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

D 6.7 Assessment, Recommendation and Roadmap

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Abstract

The European Union (EU) project PROMINENT[1] - Promoting Innovation in the Inland Waterways Transport (IWT) Sector - which was launched in May 2015, is a multiannual research and innovationi programme for inland navigation, funded by the Horizon 2020 programme of the European Union. Running until April 2018, and involving a number of important stakeholders of the IWT sector of the EU, the project focusses on:

- massive transition towards efficient and clean vessels by developing cost-effective solutions applicable to 70 % of the EU fleet and reduction of the corresponding implementation costs by 30 %;
- certification and monitoring of emission performance and development of innovative regimes;
- harmonisation and modernisation of professional qualifications and the stimulation of the further integration of IWT into sustainable transport chains.

Building upon the identification of the most promising greening technologies and the technical developments carried out in the project, several pilots were set up and started, delivering a great number of interesting results of significance to the IWT sector.

Based on the validated findings from amongst the research and the pilots, this report contains the policy conclusions, recommendations and roadmap. This is based on the evaluations and assessments for the various fields of the PROMINENT innovations. The goal is to prepare for mass implementation of the innovations that serve the overall aim of PROMINENT in terms of market reach and cost reductions.

It turns out that significant external cost savings can be reached.

The PROMINENT Roll Out Strategy and Implementation Plan consists of a number of proposed activities, to be implemented in parallel:

i. Legal and policy actions

1. Update the EU greening the fleet policy and set clear and ambitious targets in the field of emission limits which are to include the existing fleet and engines:
    - Set medium/long term policy, pathways and targets for addressing CO2 reduction towards zero-emission (biofuels with clean combustion engines, fuel cells/battery and electric propulsion);
    - Provide the legal basis and budgets in the Connecting Europe Facility for providing funds by the European Commission for the Greening Fund supporting voluntary investments by ship-owners in air pollutant and greenhouse gas emission reduction technologies, linked to the policy targets and required investments.

[1] http://www.prominent-iwt.eu/

2. Introduce targets to be enforced by the legal regime and monitoring systems:
    - Legislation and regulations in this field to be developed, air pollutant emission test procedures and limits for the existing fleet;
    - Including On Board Monitoring to ensure emission control systems are working properly.

3. Incorporate in the legal framework of River Information Services (RIS) and the TEN-T guidelines/Good Navigation Status the obligation for providing detailed data on waterway conditions and waiting times to enable more energy-efficient navigation.

4. Provide the legal support for digitisation of the service record book and logbook (e-SRB, e-logbook) in the framework of the Digital Inland Navigation Area (DINA);

5. Provide the legal support for minimum requirements and certification of Inland Navigation Vessel Handling Simulators.

ii. Financing for reaching Stage V and zero-emission

6. Development of an EU-wide Greening Fund to finance a large scale uptake of proven solutions, dedicated to reducing air pollutant emissions and greenhouse gas emission:
    - The fund can be filled in several ways, through stakeholder contributions supporting green initiatives:
        - Grants from EU, Member States and regional governments;
        - Sector contributions by means of revenues provided by a differentiated environmental surcharge on IWT fuel and the Reserve Fund;
    - Technology neutral, level playing field;
    - Revenues from the environmental surcharge are earmarked to the Greening Fund, with a strong governance by the sector;
    - Further supporting incentives from shippers and port authorities.

iii. Research and Development and Innovation deployment

7. Programme Research and Development calls (H2020, FP9) as well as supporting actions for deployment (CEF) related to the promising solutions focused at:
    - Widening the geographical scope of PROMINENT energy efficiency tools (ENAT), equip more vessels, set up central database(s) for processing the data from the vessels, execute ship borne measurements of waterway conditions and combine data with those provided by the waterway administrations;
    - Digital tools / DINA: e-SRB and e-Logbook;
    - Monitoring data for more vessel types, operation schemes etc.;
    - Further technological research to promising greening engine room techniques with low TRL such as full electric (battery) sailing, hydrogen and biofuels.

iv. Support for promotion, training and education

8. Providing funding support for purchasing of Vessel Handling Inland Navigation Simulators across Europe;

9. Providing support for promotion activities aiming at knowledge collection and dissemination on greening technologies and innovations to the entrepreneurs in the sector, through continuation and expansion of the platforms (e.g. EIBIP), and training/education institutes, hosting and further developing I-Steer App as well as energy efficient navigation, including awareness campaign on energy consumption and emissions

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Executive summary

This report contains the policy conclusions, recommendations and roadmap based on the evaluations and assessments for the various fields of the PROMINENT innovations. The goal is to prepare for mass implementation of the innovations that serve the overall aim of PROMINENT in terms of market reach and cost reductions.

a. Targets

The PROMINENT project has the ambitious target to ultimately provide technologies and concepts which make inland navigation as competitive as road transport in terms of air pollutant emissions by 2020 and beyond, while keeping inland waterway transport's (IWT) advantage regarding the 60-80% lower energy consumption and carbon footprint.

PROMINENT takes into account a series of technologies and concepts, which are grouped around several main themes:

- efficient and clean IWT, to be realized through engine room improvements and energy efficient navigation leading to NRMM Stage V emission levels for NOx and PM and savings on fuel consumption and CO2 emissions;
- certification, monitoring and enforcement of stringent emission limits (NRMM Stage V);
- skilled workforce and quality jobs, through harmonisation and modernisation of professional qualifications and integration of IWT into transport chains.

The technologies and concepts developed in PROMINENT must provide cost effective solutions, which is defined as:

- applicable to 70 % of the fleet;
- lead to 30 % reduction of implementation costs;

which is to be realised through:

- 100% stakeholder involvement;
- actively addressing and removing implementation barriers.

b. Key results from the studies and pilots

The PROMINENT project has resulted in a huge set of deliverables containing detailed studies on new technologies, new concepts, simulations, real-life tests and pilots, simulations, impact studies, training programmes, awareness actions and stakeholder consultations, dialogues and involvement.

The main conclusion in the field of emission control and energy savings is that from a technical viewpoint substantial improvements can be realised. A saving of around 915 million euro can be reached by means of a combination 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;
- 78% reduction of external costs for emissions by reaching Stage V emission levels, meaning 848 million euro savings per year.

What also can be seen is that NOx has by far the highest external costs. Currently the NOx emissions have an external costs of 825 million euro per year.

The following table presents the figures.

	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 1: 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.

Costs for implementing the Stage V levels sum up to around 1 billion euro. It can therefore be concluded that from a socio-economic viewpoint, these costs will be earned back within 14 months. As a result it can be concluded that the cost-benefit ratio for providing support measures (e.g. by means of grants) is very high.

Furthermore, the developed and validated greening technologies contribute and fit into the long term ambition to reach zero emission transport and decarbonisation. At present several techniques have reached a high Technical Readiness Level (TRL), meaning that they are market ready. Some other techniques require further development first before they are ready for commercial applications. They are promising, but are still in the initial stages of development, and deployment is a number of years away. Pilots show that LNG and retrofit after-treatment systems (SCR-DPF) reaching Stage V emission levels are ready for the market. Furthermore, the required monitoring and certification systems are also in sight and can be rolled out on the short term.

Low emission and low carbon vessels are generally more expensive than diesel run vessels, although costs will come down with an increased uptake of these new technologies. It is concluded that implementation of a number of the solutions studied leads to increasing of cost, without generating sufficient operational advantages to reach any break-even point for the ship-owner/operator. The potential benefits for society are however very high. In other cases, there is a cost advantage on medium term for the ship-owner/operator, but this only applies to specific type of operations and/or specific vessel types. Solutions leading to lower energy use of course do relate to cost advantages, but may have operational disadvantages, such as a longer sailing time which might not be acceptable for the client. If waiting times at locks and terminals are reduced, the overall trip time can remain the same.

Although cargo owners appreciate the attempts of the inland navigation industry to take measures in emission reduction, there is no general financial compensation in terms of higher freight rates. Only a few frontrunners (e.g. Heineken, Akzo) are investing in low emission transport. This is done by means of offering long term contracts and sometimes by means of discussing and accepting open calculations with the involved transport operators. However, the vast majority of the cargo owners make the transport choice based on the lowest price and the majority of cargo is traded on the spot-market, often on single trip basis via multiple brokers.

All in all, the conclusion is justified that operators investing in clean solutions are not rewarded for these investments. This can be classified as a market failure, as market forces are not driving greener inland shipping. The external costs of air pollution and greenhouse gas emissions are not internalised.

There is a number of failures and reasons for the slow uptake of greening technologies:

- Investments in greening technologies and measures do not generate cost reductions, while reduced external costs are not internalised to create a business case, there is a lack of incentives and willingness to pay by shippers/forwarders;
- Financers like commercial banks are hesitating to invest in new technologies, which are yet to prove its value (risk avoiding behaviour);
- The regulatory framework and EU IWT policy, does not include stringent emission targets/regulation and timeline for existing vessels and their engines to accelerate greening of existing vessels.

c. Prominent Roll-out Strategy

In order to reach the original PROMINENT targets, a balanced package of measures is required in different areas:

- Regulations on EU level;
- Incentives;
- A financial support scheme;
- Further R&D in the technical field;
- Expansion of pilot systems to other areas.

The Roll Out Strategy for PROMINENT does focus at:

- speeding up the solutions which have a positive impact on society and at the same time have a positive business case,
- giving support to the solutions which have a positive impact on society but miss the positive business case.

This support strategy can contain measures in the field of giving incentives and subsidies, but could also relate to tax measures for systems which contribute in a negative way to society but are positive on business level (e.g. pollution causing negative impact for society could be taxed, while zero emission transport which has a negative impact on business level should be supported). The next figure illustrates the policy strategies for the different situations.

