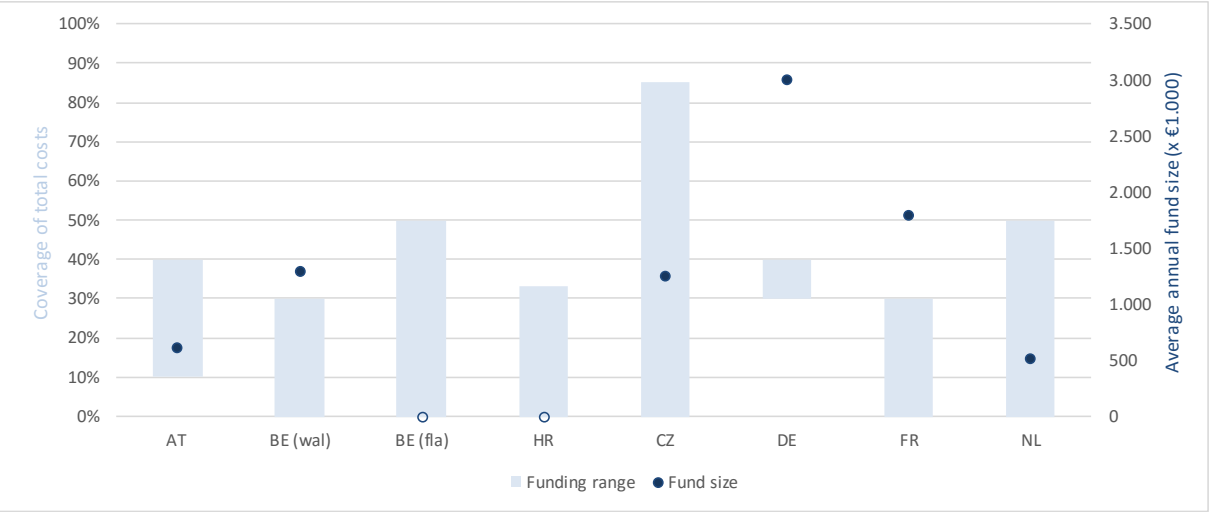

Figure 1: Overview of IWT funds for green technologies

Source: PROMINENT * no information could be retrieved on available funds in Belgium (Flanders) and Croatia.

Generally, between 30 to 50% of the eligible costs can be covered by the 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. In terms of the annual funds that are available we notice some profound differences. While the Netherlands provided a little over 500.000 EUR per year, Wallonia and the Czech Republic could disperse over 1 million EUR annually. Germany's IWT fleet modernisation fund provides over 3 million EUR annually to ship owners. Combined, these figures point at the availability of funds for green technologies up to 8.5 million EUR in Europe.

A few remarks should nonetheless be made from the perspective of the PROMINENT project. Firstly, the availability and size of the available funds is not well-aligned with the division of the European fleet amongst the different MS. As vessels need to be registered and flagged in the funding countries, this may exacerbate the gap between demand and supply. In addition, the eligibility criteria may limit the extent to which available funds are actually dispersed. Funds also could be spent on technologies which, from a PROMINENT perspective, are suboptimal to reach the set greening objectives.

There are a few indications to believe that the mentioned points are indeed salient issues. Figure 2shows the various categories of measures for which German ship owners could request funding. Despite the available options, ship owners used the fund almost exclusively to finance the purchase of new diesel engines, which are still rather polluting as these are most likely CCNR Stage 2 without any after treatment of exhaust gasses to reduce NOx and PM levels.

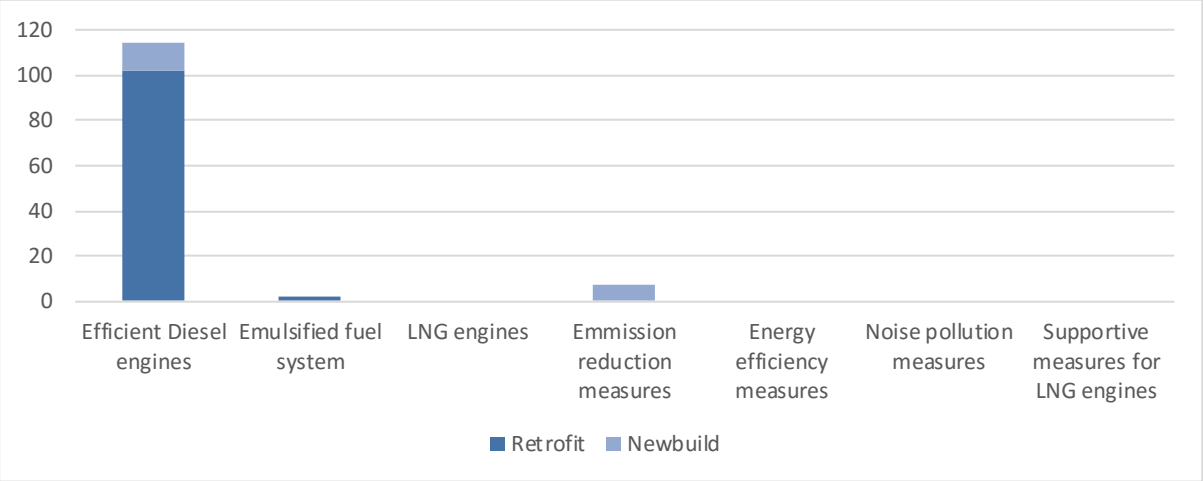

Figure 2: Overview of granted applications for the German IWT modernisation fund

Source: ELWIS.de

Similar conclusions also apply to other fleet modernisation funds. For instance, the Walloon fund allows for the funding of technologies such as LNG, navigation systems and hydraulic improvements. A large share of the funds is nonetheless directed towards more efficient diesel engines. The Polish soft loan system also is used to a very limited extent to enable the purchase of new green technologies. These observations are indicative of the difficulties of promoting green technologies through government incentives as legacy technologies seem to maintain the upper hand.

At the same time the risk is acknowledged that funds are too strongly focused on novel technologies with higher risk profiles, such as LNG engines. Such a strong focus may lead to a limited market interest in a fund, as experienced by the IWT fund of Flanders.

Several of the interviewed stakeholders also pointed to the *de minimis* rule that limits contributions to ship owners to EUR 200,000 in a three-year period. For some technologies this limitation will not be problematic. For resource intensive technologies, such as LNG, the *de minimis* rule can limit governments in their ability to promote such technologies since the investments are usually around 4 to 6 times the value of 200,000 EUR.

Loans

As shall be discussed in the following section on banks, governments do indirectly support loans for green innovation in IWT through the EIB. Poland is the exception as it is the sole country with a separate state-supported loan instrument for IWT operators. Together with Bank Gospodarstwa Krajowego the loan instrument is coordinated in Poland.

The instrument provides soft loans to promote the rejuvenation of the Polish fleet and is not directed solely to investments in novel technologies. Loans of over EUR 2.5 million (up to PLN 10 million) can be concluded, with a total of five loan agreements being concluded over the last three years. The agreements can cover the purchase or retrofitting of multiple vessels.

As it stands, discussions are ongoing to connect the loan to an additional funding mechanism in order to enable blended financing. No decision has been reached on this to date.

Fiscal incentives

In addition to the mentioned funds and loan instrument, several government provide fiscal incentives to promote investments in energy efficient technologies. Typically, these incentives are not specific for IWT technologies, but may be leveraged by IWT operators. It is nevertheless our understanding that fiscal instruments typically are of limited relevance to promote novel technologies as it does not significantly impact the return on investments. While certain technologies, e.g. SCR/DPF do not have a return on investment, fiscal incentives could mean a small contribution to increased uptake. An important pre-condition for the contribution of fiscal incentives is that the operator's business should be profitable, which in recent years (and still for some operators) has been proven a real challenge.

Other governmental instruments

A final note on financial incentives concerns port authorities. Several port authorities have taken the initiative to develop local schemes to promote greener shipping. While most of these measures concern sea-going vessels, some apply specifically to IWT. These include e.g. future restrictions that forbid access to CCR1 and unregulated engine vessels, but also entail rewards such as environmental discounts. The Port of Amsterdam, for example, introduces a scheme that gives 5 to 15% discount to vessels that carry an environmental label. E.g. the 'Green Award' certifies and labels ships (in the maritime and inland shipping sector) that are extra clean and extra safe. Ships receiving this certificate reap various financial and non-financial benefits. It was established in 1994 and expanded to IWT in 2011. The IWT program has turned out to be a success. Due to this success and demand for the Green Award certification, the program was developed further and a 3-tier certification was introduced; namely, Bronze, Silver and Gold certification levels and a Platinum

label for emission-free ship operations. The certification is based on a points system where a Stage V engine complying for NOx targets for example is awarded 200 points (from august 2017 on).

In the Netherlands, the Port of Rotterdam, has the intention to limit the access to vessels from 2025 onwards that do not comply with CCR2 emissions levels or better. Currently, IWT vessels calling at Port of Rotterdam receive a 15% discount when having a Green Award certificate and a score below 400 points for the main engine and a 30% discount for inland vessels with a certificate dated later than 17 June 2014 and a score of 400 points or more for the main engines.

To date, these incentives are particularly relevant for vessels operating in the ARA-region where ports have been particularly active in developing these schemes. Also, some inland ports have introduced discounts based on Green Award certification. Anticipating the broader spread of similar local 'bottom-up' initiatives, there may be more financial incentives for green technologies. However, although everything helps, the costs for port dues are generally rather limited in view of the total cost structure for operating a vessel. Therefore, such a broader spread will have a marginal effect on greening roll-out.

2.2 Banks

Financing of the IWT sector by banks is organised in a dispersed manner. The commercial banks are in general less interested in financing projects in this sector. Market knowledge is limited, the risk perception is high. Only a select number of banks per Member State have a specific transport, shipping and/or IWT desk. The general banking services are combined with European Investment Bank (EIB) funds in order to leverage investments thereof.

The loans will be reviewed from a number of perspectives:

- From the commercial banks' viewpoint.
- From the viewpoint of the EIB, providing funds in cooperation with Financial Partner Institutes (typically commercial banks)

Two aspects further discussed are related to:

- The option of cooperative lending and banking
- The aspect and level of socialisation of investments in greening objectives and own-account lending

Commercial banks have limited knowledge and interest in financing the IWT sector

In general, commercial banks already provide financing for SMEs that present a positive business case. So, an important condition for a barge operator to receive financing is a positive nett operation or exploitation result.

Still, this precondition is not enough for receiving funding. The knowledge and interest of general commercial banks in financing these investments is limited. The investments in the IWT are only concentrated in some banks, and within these banks in some desks. The Belgian example for example backs this statement, where only two banks have a specific IWT desk and some others provide only ad-hoc financing. In general, in Europe, only a couple of banks have a specific desk for the IWT sector. The larger investments (e.g. fleets of vessels and maritime vessels) are only possible with the bigger (European) banks. Smaller investments, and SME clients, have a wider choice of banks. The larger banks providing financing to the IWT sector focus on companies with

fleets or being part of a larger conglomerate of companies (e.g. providing a combination of services as IWT, shipping, terminals, trucking). Also, being part of a supply chain concept rather than a point to point transport service provider is a plus for being eligible for financing. The smaller SMEs will be financed by banks who have a historic position in the IWT sector. The banks indicated not to have chosen this market of IWT, but to have inherited these clients via taking over and merging with specialized banks and insurance companies in the past.

Although the market situation, due to a growth in transport demand, is slowly improving in some market segments, there is still overcapacity in various vessel categories, and the financial situation therefore is still volatile. Also, because the income is generated mostly on the spot market with fluctuating freight rates, this exposure leads for banks to a higher risk for financing the IWT companies. It helps if the IWT company has a stable long-term relationship with a broker or shipper and if the company is part of a cooperative organisation. However, only a minority of the IWT companies is part of such cooperative structures or has a long-term contract.

In many cases the required investment also exceeds the value of the vessel, and commercial banks grants credit in case of sufficient security and a solid business case. Whereas the larger shipping companies have higher chances to attract borrowed capital or succeed in requesting CEF subsidies, the volatile and fragmented market mainly limits financing opportunities for smaller companies (owner/operators). For smaller companies, and thus the majority of the inland shipping sector, it is rather difficult to apply for subsidies on individual basis and also, in many cases, due to the after-effects of the financial crisis, their financial position is not yet stable enough to attract borrowed capital. This is in particular true for access to large scale subsidies such as CEF. More regionally organised subsidies, e.g. by regional authorities are better accessible for small companies.

Banks put limitations in the financing of these SMEs via various options. The share of own capital, to be included in the business case presented to the bank, should at least exceed 30% of the total investment. The investment and payback period are kept short, e.g. 10 to 15 years. This limits the chances to attract capital considerably. The interest rates are differentiated based on risk profile, and the Internal Rate of Return (IRR) in the business case provided to the bank is at a relatively high level compared to other sectors. The trucking sector for example has access to better leasing and financing options, with lower interest rates and more competition between banks.

Lower interest rates, by means of secured loan programmes, are helpful yet their effect is marginal to initiate and accelerate the required transition to contribute to emission reductions and achieve the emission targets related to air pollutants and greenhouse gas emissions. The commercial banks first evaluate the business case itself and the financial health and strength of the concerned company. The guarantees by Member States, the subsidies and fiscal incentives are generally only taken into account at a second stage of decision making.

Investments in greening the fleet often do not generate enough return, therefore banks limit their investments in these cases. The investments in newer diesel engines are evaluated positively, as they often generate lower operational costs. Moreover, these investments a more known, rather common and guarantees are in place by suppliers and engines are ensured. This reduces the investment risk for the owner and loan risks for the bank. Other new technologies have not proven to have generated the same financial/operational return, notably SCR-DPF after treatment systems add costs while the clients are in general not willing to pay for transport with less air pollution.

However, some cases received investment from banks (e.g. LNG), mainly as a pilot case for evaluating the possible impacts. In this respect, LNG as a technology can have a win-win business case, depending on the fuel price spread between gasoil and LNG.

EIB funds in cooperation with FPIs

In 2016, the EIB assessed the main financial constraints in the European shipping sector. The lack of financing investments in environmental friendly solutions was related to the perceived risks associated with the shipping sector, market structure, supply and demand, but also the reluctance of commercial lenders to finance (and value) environmentally focussed investments especially on the existing fleet.

Therefore, EIB introduced a sustainable, scalable and commercial financial instrument to support investments in greener shipping, to support compliance with new regulations, which will work through financial institutions in the sector. This EUR 750 million Green Shipping Guarantee (GSG) programme is a follow-up to the work of the European Sustainable Shipping Forum (ESSF), an expert group bringing together Member States, maritime industries' stakeholders and the European Commission. The GSG programme is supported by the EU's Connecting Europe Facility (CEF) Debt Instrument and the European Fund for Strategic investments (EFSI) and is designed both for retrofitting of existing shipping as well as for projects that envisage the construction of new vessels with a green innovation aspect, it applies to both inland shipping and seagoing operators.

The GSG intends to address the main market gaps/constraints to access financing and (re-)attract commercial lenders to the sector by reducing the credit risks for loans to the shipping industry in environmentally focussed investments. The programme is not intended to address any structural (financial) issues in the shipping sector as a result of the fragile market situation nor provide financing to operators that do not have a sustainable business perspective.

The shipping segment that the GSG is trying to support, is characterised by small and medium size enterprises with investment needs that are below EIB's traditional ticket size (EUR 50M and above), and this requires the EIB to partner up with commercial banks that have knowledge of the sector and can play a front office role. Therefore, a guarantee or funded participation scheme with commercial banks is considered as the optimal structure to achieve the stated objectives and cover the market needs.