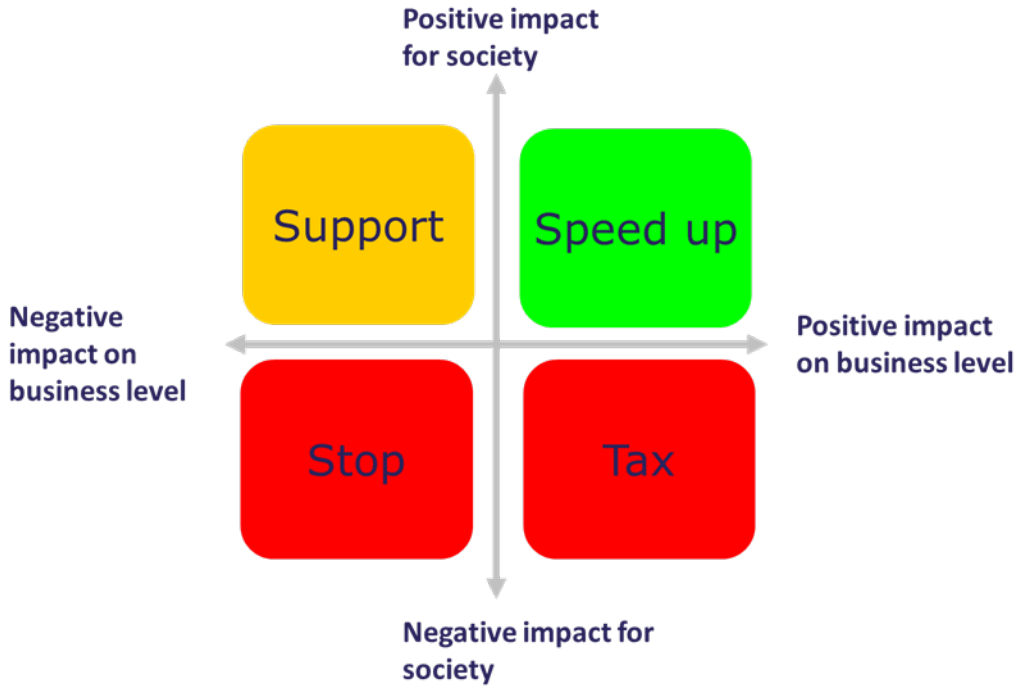

Figure 1: Policy strategies for different situations

Although there is a great variety in Technical Readiness Levels, barriers identified, challenges to address and actions needed for roll-out and implementation of the solutions, there is a lot of synergy between the four PROMINENT areas:

- Certification, Monitoring and Enforcement;
- Engine Room;
- Energy-Efficient Navigation;
- Skilled Workforce and Quality Jobs.

The challenge is to prepare a strategy with follow-up actions which leads to the realisation of the PROMINENT targets. This means that the synergies between the four PROMINENT areas are determined and to be translated into the overall roll-out strategy and detailed actions, actors, budgets and support programmes.
In defining the roll-out strategy, three main variables are of importance:

1. the broader societal impact of solutions, technologies, instruments
    - in terms of energy savings, emission reduction, and market volume that will benefit.
2. the barriers that have to be addressed for further uptake and roll out:
    - technical (barriers caused by immaturity of technology or operational requirements);
    - legal (barriers caused by regulations and laws, or a lack of this);
    - financial (barriers caused by access to capital or business case);
    - knowledge (barriers caused by a lack of expertise or skills);
    - market (barriers caused by market conditions, infrastructure, and the supply chain);
    - cultural (barriers caused by behavioural routines).
3. the business case for the actor who needs to decide on the investments (usually the ship-owner/operator)

A package of actions is recommended to stimulate specific positive developments (e.g. uptake of LNG, applying slower sailing speeds) and to carry out more R&D in specific areas (e.g. ENAT, zero-emission technologies).

Next to providing support programmes through incentives, it may also be needed to take certain actions against polluting systems and polluters, so as to discourage unwanted developments from a socio-economic viewpoint. This is especially the case when operators carry on using old diesel engines, do not invest or pay for after-treatment or other measures, and find a good business case in such continuation. For these operations and operators, no improvements are expected on a voluntary basis. Measures and actions could come from other stakeholders such as port authorities, municipalities, and a few pioneering cargo owners, but will also need regulatory reforms to enforce the change that is necessary and to internalise greening of the fleet in market mechanisms.

One of the keys to unlock the greening door is of course creating financial benefits. One of the conclusions of the cost and benefit analyses and the I-STEER App developed in PROMINENT is that most of the greening 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 is a positive business case in only some cases. This lack of a positive business case complicates the financing of emission reducing technologies, which is a major bottleneck for the Roll-Out.

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.

At the same time it was found that the supply is minimal compared to the actual demand, which shows figures between euro 1 and 2 billion to bring the fleet to Stage V emission levels.

An additional difficulty is that loans often do not suffice for innovative technologies that have greatest positive impacts for society, for the simple reason that the Return on Investment (ROI) is too low and risks are considered to be high. So despite the theoretically legitimate ground to support green technologies in IWT, current instruments are mostly insufficient.

The inland navigation industry is requesting certainty about the desirable pathway for a lower carbon footprint and emission. Investment in new technologies will be done quicker, once it is clear where the industry will head to, and when existing vessels and engines will have to meet higher requirements. The inland vessel industry is in this field often compared with the sea going ships and marine industry, which is a misperception. Inland shipping is competing with trucks and rail, and the industry resembles much more the inland transport systems and technologies. Moreover, the lifetime of inland vessels and their engines is much longer compared to trucks, which calls for a stable medium/long policy for greening the fleet.

Despite the differences, much can be learned by looking at the way how the trucking sector evolved from polluting trucks to the present green truck fleet, enforced by stringent emission limits (E.g. Euro VI) in combination with an extensive emission test procedure, supported by incentives (e.g. subsidies for purchasing cleaner trucks) and implementing emission zones where old and polluting trucks are not allowed anymore. This could not have happened without the technical innovations in the sector, but was heavily supported by a clear regulatory regime and funding from public bodies.

A regulatory system for the existing fleet on EU level, in combination with admission limitations by countries, municipalities, and ports (sector regulation), requirements from cargo owners and traders to lower carbon footprints, and the creation of a support fund, will lead to realisation of the PROMINENT targets. As aforementioned, a clear guidance is of the utmost importance for the inland navigation industry to accelerate the change towards clean and greener inland shipping.

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    - Provide the legal basis and budgets in the Connecting Europe Facility for providing funds by the European Commission for the Greening Fund supporting voluntary investments by ship-owners in air pollutant and greenhouse gas emission reduction technologies, linked to the policy targets and required investments.

2. Introduce targets to be enforced by the legal regime and monitoring systems:
    - Legislation and regulations in this field to be developed, air pollutant emission test procedures and limits for the existing fleet;
    - Including On Board Monitoring to ensure emission control systems are working properly.

3. Incorporate in the legal framework of River Information Services (RIS) and the TEN-T guidelines/Good Navigation Status the obligation for providing detailed data on waterway conditions and waiting times to enable more energy efficient navigation.

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6. Development of an EU-wide Greening Fund to finance a large scale uptake of proven solutions, dedicated to reducing air pollutant emissions and greenhouse gas emission:
   - The fund can be filled in several ways, through stakeholder contributions supporting green initiatives:
     - Grants from EU, Member States and regional governments;
     - Sector contribution by means of revenues provided by a differentiated environmental surcharge on IWT fuel and the Reserve Fund.
   - Technology neutral, level playing field;
   - Revenues from the environmental surcharge are earmarked to the Greening Fund, with a strong governance by the sector;
   - Further supporting incentives from shippers and port authorities.

iii. Research and Development and Innovation deployment

7. Programme Research and Development calls (H2020, FP9) as well as supporting actions for deployment (CEF) related to the promising solutions focused at:
   - Widening the geographical scope of PROMINENT energy efficiency tools (ENAT), equip more vessels, set-up central database(s) for processing the data from the vessels, execute ship borne measurements of waterway conditions and combine data with those provided by the waterway administrations;
   - Digital tools / DINA: e-SRB and e-Logbook;
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iv. Support for promotion, training and education

8. Providing support for purchasing of Vessel Handling Inland Navigation Simulators across Europe

9. Providing support for promotion activities aiming at knowledge collection and dissemination on greening technologies and innovations to the entrepreneurs in the sector, through continuation and expansion of the platforms (e.g. EIBIP), training/education institutes, hosting and further developing I-Steer App as well as energy-efficient navigation, including awareness campaign on energy consumption and emissions.

More details about the above mentioned clustered actions are provided in the following section.

d. More details on actions for each area in PROMINENT

This section presents the main results of the studies and pilots for each of the specific area that was distinguished in PROMINENT:

- Certification, monitoring and enforcement;
- Engine room;
- Energy-efficient navigation;
- Skilled workforce and quality jobs.

It presents a concise description of the main barriers and measures and actions needed for support and speeding up of promising solutions.

i. Certification, monitoring and enforcement

The first PROMINENT area deals with certification, monitoring and enforcement of air pollution emission performance of vessels, notably NOx and PM. It addresses the options for introducing additional regulatory emission schemes for the existing fleet and their engines, on top of the laboratory based type approval of the engine. A regulatory framework shall support reaching NRMM Stage V equivalent emission levels for existing vessels equipped with greening technologies such as SCR-DPF.

Study and pilot results show that the practical Type Approval procedure for Retrofit Emission Control devices (REC) developed in PROMINENT can support the greening of the inland vessel fleet, and that On Board Monitoring (OBM) can fulfil an important role in securing and demonstration of the environmental performance of a vessel. RECs are after-treatment systems consisting of SCR catalyst and Diesel Particulate Filter (SCR-DPF).

A number of barriers prevent a quick and easy deployment of the devices and tools. Concerning REC, currently there are no legal requirements. There is no formal certification procedure yet either for REC for operators who are willing to (voluntary) invest in after-treatment systems (e.g. SCR-DPF). Moreover, there are no clear financial benefits for the ship-owner/operator if engines comply with stringent limits (NRMM Stage V) due to installed REC, and the market has limited financial means to invest in REC systems.

For OBM, there is no legal requirement for continuous OBM, there are significant installation and operating costs for OBM. Looking at the positive societal benefits, and in line with the strategy types mentioned in the introduction, a series of actions and measures are needed for the market uptake. This is a balanced combination of different types of measures.

For REC devises a certification procedure is required: PROMINENT proposes to implement the 'Retrofit' type Approval procedure as CESNI ES-TRIN standard (e.g. a new Article 9.10), REC type approval procedure to be based on a scaled engine test. Detailed procedures will need to be written for that. This would also require a special technical working group to make a number of specific choices and to review the detailed procedure.

The roadmap for REC and OBM is summarised in a number of specific actions:
For REC:

- CME - Action 1: Development of test procedure (approved on CCNR or EU level) for retrofit Stage V (equivalence to OEM Stage V); Obtain support from stakeholders such as shipping organisations ESO, EBU and award organisations like the Dutch Green award;
- CME - Action 2: Implement Stage V emission requirements for existing vessels at some point in the future.

For OBM:

- CME - Action 3. Create support to accept OBM in combination with independent emissions test, as alternative to type approval for Stage V emission requirements;
- CME - Action 4: Implement OBM as formal additional requirement for Retrofit and OEM Stage V (2020-2025);
- CME - Action 5: Develop emissions control centre for OBM with algorithms for pass/fail based on simple parameters, to be operated by a public body;

- CME - Action 6: To integrate OBM standard in REC control systems or in OEM engine management control systems.

The REC and OBM implementation is highly depending on the overall scheme to introduce incentives, funds and a business case for the ship-owner/operator to invest in retrofit technologies on existing vessels to reaching Stage V emission levels. This concerns installation of incentives from shippers if vessels comply with Stage V requirements such as 'condition to tender', 'slightly better price', 'longer contract period', etc.. Notably if the vessels is continuously monitored (CO2 and NOx emission) an additional incentive can be provided by the shipper. Also a green fund and further incentives are crucial to create a business case to invest in greening technologies. These Actions are addressed in the section 'Engine Room' (Engine Room).

Concerning REC and OBM, these are at a high level of technical development although some R&D is still necessary, the regulatory framework is required and a market push and acceptance from industry is needed.

ii. Engine Room

The topic engine room addresses the engine, drivetrain and the fuels in relation to the emission performance. PROMINENT focus in particular is on the air pollutant emissions, NOx and PM. However, also fuel consumption and choice on the type of fuel are relevant in view of the global challenge to reduce greenhouse gas emissions (CO2 reduction).

The studies and pilots carried out in PROMINENT show that SCR-DPF and LNG from a technological viewpoint are able and mature to reach Stage V emission levels. Due to the modular design, the SCR-DPF systems are quite well transferable to other vessels if the engine is a medium or high speed type. The certification is however an issue to be addressed in this roadmap (as discussed in the above section on REC) and also the legal arrangements. Last but not least, the business case for the ship-owner/operator proves to be negative based on the PROMINENT research.

LNG has a positive case only for the operators that consume a high volume of fuel. The Cost Benefit Analysis shows a severe dependency of the economic feasibility in relation to the fuel prices for gasoil and LNG. The uncertainty of the price developments and the rather low gasoil prices seen over the past couple of years make the ship-owner/operators reluctant to invest in LNG drive trains. First certified NRMM Stage V approved LNG engines are expected to be available in 2019. The pilot tests with the LNG designs validate that emission limits for Stage V will be reached.

Moreover, variety of alternative fuels are currently being discussed (e.g. biofuels, full-electric/battery, fuel-cell hydrogen, methanol, ethanol), given also the need to reduce the CO2 footprint. In addition application of marinized Euro VI truck engines is one of the additional options which seem suitable for smaller vessels and engine power. This may bring emission levels further down, notably NOx emissions. However, it is yet too early to make solid conclusions on the EU-wide application of this option for the PROMINENT fleet families. Further R&D will be needed on these technologies and alternative fuel/power sources. This will help to get a view on pathways towards a zero-emission performance of inland waterway transport with intermediate targets and realistic ambitions.

The right sizing of engines (in case of engine replacement) is an economically viable way to reduce fuel consumption and therefore also the emissions to air. The application of right sizing shall be promoted. However, it requires changing the engine and from 2019/2020 this implicates a Stage V engine which may be more expensive for an existing vessel compared to overhauling the existing engine. Calculations will need to be made for the specific vessel and operational profile to see if changing the engine has a business case and if the investment for doing so has a reasonable payback time. Tools like the I-Steer App are therefore important instruments to facilitate these assessments.

For the IWT fleet there is a small but growing group of electrical hybrid and diesel electric vessels appearing on the market, although energy savings are still uncertain. Electrification of vessels gives additional options to the dimensioning and operational use of the combustion engines. Despite the disappointing results from the cost benefit study, electric propulsion is for the long term a promising technology contributing to zero-emission sailing. More effective, and more costly technologies such as batteries and fuel cells are suggested. Their capability to bring green energy on board is expected to overcome the disadvantages of diesel electric vessels compared to conventional vessels. However, the roadmap for implementation of fuel cells and full electric vessels is yet unknown and uncertain, since there are still many questions on the costs and applicability of these technologies. Investments in these technologies is out of reach for the dominant group of conventional vessel owners which usually operate on the spot market.

It can be concluded from the study, models and pilots that a transition using clean combustion engines with bio-fuels (e.g. biodiesel/HVO or bio-LNG) will be the preferred route to follow for the short term for many of the ship-owner/operators, depending on the operational profile and vessel type.

As discussed, there is no push from European or national legislations to green the existing engines, which is a major barrier for development. This in combination with the fact that there is no commercial added value in application of exhaust gas after-treatment systems (SCR-DPF) or to replace or modify the engine to use LNG or other clean fuels.

The analysis summarised above, leads to the conclusion that despite the very positive results for society in terms of energy use and emissions, a number of barriers are a hindrance for market uptake. These are:

- In the policy and regulatory field (lack of a medium and long term EU policy towards zero-emission inland waterway transport, and missing legislation for existing engines/vessels to comply with low air pollutant emission levels and to enforce low Real Sailing Emissions for both Retrofit solutions and OEM engines, for example by On Board Monitoring);
- In the economic and financial field: in general there is no business case for greening the fleet on business economic level for the ship-owner/operator as well as difficult access to finance (loans) and lack of long term contract and willingness to pay from shippers/forwarders for green vessels;
- In the technical field: no mature zero-emission technology available and commercially viable for 70% of the market, and unclear how the market position can be of these zero-emission technologies and what will be the time-frame for the market implementation;
- the missing know-how and capacity of most (small) companies (80% of the EU fleet owners) to investigate the greening technologies/fuels for their specific business situation (vessel characteristics and sailing profile).

The main actions for the Roadmap addressing the drive trains, engine room and fuels are aimed at providing the proper framework conditions to create the business case for greening the fleet. This shall be done by implementation of a stick & carrot scheme with clear overall targets and timelines for greening the fleet with respect to both air pollutant emissions and climate change emissions towards the year 2050. The development of a supportive greening fund is a useful and practical instrument in this respect. Shippers, forwarders, port authorities, regional and national authorities as well as the sector itself are recommended to align with the defined targets for supporting instruments. And a regulation should be implemented that prescribes the maximum emission limits to be reached within a certain timeframe.

Specific actions in this field concern:

- ER - Action 1: development of a EU policy taking into account realistic technology and energy transition pathways and derived targets on reduction on greenhouse gas emissions and air pollutants for IWT specifically (CO2, NOx and PM), including existing vessels;
- ER - Action 2: development of European wide financial support scheme and a funding regime based on a differentiated environmental surcharge on fuel to provide the business case and funding for supporting the large scale deployment of greening technologies and alternative fuels, aiming at Stage V emission levels and further development towards zero-emission IWT. Such a scheme shall be technology neutral support possible incorporation of grants and public loans from regional authorities, Member States, European Commission and EIB;
- ER - Action 3: initiating Research and Development projects dedicated to IWT for promising zero-emission technologies to be applied in IWT in the period 2020 onwards such as application of biofuels (e.g. 100% or blends), hydrogen/fuel cells, biofuels and full electric, e.g. new R&D and pilot projects funded by the European Commission (H2020, FP9);
- ER - Action 4: supporting platforms such as EIBIP and development of tools, pilots and dissemination work to bring more awareness and sharing information on the various technical options and alternative fuels, taking into account promising zero-emission technologies. Also right-sizing and diesel-electric and hybrid solution need more support due to the enormous diversity (ship types and sailing routes) of the inland shipping fleet. For diesel-electric and hybrids propulsion more data is needed to proof the advantages for certain market segments

iii. Energy-efficient navigation

The effect of energy-efficient navigation was included in several study parts, pilots and simulations in PROMINENT. Both different sailing strategies as well as implementation of new technologies and ship modifications have an impact on fuel consumption and CO2 emissions. Advanced simulations revealed that sailing with constant rate of revolutions or delivered power results in a fuel consumption rather close to the minimum for a prescribed sailing duration. However, the most significant savings in fuel consumption can be achieved by sailing slower, which depends on the permitted duration of the trip (the time of arrival at the client for offloading the cargo or passengers). Reducing overall speed is of most importance. It shall be noted though that boatmasters often don't have much degree of freedom to choose the sailing duration and respective required speed. Therefore, also shippers (clients of IWT) shall be made aware of the relation between the journey time/arrival time and the fuel consumption.