While the EIB may support up to 100% of the incremental environmental investments on existing vessels or up to 50% of the debt financing on new vessels, in all cases (existing and new vessels) the financial instrument amount will remain a fraction (between 20% and 50%) of the ship's overall financing. This will require commercial banks to finance part of the operation. This co-financing will translate into significant leveraging of EU resources and ensure the GSG does not support operators that would not be otherwise bankable and therefore avoiding GSG having a market distortion effect. The actual financing of greening initiatives under the GSG will be facilitated via a Partner Financial Institution (PFI). To arrange this, first a Framework Agreement with the PFI has to be established to constitute key terms and conditions for cooperation on:

- Agreed funding/guarantee envelope
- Transaction eligibility
- Credit terms/structures
- Transaction approval process

Individual transactions are originated, screened and assessed by the PFI and presented to EIB for internal review and pricing with an EIB accelerated/short approval cycle. The PFI concludes transaction with the borrower. The PFI retains client interface and transaction control. Furthermore, the PFI contributes through its in-depth market experience and presence, specific sector expertise, co-financing capabilities and facilitative and administrative capacity.

As part of this GSG programme, EIB has already signed agreements with several PFI's involved in, amongst others, financing the inland shipping sector. In April 2017, an agreement was reached with the Dutch bank ABN Amro (total value of EUR 150m) and in February 2018 the ING bank followed (total value of EUR 300m). It is also expected that the Rabobank will follow shortly and comes to a similar agreement with the EIB under the GSG programme. For financing innovative solutions, the Rabobank has already an attractive loan system in place for SMEs (max. 3,000 FTE) that are forefront of innovations. The 'Rabo Impact Loan', which is also supported by EIB and has been extended with multiple subsequent tranches, provides advantageous interest rates for loans between 5 and 10 years for financing needs between EUR 250k and EUR 12.5m per loan (max. EUR 25m total per SME).
The main benefit of the programmes mentioned above, and especially the GSG programme, is that it foresees in the extension of the financing period for greening investments, which has been limited through stricter lending terms since the economic downturn and related developments in the shipping sector. In recent years, the financing period (related to the return of investment) of environmental friendly solutions in the shipping sector, would have to be paid back within 10 to 12 years, commercial banks are now in the capacity again to stretch loans towards a period of 15 to 18 years. However, it shall be stressed that this 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.

Market cooperation could limit risk profiles of SMEs
At the demand side, a better organisation of the lending needs could lead to better business cases, lending conditions and more leverage. One of the solutions of lenders to limit their risk profile when applying for financing is organising the market differently. E.g., cooperative behaviour might increase the scale of their companies, so limiting the risk profile. This should (in this perspective) be organised on the demand side by the barge operators and/or brokers. Banks just want a solid business case or sufficient leverage. Nevertheless, forming a cooperative by itself is not sufficient if the members would still acquire most of their work on the spot market.

Collaboration is key, also to counter possible rigorous measures that greening is enforced through additional regulations if the sector does not manage to reduce their emission levels quick enough. If the speed of transition needs to be accelerated, then it is possibly not enough to only target and stimulate the individual IWT operators.

Individually, the IWT operators lack the scale and financial basis to speed up investments in greening technologies. Collaboration will help. It can be arranged between vessel owners through cooperatives, which leads to enlargement of scale of the supply side and to larger professionally organised IWT companies. For example, via shared and professionalised shore-based management, back-office, central planning, marketing, etc., which can be a more attractive position vis-à-vis

shippers to negotiate (long-term) contracts with better prices, rather than negotiating contracts between shippers and individual barge operators. Committed prices and volumes could allow SME companies to invest in newer technologies. Moreover, specific greening collaborations can be started for a group-buy action of greening technologies which will lead to reduced investment costs due to the economies of scale.

Stability in terms of income on the longer term may provide sufficient revenues, or possibilities, to attract borrowed capital, to optimise vessels for cargo flows and may result in joint investments in innovations resulting in higher efficiency or clean vessels. Examples of existing cooperatives and long-term commitments from shippers towards operators show good outcomes, e.g. AKZO-NPRC and TATA-PTC. Committed prices and volumes could allow SME companies to provide more sound business cases to banks.

Although more can be achieved if the level of cooperation in the logistics chain is increased. Given the existing market situation and the currently still volatile financial position of a large share of inland shipping companies (mostly the owner/operators), for commercial banks it seems inevitable that some level of subsidy is needed. Forming a cooperative by itself is not sufficient if the members would still acquire most of their work on the spot market.

Subsidies could generate a momentum for greening the European inland fleet. The market itself has not the margins or financial stability to invest in the technologies. As heard in interviews, in comparison to current CEF instruments, such a programme shall be accessible to small inland shipping companies and second the application process should be kept straightforward and accessible.

Will operators finance the greening investments fully on own account?
From the perspective of the shippers, the use of green vessels may also become a requirement, but at the same time this should also be expressed in the remuneration towards barge operators. In some European Member States, the national government may also be a major client for the inland shipping sector (e.g. in the sand/gravel segment for construction works). In this case, also the Member State could stimulate the use of vessels with low emissions by means of financial compensation or putting strict requirements on the maximum emission levels of the contracted vessels (e.g. Stage V equivalent only). Higher market prices and more chance on contracts for greener fleets will certainly stimulate the companies in the sector to invest in newer technologies.

A possible solution-path on a more abstract level, has to do with the way the costs for the required transition towards a greener inland shipping sector are socialised. The required investments can be totally attributed to the barge operators / inland shipping company. Other market actors could contribute to greening the fleet, via a long-term strategy. Governments could provide a legal, fiscal and subsidy framework. If the objective is considered to be of key European or national interest, subsidies could also be introduced to generate a momentum. But also, the shippers can take a strong role and responsibility in this development, e.g. contribute by covering a part of costs or by expressing long-term commitments. An integrated solution using common standards (e.g. Stage V equivalent as common aim for the sector), that requires a contribution and enhanced collaboration from all parties involved (EC/national governments, shippers, freight brokers and barge operators) seems the way to deal with the greening objective.

2.3 System suppliers

In the D1.3 report on the barriers for innovation uptake, it is stated that because of the small inland waterway transport (IWT) market, it very difficult for innovators and manufacturers is to regain their original R&D investment. In this report, it is mentioned that the market structure with its limited number of technology suppliers (e.g. multinational engine manufacturers and fuel suppliers) in the IWT sector is acknowledged by a low level of competition. These factors could lead to increasing prices and decreasing investments in innovations for inland waterway vessels. Therefore, the supply side, the scale disadvantages in the IWT sector and the co-financing options are discussed.

Composition of supply side: Limited number, heterogeneous group

In addition to the conclusion of the D1.3 report and as a first step in the consideration of the perspective of the supply side on the financing of the most promising technologies, it is important to further analyse the composition of this group. Besides the limited number of suppliers, it is also a heterogeneous group of companies, in type and size of companies as well as in the products and services they provide. It consists of multinational engine manufacturers and fuel suppliers, for whom the IWT ship-owning companies are only a small market. Furthermore, there are the local distributors of these products, a few SMEs providing after-treatment and alternative solutions and some system integrators dedicated to inland waterway transport. In the Netherlands this group of suppliers of engines, after-treatment systems, alternative solution are gathered in the EICB Innovation Lab together with some ship-owning companies. In this way there is already a kind of coordination and information exchange between these companies which may be further utilised and developed.

Lack of scale effect in supply of IWT

The scale on which the technology providers in the IWT sector operate is small. This is partly a result of the above-mentioned composition of suppliers. However, this is also caused by the market structure of the demand side (the ship-owning companies). The small-scale effect as mentioned by a study of STC-NESTRA and Maverick is seen in the small and specific fleets in the sector, the different ships types per Member state, waterway system and even canals.

The relatively small and dispersed IWT market results in relatively high investment costs for technology providers in the IWT sector. The cost of developing engine technologies suitable for the inland shipping industry does not weight up to the market potential of these products. Chances are high that only a limited number of ships will be equipped with the technologies, leading to very high R&D costs per application. This was confirmed by engine and other technology suppliers. An engine supplier mentioned that the market for engines for inland waterway vessels as too small, e.g. where tens of thousands of a certain engine type are sold in the off-road machinery or rail sector, the total IWT will only need around 200 of one type (e.g. canal-specific engine type).

A complicating factor is that there are vast differences between the (Member state and EU specific) standards and requirements for engines for IWT use (e.g. NRMM Stage V), and those for other use (e.g. engines for automotive, sea shipping, other non-road applications). This further causes that specific adaptions to the already manufactured engine are needed. Using non-road or rail engines in vessels is often never possible as they need to be marinized to be able to cope with the specific conditions and performance requirements of an inland vessel. And in most of cases the specific IWT requirements also require separate certification. For the different emission-reducing technologies

the market is even smaller, as it is only applied in part of the IWT vessels given the generally negative business case for emission reduction technologies (e.g. SCR-DPF).

Current financing issues
One of the conclusions of the cost and benefit analyses in WP2 is that most of these technologies also result in increased costs, in investment or operating costs or even both. In the latter two, there is no return on investment and in the first one (only higher investment costs, there's a positive business case in only some cases). This lack of a positive business case complicates the financing of emission reducing technology, which is already a major bottleneck. This is also a conclusion of the report of STC-NESTRA and Maverick on the IWT market structure.

Co-financing from the supply side: lease constructions
The report of STC-NESTRA and Maverick also concludes that there is a relatively large role for the technical suppliers (such as ship engine suppliers). In a study on greening the fleet within the Dutch programme 'Impulse Dynamic Waterway Traffic Management' (Rijkswaterstaat), the co-financing from the supply side was also identified as a possible solution. One of the possibilities of co-financing from the supply side is equipment leasing, in which the whole vessel or components will be leased by the ship-owning company.

While equipment leasing is an often-used construction in other modes of transport, e.g. the leasing of trucks by transport companies, this is rarely used for inland waterway vessels (or belonging equipment). Especially for technologies with a large investment, such as the application of LNG, leasing constructions have also been suggested in interviews. However, banks are not keen on leasing specific parts of the vessel as the systems are fixed part of the overall vessel. In case of financial difficulties, it is no option to take out the engine system, as it will have high costs and a dramatic effect on the value of the vessel.

Others roles of system suppliers in financing
There are limited examples of the use of leasing constructions in financing inland waterway vessels or components. Some of Europe's IWT vessels are built and leased out / chartered for longer periods up to 10 years. However, this can only be done by larger shipping companies and/or brokers (or companies which are both). Most of the financing is still done by the use of own means of the ship-owning company or provided by a loan of traditional financing institutions (banks). However, in the whole course of selection, provision and installation of technologies, the supplier (the system integrator) also pays attention to the financial part.

There are several examples in which suppliers are actively involved in seeking external finance for the customer, mostly in grants or utilising tax discount benefits. While there are possibilities for innovative financing solutions by the system supplier, it is more likely that the financing will rely on traditional financing from banks combined with subsidies. Establishing a greening fund is one of the recommendations from the system suppliers. An easier to implement measure is their wish for implementation of further incentives for emission-reducing technologies, such as lower port dues and tax discount benefits.

2.4 Operators

The IWT operators are the key actors in the greening challenge of Europe's IWT sector. These often own and operate their vessel(s) and are the decision makers on investments in new fleets,

retrofitting or upgrading the vessel's engine. The operators were surveyed in this study, providing insight in their investment intentions and capabilities.

Survey among IWT operators in Europe

In 2016, supported by PLATINA II and executed by STC-NESTRA, a comprehensive survey was conducted on the financing needs of the IWT sector. The 280 participating organisations give a good snapshot of the status of the financial situation of the sector and the ability of ship owners to invest in green innovations.

The survey highlighted the limited own financial means available to finance greening technologies. This is a particularly pertinent issue for smaller firms / SMEs. Of the firms that are inclined to invest in greening solutions, about 46% experienced problems to obtain a bank loan. Policy approaches that lower interest rates would be a particularly relevant option for this group, making the majority of the market. In addition to the results of the survey, the following two statements can be added based on the interviews conducted in the framework of PROMINENT as regards the supply and demand for financing:

1. **There are strong regional differences in financing supply**

The supply of financing significantly differs between Member States and even on a regional basis. Whilst in the Western part of Europe, stakeholders are having fruitful and promising, even well-established financing frameworks, in the Eastern part (Danube Region) it is very difficult to find financing solutions.

One of the reasons for this difference is that in the Western regions, waterborne transport is organised based via the commercial market which implies that the financing supply is also generated based on underlying market needs. The operators are SME (usually very small companies), and banks have adapted their interests to this market structure. The fragmented market structure leads to diseconomies of scale. In Eastern European countries, fleet operators and also freight forwarders used to be larger state-owned or stated-supported entities. These had their financial background provided by government, thus the bank sector did not even need include waterborne transport in their portfolios. The concentrated market could lead to economies of scale. But the historic position of the state-led companies also implies that commercial banks have less experience and know-how than in the Western European market segment.

Thus, the funding for inland waterway transport investments in vessels and equipment, is rather a new business segment in Eastern Europe. This brings new aspects, whereas international financing institutes might transfer their know-how into the new segment. At the same time, EU Members States can consider to design and implement state aid schemes that support fleet modernization like is/was done in Western Europe as well. On top of all these, it would is highly recommended if the mix or blending of these possibilities would be made available to operators or groups of IWT and logistics operators.

2. **Financing demand shows regional differences too**

The demand for funding and financing also differs from region to region. In Western Europe, demand is rather generated towards upgraded vessels or part of the vessels, to the highest available technological standards and solutions which are economically viable. Whereas in the Eastern region financial resources are needed still to comply with regulations. As described above, a promising approach is to find suitable schemes is to bring the stakeholders (governments – financing institutes – fleet operators) together, learn from each other and create or customize existing solutions for the widest possible range.

2.5 Summarizing overview of financing supply and market structure

The governmental supply of funds and loans to IWT companies differs significantly in size and in eligibility criteria. The fund sizes seem not to be at par with the regional size of the IWT sector across Europe. Given that a major share of operators is based in the Western-European Member states, the funds available per IWT company or vessel seem to be quite low compared to the financing need for greening the fleet. The governments tackle this aspect partially via the fund set-up, e.g. via the fund's eligibility criteria, and co-funding percentages. The funds seem to be connected to the registration of the vessel, while however a lot of vessels travel across borders on a frequent basis. Operational use and funds available seem not to align for that reason. Given the international market and the fragmentation, it would make more sense to bundle the regional and national funds into an overall European financing scheme. The majority of government funds provide funds, subsidies and some also provide fiscal incentives. The latter was not regarded in this WP.

The banking sector seems to have a limited knowledge on the specific characteristics of the IWT sector. Financing by commercial banks seems concentrated in a limited number of banks, which provide the sector a specific desk. The larger banks opt for limiting their investments in larger IWT companies of 5 and more vessels, while the specialised banks can also provide financing to the very small operators. Companies of 5 or more vessels are usually still SME companies. Larger companies of more than 10 are limited, though the overview in the figure below shows vast regional differences.