Obviously the greatest impact of energy-efficient navigation will be obtained by vessels with high fuel consumption, e.g. pushed convoys, or vessels with steep power-speed relations sailing with high brake power (tankers, container vessels). Most effective is therefore raising the awareness of the impact of different sailing strategies, provision of real-time information on energy-efficient ship operation and navigation conditions, as well as improvement and better utilisation of the waterway infrastructure through better knowledge on the conditions for these fleet families and operational profiles. The investigations carried out show that savings in CO2 up to 25 % may be achieved without additional large investment costs. However the results differ greatly. They depend on the ship sizes, the characteristics and mode of operation of the vessel and the sailing area. In general it was stated that a 10% saving of CO2 is certainly feasible on medium term as result of more efficient navigation.

The simulations carried out reveal that for a typical Rhine vessel, a time increase by 1 % derived by slower sailing can result in a reduction of fuel consumption by 3 %; for a Danube vessel in single operation, a time increase by 1 % may result even in 4 % reduction of fuel consumption. For modified lock operations between Rotterdam and Maastricht, allowing for slower sailing between the locks on the route, the fuel consumption of a large motor cargo vessel may be reduced by 13% according to results derived from the energy-efficient navigation tool (ENAT).

The slower speed of the vessel leads to a longer sailing time, and thus could lead to a lower earning capacity of the vessel. In the current round trip time of an inland navigation vessel, there is usually however a lot of slack (e.g. waiting time at bridges or locks or at terminals). Improved alignment in the supply chain and interaction with terminal and waterway managers (e.g. specific slots for loading/unloading and passing locks) will enable more energy-efficient sailing. This links to concepts addressed in DINA (Digital Inland Navigation Area).

It can be concluded that a number of barriers exist to apply energy efficient navigation:

- The lack of availability of suitable information on navigation conditions (water depth, flow velocities);
- The difficulty to include locks and waiting time at terminals in voyage planning;
- The lack of availability of information on ship performance of a sufficiently great amount of vessels in order to cover the EU fleet (at least in the Rhine-Danube corridor);
- The poor capability to consider modified designs and new technologies;
- Stakeholders in the supply chain are not yet informed on the benefits of more efficient navigation.

Further R&D, innovation deployment, measurement projects, data collection and awareness campaigns are therefore needed and recommended by PROMINENT.

The ENAT tool, developed in PROMINENT, can be a great support to more energy-efficient navigation, but, in line with the barriers mentioned before, better data on navigation conditions in different areas is required for validation of the tool, allowing a wider use and its integration in commercial route planners.

In the field of energy-efficient navigation a number of actions are required to address the identified barriers, relating partly also to the better use of simulators, the actions needed for simulators specifically are described in the previous paragraph. The following actions shall be taken:

- EEN - Action 1: further development of the simulation environment: to increase the amount of vessels to be considered for simulation (e.g. DST tank tests and modelling), their speed/power profile and resistance in different water conditions to further develop the models to calculate interaction between waterway information and the vessel. The results shall feed the further development and applications of tools such as ENAT (see next Action)
- EEN - Action 2: further development of the tool for energy-efficient navigation (ENAT): to make infrastructure operating times and locations (locks, terminals at harbours) available as input and use real time information on the current availability of infrastructure (terminals and locks) for real time advise on the most efficient sailing speed and on the preferential ETA. This requires investments in data exchange between stakeholders (e.g. through RIS applications as developed within the framework of RIS COMEX at the moment) and improved logistics data analytics. It is advised to make this an important part of the digital infrastructure, DINA. This can lead to substantial energy savings without increase of overall sailing time. Once the tool has reached a TRL such that it can be put in commercial operation, organisational and financial actions are to be elaborated and initiated in order to guarantee a continuous availability of the services the tool is going to provide;
- EEN - Action 3: water conditions and shipborne measurements on the Rhine and Danube: it is needed to improve the availability of detailed waterway information (water depths, currents, riverbed composition and riverbed shape) through measurements from waterway managers, notably water depth information on the Danube river is crucial. Another element is providing support for the continuation of the operation of the PROMINENT vessels equipped providing information on the waterway and expansion of fleet measuring the water conditions to provided data to ENAT. It is needed as well to establish further cooperation activities with ship-owners, including the set-up of an agreement with respect to sharing the data collected as well as the establishment of legal and organisational solutions for continuous running of the system and involvement of new ship-owners.
- EEN - Action 4: carry out comprehensive promotion activities. For an efficient roll-out of the toolset, awareness campaigns are required, both for aimed at ship operators and at other stakeholders in the logistics chain, such as cargo owners, freight forwarders, terminal operators and infrastructure managers. This action shall be combined with Action 9 of the Engine Room (promotion and dissemination platforms such as EIBIP) and has also close links to feeding education programmes for students and crew working on vessels (e.g. full bridge simulator training facilities).

iv. Skilled workforce and quality jobs

The PROMINENT work in this field considers three areas:

- The use of simulators and digital tools for the crew of vessels;
- The European electronic service record book and logbook;
- The integration of inland navigation in general logistics education through a Community of Practice;

The full bridge simulators for crew training can contribute to an increased safety level as well as to energy-efficient navigation. A major challenge is to make the profession of working in IWT more attractive and accessible for interested people. It therefore shall reduce the shortage of qualified nautical personnel.

Specifically in CO2 savings, the effect of the use of simulators very much depends on the application; the awareness of impact of different sailing strategies (5 %), new technologies and ship modifications. In terms of improvements of efficient navigation, the full bridge simulators can play a significant role in raising awareness and knowledge about fuel consumption in relation to speed and manoeuvring the vessel. This combination with application of tools such as ENAT and advanced route planners in the operation of a vessel shall support more energy-efficient sailing.

With the introduction of the electronic service record book (e-SRB) and the e-logbook considerable benefits are to be gained, for example through the reduction of the administrative burden for stakeholders, and less time loss for inspections. In the field of e-SRB and e-logbook there are some issues to be solved and the legal base has to be settled. This is a bottleneck for implementation and roll-out. It requires an Impact Assessment procedure by EC (DGMOVE) in order to address this issue and to prepare a legal intervention to support implementation of e-SRB and e-logbook.

A more top-down approach to realise sustainable transport (less external costs) is to increase the modal share of IWT and to shift freight carried by trucks to the inland waterways. This requires however logistic decision makers to be aware of the performance and services that can be offered by IWT. The integration of knowledge about IWT services and performance in wider logistics education is therefore a major element. PROMINENT therefore addressed the integration of inland navigation in general logistics education by means of developing and testing an online web-based Community of Practice (CoP) to provide free up-to-date learning materials on the topic of IWT for general logistics education at an international basis. The CoP provides various types of learning materials, covering the aforementioned important topics of inland navigation which are currently underrepresented in general logistics education. The long-term goal is that the web-based CoP is used as a source for learning materials on the topic of inland waterway transport which can be integrated in logistics education. In addition, it should be used for all sorts of issues and discussions on the topic of IWT by different stakeholders from industry, research and education.

In the simulator field a wider application, in scope and scale, is possible and desired, but a number of barriers still prevent this. Notably a legal base is needed and standards for requirements for Vessel Handling Inland Navigation Simulator (as being developed by CESNI/QP) need to be adopted and applied. In addition funding will be needed for roll-out of these simulators across the education and training institutions in Europe.

The barriers to better integrate inland navigation in general logistics education are limited, the main issue here is to overcome administrative barriers to include the developed learning materials and the capstone course.

One of the actions is to carry out promotion activities for energy efficient navigation, however this action is already addressed in action 12 under the previous section (Action 12: carry out comprehensive promotion activities).

The remaining specific actions recommended by PROMINENT are therefore the following:

- SKQJ - Action 1: establishing the legal basis for minimum requirements and certification of Vessel Handling Inland Navigation Simulators as well as supporting funding schemes for roll-out;
- SKQJ - Action 2: e-SRB & e-logbook: carry out an Impact Assessment study leading to regulations for implementation within the wider framework of DINA. E-SRB and e-logbook shall be implemented together with a short transition period (an in-depth investigation of the investment costs needed has to be done related to this). Harmonisation of the format/procedure and exchange of information related to e-SRBs and e-Logbooks shall be settled in this way at EU level, creating a level playing field;
- SKQJ - Action 3: integration IWT in logistics: adapting the logistics curricula, and it shall be stimulated to use the web-based CoP as a source for learning materials, CoP for discussions on the topic of inland waterway transport. Funding is needed for training the teaching staff following the adaptations of the curricula.

1. Introduction

a. Background

The EU project PROMINENT[2] - Promoting Innovation in the Inland Waterways Transport (IWT) Sector - which was launched in May 2015, is a multiannual research and innovation programme for inland navigation. 17 parties from five European countries are collaborating to green the inland navigation industry. Running until April 2018, the project foresees the forward-looking approach bringing together the economy, the environment and safety for inland navigation with a clear focus on reduction of greenhouse gas emissions and increased environmental friendliness of navigation as well as an increase of competitiveness of inland navigation in logistics networks.

PROMINENT has been addressing the key needs for technological development, as well as the barriers to innovation and greening in the European inland navigation sector. PROMINENT thereby is fully in line with the objectives of the European action programme NAIADES-II, *COM/2013/0623 final*, and ultimately aiming at providing solutions which make inland navigation an ever more competitive alternative to road transport in terms of air pollutant emissions by 2020 and beyond. In parallel, PROMINENT aims at further decreasing the energy consumption and carbon footprint of IWT, an area where it already has a strong advantage compared to road transport.

b. Prominent targets

The main three PROMINENT targets are:

1. developing cost-effective solutions and standardised applications characterised by:
    - 70%+ coverage – Developing solutions reaching Stage V emission levels and energy reduction that are applicable to at least 70% of the European inland fleet and their operating areas;
    - 30% costs reductions – Reducing implementation costs of innovative greening solutions by 30%.

2. Involving all relevant actors concerned in the research and innovation process
    - 100% inclusive - All stakeholders who are required for the full coverage of the innovation cycle from initial concept to real-life deployment are to be taken on board.

3. Actively addressing and removing current implementation barriers by 2020:
    - Visible and physical results by 2017 onwards;
    - Producing results on the ground during the project lifetime;
    - 2020 as ultimate time horizon – Setting up a roll-out strategy which is geared towards actions leading to results on short term.

In PROMINENT, the involvement of stakeholders plays a key role. Consultation with the project Advisory Board, presentation of project results in expert groups, as well as interviews with representatives of the shipping industry - users and shippers – serve the verification of the results. Fleet families, operational profiles, the selection of the greening technologies and concepts, as well as the assessment of technology-specific barriers and facilitating factors, all these have been and will be further assessed by the stakeholders. As a consequence of this approach there is a broad support for the PROMINENT findings and recommendations among political and commercial decision

[2] http://www.prominent-iwt.eu/

makers in the field of inland navigation. This was illustrated by the lively and interactive discussions at the PROMINENT Final Event which took place on 17th of April.

This report is prepared in the Work Package Roll-Out (WP 6). It does address the following four topics addressed by PROMINENT:

- Certification, monitoring and enforcement emission limits;
- Engine room improvements;
- Energy-efficient navigation;
- Skilled workforce and quality jobs.

c. Correlation with other initiatives

PROMINENT addressed all topics included in call MG.4.4-2014 and is geared towards reaching its full impacts during the project lifetime. PROMINENT is ultimately aimed at providing solutions which make inland navigation as competitive as road transport in terms of air pollutant emissions by 2020 and beyond. A number of relevant initiatives are identified which are relevant for synergies and follow-up of PROMINENT:

- The CLINSH project (LIFE programme) https://www.clinsh.eu/
  One of the activities of CLINSH is the demonstration and monitoring of emission-reducing technologies and alternative fuels. This will be done with on-board, continuous monitoring before and after installation or application of the technology or fuel. During this monitoring campaign, validation will be done by more conventional discontinuous measurements. The outcomes of PROMINENT on the monitoring methodology and best available technologies are used for the demonstration and monitoring. The outcomes of the demonstration and monitoring are used for modelling the emissions by IWT and to draft recommendations for ship-owning companies as well as policy makers. In the scenarios for these recommendations, the data on fleet composition are used. In the policy recommendations, there will be build further on the outcomes of the recommendations formulated in this document.

- LNG Breakthrough (CEF programme): https://lngbinnenvaart.eu/
  This project is focussed on achieving a breakthrough of the deployment of LNG in inland waterway vessels by equipping six vessels with LNG configurations and building LNG bunker stations. The designs and tests from the LNG activities within PROMINENT can be used in the construction of the LNG configuration of the inland vessel of one of the suppliers. Another aspect of achieving a breakthrough is the development of business cases, the methodology for the cost-benefit analysis and the fleet overview from PROMINENT has been used in the business case analysis.

- EIBIP (CEF-PSA Action): https://eibip.eu/
  The European Inland Barging Innovation Platform with its innovation centres in Germany, France, Danube region and the existing Dutch Innovation Lab and the new Polish innovation centre, aims at the market uptake of innovations by the IWT sector. One of the direct results adopted from PROMINENT by EIBIP is the implementation of the I-STEER app in the set of tools. The roll-out activities as well as the analyses on the IWT fleet and the available technologies are used in EIBIP's dissemination activities and

tools. This includes the Innovation Radar with the best available technologies and concepts, a funding database for the financial support of the uptake of these technologies. Outcomes on financial support (e.g. a Greening Fund) will be disseminated in this project.

- COBALD Green Deal in The Netherlands: http://www.greendeals.nl/wp-content/uploads/2016/09/GD208-samenvatting-COBALD.pdf
  The Dutch COBALD Green Deal studies the option of on board measurement and monitoring of exhaust gas emission. It shall also lead to policy recommendations. The Green Deal includes contribution from many partners which are also partner in PROMINENT (TNO, EICB, SGS, STC-NESTRA). PROMINENT results on Certification, Monitoring and Enforcement will be taken into account. Finalisation of the Green Deal is expected in the course of 2018.

d. Dissemination of results and next steps

Within WP6 the Roll-Out Plan was developed for innovative greening technologies and concepts. It has been an iterative process with multiple feedback loops after consultation of PROMINENT partners and consultation of stakeholders. Notably the presentation at the Final Event was a milestone moment for the validation of the Roll Out plan by key stakeholders.

The final results are presented in this report. It contains the assessment, recommendations and the proposed roadmap addressing:

1) actions for implementing certification, monitoring and enforcement of low emission levels of vessels;
2) supporting actions for engine rooms improvements of vessels to drastically reduce emission levels;
3) actions to enable and facilitate more energy efficient navigation;
4) actions to support a more skilled workforce and quality jobs.

2. Certification, monitoring and enforcement

The practical Type Approval procedure for Retrofit Emission Control devices (REC) developed in PROMINENT can support the greening of the inland vessel fleet. It shall help to reduce air pollutant emission levels for the existing vessels and their engines. The approach to certify after-treatment systems (retrofit) therefore avoids high investment costs for removal of the old engine and installation of a new (NRMM Stage V) engine. This approach has an important added value since the lifetime of the engine is very long (e.g. compared to truck engines). Furthermore, the approach makes the sector less dependent from engine manufacturers which are reluctant to invest in R&D to provide Stage V OEM engines. A modular SCR-DPF system can be applied as retrofit on an engine family and can therefore reach Stage V equivalent emission levels.

In addition On Board Monitoring can fulfil an important role in securing and demonstration of the environmental performance of a ship.

a. Main results of deliverables and transferability of results

i. Retrofit Emission Control devices – certification procedure

The concept of a type approval for retrofit emission control devices (REC) was defined based on the UNECE type approval procedure for road vehicles and land based NRMM ECE R132. On a number of points this new type approval deviates from R132, particularly to make it suitable for inland vessels and to increase the value of such a type approval. Important in this respect is that the emission standards and general (quality) requirements are synchronized with 2016/1628 NRMM Stage V. Special requirements for non-regulated pollutants from R132 are not included in this new proposal, since they are also not a part of NRMM Stage V.

It is proposed to implement the 'Retrofit' type Approval procedure as CESNI ES-TRIN standard (for Inland Navigation vessels). E.g. as new Article 9.10 with title 'Technical procedure for type approval of Retrofit Emission Control devices (REC)'. Article 9.10 would then be a summary, and the actual full procedure would be an Annex.

REC type approval procedure is based on a laboratory test, but this can be a scaled engine test. E.g. the laboratory engine can be up to a factor of 4 smaller than the full size engine application, provided that the REC is modular and condition can be equivalent to those in normal application. A full size engine test must then be done on board of a vessel. The emissions durability test can be done on board of a vessel in normal operation. This will enormously reduce the costs compared to a laboratory durability tests. During testing in the lab and on board of the vessels additional tests will be done to secure 'In-Service Conformity' ISC, meaning that in normal operation (above approximately 20% load), the NOx emission always stays below a certain limit value. This is equivalent to the method as required for NRMM Stage V for inland navigation. Apart from these tests, also proper documentation is a part of the proposed type approval procedure.

ii. On-Board Monitoring

Concepts for continuous on-board monitoring (OBM) were developed in PROMINENT, distinguishing two options:

- Real Sailing Emissions: monitoring of engine pollutants in relation to engine type approval;
- Environmental Performance Monitoring: monitoring standards for ship pollutants and CO_2 emission expressed in grams per kilometer and grams per tonkilometer.

Also several operational parameters are standard included in OBM such as engine load pattern and geographical locations and speed. Waterway parameters such as depth and stream velocity can also be included.

Within PROMINENT on board monitoring is seen as a voluntary option to secure and monitor the environmental performance of engine and/or vessel, in addition to a type approved engine or a retrofit after-treatment system.

OBM has been demonstrated on 19 vessels in total from which 9 Rhine and 10 Danube vessels. About 7 of these vessels were equipped with actual NOx monitoring in the exhaust pipe. The monitoring of the 10 Danube vessels was focused on Danube depth and stream velocity monitoring in addition to continuous engine load and fuel consumption monitoring. The demonstration included automatic wireless data transmission and storage in a central and secured database. A number of tools was developed to access and process the data in standard graphs.

b. Where are we now?

i. Retrofit Emission Control devices – certification procedure

Conceptual type approval procedure for REC has been defined by key PROMINENT partners who are experienced in this field. This included Technical Services (conduction Type Approval testing and test procedure development), REC manufacturer and research institutes. The concept type approval procedure has been presented to and discussed with CESNI PT and EUROMOT on several occasions. It has also been presented to the German and Dutch ministries responsible for these legislative developments.

Detailed procedure still needs to be written. This would also require a special technical working group to make a number of specific choices and to review the detailed procedure.

ii. On-Board Monitoring

OBM including Real Sailing Emissions (RSE) and Environmental Performance Monitoring (EPM) was demonstrated on 19 vessels in total. Seven vessels were fitted with actual NOx monitoring in the exhaust pipe. Wireless data transmission and central data storage is in place and works trouble free. Standard reporting formats are developed.

Combined monitoring for vessel and cargo parameters is not yet seriously developed. This is important for the gram per ton.km cargo emissions. This still requires a substantial effort to combine these ship and logistic parameters in one monitoring system.

c. Main barriers for Roll Out

The main barrier for retrofit Emission Control devices is that there is no legal requirement for retrofitting emission control devices.
For On Board Monitoring, the barriers are that there is no legal requirement for continuous on-board monitoring and that there are significant installation and operating costs for OBM.

d. Roadmap for Roll Out

The overview of actions are barriers for Retrofit Emission Control devises – certification procedure for REC is:

Barrier 1. No legal requirement for retrofitting emission control devices (also refer to barrier 2 engine room, see next chapter).