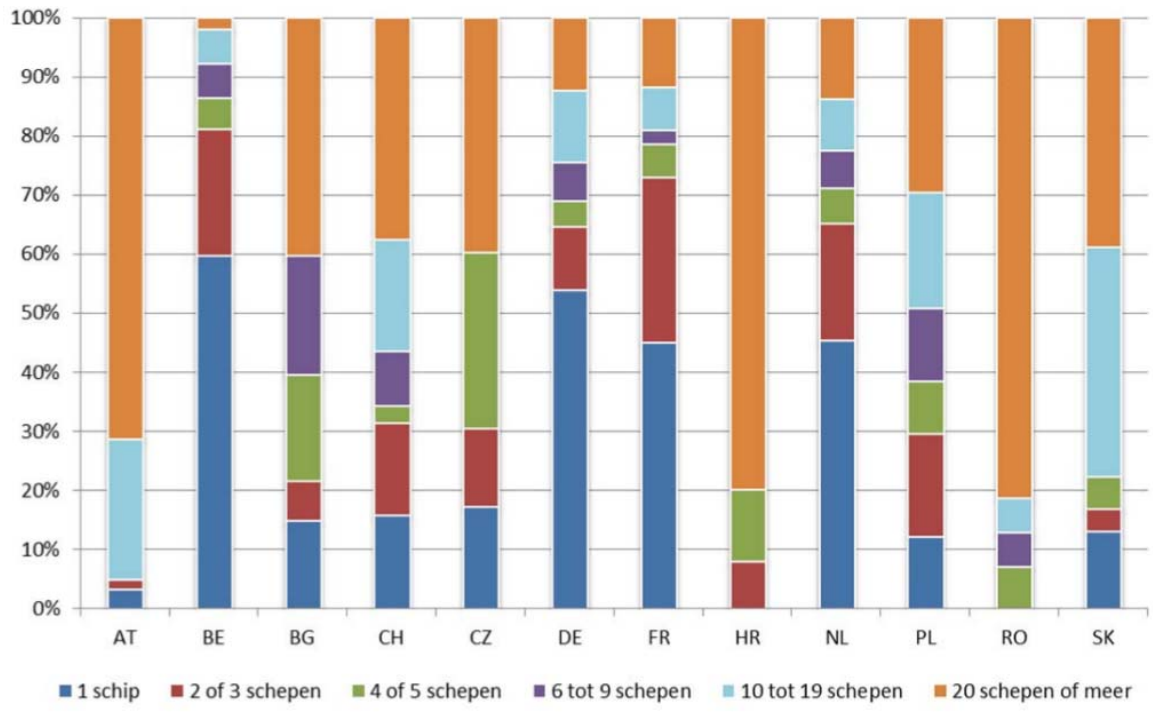

Figure 3 Number of IWT vessels per company per European Member State

Source: STC NESTRA and Maverick, 2015

In general, banks only regard the business case of the investment. Subsidies, grants and guarantees of governments can influence the business case positively. However, the business cases which are positive only because of government support are regarded to be risky for bank lending. The banks limit investment risks by only financing larger fleet owners, operators being part of a supply chain concept, or by demanding own-capital of over 30% of the investment size. By decreasing payback periods, demanding a higher IRR or by choosing known investments banks try to invest in the less-risky cases. Especially this last aspect shows the risk-avoiding behaviour when newer technologies are evaluated in an investment decision. Newer diesel engines are seen as a “more safe” and known investment for banks compared to LNG and SCR-DPF technologies as new engines are insured and the engine has a guarantee from the manufacturer. However, new engines (CCNR Stage 2, NRMM Stage 3A) are still quite polluting compared to modern truck engines (Euro VI). The other technologies, such as SCR-DPF and LNG, are regarded by banks as less mature, and thus riskier. However, LNG may bring a positive business case due to fuel cost savings, especially at higher oil prices in future. Therefore, these are only financed limitedly, e.g. in pilot tests.

The EIB set up a structure (GSG) where Partner Financial Institutions provide investment desk services for EIB funds. As such the market agents can find investment credits via their regular channels. EIB funds can leverage the investment budget via this cooperation with commercial banks. Lower interest rates provided via this channel can support SME uptake of investments. Some specific loans are developed under this framework, providing at first sight positive results.

The technology providers are limited in providing funding or lending to their clients. The R&D costs for the specific engines used in IWT are high, due to the small market which limit the number of units to be sold to offset the R&D costs. Therefore, the capacity of technology providers to make profit in this market segment is limited, which also results in a limited number of suppliers which in turn limits competition and market offer of products. Some provided extended payment options for new engines. However, this has proven to be risky. The leasing or renting of engines or fleets is a common practice in the rail and trucking sector, but not in the IWT sector.

3 Financing demand

This chapter deals with the business economic assessment of innovations as well as the extrapolation to the EU fleet of inland vessels.

The first part of this chapter presents costs, benefits, required investments, risks, sensitivities and further indicators for most promising innovations for various different vessel types and operating profiles. This mainly focuses on the three solutions for further greening the fleet: LNG, SCR and DPF. Information on the business cases is sourced from earlier deliverables under WP2.

Then, the chapter elaborates briefly on the methodology that was used to design scenarios for deployment of technologies on board of the whole EU IWT fleet. The scenarios aim to advance the most cost-efficient solutions to reach the PROMINENT objectives. The results display the number of vessels categories to be equipped with specific technologies. Further details on the methodology are included in Annexes III to VII.

3.1 Business economic assessment of greening technologies

In the PROMINENT project, a large number of technologies have been assessed on their potential contributions to greening the fleet. Not only financial barriers limit the uptake of greening technologies. The barriers for uptake are mainly characterised by their technical, legal and financial facets. Moreover, three additional generic barriers were identified. These are related to knowledge, market and cultural aspects. This division in six barrier types aligns with previous research for the Dutch Ministry of Infrastructure & Environment (IDVV, concluded in 2013) and the POLFREE study (Bastein, Kroes et al., 2014). An overview of these six barrier types is given in the table below. The detailed analysis of the barriers for the longlist of identified technological options can be consulted in D1.3.

Barrier type	Definition	Example
Technical	Barriers caused by immaturity of technology or operational requirements	Space requirements reduce payload substantially
Legal	Barriers caused by regulations and laws	Safety regulations concerning LNG bunkering
Financial	Barriers caused by access to capital or business case	Reluctance of banks to finance measures with low ROI
Knowledge	Barriers caused by a lack of expertise or skills	New navigation system requires new procedures to be learned
Market	Barriers caused by market conditions, infrastructure, and the supply chain	Ports do not allow ships with new technology to berth
Cultural	Barriers caused by behavioural routines	Reluctance amongst ship owners to consider new technology

Table 1: Barriers for uptake of technologies in the IWT sector
Source: D1.3

The intensity (severity) of each of the six barrier types vis-à-vis each of the 14 selected technologies is depicted in the matrix below. The colour codes indicate the level of the barrier (the darker the shading, the more important the barrier is for the specific technology), which is based on the literature review and validated in an expert workshop.

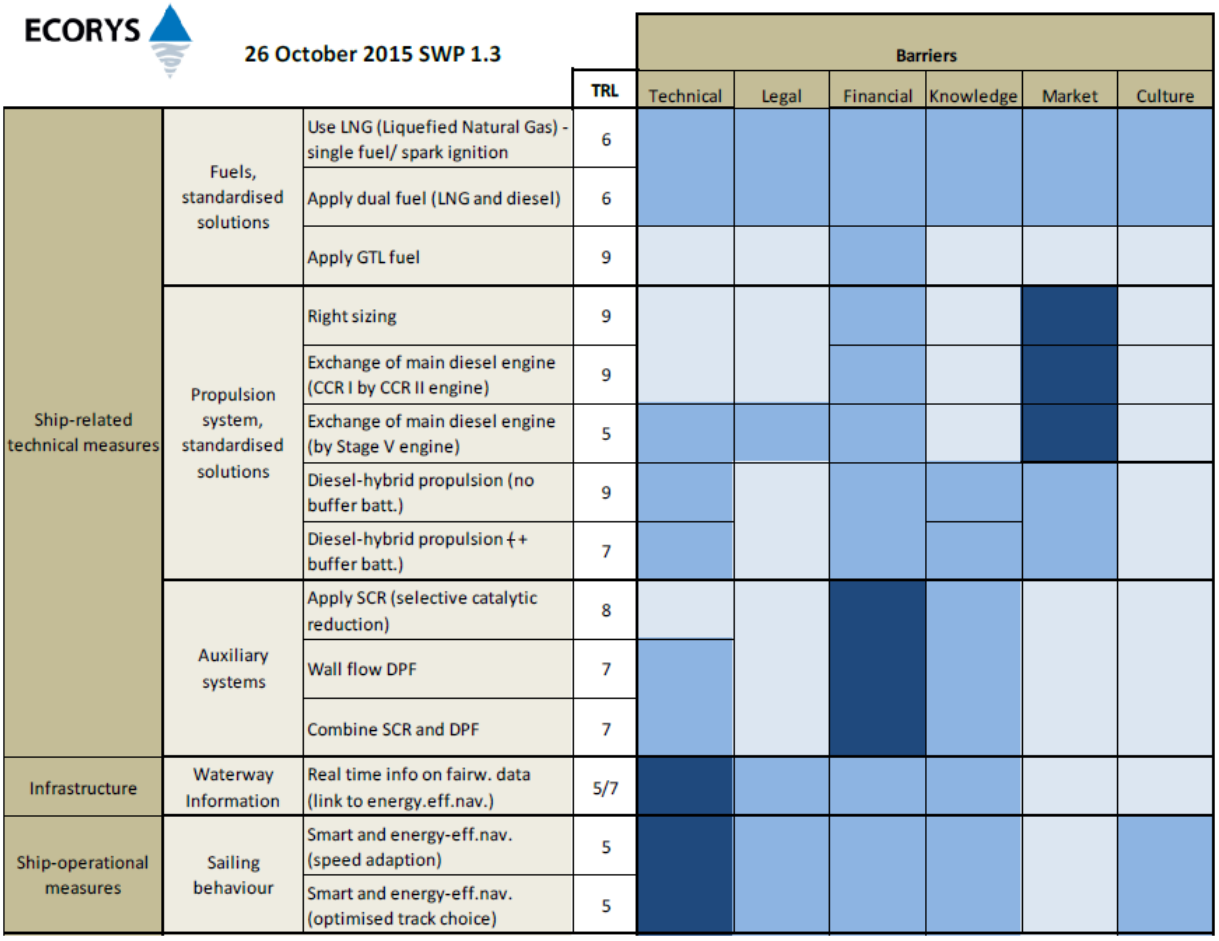

Table 2: Analysis of barriers for uptake of long-listed technologies in the IWT sector
Source: D1.3

Based on a shortlisting exercise of technologies, and experience in pilot studies, the following three technologies were identified to be the most effective, having low or medium barriers for uptake, and able to contribute to achieving the PROMINENT goals:

- Liquefied Natural gas (LNG)
- Selective Catalytic Reduction (SCR)
- Diesel Particulate Filter (DPF)

Besides these most promising technologies, three other approaches have been identified as potentially valuable additional solutions for more sustainable inland waterway transport:

- Efficient Navigation
- Right Sizing
- Hybrids

These technologies and solution have been further assessed within the PROMINENT project. In the next section, the main results of the business economic assessment of the six greening technologies is summarized.

Liquefied Natural Gas

As presented previously in report D2.6 of this project, the application of LNG as an alternative fuel offers a main opportunity for large vessels with a high annual fuel consumption. In that case, the

high investment costs of the LNG tank and fuel system can be earned back through savings in fuel costs. The number of vessels for which the application of LNG is feasible, depends on the investment costs, the fuel consumption and especially the fuel price scenario and difference between gasoil and LNG.

Costs: Additional investment costs
In order to transition to LNG as a fuel, investment costs are required to replace the gasoil engines with engines suitable for LNG. In this analysis, the investment costs were taken as the additional costs compared to the installation of a regular gasoil. These costs depend on several factors, like the number and the installed power of the engines and the place of the fuel tank. The engine configurations are also a determining factor, with the investment costs for applying these configurations in the considered vessel types. Mono-fuel can result between € 1.8 million (€ 2 million under deck) and € 3.2 million investment costs. While Dual-fuel has between € 1.4 million (€ 1.6 million under deck) and € 2.2 million investment costs. Dual-fuel refit has investments in the same magnitude.

Benefits: Fuel consumption and fuel price scenario
In order to earn back these investment costs in twelve years (the assumed return on investment), it is important to have enough savings in fuel costs. This depends on the price advantage of LNG compared to gasoil. Four scenarios were used assuming a n LNG price advantage of € 0.05, € 0.17, € 0.27, € 0.35 to diesel fuel. The annual fuel cost reduction for the different vessel types with their average fuel consumption lies in a range of € 15,357 (110m MVS) and € 116,132 (Push B6) in a scenario with a € 0.05 price advantage gap. While the scenario with a € 0.35 price advantage gap results in annual benefits between € 107,501 and € 812,925 for the vessel owner / investor, depending on the vessel types.

These benefits were also calculated for specific journeys, resulting in an annual fuel cost reduction for in a range of € 15,529 (110m MVS operating between Rotterdam and Duisburg with containers) and € 196,973 (push boat with ore between Rotterdam and Duisburg) in a scenario with a € 0.05 price advantage gap. The scenario with a € 0.35 price advantage gap results in benefits between € 108,701 and € 1,373,809.

Costs and benefits
WP2 concluded based on the average fuel consumptions (and resulting, the average savings in fuel costs) for each of the IWT vessel types, the application of LNG is particularly (economically) feasible for the larger push boats on the Rhine as well as on the Danube. Although the particularly high investment costs for these vessel types, there is an ROI for almost every configuration, except for the worst-case scenario of € 0.05 price difference. A limitation of the application of LNG on this vessel type is that it is currently not expected to be possible to apply LNG on existing push boats.

On the contrary, for the two (average) types of 135 metre motor tank vessels, there is no positive business case in any of the situations, caused by the (relatively low) average annual fuel consumption, which can be seen if it is compared with the analysis for the representative journeys.

Required fuel consumption for a positive return on investment
It is important to notice that the fuel consumptions under the vessel types are averages. Most interesting is the application of LNG for inland vessels with a high fuel consumption. This can be seen in the assessment of the application on the representative journeys, in which the annual fuel consumption is relatively higher than the averages of the respective vessel types. In the worst-case price scenarios (with only € 0.05 price advantage), for a dual-fuel engine (with a tank above deck or

on a newly built vessel) an annual fuel consumption of at least 2,400 m^3 is needed (for a push boat with four/six barges even more than 3,600 m3). In this scenario, earning back the investment is unlikely for inland vessels. In the best-case scenario (price advantage of € 0.35), an annual fuel consumption of at least 340 m^3 is needed (push boat with four/six barges: around 525 m^3).

In the worst-case price scenario, there is no positive business case for the application of LNG. For all vessel types, even with an annual fuel consumption of 3,000 m3, the net-present value is negative in this scenario. If the price difference is € 0.17 or higher, a fuel consumption of 1,000 m3 per year is sufficient for a 110 metre motor tank vessel to get a positive business case.

Considering the business case for LNG, the determining factors for a positive return within an acceptable period of time (12 to 15 years) concern the fuel consumption related to the price difference between diesel and LNG (see graph below).

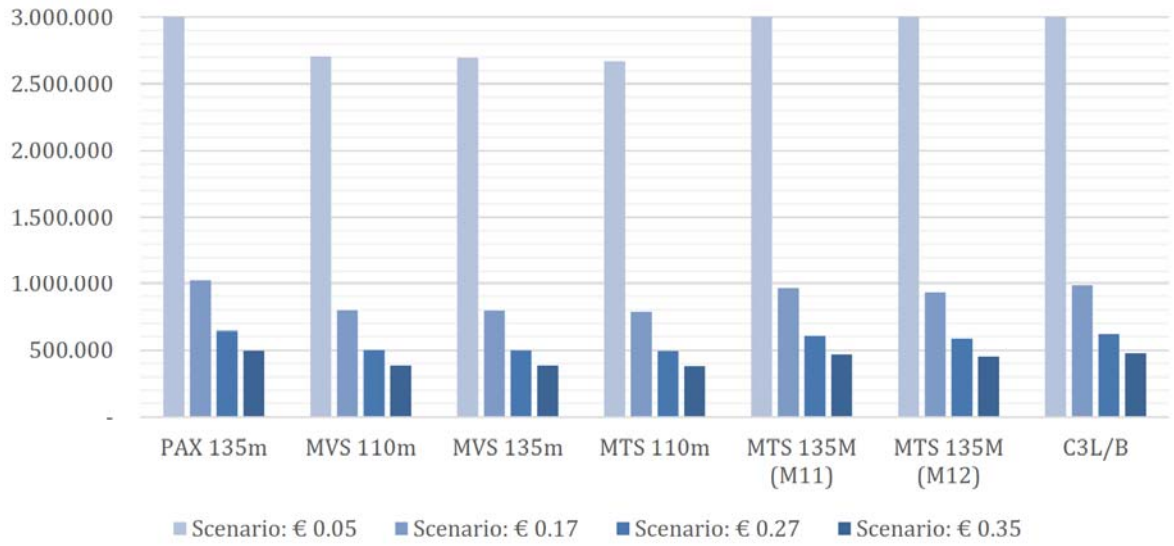

Figure 4: Required fuel consumption (in litres) to get the investment costs earned back in twelve years per vessel type for dual-fuel LNG configuration on existing vessels with a tank under deck (source PROMINENT D2.6)

Investments in greening technologies are made over a long-time period (typically 10 – 15 years, or even longer), while fuel price difference are subject to market dynamics and may variate substantially within a short period of time. Even if for a short period of time the price difference between diesel and LNG fuel is significant, there is no guarantee this will last for several years. On the contrary, the situation could be completely different again a few months later. An interesting mechanism to insure such risks and market dynamics is to introduce fuel hedging contracts, that allows a fuel-consuming company to establish a fixed or capped cost, via for example a commodity swap or option. Additionally, an interesting idea to improve the business case for LNG, with respect to fuel hedging contracts, is to establish a (guaranteed) minimum price difference between diesel and LNG (e.g. 20 eurocents per litre diesel fuel). If market dynamics would result in higher price differences (e.g. 25 eurocents per litre diesel fuel), the advantage would be attributed to the counterparty providing the guarantee.