- Action 1: Development of test procedure (approved on CCNR or EU level) for retrofit Stage V (equivalent to OEM Stage V); Obtain support from stakeholders such as shipping organisations ESO, EBU and award organisations like the Dutch Green award;
- Action 2: Implement Stage V emission requirements for existing vessels at some point in the future (2030). Combination with retrofit is important to give ship-owner more options.

For On Board Monitoring the following actions are linked to solving the barriers:

Barrier 2. No legal requirement for continuous on-board monitoring

- Action 3: Create support to accept OBM in combination with independent emissions test, as alternative to type approval for Stage V emission requirements. To implement this as standard in ES-TRIN if formally accepted by CCNR – CESNI PT;
- Action 4: Implement *OBM as formal additional requirement for Retrofit or OEM Stage V (2025-2030).* This should be implemented on EU level, an expansion to EU 2016/1628. This would be an enormous step, with probably several intermediate steps such as formal In-Service Monitoring (ISM) for inland shipping and formal In-Service Conformity (ISC) for inland shipping.

Barrier 3. Significant installation and operating costs for OBM

- Action 5: Develop database and emissions control centre for OBM, to be operated by a public body; for example by EMSA or national inspections (e.g. Dutch ILT);
- Action 6: To integrate OBM standard in REC control systems or in OEM engine management control systems; certification is required (e.g. parallel with type approval).

i. CME - Action 1: Development of test procedure for retrofit Stage V

This concerns the development of a procedure and approval on CCNR or EU level for equivalence procedures between OEM Stage V and retrofit Stage V. A first concept for this is developed in PROMINENT based on the UNECE R132 procedure. This is a procedure for REC for land based NRMM and for road vehicles.

The action addresses the legal barrier, barrier 1. No legal requirement for retrofitting emission control devices (also refer to barrier 2 engine room).
Currently there is no formal approval procedure for Retrofit Emission Control devices (REC). For ship-owners it is extremely important that engines equipped with REC are formally equivalent to OEM Stage V engines (complete engines with after-treatment type approved under EC/2016/1628). There is not yet a shared vision on this by the public bodies, the CCNR and the European Commission.

The action involves the flowing activities:

- To agree on an approach with the main stakeholders:
    - With public stakeholders such as CCNR, the European Countries, front running member states on this topic such as Germany and The Netherlands about the legal aspects, boundary conditions and precise applicability and the structure of implementation. An earlier discussed option is to implement the 'Retrofit' Type Approval procedure as CESNI ES-TRIN standard (for Inland Navigation vessels). E.g. as new Article 9.10 with title 'Technical procedure for type approval of Retrofit Emission Control devices (REC)'. Article 9.10 would then be a summary, and the actual full procedure would be an Annex;
    - With industrial stakeholders such as the REC manufacturers, AECC, engine manufacturers and EUROMOT on the precise technical approach based on the PROMINENT proposal. Also the classification societies should be involved at a certain point of time.
- To work out the detailed test and type approval procedure. The preliminary procedure based on R132 needs to be worked out in more detail and technical choices need to be made. Workshops with industrial and independent specialists are needed for this. Detailed procedure needs to be written by the independent specialists

The drafting of the new regulation can mainly be done by TNO and TÜV Nord. But also a number of meetings or workshops are required with the main stakeholders, being the REC manufacturers and the type approval authorities. Also EUROMOT and EICB can (partly) participate in these workshops. The number of workshops is uncertain, but it could be somewhere between five and ten. The workshops will be used to review, provide input and make decisions on text proposals provided by TÜV Nord and TNO. The final delivery is the regulation. The estimated total budget needed for TÜV Nord and TNO is estimated to be around 200,000 EUR. Also in-kind contributions are needed from the stakeholders for reviewing documents and participation in the workshops. TNO or TÜV Nord can lead this action, or one of the type approval authorities. The defined work is within the main focal points of TNO, TÜV Nord or a type approval authority, so the level of commitment is high. Also for the REC manufacturers it is of key importance that this regulation is developed, because it will open a new market. Also other technical service providers like SGS, engine labs, classification societies, branch organisations (e.g. the Dutch VIV and EICB) and CCNR/CESNI-PT should be updated during

the process or could participate in one or more of the workshops. The work can be carried out in 2018 and 2019.

The main relevant policy documents are: UNECE regulation R132, PROMINENT Deliverables D3.2/3.3 and D5.8, EC regulation 2016/1628 and the Swiss VERT regulation.
The risks and uncertainties are relatively low. A retrofit REC type approval was already introduced for land based NRMM and for road vehicles, UNECE R132, which will also form an important basis. This forms also a risk, since R132 included actually more requirements than normal type approval procedures, such as limit values for certain non-regulated pollutants. So it is important to not go beyond 2016/1628 in terms of strictness, apart from specific requirements meant to be able to use the REC for a wide range of engines. The principle of retrofit emission control devices have broad support in Europe and also in other parts of the world.
There may be (legal) objections of engine manufacturers because it might reduce their market for OEM Stage V engines.

The expected impact of the action is large, because retrofit (REC) is one of the main options to clean up the existing IWT fleet. Currently there are doubt if there will be sufficient OEM Stage V engine types available in 2019-2020, because of the high costs of type approval and the limited market size. Also a large number of ship-owners will not be able to afford a complete new set of engines for their vessels. An REC system would offer an alternative option to comply with Stage V emissions.

Making the existing fleet compliant with Stage V is necessary for environmental reasons due to the slow renewal rate of vessels. Apart from the large NOx and PM reduction (more than 75%), there is potentially a CO2 reduction of 0-5%, by more optimal settings of the base engine in combination with after-treatment. Cleaning up existing vessels is also important to not lose the (environmental) competition with road and rail transport.
The OBM option can be applied to almost all IWT vessels, provided some space can be found for the REC system. Systems have become more compact over the past decade (also by using HD engine components), so this is not expected to be a problem. The engines need to be in a good condition otherwise the life time of the REC might be compromised or not possible at all. In that case a new OEM Stage V engine, if available, is recommended. Or a new CCNR II engine can be installed with an REC system.

ii. CME - Action 2: Implement Stage V emission requirements for existing ships

This is included in the description of action 1 of the engine room actions (see ER – Action 1 Updated EU policy on greening the fleet).

iii. CME - Action 3: Create support to accept OBM, as alternative to type approval for Stage V

The action is to create support to accept continuous On Board Monitoring (OBM) with NOx and optionally also PM sensor as alternative to a type approval for Stage V. The alternative certification would include an independent emission test on board of the vessel (for each vessel) to verify the components which are not (fully) included in the OBM (PM, PN, HC, CO, NH_3, CH_4) and also to validate the proper working of the OBM system.

The second part of this action is to develop the precise OBM procedure and to implement this as standard in ES-TRIN.

This action addresses barrier 2; no legal requirement for continuous on-board monitoring

The action involves the following main activities:

- Creating support from authorities: CESNI-PT, EU member states, European Commission, Engine manufacturers (EUROMOT).

Ideally the European Commission, or the Rhine and Danube Commissions would formally accept OBM as alternative to type approval, but there might be legal barriers. There are three sub-option:

A. OBM is only used in combination with an engine with a NRMM IWT type approval, e.g. CCNR 1 or CCNR 2, or
B. OBM is used in combination with an engine with another type approval, e.g. land bases NRMM, IMO2 or IMO3, or a USA NRMM type approval, or
C. OBM is used in combination with an engine which is not type approved at all.

If OBM cannot be accepted on a European level, it could only be accepted by individual member states or even by only regions (ports, cities along the water ways). In that case for example port incentives meant for OEM Stage V can also be given to ships with OBM Stage V (usually equipped with retrofit stage V).

The action mainly involves in convincing the stakeholders that the OBM route would offer the same quality as the OEM Stage V or the Retrofit Stage V with type approval. This can be done by showing monitoring data of vessels and the overall system set-up, including formal procedures, precise parameter and dimensions, pass/fail criteria, etc.. This is the second main activity. An important basis for this is laid in PROMINENT (deliverables D3.2/3.3 and D5.8). In these reports the overall system setup is defined, but it includes also a number of format and reporting options. Final choices need to be made including aspects like pass/fail criteria. For this a detailed comparison is necessary with the requirements for OEM Stage V (EC regulation 2016/1628). The activities are similar to those for action 1. A number of workshops with specialists in the areas of type approval, engine & emission control are necessary to create broader support in Europe, or at least among several member states.

The action can be carried out by TNO and TÜV Nord. The estimated budget is 100,000 to 200,000 euro. Apart from that support is needed from a stakeholders group consisting of type approval authorities, REC system suppliers and possibly engine suppliers. TNO can lead this activity. TNO has a lot of experience with OBM and with real world emissions and considers this as one of its main working areas. The work can be carried out in 2018 and 2019 if there is sufficient support from the authorities.
The main relevant policy documents are: UNECE regulation R132, PROMINENT Deliverables D3.2/3.3 and D5.8, EC regulation 2016/1628.

The risks and uncertainties are relatively clear. OBM is currently rather broad accepted in the Netherlands, but outside the Netherlands the support is limited, or there are doubts. So it is the first priority to work on this. There may also be (legal) objections of engine manufacturers because it might reduce their market for OEM Stage V engines.

The expected impact of the action is large, because OBM is one of the main options to clean up the existing IWT fleet. Currently there are doubt if there will be sufficient OEM Stage V engine types available in 2019-2020, because of the high costs of type approval and the limited market size. Also a large number of ship-owners will not be able to afford a complete new set of engines for their vessels. OBM would offer an alternative option, with a retrofit emission control device (REC) to comply with Stage V emissions and proof that with OBM (plus on board test).

Making the existing fleet compliant with Stage V is necessary for environmental reasons due to the slow renewal rate of vessels. Apart from the large NOx and PM reduction (more than 75%), there is potentially a CO2 reduction of 0-5%, by more optimal settings of the base engine in combination with after-treatment. Cleaning up existing vessels is also important to not lose the (environmental) competition with road and rail transport. The OBM option can be applied to all IWT vessels, including all geographical areas in Europe. The environmental aspects might be higher on the priority list in North-West Europe than in Eastern-Europe, also due to the more dense IWT traffic on the main rivers and canals in NW Europe.

iv. CME - Action 4: Implement OBM as formal additional requirement for Retrofit and OEM Stage V

The action to implement OBM as formal additional requirement for Retrofit and OEM Stage V (for example by 2025-2030), goes beyond the current level of legislation for road vehicles and for non-road mobile machinery. It is however important due to the complexity of emission control systems and the widely varying load profiles of engines. This broad field of load profiles is hard to cover in a type approval procedure. Moreover in practise systems can fail or wear or there can be tampering. OBM could fill in this gap. At the same time it can proof the good performance of the vessel to the shippers (clients of ship-owners), which could also be valued in contracts, green awards, etc..

This should be implemented on a EU level, as an expansion to new REC regulation (action 1) and also to EU 2016/1628. This would be an enormous step, with probably several intermediate steps such as formal In-Service Monitoring (ISM) for inland shipping and formal In-Service Conformity (ISC). If NRMM/IWT would take the lead in OBM, it can show its environmental edge compared to road transport, which might help with keeping and expanding the IWT transport modality.

Monitoring and transmission of engine data to a database is already standardised and widely spread since a number of years. This is according to the ISO15143 standard. Adding standardised NOx and PM emission parameters is just a small expansion to this monitoring system.

This action addresses barrier 2. No legal requirement for continuous on-board monitoring.

The action requires a lot of lobbying with the European Commission and EU member states. The necessary effort would be very much dependent on the support from industrial stakeholders such as the ship-owners and also the engine and REC system manufacturers. It will need good technical and legal proposals, to be worked out in technical working groups and meetings with the representatives of the European Commission and member states responsible for this kind of policy development.

The leading organisation should probably be a ministry or type approval authority of one or two member states. Organisations like TNO and TÜV Nord can support these activities, by drafting

proposals and providing technical support. Required budget is currently hard to estimate, but could be in the order of 100,000 EUR. The level of commitment of the ministries is probably modest. Involved stakeholders include primarily engine and REC system manufacturers, type approval authorities and Technical Services companies (TUV, TNO, etc.).
Expected timeline: 2019 – 2025.

Relevant policy documents: EU 2016/1628, new REC type approval procedure, ISO15143 standard

The risks and uncertainties are relatively high. Currently there is no mandate/regulation to implement OBM on combustion engines in the future. It is earmarked however as important development for the future, and it is addressed in H2020 calls. There are hardly any technical risks. Basically the sensors are already widely used for emission control and OBD (on board diagnostics). The only extra step is to transmit this to a central database and to implement pass/fail criteria and algorithms. Also the formal and legal protection of ship-owners, and engine and REC system manufacturers should be precisely defined.

The expected impact is substantial. For road vehicles we have seen examples of failing legislation, e.g. with diesel cars (diesel gate) and also earlier with diesel trucks (Euro V). OBM is the main option to prevent this. It is also important for ship-owners to demonstrate their environmental performance in order to keep and expand the transport volume for the IWT modality.

European legislation would be applicable to all new Stage V engines in Europe.

v. CME - Action 5: Development emissions control centre for OBM operated by public body

This action includes the develop of a database and emissions control centre for OBM, to be operated by a public body; for example by EMSA or national inspections (e.g. Dutch ILT). Basically the possibilities and configurations of the data transmission and database have already been demonstrated in a number of projects such as PROMINENT, COVADEM, COBALT. Important is to develop and add criteria and algorithms for pass/fail and follow-up actions, such as clear messages to the ship-owner and/or engine or REC system manufacturer about the emissions performance. Privacy should be guaranteed, since there could be all kind of reasons for higher or lower emission levels.

This addresses barrier 3: Significant installation and operating costs for OBM.

This action includes the following activities:

- Standardisation of the monitoring data. This builds on the work on OBM options described in PROMINENT, COBALD and CLINSH documents and proposal. There is a significant difference between CCNR II and Stage V due to the more extensive procedure requirements with Stage V (such as emission control area not-to-exceed requirements). It should also build on experience with and procedures defined for In Use Conformity and PEMS testing for HD vehicles and land based NRMM. TNO can make proposals but an international technical working group is needed to review the proposals and to make a number of final choices

- Development of criteria and algorithms for interpretation of data and pass/fail messages:
  The monitoring data should be automatically reviewed by algorithms using sensible pass/fail or more general emission status messages. High emissions are not necessarily a failure, because it depends strongly on the load profile of the engine. Outside the defined emission control area of the engine map (corresponding to about loads higher than 20% (of max engine power)) emissions do not have to comply with stringent standards. This should be clearly taken into account in the criteria and possible messages. The principle of the criteria for the PEMS testing for HD vehicles and land based NRMM should serve as a baseline for this. In this whole process, the privacy of data should be guaranteed to the main stakeholder being the ship owners and the engine and REC system manufacturers. It is envisioned that only these stakeholders receive messages about the emissions status. Only when emissions remain high over a longer period, other stakeholders such as authorities are flagged on the emission status.

- Protection of data:
  As already mentioned the monitoring data should be protected for privacy reasons, and against possible abuse, theft, manipulation, etc.. The ship-owner should specifically indicate which type of data he wants to submit. It does not necessarily needs to include geographical data, for example. The user interface developed for COVADEM/COBALD or PROMINENT can serve as examples for this.

The required budget is difficult to estimate and it strongly dependent on the number of working group meetings that are necessary. It is important that a number of EU Member States are involved and support the principle and all technical choices. This automatically means that a lot of communications, meetings, review actions and adaptations are necessary. The leading organisation could be TNO among others. Stakeholders involved should be the type approval authorities, Technical Services (for type approval) and engine and REC system manufacturers. Also European bodies such as EMSA could be involved. The timeline of this action would ideally be 2018 and 2019, parallel to the other certification actions. The funding would ideally be European public funding or public funding from several Member States. Required budget could be in the range from 150,000 to 300,000 EUR, for the main parties drafting and working out the technical documents and organising the workshop. Additionally in kind contributions are needed from the mentioned stakeholders.

Relevant policy documents include: EU 2016/1628, PROMINENT deliverable D5.8, ISO standard 15143-3 and to be selected COBALD/COVADEM documents.

The risks and uncertainties are associated with the legal obstacles such as the implementation of monitoring system in addition to a type approval, and also related to privacy of data. These aspects are very much dependent on whether the monitoring is set-up on a voluntary basis or an obligatory basis. If implemented on a voluntary basis, there is a risk that only a small group of shi- owners will participate. This can on its turn be stimulated with possible incentive schemes which do require a (still voluntary) OBM participation.

Taking the lead with an ‘emission control centre’ by a public body is considered as very important, if not crucial, for making OBM a success (either on a voluntary or obligatory basis).

The expected impact of the action is large, because OBM is one of the main options to clean up the existing IWT fleet. Currently there are doubts if there will be sufficient OEM Stage V engine types

available in 2019-2020, because of the high costs of type approval and the limited market size. Also a large number of ship-owners will not be able to afford a complete new set of engines for their vessels. OBM would offer an alternative option, with a retrofit emission control device (REC) to comply with Stage V emissions and proof that with OBM (plus on board test).

Making the existing fleet compliant with Stage V is necessary for environmental reasons due to the slow renewal rate of vessels. Apart from the large NOx and PM reduction (more than 75%), there is potentially a CO2 reduction of 0-5%, by more optimal settings of the base engine in combination with after-treatment. OBM is important to avoid setbacks in low emissions such as have been seen with road vehicles (e.g. diesel cars and trucks). Cleaning up existing vessels is also important to not lose the (environmental) competition with road and rail transport. The OBM option can be applied to all IWT vessels, including all geographical areas in Europe. The environmental aspects might be higher on the priority list in North-West Europe than in Eastern-Europe, also due to the more dense IWT traffic on the main rivers and canals in NW Europe.

vi. CME - Action 6: To integrate OBM in REC control systems or in OEM engine management

The OBM system can be a standalone system or it can be integrated in the emission control system for the REC or OEM Stage V engine. The latter would save costs, since the necessary sensors for NOx and PM monitoring are standard included in the emission control system. Naturally proper working of the OBM system should be independently verified. This could for example be combined with the type approval tests.

This addresses barrier 3: Significant installation and operating costs for OBM

This action includes the following activities:

- Working out the detailed description of the OBM, and how this should be combined with the control systems.
  This partly overlaps with the earlier actions under certification. Data formats, frequencies, transmission periods, etc. should be precisely defined;
- Technical working group workshops.
  The precise formats and methodology, data protection, etc.. should be agreed upon with the engine and REC system manufacturers. A number of meetings will be needed for this.

A lot of the detailed work will already be done under the previous action, particularly actions 3 and 5. So the budget for this action could be limited. An indication is 50,000 to 100,000 EUR.
The leading organisation should preferably be one of the type approval authorities or possibly the European Commission services. TNO or another technical services organisation can prepare the necessary input to the meetings and workshop, and also draft the final documents.

The preferred timeline is parallel to the other certification actions, namely 2019 and 2019.
The relevant policy documents are the documents prepared for the actions 3 and 5.

The expected impact of the action is substantial, since a cost reduction of OBM will make it much more acceptable, and worth the trouble, for particularly the ship-owners.