Emission savings

It is expected as of 2019, a LNG solution will be ready for market uptake that is fully compliant with Stage V emission limits. Therefore, an important factor for the application of LNG is the environmental benefits in the reduction of CO_2, PM and NOx. These environmental benefits result in

the reduction of external costs. It is important to take this external cost reduction into account as a benefit, in addition to the fuel prices differences.

Selective Catalytic Reduction and Diesel Particulate Filter

As already concluded in report D2.2, with the application of SCR and DPF (after-treatment) it is possible to achieve a major reduction of air pollutant emissions. However, this reduction comes with a price, as there are no benefits covering the entire costs of the application.

Annual costs SCR and SCR+DPF: Highly dependent on vessel type and engine type

The annual costs of after-treatment differ per vessel type, influenced by a number of factors, such as the fuel consumption, the number and size of the engines (in installed power), the power used in normal conditions and the engine hours. This results in annual costs of applying SCR of maximum around 30,000 euro for the regular motor cargo vessels with CCNR Stage-I engines, which mostly depends on the size of the vessel (e.g. € 4,521 for a 38.5 metre motor vessel). At the other side, for the coupled convoys and especially the larger pushed convoys, these costs can range from around € 47,000 to € 117,000. For vessels with CCNR Stage-II approved engines, the annual costs of applying SCR can be 5-22% lower than with CCNR Stage-I or non-type approved engines.

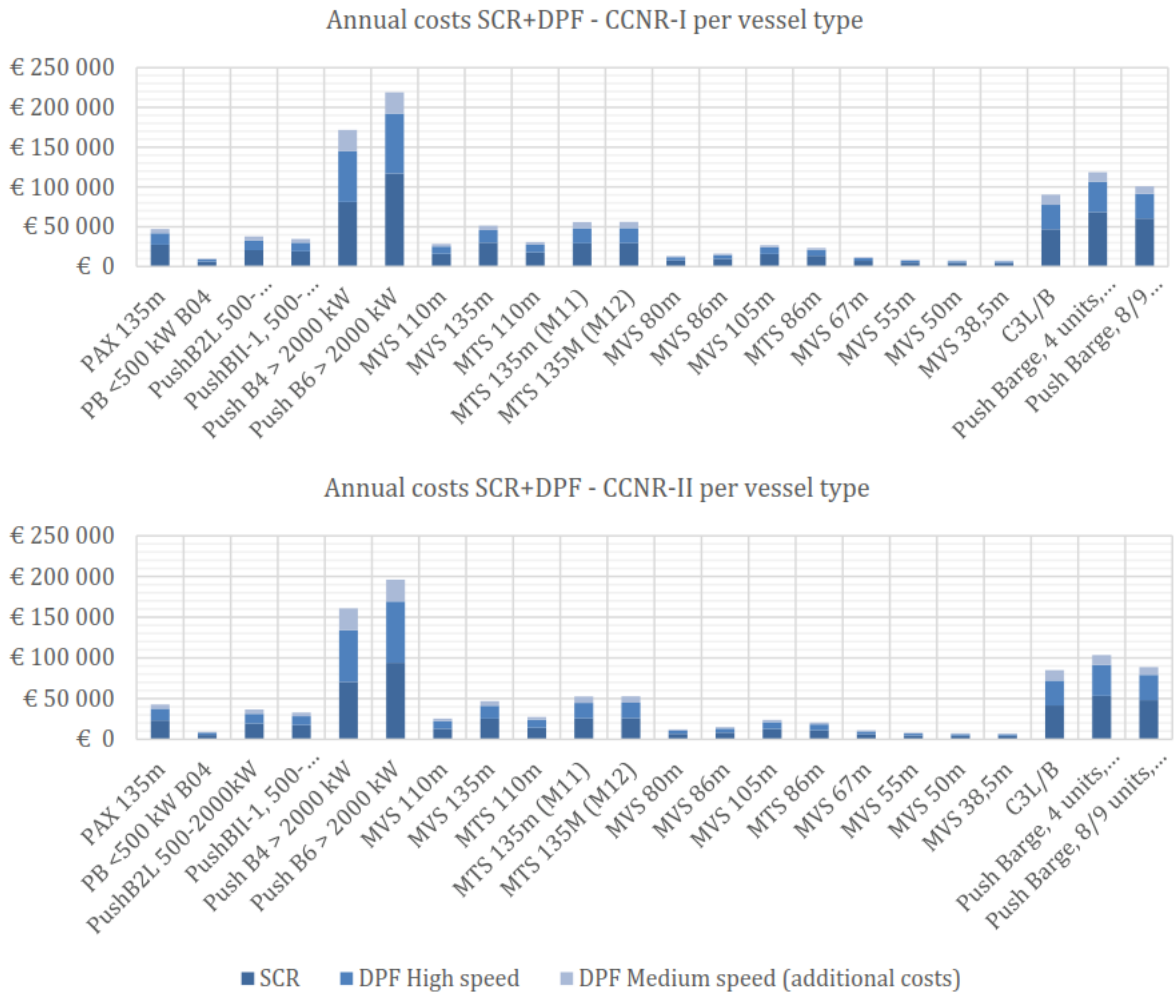

Figure 5 : Annual costs SCR+DPF per vessel type for CCNR Stage-I and CCNR Stage-II engines (with the costs of SCR in dark blue, of DPF for high speed in medium blue and DPF for medium speed in light blue)

For the application of SCR and DPF, the annual costs can be 45% to 91% higher for high-speed engines than the annual costs for the application of only SCR. Due to the higher investment costs for the filter, this is even higher for the medium-speed engines (between 64% and 129%). The annual costs can go up to € 219,000 for a pusher with 6 barges and medium-speed CCNR Stage-I engines.

Relative cost increase of applying SCR and SCR+DPF compared to base line costs

There are major differences between vessel types and engine types in absolute annual costs for the application. To show the business case in relation with the general costs a ship-owning company has in operating a vessel, the relative cost increase of the application of SCR and SCR+DPF has also been calculated. For application of SCR this cost increase is on average around 2.4% (for CCNR Stage-II engines) and 2.8% (for CCNR Stage-I engines). For SCR+DPF this is on average around 3.9% (for CCNR Stage-II, high speed) to 4.9% (for CCNR Stage-I, medium speed). For some vessel types, like passenger vessels, this is even much lower (e.g. 1.3%). The cost increase for the larger motor tank vessels is also relatively low. At the other side, for the Danube push boats with four barges, this can be around 6.3% for SCR-DPF on the most common engine. In lesser extent, this counts also for the coupled convoys, the other push boats with high installed power, but also for some smaller vessel types.

The same conclusions can be seen in the outcomes for the representative journeys. Because of the high relative costs for the Danube push boats, this is also relatively high for the Danube journeys. On the Rhine journeys, most of the ship-owning companies can benefit from the discount on the port dues, which covers in the most positive situation for 15% (SCR+DPF) and 24% (SCR-only) of the extra annual costs, resulting in a net annual cost increase of 2% (SCR+DPF) and 3.5% (SCR-only).

Relative costs SCR and SCR+DPF per tonne cargo transported

Considering the representative journeys, as analysed in PROMINENT WP2, Rhine journeys have the most “positive” business case, if expressed as costs per tonne cargo transported, € 0.03 and € 0.05 for respectively SCR-only and SCR+DPF. Although the discount on the port dues reduces the net annual costs of applying SCR and SCR+DPF for the Rhine journeys, there is not a big difference between the average costs per tonne cargo transported for the Rhine and Danube journeys. For the Danube journeys, these costs are between € 0.07 and € 0.29 for SCR and between € 0.11 and € 0.44 for SCR+DPF. For the journeys on the other waterways these costs are higher (between € 0.23 and € 0.32 for SCR and between € 0.35 and € 0.48 for SCR+DPF), because of the low average payload.

Relative costs SCR and SCR+DPF compared to environmental benefits

SCR and DPF are effective in reducing NOx and PM emissions, making it possible to achieve emission levels proposed for new emission standards. For that reason, the annual costs of applying SCR and SCR + DPF are expressed here as costs per kg NOx and PM reduction. This shows that although the annual costs of applying SCR on a CCNR Stage-I engine is higher than on a CCNR Stage-II engine, the costs per kg NOx-reduction are lower. For the CCNR Stage-I engines these costs range from € 1.12 to € 5.04 and respectively € 1.68 to € 9.23 for CCNR Stage-II engines. These costs are lower for some of the Rhine/ARA journeys, because of the discount on the port dues, ranging from € 0.99 to € 1.87 for SCR-only. For the Danube journeys these costs are between € 1.16 and € 1.41 per kg NOx reduction, for the journeys on the other waterways between € 1.44 and € 1.90 and relatively high for the passenger journeys (€ 2,97 and € 3.82).

For the additional costs for applying a DPF on an SCR system, the costs are formulated per kg PM emissions. This ranges from € 33.36 to € 122.50 for high-speed engines and € 43.72 to € 177.43 for the medium-speed engines. The costs compared to the emission reduction are relatively high for the smaller motor cargo vessels and the push boats with 500-2,000kW installed power. The most

positive case compared to the emission reduction is for the Danube push boats, the medium-large motor cargo vessels and motor tank vessels, and the passenger vessels.

Energy efficient navigation, rightsizing and hybrids

In addition to the application of LNG as an alternative fuel, and SCR and DPF as after-treatment to reduce air pollutants, several other options exist that can contribute the PROMINENT targets. The approaches discussed here include energy efficient navigation, rightsizing and hybrids (PROMINENT deliverables D2.4, D2.8 and D2.9).

Energy-efficient navigation

The major goal of energy-efficient navigation is to reduce the fuel consumption of a vessel while preserving or even improving the service quality of transportation. This shall result in cost savings for the ship owner/operator, as well as a reduction of climate emissions (CO_2) and air-pollutant emissions such as NOx and PM. Fuel savings are expected to result from sailing at the optimal location in the fairway (causing the least resistance), as well as by means of optimising the sailing speed based on the actual conditions of the waterway. Savings lie in the magnitude of 10%.

For the base case scenario, the business case is positive from a fuel consumption of around 70 m^3 per year in case of high fuel prices, around 100 m^3 per year for average fuel prices and 250 m^3 per year for low fuel prices. In case of very high fuel-consumption figures such as 1000 m_3 per year, the total sum of the discounted saving (NPV) over a 15-year period can be 250,000 EUR at low fuel prices and up to 850,000 EUR at high fuel prices. Compared to an investment of 40,000 EUR, these benefits are quite remarkable. This means that each euro initial investment (40,000 EUR) will yield 21 times more money (850,000 EUR / 40,000 EUR) in case of high fuel prices over a 15-year time period and about 6 times more in case of low fuel prices (250,000 / 40,000 EUR).

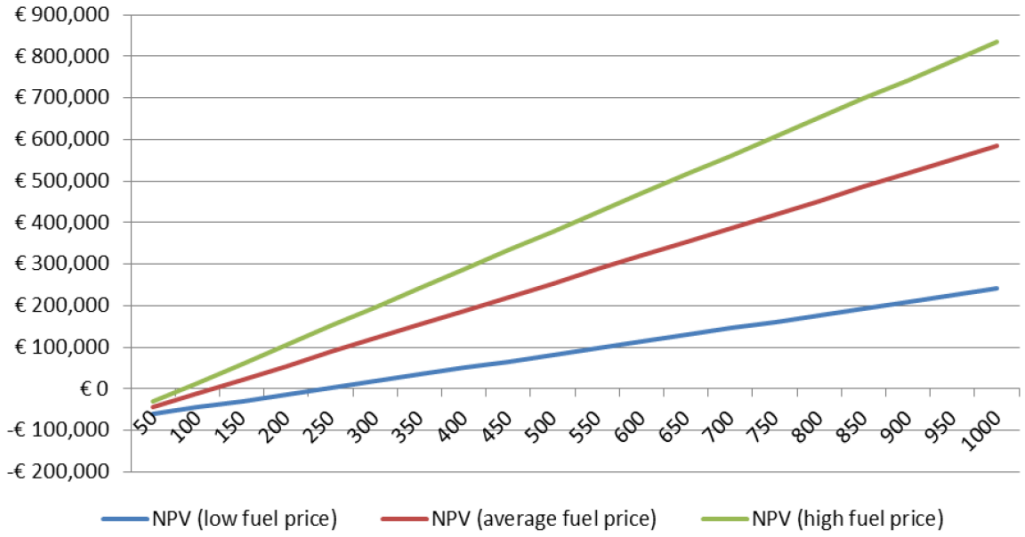

Figure 6: Development of Net Present Value (NPV) depending on fuel consumption (m3/year) at different fuel-price levels calculated for the base-case scenario.

Rightsizing

For some categories of vessels, installed propulsion power has shown to be larger than strictly needed. For these vessels smaller engines can be fitted which is meant by right-size engines. The installation of smaller engines leads to benefit-benefit analysis as the choice for smaller engines (and other components) reduces investment costs. In operation, fuel costs will reduce due to the better performance of the right-size engine. Furthermore, maintenance costs will reduce.

Stakeholders indicated that right-sizing may be unfavourable with respect to obtaining contracts that require sailing on different routes or with different cargo.

Engine suppliers indicate that reduction of engine size is possible in practice and proposed the case of replacing a 1250kW engine to 1000kW or even to 750kW. This leads to investment savings of at least respectively 55kEUR to 110kEUR in the average investment cost scenarios. In this scenario with a pessimistic fuel saving scenario, this results in a net present value of at least 136kEUR to 273kEUR in 20 years.

Hybrids
For a 105m vessel, the energy model developed in PROMINENT was used to compare the fuel performance of electric drivelines (diesel electric and hybrid) with a diesel direct driveline:

- Diesel electric propulsion consumes significantly more across most of the sailing speed range (0% to some 10% increase, with two constant speed gensets);
- Between 8 and 14 km/h, the mostly used speed range, the fuel consumption increase of the electric propulsion is in the range of 0% to 5% increase;
- The main reasons for the fuel consumption increase of electric propulsion according to these simulations are the electric power losses in generator, electric motor and invertor/rectifier: 12% or more of the power output;
- Diesel electric propulsion with two (half-sized) constant speed generator sets performs much better that with one (full sized) constant speed generator set. Comparing the generator sets solely, the fuel consumption of the latter is 5% to 15% higher in the sailing speed range from 8 to 12 km/h.

The total lifetime costs including investment, fuel consumption and maintenance costs have been calculated for different types of drivelines based on the modelling results (for a 1,250 kW reference driveline). Initial investment increases due to the higher per kilowatt price of the electric components. Choosing for a hybrid with 750kW mechanical and 250kW electric propulsion requires additional investment of 102,000 EUR. This number becomes 260,000 EUR with 500 kW for both mechanical and electric power. A full diesel electric driveline of 1,000 kW requires 575,000 EUR additional investment costs.

In the average investment costs and fuel price scenarios, the total costs over a period of 20 years expressed as Net Present Value (NPV) yields from -92,000 EUR to -20,000 EUR for 250 KW electric hybrid, and from -178,000 EUR to -393,000 EUR for the 500 kW electric hybrid vessel. For the diesel electric, the NPV ranges from -887,000 to -529,000 EUR. Range for each configuration depends on the uncertainty in the actual fuel consumption realized. It can be concluded that according to the simulations, the costs of hybrid (electric) or diesel electric propulsion leads to higher costs during the lifetime of the vessel. It only applies for vessel with frequent start-stop movements.

Conclusion business economic assessment
Looking at the business cases of available and mature Stage V technologies, currently there is no significant incentive for barge owners to invest in e.g. SCR and DPF. Some ports provide discount in port dues to green vessels that can overlay a Green Award certificate, however these effects are marginal with respect to the investment (CAPEX) and/or operational costs & maintenance (OPEX).

In order to transition to LNG as a fuel, investment costs are required to replace the gasoil engines with engines suitable for LNG. In order to earn back these investment costs in twelve years (the investment is significant and can amount up to 1 to 2 mln EUR), it is important to have enough savings in fuel costs. This depends on the price advantage of LNG compared to gasoil. In the worst-

case price scenario, there is no positive business case for the application of LNG. In the best-case scenario, especially larger ships can make advantage of shifting to LNG.

For some categories of vessels, installed propulsion power has shown to be larger than strictly needed. For these vessels smaller engines can be fitted which is meant by right-size engines. Engine suppliers indicate that reduction of engine size is possible in practice. More efficient sailing can help to lower fuel consumption, regardless of the greening technique applied. The other techniques are less favourable in the short term. The hybrid vessels only result in savings for certain vessel trajectories, the ones that require frequent stop-start movements (e.g. bunkering vessel or bilge water collector).

3.2 Extrapolation to macro-economic level

The ultimate aim of the PROMINENT project is to provide solutions which make inland navigation as competitive as road transport in terms of air pollutant emissions by 2020 and beyond. In parallel PROMINENT aims to further decrease the energy consumption and carbon footprint of IWT, an area where IWT has already a strong advantage compared to road transport. PROMINENT focusses therefore, amongst other objectives, on the massive transition towards efficient and clean vessels.

The problem to determine the allocation of different greening technologies across a wide spectrum of vessel types operating on the EU river and canal network is rather complex. The choice of different technologies is wide, and not all of those technologies can be applied on every vessel type. Therefore, the CBA outcomes on the selected technologies are used to extrapolate the EU-wide financing demand.

Technologies as LNG and SCR and DPF can be combined to reach PROMINENT' objectives. The business cases pointed out that the first technology is only applicable for larger ships, and that even then the business case is challenging. The SCR and DPF technologies are applicable to the whole fleet but does not result in business economic savings. Emission savings are certain for all three technologies. Therefore, a differentiated approach is used to obtain first maximum financial efficiency in reaching the objectives, and second obtain more uptake of LNG in the IWT sector.

The extrapolation provides a range on the funding needs, and then proposes a way to stimulate the uptake via funding. Funding approaches are mapped in 3.3, where recommendations are made.

State of play

The fleet families / vessel types addressed in the PROMINENT project are presented in the table below, which comes to a total of 12,262 *registered* European Inland Vessels from:

- Rhine and other waterway MS[2] [1]: Belgium, France, Germany, the Netherlands, Luxembourg, Switzerland and Czech Republic;
- Danube MS: Bulgaria, Hungary, Croatia, Moldova, Ukraine, Austria, Romania, Serbia, Slovakia.

[2] The database also includes some passenger vessels registered in Cyprus and Malta, but active on the Rhine and other waterways.

Fleet families	
Vessel type	Total number of vessels
Passenger vessels (hotel/cruise vessels)	2553
Other push boats <500 kW	890
Push boats 500-2000 kW	520
Push boats >=2000 kW	36
Motor vessels dry cargo >=110m	610
Motor vessels liquid cargo >=110m	602
Motor vessels dry cargo 80-109m	1801
Motor vessels liquid cargo 80-109m	647
Motor vessels <80 m. length	4463
Coupled convoys	140
Total	**12262**
Other type of vessels (barges + other vessels)	*5179*
Total database	17441

Table 3: Overview European Inland fleet (source: Prominent D1.1 - List of operational profiles and fleet families)[3].

As illustrated in the PROMINENT D1.1, based on the IVR database / macro model and the information gathered for fleet families, data on the construction year of the main propulsion engine is available. Based on approximately 3,200 observations, the distribution of Engines types justify the required focus of PROMINENT on reduction of air pollutant emissions considering that a large part of the European IWT fleet is equipped with relative polluting CCNR stage 1 engines and unregulated engines (see Table 4 below) in terms of NOx and PM emissions.

Even in case a vessel is installed with CCNR STAGE 2 engines, in comparison to the new NRMM Stage V emission limits, the difference is substantial: factor of (at least) 3.3 for NOx and a factor of 13.3 for PM (for engines >300 kW). It can therefore be concluded that by means of a massive transition to reaching Stage V emission levels, drastic emission reductions can be realised.

	Unregulated (before 2003)	CCNR stage 1 engine (2003-2007)	CCNR stage 2 engine (>2007)
Passenger vessels	70%	12%	18%
Other push boats <500 kW	87%	7%	6%
Push boats 500-2000 kW	53%	29%	18%
Push boats >=2000 kW	36%	27%	36%
Motor vessels dry cargo >=110m	13%	52%	34%
Motor vessels liquid cargo >=110m	11%	32%	57%
Motor vessels dry cargo 80-109m	73%	18%	9%
Motor vessels liquid cargo 80-109m	44%	19%	37%
Motor vessels <80m	77%	16%	7%
Coupled convoys	12%	42%	45%

Table 4: Estimates on the year of construction of engines

Looking at the business cases of available and mature Stage V technologies, currently there is no significant incentive for barge owners to invest. Some ports provide discount in port dues to green vessels that can overlay a Green Award certificate, however these effects are marginal with respect to the investment (CAPEX) and/or operational costs & maintenance (OPEX).

[3] Source: http://www.prominent-iwt.eu/wp1-state-of-play/

From public perspective, large societal benefits can be achieved when inland vessels comply with Stage V emission requirements. To illustrate this, based on the existing building year of engines[4] as analysed in Prominent D1.1, the existing emissions of the European Inland fleet can be estimated, and related the external costs, taking into consideration the estimated annual fuel consumed by inland vessels per vessel class.

Emission profile Engine year	NOx [g/kWh]	PM [g/kWh]	Fuel consumption [g/kWh]	Comment
< 1975	10,8	0,6	235	
1975-1979	10,6	0,6	230	
1980-1984	10,4	0,6	225	
1985-1989	10,1	0,5	220	
1990-1994	10,1	0,4	210	
1995-2002	9,4	0,3	205	
2003-2007	9,2	0,3	200	CCR 1 from 2002
> 2007	6,0	0,2	200	CCR 2 from 2007

Table 5: Emission profile based on the year of construction of engines (source: EMS- protocol).

The total external costs emitted by inland vessels in Europe sums up to a total of more than 1 billion euro per year, broken down into NOx-emissions (approx. 75%), PM-emission (13%) and CO2-emission (12%). A distribution of external costs per vessels class is given in the table below. Air pollutant emissions (NOx and PM) have a share of 88% in the total external costs (965 million euro per year), emphasizing the sense of urgency to reduce air pollutant emissions (NOx and PM) and reach Stage V compliance as soon as possible.

Vessel information			Estimated current emissions per year		
Fleet families Vessel type	Total number of vessels	Estimated fuel consumption in m3	NOx [tons]	PM [tons]	CO2 [tons]
Passenger vessels (hotel/cruise vessels)	2553	106516	3895	177	281201
Other push boats <500 kW	890	28644	995	49	75620
Push boats 500-2000 kW	520	81970	2966	125	216400
Push boats >=2000 kW	36	74520	2647	116	196733
Motor vessels dry cargo >=110m	610	206740	6681	234	545794
Motor vessels liquid cargo >=110m	602	83168	6089	211	544582
Motor vessels dry cargo 80-109m	1801	291470	11386	551	769482
Motor vessels liquid cargo 80-109m	647	153209	5171	219	404473
Motor vessels <80 m. length	4463	219456	8707	432	579363
Coupled convoys	140	78155	2432	85	206328
Total	**12262**	**1323847**	**50969**	**2200**	**3819976**

Table 6: Estimated existing emission per year (source: STC-NESTRA B.V.).

The tables above and below illustrate that despite the high share of 57% in the total number of vessels, the fleet families motor vessels <80m and passengers vessel (of which also the majority of the vessels are lower than 80 meters in length) only have a share of approximately 25% in the total fuel consumption and external costs. This means that the remaining 43% of the European Inland fleet is responsible for 75% of total fuel consumed and related external costs (air pollutant and greenhouse gas emissions).

[4] EMS-protocol Emissies door Binnenvaart: Verbrandingsmotoren (TNO, 2012)

Vessel information		Estimated external costs per year				
Fleet families / Vessel type	Total number of vessels	NOx [mln EUR]	PM [mln EUR]	CO2 [mln EUR]	TOTAL [mln EUR]	Share %
Passenger vessels (hotel/cruise vessels)	2553	63	11	9	84	8%
Other push boats <500 kW	890	16	3	2	22	2%
Push boats 500-2000 kW	520	48	8	7	63	6%
Push boats >=2000 kW	36	43	7	6	57	5%
Motor vessels dry cargo >=110m	610	108	15	18	141	13%
Motor vessels liquid cargo >=110m	602	99	13	18	130	12%
Motor vessels dry cargo 80-109m	1801	184	35	25	245	22%
Motor vessels liquid cargo 80-109m	647	84	14	13	111	10%
Motor vessels <80 m. length	4463	141	28	19	188	17%
Coupled convoys	140	39	5	7	52	5%
Total	**12262**	**825**	**140**	**126**	**1092**	**100%**

Table 7: Estimated existing emission per year (source: STC-NESTRA B.V.).

Applied shadow prices (2018):

NOx: 16,192 euro/ton, Ricardo-AEA Update Handbook External costs of Transport, EC DG MOVE, 2014 (see Annex I and II)

PM: 63,778 euro/ton, Ricardo-AEA Update Handbook External costs of Transport, EC DG MOVE, 2014 (see Annex I and II)

CO2: 33 euro/ton, Guide CBA DG regio

As discussed in section 3.1, the PROMINENT project has shown that from a technological viewpoint large external savings in terms of reduced air pollutants and energy savings. A saving of around 915 mln euro can be reached by means of:

- 10% fuel saving by means of application of energy efficient navigation and right sizing new Stage V engines, meaning a saving of fuel costs of 65 million euro per year,
- combined with a 78% reduction of external costs for emissions by reaching Stage V emission levels, meaning 848 million euro savings per year.

An overview of potential savings, considering a situation in which Stage V has been reached for all cargo and passenger vessels and 10% fuel savings for the whole fleet is achieved is presented in Table 8 below.

	NOx [mln EUR]	PM [mln EUR]	CO2 [mln EUR]	TOTAL [mln EUR]
External costs per year in current situation	825	140	126	1092
Savings Stage V	-686	-135	-3,2	-821
10% fuel saving energy efficient navigation	-83	-14	-12,6	-109
Remaining external costs Stage V	139	5	123	271
Relative reduction Stage V	**83%**	**96%**	**3%**	**75%**
Reduction Stage V and 10% fuel cost saving	700	135	15	848
Remaining external costs Stage V + efficient navigation	125	5	111	244
Relative reduction Stage V and 10% fuel cost saving	**85%**	**96%**	**12%**	**78%**

Table 8: External cost for current situation, the situation after Stage V reached for all cargo and passenger vessels and situation with 10% fuel savings for the whole fleet.

Minimum investment costs for reaching Stage V

Given the prospect of the large societal benefits for inland vessel to comply with Stage V emission levels, the minimum investment has been analysed following a bottom-up approach based on vessel information gathered per fleet family (with reference to Prominent D1.1) on the number of engines installed, total installed power and fuel consumption. For this analysis, the targeted reference case is set to stage V compliance for all 12,262 European inland vessels by 2030. From the perspective of financial investment only, disregarding the business case and return of investment for greening technologies for this moment, the total minimum investment costs have been estimated based on the following considerations:

- From the perspective of lowest investment costs, theoretically the whole European fleet could be installed with after-treatment systems to reach Stage V compliance. This results in the lowest investment costs (financing demand) in terms of total CAPEX, which clearly excludes the fact that there is no business case or significant financial incentive for the barge owners to equip vessels with engine after-treatment systems (SCR + DPF, either by installing a new Stage V engine after 2019/2020 or by retrofits of existing engines);
- It is expected that a large increase in demand for after-treatment systems will result competition amongst technology providers, resulting in a cost reduction of approx. 20% - 30%. In the estimation of investment costs these scale effects in production of after-treatment systems are accommodated;
- Operational costs for urea (AdBlue) and idle time for installation are not included in the investment costs. Furthermore, the investment costs are based as a one-time investment in hardware and thereby excluding replacement costs after the lifetime of the technology has exceeded (lifetime after-treatment systems is 30,000 engine hours).

Based on the considerations mentioned above, 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. In Table 9 below, an overview is given of the total number of vessels per vessel type / fleet family: related average investment costs per installed power, total investment costs and external savings over 10 years and per euro invested.

Over a period of 10 years, a total of 5 billion euros in external costs (NOx and PM) can be saved by investing 508 euro in approx. 35% of the European inland fleet (vessels larger than 80m and push boats only). The highest return on investment is achieved with large push boats, with a total installed power of ≥ 2000 kW: for every euro invested in this vessel class the benefits for society over 10 years comes to 32.4 euro.

An additional investment of 539 million euro in passenger vessels (all sizes, small up to 135m cruise vessels) and motor vessels < 80 m length, has an added value of approx. 1.8 billion euro in 10 years, summing up to a total of 6.86 billion euro over 10 years. Conclusively the whole European inland fleet could be compliant with Stage V emission limits for an investment of 1.05 billion euro, with a return in external costs of 6.6 euro for every euro invested.

Vessel type	Total number of vessels	Investment costs		External cost savings	
		EUR per kW	in mln EUR	Over 10 years mln EUR	per 1 EUR invested
Push boats >=2000 kW	36	91	11	357	32.4
Coupled convoys	140	96	29	319	11.2
Motor vessels liquid cargo 80-109m	647	112	65	690	10.6
Motor vessels dry cargo >=110m	610	95	88	883	10.1
Motor vessels liquid cargo >=110m	602	95	83	788	9.5
Motor vessels dry cargo 80-109m	1801	124	167	1564	9.3
Push boats 500-2000 kW	520	136	65	402	6.2
Subtotal	***4356***	***110***	***508***	***5003***	***9.9***
Motor vessels <80 m. length	4463	218	276	1199	4.3
Passenger vessels	2,553	260	198	528	2.7
Other push boats <500 kW	890	236	65	134	2.1
Total	***12262***	***151***	***1046***	***6864***	***6.6***
Other type of vessels	5179				
Total vessels	**17441**				

Table 9: Investment costs to reach Stage V per vessel class, including external savings over 10 years and related ratio per euro invested.

Additional opportunities for investing in LNG (soft loans)

The lowest investment costs have been based on compliance of Stage V emission levels by means of investment in after-treatment systems as SCR and DPF. However, the after-treatment systems cause additional operational costs for urea consumption and additional maintenance.

The situation for LNG is however quite different. Although the investment is higher compared to equipment for after-treatment, Stage V levels can be reached without after-treatment while LNG fuel is cheaper compared to diesel. For vessels with a high fuel consumption and with sufficient space to accommodate the LNG fuel tank, LNG is a technically and economically viable solution. The precondition for the business economic feasibility is that the price gap between LNG and gasoil needs to have a certain size in order to provide a significant saving on fuel costs to offset the additional investments (capital costs) within a reasonable time period. Also, over the next years other Stage V technologies may become mature, which could have a positive business case / return of investment for (specific) vessels or fleet families.
The graph and table below provide an overview of the potential share of vessels operating on LNG and related investment need. This analysis takes into consideration, the incremental costs to invest in a LNG DF propulsion system as opposed investing in a Stage V compliant diesel engine. Furthermore, from the perspective and requirement of commercial banks the investment should be paid back within a period of 15 years. Also, only vessels larger than 110m (incl. passenger cruise vessels), push boats and pushed convoys are considered to have the potential to install LNG engines, mostly due to the share of payload loss in respect to the capacity of vessel (See Prominent D2.6).

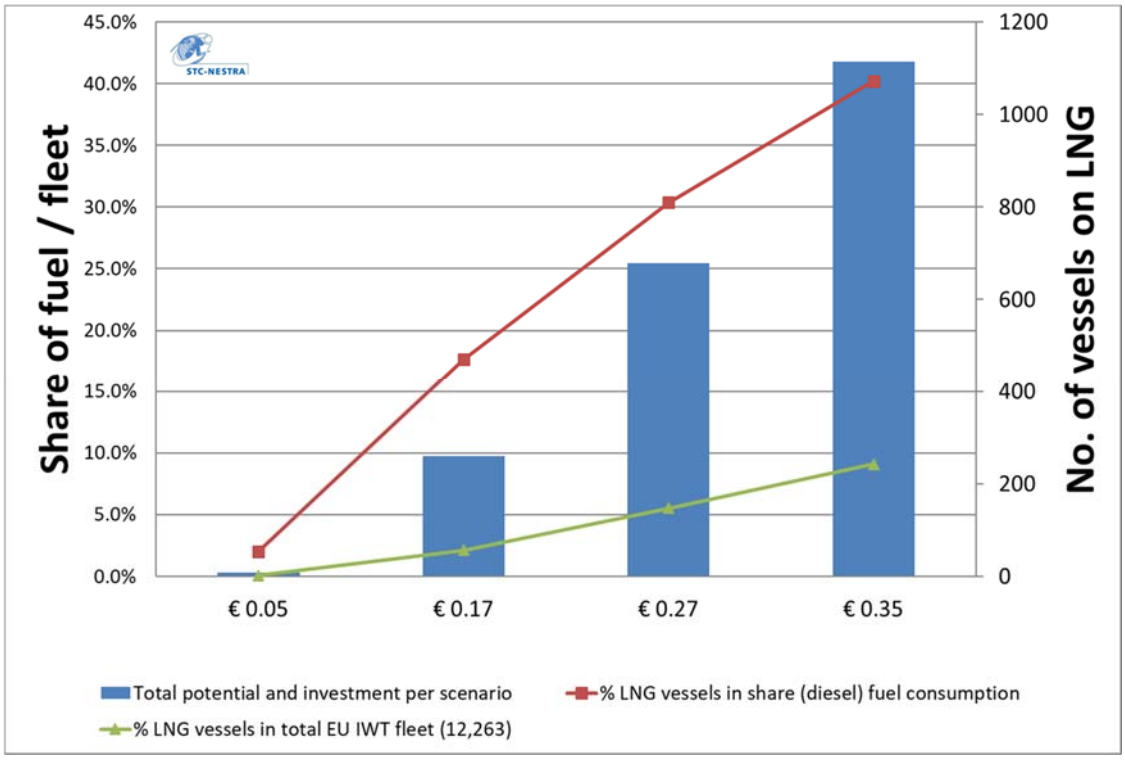

Figure 7 : Share of LNG vessels in: total number of vessels and share in diesel fuel consumed, depending on price gap development LNG vs. Diesel in € per liter. Source: STC-NESTRA B.V. based on PROMINENT D1.1 analyses

As illustrated in the graph up to 40% of the Inland fleet could be equipped with an LNG installation, given that the price difference between LNG and Diesel is at least € 0.35 per litre. Furthermore, the potential for LNG powered vessels is very small when the spread in fuel price difference is small (scenario €0.05). The total financing demand (loans) ranges between 9.5 mln euro and 929 mln euro. An overview of investment per scenario and fleet family is given in the table below,

Given the current mature options to reach Stage V, the total financing demand depends largely on the share of LNG and ranges between approx. 1 – 2 billion euro.

Potential no. IWT vessels on LNG	**scenario1**		**scenario2**		**scenario3**		**scenario4**	
Payback period (years) / requirement from banks	15							
Price difference LNG-Diesel (€ per liter)	0.05		0.17		0.27		0.35	
Vessel type	**No. Vessels**	**Investment need [mln]**	**No. Vessels**	**Investment need [mln]**	**No. Vessels**	**Investment need [mln]**	**No. Vessels**	**Investment need [mln]**
Passenger vessels (hotel/cruise vessels)	0	€ -	5	€ 4.4	20	€ 17.7	27	€ 24.4
Other push boats <500 kW	0	€ -	2	€ 1.3	6	€ 3.8	8	€ 5.1
Push boats 500-2000 kW	0	€ -	7	€ 5.5	14	€ 10.7	69	€ 51.7
Push boats >=2000 kW	8	€ 9.5	32	€ 37.7	33	€ 39.0	34	€ 40.2
Motor vessels dry cargo >=110m length	0	€ -	57	€ 51.1	222	€ 191.7	428	€ 364.8
Motor vessels liquid cargo >=110m length	0	€ -	83	€ 63.2	277	€ 222.9	426	€ 352.2
Coupled convoy (mainly class Va + Europe II lighter)	0	€ -	73	€ 54.4	106	€ 77.7	122	€ 90.8
Total potential and investment per scenario	**8**	**€ 9.5**	**259**	**€ 217.5**	**678**	**€ 563.6**	**1114**	**€ 929.2**
Respresentative diesel fuel to LNG in m3	26,788		233,377		402,209		532,107	
% LNG vessels in total EU IWT fleet (12,263)	0%		2%		6%		9%	
% LNG vessels in share (diesel) fuel consumption	**2%**		**18%**		**30%**		**40%**	

Table 10: Investment in LNG vessels depending on price difference LNG-Diesel in € per liter.

3.3 Financing options for Stage V compliance of Europe's IWT fleet

As mentioned earlier, for except a marginal effect in port dues, currently there are no significant incentives for barge owners to be green. At least, at this moment amongst shippers, there is no willingness-to-pay for more expensive green inland vessels. The business case is simply not there. And margins in the transport market are small. On the other hand, in order to remain competitive to road transport, the IWT sector will have to comply with Stage V emissions in the short to keep its "license to operate" and take responsibility in reducing emissions that cause damage to health and environment.

Within the PROMINENT project technological solutions have been developed to reduce air pollutant emissions in the IWT sector. The proposal is to develop an incentive scheme according to the "polluter pays principle": a European wide financial support scheme and an internal funding regime linked to (fossil) fuel consumption to provide the business case and funding to support the large-scale deployment of greening technologies and alternative fuels. Such a scheme shall support possible incorporation of grants and public loans from regional authorities, Member States, European Commission and EIB.

Setting up a EU-wide Greening Fund

The proposal is to develop an EU-wide technology neutral Greening Fund dedicated to IWT. The fund can be filled by means of grants from EU (CEF), Member States and regional governments. The sector contribution for the fund can for example be provided by means of resources from the Reserve Fund as well as introducing differentiated environmental surcharge on fuel used in IWT. This will directly address the amount of (fossil) fuel burned by inland vessels / barge owners, making the action effective, efficient and fair. It will require legal actions to provide the framework for the Greening Fund (e.g. updated CEF regulation) and the EU-wide environmental surcharge on fuel dedicated to feeding the Greening Fund.

If the Greening Fund is directly related to the minimum investment need to comply with Stage V emission standard, the fund would eliminate the barrier to invest in after treatment systems (SCR-DPF) for most vessels and improves the business case for conversion to LNG to address air pollution emissions, since the application of the fund will be technology neutral. At the same time, it gives an incentive as well to CO2 reduction and low/zero carbon drivetrains: less fuel consumed, results in less CO2 emitted.

There are several parameters to influence the development and implementation of such a scheme:

- **Scope of fund:** focus and/or priority may be given to inland vessels have a high share in the total fuel consumption and external costs by the IWT sector. For these vessel types (freight vessels >80m and push boats/convoys) the return in terms of external savings per 1 euro invested is the largest. On the other hand, addressing the whole fleet would create a level playing field amongst vessel owners with respect to depreciation, operational and maintenance costs;
- **Duration and timing:** the length of the period that a surcharge will be collected, also depending on the surcharge level and the need to payback all (public) loans. Will the Greening Fund stop when the whole or part of the fleet is compliant to Stage V emissions limits or will the Greening Fund continue to transition towards zero-emission transport?

- **The share of public / private:** revenues from the surcharge may feed the Greening Fund, blended with grants from governments. The ratio to be applied between public and private contributions will be a political choice, related to willingness to publicly finance the required transition towards green inland vessels;
- **Sector contribution - surcharge level and differentiation:** The level surcharge and differentiation (e.g. per type of emission) will affect the competitivity of inland vessels. For example, vessels that have invested in greening technology and comply with Stage V emission standards may receive a discount, whereas zero-emission vessels may be excluded to from any environmental surcharge payments.

Additionally, in relation to the parameters mentioned above, the management structure of the Greening Fund will would have to incorporate periodic review of surcharge levels and differentiation, depending: on monitoring Greening Fund expenditures in relation to revenues, the rate of greening the fleet in relation to policy targets, Fuel consumption development. These effects could be worked out in several scenarios in order to assess the effects on the surcharge level and operational costs for barge operators.

In order to illustrate the feasibility of an environmental surcharge and effects on operational level, three possible scenarios have been considered, taking into consideration the duration of the Greening fund (10 or 20 years) and the scope of the Greening Fund (excluding vessels <80m and passenger vessels = A, including is B) and related estimated fuel consumption per year (see Table 6):

- **Scenario 1 - Greening Fund is 100% financed by an environmental surcharge on fuel:**

	Scenario 1 - 10 years		Scenario 1 - 20 years	
	A	B	A	B
Investment - share 100% by Greening Fund (grant) mln euro	**508**	**1050**	**508**	**1050**
Share public funded:	**0%**	**0%**	**0%**	**0%**
EU	0%	0%	0%	0%
MS	0%	0%	0%	0%
Regions	0%	0%	0%	0%
Share private funded	**100%**	**100%**	**100%**	**100%**
Public part:	**0**	**0**	**0**	**0**
Grant EU (mln euro)	0	0	0	0
MS (mln euro)	0	0	0	0
Regional bodies (mln euro)	0	0	0	0
Private part:	**508**	**1050**	**508**	**1050**
Fuel per year (billion m3)	1.0	1.3	1.0	1.3
Time period (years)	10	10	20	20
Total fuel billion m3 during period	10	13	20	26
Environmental surcharge per liter fuel during period	**€ 0.051**	**€ 0.081**	**€ 0.025**	**€ 0.040**

Table 11: Greening Fund Scenario 1 – 100% financed by environmental surcharge on fuel.

- **Scenario 2: Greening Fund is 100% financed with public funds (grants from EU (CEF), Member States and regional governments)**

	Scenario 2 - 10 years		Scenario 2 - 20 years	
	A	B	A	B
Investment - share 100% by Greening Fund (grant) mln euro	508	1050	508	1050
Share public funded:	100%	100%	100%	100%
EU	20%	20%	20%	20%
MS	40%	40%	40%	40%
Regions	40%	40%	40%	40%
Share private funded	0%	0%	0%	0%
Public part:	508	1050	508	1050
Grant EU (mln euro)	102	210	102	210
MS (mln euro)	203	420	203	420
Regional bodies (mln euro)	203	420	203	420
Private part:	0	0	0	0
Fuel per year (billion m3)	1.0	1.3	1.0	1.3
Time period (years)	10	10	20	20
Total fuel billion m3 during period	10	13	20	26
Environmental surcharge per liter fuel during period	€ -	€ -	€ -	€ -

Table 12: Greening Fund Scenario 2 – 100% financed by public financing schemes (grants).

- **Scenario 3: Greening Fund is financed by public funds and environmental surcharge on fuel with a 50/50-ratio[5]**

	Scenario 3 - 10 years		Scenario 3 - 20 years	
	A	B	A	B
Investment - share 100% by Greening Fund (grant) mln euro	508	1050	508	1050
Share public funded:	50%	50%	50%	50%
EU	17%	17%	17%	17%
MS	17%	17%	17%	17%
Regions	17%	17%	17%	17%
Share private funded	50%	50%	50%	50%
Public part:	254	525	254	525
Grant EU (mln euro)	85	175	85	175
MS (mln euro)	85	175	85	175
Regional bodies (mln euro)	85	175	85	175
Private part:	254	525	254	525
Fuel per year (billion m3)	1.0	1.3	1.0	1.3
Time period (years)	10	10	20	20
Total fuel billion m3 during period	10	13	20	26
Environmental surcharge per liter fuel during period	€ 0.025	€ 0.040	€ 0.013	€ 0.020

Table 13: Greening Fund Scenario 3 – 50% financed by environmental surcharge on fuel and 50% by public financing schemes (grants).

[5] Revenues from the surcharge shall be earmarked to feed the Greening Fund, possibly blended with grants from governments. The ratio to be applied between public and private contributions will be a political choice. A co-finance rate of 50% has be applied as an example.

Differentiated surcharges (and fuel costs) will provide a direct competitive advantage for green vessels. In order to accelerate greening and compensate additional operational costs (urea/AdBlue…), an additional surcharge may be added up to 4 cents per litre fuel (worst case: based on urea consumption to bring the NOx level down from 10.8 g/kWh to 1.8 g/kWh NOx). To enhance to business case for green investments, the environmental surcharge may be reduced for the air pollutant part for Stage V classified vessels (-4 cents) and greenhouse gas part (further reduction or no surcharge) for low/zero carbon energy vessels. Application of a differentiated surcharge would result in a discounted minimum surcharge of 0 eurocents (zero emission) and a maximum of approximately 8 eurocents per litre fuel (considering scenario 3B and an additional differentiated surcharge of 4 eurocents per litre). It will be needed to monitor revenues and expenditures and to periodically review the surcharge rates to be applied (e.g. each 3 years).

Estimated impact of contribution to the fund on IWT operational costs

Based on the operational profiles and representative vessels of the fleet families researched within the PROMINENT project, the impact of an environmental surcharge on operational costs has been estimated. For this a few typical vessels and average operational characteristics have been selected, with varying total operational costs. As indicated in the table on the next page, taking into account a surcharge of 2, 4 and 8 eurocents, the impact on the total annual costs varies between the 0.3 and 4.1 %. In a situation with energy efficient navigation or other techniques/solutions, compared to the current situation, the fuel consumption can be reduced with 10%, the total annual effect would be between the 1.6 and -1.5% (is costs saving).

It shall be noted that in many cases the fuel bill is paid separately by clients. This makes it easier to forward a small cost increase to the shipper and finally the consumer. As a result, costs for greening the fleet will be internalized. Moreover, as the vast majority of the IWT market is captive for IWT (there is no significant competition from road haulage or rail)[6], it will not result into significant loss of market share for IWT. It can be remarked that other situations, such as waiting times at container terminals, low water periods have a much bigger impact on the cost price of inland waterway transport. Finally, fuel prices fluctuate anyhow within rather large bandwidths and as PROMINENT did show, fuel cost savings are within range of 10% by means of right sizing and energy efficient navigation. Therefore, seen as a package of measures (energy efficient navigation and the surcharge) there is still a direct economic benefit for the industry as well while it safeguards the licence to operate.

[6] Study by Policy Research Corporation and NEA for Varen voor een Vitale Economy, Ministry of Transport in The Netherlands (2005).

Vessel type - representative vessels	PAX 135m	Push B4	MVS110m	MTS 110m	C3L/B
Total fixed costs per year	€ 1,487,828	€ 1,609,849	€ 281,720	€ 536,281	€ 560,785
Total labour costs per year	€ 1,429,672	€ 610,746	€ 171,686	€ 219,353	€ 475,698
Total fuel costs per year (average)					
Excl. surcharge (€ 0.49 / liter)	€ 215,956	€ 545,370	€ 153,092	€ 177,111	€ 274,815
Incl. surcharge + € 0.08 / liter	€ 251,036	€ 633,958	€ 177,959	€ 205,880	€ 319,455
Incl. surcharge + € 0.04 / liter	€ 233,496	€ 589,664	€ 165,525	€ 191,496	€ 297,135
Incl. surcharge + € 0.02 / liter	€ 224,726	€ 567,517	€ 159,309	€ 184,303	€ 285,975
-10% reduction fuel costs (estimated effect efficient navigation / rightsizing)	€ -21,596	€ -54,537	€ -15,309	€ -17,711	€ -27,482
Total costs					
Excl. Surcharge	€ 3,133,456	€ 2,765,965	€ 606,498	€ 932,745	€ 1,311,298
Incl. surcharge over 10 yrs	€ 3,168,536	€ 2,854,553	€ 631,365	€ 961,515	€ 1,355,938
Incl. surcharge over 20 yrs or 10 years & 50% co-finance	€ 3,150,996	€ 2,810,259	€ 618,931	€ 947,130	€ 1,333,618
Incl. surcharge over 20 yrs & 50% co-finance	€ 3,142,226	€ 2,788,112	€ 612,714	€ 939,938	€ 1,322,458
Net effect in % of total annual costs					
Incl. surcharge of € 0.08 / liter	1.12%	3.20%	4.10%	3.08%	3.40%
Incl. surcharge of € 0.04 / liter	0.56%	1.60%	2.05%	1.54%	1.70%
Incl. surcharge of € 0.02 / liter	0.28%	0.80%	1.03%	0.77%	0.85%
Net effect -10% reduction in fuel costs (in % of total annual costs)					
Incl. surcharge of € 0.08 / liter	0.43%	1.23%	1.58%	1.19%	1.31%
Incl. surcharge of € 0.04 / liter	-0.13%	-0.37%	-0.47%	-0.36%	-0.39%
Incl. surcharge of € 0.02 / liter	-0.41%	-1.17%	-1.50%	-1.13%	-1.24%

Table 14: Impact environmental surcharge on annual operational costs.

Legal assessment of Greening Fund contributions

A discussed in previous sections, a possible solution to tackle the investment problem may be found in the creation of a greening fund. Similar to the Norwegian NOx Fund created for the maritime sector, ship owners would contribute to the fund on a regular basis following the polluter-pays-principle. For instance, as an addition to port dues paid or a small contribution (surcharge / disposal charge) when bunkering gasoil. Once the ship owner wishes to invest in a green technology, they can apply to the fund for a financial contribution. Depending on the structure of the fund chosen, the ship owner could receive co- or full funding for the investment.

The Norwegian NOx tax and fund[7]

In 2006, the Norwegian Parliament adopted a new set of rules to reduce NOx in Norwegian Waters. The new laws are applicable since January 2007. The rules are fiscal measures. Vessels that produce too much NOx have to pay a fine. Subjects to this new regime are engines exceeding more than 750 kW, boilers over 10MW and flaring. Those subjects have to pay € 2,- per kilogram NOx. The penalties paid are collected in the so-called NOx fund. Companies can apply for a subsidy paid by this fund to reduce their NOx emissions. The main sectors most contributing to NOx reductions, so far, are

7 Ecorys et al. (2012) and EC (2011)

http://ec.europa.eu/transport/maritime/events/doc/2011_06_01_stakeholderevent/item14_norway_business_sector_nox_fund.pdf

offshore service ships (36%), short sea shipping (15%) and ferries /passenger vessels (11%). Measures taken to reduce NOx are SCR using urea (41%), internal engine modification (18%) and LNG and electricity (15%).

For the implementation of an EU-wide greening fund, a potential source of inspiration is the CDNI-Convention on the disposal of ship-generated waste. The Convention applies to all waterways in Germany, Belgium and the Netherlands, the Moselle in Luxembourg, parts of the Rhine in Switzerland and parts of the French waterways. Ships operating on those parts are obliged to deliver their ship waste and are obliged to pay for the disposal thereof.

The idea is to piggyback on this already existing CDNI-Convention, which includes three types of waste, each with its own disposal and payment regime. For one of the waste types, oily and greasy ship waste, the levy is linked to the bunkering gasoil (7.50 euro to be paid on each 1000 litres of fuel plus VAT).[8] Furthermore, there is already a system in place with payment cards, administration, governance etc. (SPE-CDNI)[9], which may be utilized to minimise additional operational costs related to such a Greening Fund. In this way, a sustainable instrument is provided to address the policy objective to internalise external costs and to implement the 'polluter-pays-principle' in order to reach zero-emission on longer term. Moreover, it will lead to an increased awareness among forwarders and shippers about the actual costs of greening inland waterway transport, thereby addressing the currently missing market mechanism to promote green vessels from a business economic viewpoint.

Looking at the legal context, the CDNI-Convention is based on the Mannheim Convention and can be seen as a specification of the general regime as laid down in the Mannheim Convention. The Mannheim Convention itself forms the fundament of the free shipping on the Rhine River. As such, the Mannheim Convention focuses on the realisation of four objectives, laying down rules on:

- Technical prescriptions concerning vessels;
- People involved in inland navigation;
- Governing traffic conditions;
- Governing the transport of dangerous substances.

Historically, all ships operating on the Rhine and flying the flag of one of the Signatory States fell within the scope of the Convention and therefore could benefit of the rights granted by it. Since the establishment of the European Union and the signature of the cooperation agreements between the Rhine Commission (CCNR) and the EU, the freedom of navigation on the Rhine also applies to ships not flying the flag of one the Signatory States. As long as the ship flies the flag of an EU Member State, the ship is free to operate on the Rhine River.

Article 3 of the Mannheim Convention explicitly prohibits Signatory States to impose any kind of tax, toll, duty or charge based directly on the fact of navigation. This implies that States cannot charge the inland shipping sector for activities directly connecting to shipping as such. Contrary, States are allowed to impose non-shipping related duties. For instance, applying VAT to goods transported is permitted under Article 3 of the Mannheim Convention. Additionally, States can require a retribution – charge a fee for services provided, e.g. port related services. Nevertheless, requiring a contribution to a greening fund does not fall within the scope of the two given exemptions. It neither qualifies as a non-shipping related duty nor as a retribution for services provided.

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[8] Article 6 of the CDNI-Convention lays down the financial regime in place for the disposal and reception of oily and greasy ship generate waste. Practical details concerning oily and greasy waste, are laid down in Part A of the Implementing Regulation. In Article 3.03 sub 1, the height of the disposal charge is mentioned.

[9] SPE-CDNI Administrative System: https://www.spe-cdni.org

Overall, it is uncommon to tax the inland waterway sector under the conditions set out in the Mannheim Convention, as often taxing would be contrary to the freedom of navigation. The Convention requires that no fees be paid for the use of infrastructure as well as no excise taxes on fuel for inland navigation are charged.[10] Based on these limitations it is difficult to find a legal basis for financial contributions to the greening fund under this Convention.

Taking the above into account, the CDNI Convention specifically seems to offers limited to no possibilities to connect a greening fund with the current waste disposal regime in place. This is hampered by several restrictions, such as: definitions and scope of the Convention of which the focus is on ship-generated waste; and related, the limitation to only finance solutions contributing to the reception and disposal of ship generated waste; and, moreover, the geographical scope of the Convention, that only applies to (part of) six inland waterway countries: Belgium, France, Germany, Luxembourg, the Netherlands and Switzerland. The scope of the Convention is too limited (both in emissions and waterways covered) and the clear indication of how the disposal charge has to be used further limits its usefulness.

Conclusively, it should be kept in mind that the application of the CDNI Convention is not considered as the most effective way to introduce a surcharge related to the implementation of a Greening Fund mainly due to its geographical scope. However, it does show in practice that the implementation of a surcharge / disposal charge on the consumption of fuel is not necessarily limited by the Mannheim Convention. On the contrary, the surcharge on the bunkering of for the disposal of oily and greasy ship-generated waste has been existing practice for more than eight years now. An important condition to the spending of the resources generated through the CDNI Convention, is that the inland shipping sector benefits in full from the funds raised. Furthermore, the funds are managed in a transparent way by an independent organisation under supervision of stakeholder representatives (e.g. representatives from national government bodies, industry representatives, etc.).

The way forward

To tackle the above-mentioned bottlenecks (limited geographical coverage, spending limitations and the prohibition to impose taxes etc.), the EU could provide the necessary legal basis for setting-up a greening fund. Once the fund is embedded in an EU legislative instrument (Regulation or Directive), it could apply to all European waterways, including all inland navigation countries. No distinction between ship operators would be made (by asking some to make additional costs and others denying the chance to apply for a financial contribution) and as result, greening possibilities would become available for all. Consequently, greening the entire EU-fleet would become more realistic.

The EU has competence both in the field of transport and environment (Article 4 TFEU). As suggested in PROMINENT one of the main identified gaps, that hampers the greening of the fleet, is the lack of EU legislation laying down maximum emission levels for existing vessels/engines in the inland shipping sector. A solution path would be to develop dedicated legislation for the inland shipping sector that imposes emission limits for the entire inland shipping fleet, targeting also existing vessels/engines to reach emission limits at a certain date in time (e.g. 1/1/2030). The implementation of a Greening Fund and related contribution by the inland shipping sector, by levying a surcharge on the bunkering of (fossil) fuel, could form an integrative part of this initiative

[10] Rietveld, P. et al (2007), 'Infrastructure Maintenance Costs: A Comparison of Road, Rail and Inland Navigation, and Implications for User Charges'

and related targets, under the condition to earmark the fund exclusively for greening technologies in the inland shipping sector. Furthermore, it provides also an opportunity to set targets to reduce greenhouse gas emissions and to set the course towards (almost) zero-emission.

It would not be the first time the EU would set-up a (temporary) fund to support specific goals in the inland navigation sector. During the 1990's the Commission introduced the scrapping fund, which aimed to reduce the overcapacity in the market (Council Regulation (EEC) No 1101/89). The fund was financed through contributions made by different stakeholders. First, the owner of a vessel falling within the scope the Regulation was obliged to pay a yearly contribution to the fund. Second, owners of newly build ships who did not scrap their old vessel were required to pay a contribution and third, Member States could contribute to the fund. The scrapping fund for inland ships was managed on a Member State level. Each Member State with an overcapacity in its fleet had to establish a fund and fill it with the above-mentioned contributions. To ensure pay out, national rules were needed and therefore national law had to be adopted as well. This resulted in differences between Member States, leading to different application and results.

Obviously, a differentiation between Member States is not preferred. To tackle differences between Member States, the EU could introduce one overall fund managed by an EU organisation, under the supervision of MS and industry representatives (following a similar governance structure as introduced for the implementation of the CDNI Convention). This organisation would become responsible for collecting the contributions and arranging the pay outs in case a ship owner invests in a green technology. A similar initiative is proposed in the maritime field to ensure safe and sound ship scrapping (see example below).

A financial instrument to facilitate safe and sound ship recycling

As part of Regulation (EU) No 1257/2013, the Commission assessed possibilities to introduce a financial fund that would facilitate safe and sound (maritime) ship recycling. The possibility of introducing a fund is founded in Article 29. Several instruments were considered. For each instrument, the economic and legal feasibility is assessed. Main aim was to develop an instrument that would allow ship owners to build up an individual fund for the recycling of their ship. Within a given period, the owner would systematically contribute to the fund and after a period of 20 years, the fund would be such that when the ship was recycled (according to the requirements laid down in the Regulation), the owner would receive the money saved – in order to cover the higher recycling cost made. Basis for the instrument are the EU port calls and applies to all ships, irrespective their flag.

The instrument developed is tailor-made and different solutions can be sought, allowing ship owner to opt for the instrument best suitable to their business. For ship owners only incidentally visiting the EU short-term licenses are available. Consequently, the contributions to the fund are limited and so the payment from the fund will be limited as well. Ship owners frequently operating in EU waters can opt for other instruments (e.g. insurance, bank guarantee). As their contributions are higher, the final payment will be higher as well. The proposal is currently pending in the European Parliament.

Important aspect that should be considered is the international dimension of the sector. Ships originating from non-EU countries operate on EU waters and some rivers flow to third countries (for instance the Danube and Sava River). Before establishing a fund, a decision needs to be made on how to deal with those international dimensions and whether or not these vessels should fall under the scope as well.

Summarising, the main advantages of using EU legislation as a legal basis for a greening fund are: The inclusion of the entire EU fleet and EU waterway network initiative

The possibility to widen the scope of the fund to all emissions
The opportunity to manage the fund and the pay out at EU level
The option to earmark the fund exclusively for greening technologies

4 Conclusions and recommendations

1. **High urgency**

In order to remain competitive to road transport, the IWT sector will have to comply with Stage V emissions in the short to keep its "license to operate" and take responsibility in reducing emissions that cause damage to health and environment.

The total external costs emitted by inland vessels in Europe sums up to a total of more than 1 billion euro per year, of which air pollutant emissions (NOx and PM) have a share of 88% (965 million euro per year). The underlines the necessity to reduce air pollutant emissions (NOx and PM) and thus reach at least Stage V compliance in the short term.

2. **Existing financing schemes are limited and not adapted to the challenge**

Looking at the business cases of available and mature Stage V technologies, currently there is no significant incentive for barge owners to invest in e.g. SCR and DPF. Some ports provide discount in port dues to green vessels that can overlay a Green Award certificate, however these effects are marginal with respect to the investment (CAPEX) and/or operational costs & maintenance (OPEX).

In terms of funding we found that up to EUR 8.5 million in grants is available annually. Fiscal incentives and local financial incentives are also wide spread measures that can be leveraged. Loan instruments for green shipping are developed, too. These points suggest that there are several supportive instruments to expedite the greening of the European IWT fleet. Seen the huge demand however, this governmental supply of funds and loans to IWT companies is rather limited. Moreover, it differs significantly in eligibility criteria. The fund sizes seem not to be on a par with the regional size of the IWT sector across Europe. The funds seem to be connected to the country of registration of the vessel, while a lot of vessels operate across borders on a frequent basis. Operational use and funds available seem not to align. Importantly, the conditions of grants and loans are often so strict that they are rendered irrelevant for investments in LNG and SCR/DPF solutions. The suggested technologies are unlikely to be financed by loans, as the return on investment is negative.

An additional difficulty is that loans often do not suffice for technologies that have large positive impacts for society, for the simple reason that the Return of Investment is too low. So, despite the theoretically legitimate ground to support green technologies in IWT, current instruments are mostly insufficient.

3. **Strong emission reduction and energy savings feasible, creating a win-win for society and business**

The lowest investment costs, disregarding the effect on business economic level, for the EU inland shipping fleet to reach Stage V emission levels can be achieved by means of investment in after-treatment systems (SCR and DPF). The estimated minimum investment then comes to 1.05 billion euro. SCR and DFP do not result in business economic costs savings. Though, societal benefits are high. Moreover, after-treatment systems cause additional operational costs for urea consumption and additional maintenance.

The situation for LNG is however different. Although the investment is higher compared to equipment for after-treatment, Stage V levels can be reached through installing an LNG solution (engine + tank). For vessels with a high fuel consumption and with sufficient space to accommodate the tank, LNG can be a viable solution. The economic feasibility depends on a stable price gap between LNG and gasoil and a significant fuel consumption. Reasonably, up to 40% of the Inland fleet could be equipped with an LNG installation given that the price gap is at least € 0.35 per litre diesel. The potential for LNG powered vessels is very small when the spread in fuel price difference is small (gap of €0.05). The total financing demand ranges between 9.5 mln euro and 929 mln euro.

Selective measures (investments and funding) for high societal benefits:

- E.g. over a period of 10 years, a total of 5 billion euros in external costs (NOx and PM) can be saved by investing 508 euro in approx. 35% of the European inland fleet (vessels larger than 80m and push boats only). The highest return on investment is achieved with large push boats, with a total installed power of ≥ 2000 kW: for every euro invested in this vessel class the benefits for society over 10 years comes to 32.4 euro.
- An additional investment of 539 million euro in passenger vessels (all sizes, small up to 135m cruise vessels) and motor vessels < 80 m length, has an added value of approx. 1.8 billion euro in 10 years, summing up to a total of 6.86 billion euro over 10 years.

Conclusively, the whole European inland waterway fleet could be compliant with Stage V emission limits for an investment of 1.05 billion euro, with a return on investment in external costs of 6.6 euro for every euro invested.

Given the current mature options to reach Stage V emission levels, via SCR/DPF and LNG, the total combined financing demand ranges between approx. 1 – 2 billion euro (depending on the fuel price difference between Diesel and LNG).

Financial technology, in light of the uptake of greening technologies within the IWT sector, is an under-researched topic. Given the LNG investment, market uptake will largely depend on the price gap between diesel and LNG fuel. Future hedging of the LNG fuel price might be a solution to stimulate further uptake. The price gap can be insured by fixing the LNG price or securing a minimum discount with reference to diesel fuel. This is a common technique used in large fuel consuming companies, such as in the aviation sector (airlines), maritime sector (cruise lines) and road sector (trucking companies). Such solutions could be researched to provide a more secure business case for investments in LNG in the IWT sector.

4. Greening Fund

As mentioned earlier, for except a marginal effect in port dues, currently there are no significant incentives for barge owners to be green. At least, at this moment amongst shippers, there is no willingness-to-pay for more expensive green inland vessels. The business case is simply not there and margins in the transport market are small. On the other hand, in order to remain **competitive to road transport**, the IWT sector will have to comply with Stage V emissions in the short to keep its “license to operate” and take responsibility in reducing emissions that cause damage to health and environment.

Considering the positive societal returns there remains a case for subsidies and blended financing instruments to enable the transition. From this perspective the report brings together the financing supply and demand to conclude that on EU level a financing gap of EUR ca. 1 billion remains in place.

A possible solution to tackle the investment problem could be the creation of a greening fund. Ship owners would contribute to the fund on a regular basis, by means of (partially) raising the necessary funding through a surcharge on the bunkering of (fossil) fuels. Once the ship owner wishes to invest in a green technology, he can apply to the fund for a financial contribution. Depending on the structure of the fund chosen, the ship owner could receive a partial or full funding of the investment.

If the Greening Fund is directly related to the minimum investment need to comply with Stage V emission standard, the fund would eliminate the barrier to invest in after treatment systems (SCR-DPF) for most vessels and improves the business case for conversion to LNG to address air pollution emissions, since the application of the fund will be technology neutral. At the same time, it gives an incentive as well to CO2 reduction and low/zero carbon drivetrains: less fuel consumed, results in less CO2 emitted.

5. Impact on businesses

The impact of an environmental surcharge on operational costs has been estimated. For this a few typical vessels and average operational characteristics have been selected, with varying total operational costs. Assuming a surcharge of 2, 4 and 8 eurocents, the impact on the total annual costs varies between the 0.3 and 4.1 %. In a situation with energy efficient navigation or other techniques/solutions, compared to the current situation, the fuel consumption can be reduced with 10%, the total annual effect would be between the 1.6 and -1.5% (so costs saving).

6. Stakeholder approaches

In order to address the financing gap, the following recommendations can be shared from the perspectives of various stakeholder groups. The recommendations were gathered through desk research, interviews with stakeholders as mentioned in Annex I, and the analysis of the results.

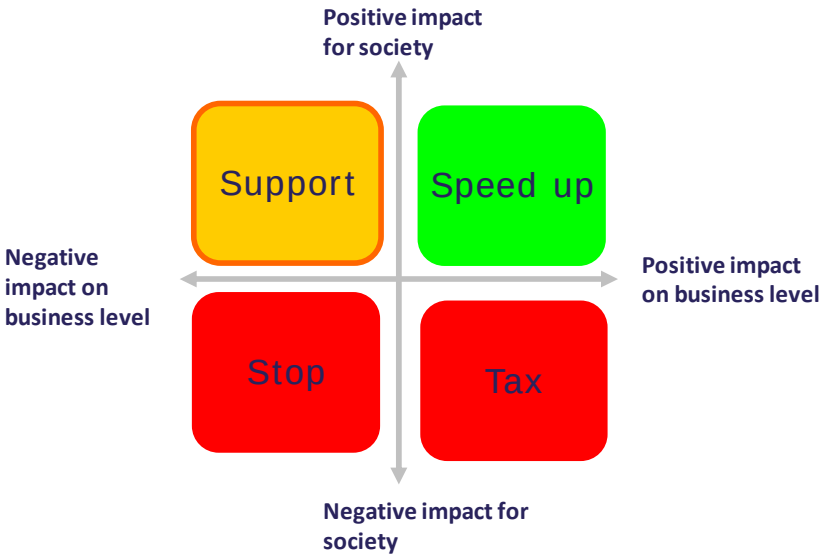

Figure 8: Role of government towards new technologies

Governments

- Align expectations of government policy, banking and other lending bodies, shippers and vessel operators. Sit together with operators to avoid a mismatch in government intentions and SME capabilities.
- Align objectives of funding better with the EU's greening ambitions for the transport sector
- Set targets for the greening of the IWT sector, but be technology-neutral
- Consider exemptions to deviate from de minimis rule for innovative technologies with substantial positive impacts for society.
- Provide a legal framework for a Greening Fund and align Member State and Regional funding therewith

Banks

- Align funding with the greening objectives and funding of governments
- Stretch funding
- Further continue the FPI partnerships between banks and the EIB

System suppliers

There are not yet real examples for the use of leasing constructions in financing inland waterway vessels or components. Most of the financing is still done by the use of own means of the ship-owning company or provided by a loan of traditional financing institutions. However, in the whole course of selection, provision and installation of technologies, the supplier (the system integrator) also pays attention to the financial part (if necessary). There are several examples in which suppliers are actively involved in seeking external finance for the customer, mostly in grants or utilising tax benefits. While there are possibilities for innovative financing solutions by the system supplier, it is more likely that the financing will rely on traditional financing combined with subsidies. Establishing a greening fund is one of the recommendations from the system suppliers. An easier to implement measure is the recommendation of incentives for emission-reducing technologies, such as lower port dues, tax benefits.

Operators

Operators working in the international environment are well aware of the technical and financial possibilities on the market. These shall be support by adequate funding and financial schemes that make innovation happen. All these together can enable the further improvement and innovation in the inland waterborne sector, which definitely requires consultations between the stakeholders on various levels.

Joint initiatives might help the operators to be able to modernize their business, including scaling of investments.

7. Legal actions needed

It will require legal actions to provide the framework for the Greening Fund and the EU-wide environmental surcharge on fuel dedicated to feeding the Greening Fund. The study assesses whether such a fund could potentially be linked to the CDNI-Convention on the disposal of ship-generated waste on a selection of waterways[11]. Ships operating on the parts covered by the Convention are obliged to deliver their ship waste and are obliged to pay for the disposal thereof.

The idea has been raised to piggyback on the already existing CDNI-Convention, for which one of the waste types, oily and greasy ship waste, the levy is linked to the bunkering gasoil (7.50 euro to be paid on each 1000 litres of fuel plus VAT). Although, the CDNI Convention is not considered as the most efficient way to implement a Greening Fund (mostly due to the limited geographical scope), it does illustrate that it is feasible to implement a surcharge / disposal charge on the consumption of fuel without being in conflict with the Mannheim Convention.
The way forward would be to introduce legislation (regulation or directive) on European level. The EU has competence both in the field of transport and environment (Article 4 TFEU). A solution path would be to develop dedicated legislation for the inland shipping sector that imposes emission limits for the entire inland shipping fleet, targeting also existing vessels/engines to reach emission limits. The implementation of a Greening Fund and related contribution by the inland shipping sector, could form an integrative part of this initiative and related targets, under the condition to earmark the fund exclusively for greening technologies in the inland shipping sector. Furthermore, it provides also an opportunity to set targets to reduce greenhouse gas emissions and to set the course towards (almost) zero-emission.

The main advantages of using EU legislation as a legal basis for a greening fund are:

- The inclusion of the entire EU fleet and EU waterway network initiative
- The possibility to widen the scope of the fund to all emissions
- The opportunity to manage the fund and the pay out at EU level
- The option to earmark the fund exclusively for greening technologies

8. Further R&D and studies

ZERO emission IWT solutions are under-researched. The current PROMINENT goals are ambitious in terms of lowering the emissions of the current fleet. Though, after obtaining this objective, the fleet can still be made greener by implementing different techniques, e.g. hybrids, battery-electric, Hydrogen solutions. This would require the allocation of time and resources for further research.

[11] The Convention applies to all waterways in Germany, Belgium and the Netherlands, the Moselle in Luxembourg, parts of the Rhine in Switzerland and parts of the French waterways.

Moreover, also the implementation of a Greening Fund seems to be a necessary instrument to close the gap between financing demand and supply. It is recommended to carry out more research to assess economic, environmental, legal, political and societal impacts of various implementation options. On European level, an impact assessment is typically considered as a dedicated tool to provide guidance to policy makers and industry representatives to assess the implementation of new policies and legislation.

Annex I: Stakeholders contacted

Organisation	Type of organisation	Geography
EBU	Association	EU
ESO	Association	EU
Netherlands – Ministry	Government	NL
Vlaamse Waterweg	Government	BE
Wallonia – Ministry	Government	BE
Voies Navigables de France	Government	FR
Poland – Ministry	Government	PL
EIB	Bank	EU
ING	Bank	EU
Rabobank	Bank	EU
ABN	Bank	EU
BNP Paribas	Bank	EU
BFS	Bank	EU
Van Breda	Bank	EU
OT Logistics	Operator	PL/DE

Annex II: Overview of government grants for green IWT technology

#	MS	Technology focus	Beneficiaries	Aid type	Grantor body/ contact	Status	Fund size (kEUR p/a)	Max funding percentage	Expiring date
1	AT	Various	EU IWW operators regularly passing AT Danube and with branch in Austria	Direct grant	Via Donau	Closed	610	10% to 40%	01-7-14 – 31-05-17
2	BE	Propulsion systems and IT systems	Physical persons and legal persons based in Wallonia	Direct grant	DPVNI - Direction de la Promotion des Voies Navigables et de l'Intermodalité	Open	1300	30% (minimally 25k)	2014 – 2020
3	BE	Not specified	Inland shipping entrepreneurs	Direct grant	Waterwegen en Zeekanaal NV + NV De Scheepvaart	Closed	n/a	50% (max 50k per owner)	01/10/2016 - 30/09/2017
4	HR	Not specified	IWT companies	Direct grant	Ministry of Transport, Legal basis Inland navigation development strategy policy for Croatia (2008-2018)	Open	n/a	33% for technical solutions	2007 – undefined
5	CZ	Various innovative technologies	CZ registered IWT operators	Direct grant	Ministerstvo dopravy	Open	1250	85% (up to 1mil EUR)	2016-2021
6	DE	Various innovative technologies	IWT cargo & pax operators	Direct grant	Wasser- und Schifffahrts-direktion West	Open	3000	30% to 40%	21-07-15 – 31-12-18
7	FR	Various innovative technologies	IWT operators	Direct grant	Voies Navigables de France (VNF)	Closed	1800	30% (cap of 60k or 150k)	01/01/2013 - 31/12/2017
8	NL	Various innovative technologies	IWT operators	Direct grant	Ministry IenM / EICB	Closed	510	50% (cap of 125k)	01/01/2016 - 31/12/2017

Annex III: Damage costs of main pollutants from transport, in € per ton (2010)

		NOx	NMVOC	SO2	PM
Country id	Country	All areas	All areas	All areas	All areas
1	Austria	17,285	2,025	12,659	43,483
2	Belgium	10,927	3,228	13,622	67,278
3	Bulgaria	14,454	756	12,598	37,206
4	Croatia	15,149	1,819	12,317	34,312
5	Cyprus	6,465	1,122	12,594	25,040
6	Czech Republic	15,788	1,648	14,112	48,279
7	Germany	17,039	1,858	14,516	64,546
8	Denmark	6,703	1,531	7,286	19,680
9	Estonia	5,221	1,115	8,441	16,930
10	Spain	4,964	1,135	7,052	22,429
11	Finland	3,328	781	4,507	9,347
12	France	13,052	1,695	12,312	40,260
13	Greece	3,851	854	8,210	24,372
14	Hungary	19,580	1,569	14,348	51,045
15	Ireland	5,688	1,398	6,959	18,610
16	Italy	10,824	1,242	9,875	38,341
17	Lithuania	10,790	1,511	10,945	25,265
18	Luxembourg	18,612	3,506	15,103	58,118
19	Latvia	8,109	1,499	10,000	21,282
20	Malta	1,983	1,007	6,420	98,132
21	Netherlands	11,574	2,755	16,738	71,628
22	Poland	13,434	1,678	14,435	52,375
23	Portugal	1,957	1,048	4,950	26,457
24	Romania	22,893	1,796	17,524	59,031
25	Sweden	5,247	974	5,389	16,186
26	Slovenia	16,067	1,975	12,422	43,290
27	Slovakia	21,491	1,709	17,134	56,018
28	United Kingdom	6,576	1,780	9,192	41,891
29	**EU**	**10,640**	**1,566**	**10,241**	**39,604**

Source: Ricardo-AEA, 2010

Annex IV: The estimated tonne km performance per operating area and country, based on 2012 data

The estimated tonne km performance based on operating area and country, based on 2012 data						
EU member state	**Rhine**	**North-South**	**Danube**	**East-West**	**ARA**	**mln tkm**
AT	51.8	0.0	1074.2	0.0	0.0	**1126**
BE	7137.4	1238.0	198.7	229.3	6480.2	**15283**
BG	212.0	0.0	1698.0	0.0	0.0	**1910**
DE	14581.1	48.2	3060.8	5495.0	915.8	**24101**
FR	421.1	5429.2	191.4	6.4	325.4	**6380**
HU	49.3	0.0	732.7	0.0	0.0	**782**
LU	533.6	3.8	25.2	29.0	669.8	**1261**
NL	42192.6	544.4	1224.9	2858.2	21096.3	**68053**
RO	121.7	0.0	7037.3	0.0	0.0	**7159**
SK	129.6	0.0	764.4	0.0	0.0	**894**
UA	9.1	0.0	4553.9	0.0	0.0	**4563**
CZ	57.0	5.6	2.2	490.4	2.8	**559**
PL	115.0	3.2	1.1	931.9	12.8	**1065**
HR	3.8	0.0	377.2	0.0	0.0	**381**
RS	9.3	0.0	1314.7	0.0	0.0	**1324**
CH	1559.9	1.9	3.7	14.8	270.5	**1853**
miljoen tkm	**67184**	**7274**	**22260**	**10055**	**29774**	**136694**
Share %	49.1%	5.3%	16.3%	7.4%	21.8%	overig/onbekend
Average NOX value € per ton	€ 14,240.78	€ 11,850.98	€ 14,143.16	€ 15,420.52	€ 15,180.00	
Average PM value € per ton	€ 54,351.51	€ 59,722.17	€ 46,340.65	€ 55,066.68	€ 69,453.13	
Average EU IWT 2010 - NOX	€ 14,373.86					
Average EU IWT 2010 - PM	€ 56,616.64					

Source operating areas and related tonkm-performance: Platina II - D 1.5: 'Analysis of Possibilities to Enhance Market Transparency and Synergistic Actions'. A weighed average of external costs has been elaborated, based upon applying.

Annex V: Sources

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