As aforementioned, cleaning up existing vessels is of key importance for the environmental competition with road vehicles and rail. OBM will avoid long term setbacks in emission performance such as were seen with diesel cars and trucks in the past. The OBM option can be applied to all IWT vessels, including all geographical areas in Europe.

3. Engine Room

The main challenge for the roll-out of greening technologies as regards the engine room is the development of the business case for the ship-owner/operator. It was concluded from the pilots that from a technical viewpoint there is no limitation as regards air pollutant emission reduction. A stick and carrot approach is recommended to overcome the barriers linked to long term targets for the sector towards zero-emission.

A legal action is recommended to enable certification of existing engines and to introduce a deadline for reaching Stage V emission levels for existing vessels and their engines. The development of a greening fund based on a differentiated surcharge on top of the CDNI for environmental protection is another recommended legal action. A dedicated greening fund shall eliminate the barrier to invest in after-treatment systems (SCR-DPF) or LNG conversion (CAPEX) to address air pollution emissions while it gives an incentive as well to CO2 reduction and low/zero carbon drivetrains. Revenues from the surcharge shall be earmarked to feed this fund, blended with grants (subsidies) from governments (EU, MS, regions). Such a surcharge can be differentiated to the emission class of the engines and the vessel and carbon intensity of the fuel or energy source. This differentiation shall provide a competitive advantage on operational costs (OPEX) for green vessels through a reduction of the surcharge to be paid. In this way, a sustainable instrument is provided to address the policy objective to internalise external costs and to implement the 'polluter pays principle'. It can be combined as well with funding instruments provided by EIB/EFSI, e.g. in order to overcome any barriers to get attractive loans for application of (Bio)LNG drivetrains in inland navigation.

It will be an instrument to support reaching zero-emissions on longer term. It shall therefore address both the air pollution emission (NOx, PM) but also climate change emissions (CO2). Seen the external cost structure of emission to air, the short term focus shall be to reduce NOx and PM, while on medium/long term the focus shall be on CO2, as soon as alternative energies such as bio-fuels, battery electric sailing and hydrogen fuel cell are further developed.

Moreover, it will lead to increase awareness among forwarders and shippers about the actual costs of greening inland waterway transport. It shall introduce the currently missing market mechanism to promote green vessels from a business economic viewpoint. The sector will be supported in this greening challenge by means of expertise centres (EIBIP) which help to make the choices between (alternative) fuels and technologies. The IWT Greening Tool developed within PROMINENT will be one of the instruments and shall be updated with new technologies such as fuel cells and full electric drivetrains.

a. Main results of deliverables and transferability of results

The topic Engine Room does in particular concern the PROMINENT technologies SCR-DPF and the LNG as fuel for vessels which were validated in practice by means of pilots carried out in PROMINENT. Furthermore, right sizing and hybrid systems were assessed based on model calculations.
The pilots with SCR-DPF (Multronic) and LNG (Wartsila) made clear that there is now proven and mature technology available for the market to reach Stage V levels also for retrofit applications in existing vessels.

i. Aftertreatment systems SCR-DPF

The SCR-DPF technology was successfully developed, demonstrated and validated in practice and even seems to reach NOx emission levels which are close to EURO VI, and therefore is far lower than the Stage V emission level. Due to the modular design, the systems are quite well transferable to other vessels if the engine is a medium or high speed type. The certification is however an issue and also the legal arrangements, as was described in the previous chapter. Last but not least, the business case for the ship-owner/operator proves to be negative from the PROMINENT research which is identified as the major barrier for market take-up of this greening technology.

ii. Application of Liquid Natural Gas (LNG)

As regards the LNG development and the pilot, it was demonstrated that, with the support from PROMINENT, the dual fuel LNG engines are able to reach the Stage V emission levels without after-treatment systems. The pilot demonstrator showed that NOx, PM and also the methane slip emission limits can also be respected with the latest adaptations on the Wartsila dual fuel engines. Avoiding the need for after-treatment systems such as SCR and DPF saves considerable investments and operational costs (urea consumption, maintenance costs) and therefore improves the business economic feasibility to apply LNG as fuel to reach low (Stage V) emission limits.

However, the CBA showed a severe dependency of the economic feasibility in relation to the fuel prices for gasoil and LNG. The uncertainty of the price developments and the rather low (untaxed) gasoil prices seen over the past couple of years make it that ship-owner/operators as well as banks are reluctant to invest in LNG drive trains. The first NRMM Stage V approved LNG engines are expected to be available for the market by 2019.

iii. Alternative fuels and energy sources

In the Deliverable 1.2 of WP1 (State-of-Play) of PROMINENT in the year 2015 a longlist was prepared of possible technologies and fuels which would be suitable to target the 70% of the market to reach low emission levels. Eventually this boiled down to the application of SCR-DPF and LNG engine room technologies which were further elaborated, developed and validated with pilots within PROMINENT as well as model calculations for feasibility of right sizing and hybrid technologies.

However, now in 2018, more and more technical options and alternative fuels are currently being discussed (e.g. biofuels, full-electric/battery, fuel-cell hydrogen, methanol, ethanol), given also the need to reduce the CO2 footprint in view of the COP21 agreement made in Paris to limit global warming.

However, it is unclear if and when such technologies/fuels will be mature and economically feasible. There is no policy either which provides clear targets and directions for IWT on EU level. Therefore, due to the wide range of different technologies many ship-owners don't know what the right choice is for them, seen also the long lifetime of engines and equipment. Moreover, a phenomenon is that ship-owners install a conventional CCNR2 engine before the year 2019/2020 in order to avoid higher costs for Stage V engines.

iv. Right sizing

As regards the application of right sizing (right dimensioning), long term engine monitoring shows applicability to most dominating ship classes. Numerous benefits for ship-owners and society are expected such as reductions of investment costs, maintenance costs and fuel consumption and related emissions. Moreover, a right sized engine increases the effectiveness of SCR systems and improves regeneration of DPF systems. A scalable cost-benefit model to quantify costs reduction by right sizing was made publicly available, together with typical savings on investment and operational costs.
Typical right sizing values for the different ship classes are found in table 2. Note that the right size power fully conserves current operational employability. When right sizing for a dedicated area such as ARA, further power reduction is possible.

Ship class	Currently installed [kW]	Right size power[kW]	Estimated Fuel savings	20 Year NPV [kEUR]
M4 bulk	550	550	N/A	N/A
M8 container	1500	1000	6%	425
M8 bulk/liquid cargo	1200-1600	1250	N/A	N/A
M9 container	2060-2300	1350	6%	530
M9 bulk/liquid cargo	2200	1250	6%	770
Danube pusher	1900	1500	5%	570
Danube pusher	2500	1500	2.5%	500
Rhine bulk pusher	4110	2700	6	950

Table 2: Observed right sizing potential in the representative PROMINENT vessel pool. Note that savings strongly depend on the operational profile and the amount of power that can be reduced. Ship classes that are not oversized are indicated with N/A .Overview of the two main monitoring options: Real Sailing Emissions (RSE) and Environmental Performance Monitoring (EPM).

Several explanations were found for the current oversizing of engines, mainly from the view of the ship-owner:

- confidence in their flexibility to move to other goods or routes in case the current contract ends;
- confidence that the vessel will be able to sail with harsh water level conditions;
- making sure to be compliant with minimum speed and stopping distance requirements;
- unawareness of the costs related to installation of an oversized engine;
- the difficulty of estimating the needed propulsion power for a newly designed hull;
- value of the ship on the re-sale market.

v. Electrification, hybrid drivetrains

For the IWT fleet there is a small but growing group of electrical hybrid and diesel electric vessels appearing. Electrification of vessels gives many additional options to the dimensioning and operational use of the combustion engines. Often the vessel can sail on one or two relatively small engines which provide the power for all energy systems, including household energy and bow thrusters. From the market study it is seen that de designs op the vessels appearing in the fleet are still changing, indicating that industry is searching for optimal configurations.

As there is no reliable public data available on the fuel performance of IWT hybrid vessels, a scalable cost-benefit model was published, allowing public insight in the investments that are associated with hybridization. The cost-benefit model was applied to the most promising configurations appearing in the fleet. The results showed that additional power losses in the drivetrain cause hybrid vessels to use at least as much fuel than their conventional versions, if electricity is produced using generators.

One of the major reasons to invest in (new) hybrid vessels is to be prepared for the future and expected return on investment via fuel savings. Long term expectations are that full electric vessels or fuel cell powered drivetrains may become economically available. In case of hybrid systems, the generators running on diesel are expected to be replaced at some point in future by batteries or a fuel cell. However, such development and the timeline is difficult to assess, since prices of batteries and fuel cells are yet unknown as well as the price for the electric power or (green) hydrogen fuel. Moreover, such zero-emission energy concepts need to compete with relative cheap gasoil, which will be quite challenging without strong policy interventions to provide a strong supporting framework with financial incentives and legal requirements as regards air pollutant and climate change emissions. It can therefore be concluded that a transition using clean combustion engines with bio-fuels (e.g. biodiesel/HVO with SCR-DPF or application of bio-LNG) will be the preferred route to follow for the short term for many ship-owner/operators. A mix of different transition paths is likely to be distinguished for the future.

b. Where are we now?

Only for new engines there is the more stringent Stage V regulation coming into force by 2019/2020 which addresses the air pollutant emissions. However, only a relatively small number of new engines is sold each year to the IWT sector and the lifetime of existing engines is rather long. The willingness from the engine manufactures to provide a wide range of certified Stage V engines for IWT is due to limited number of sales very low and R&D costs to develop Stage V OEM engines are relatively high.

This calls for an approach to facilitate after-treatment systems for existing engines and application of competitive alternative fuels such as LNG. It shall be noted that this is a 'no regret' measure seen towards the further future. Through application of biofuels, such investments are future proof as well as they can develop towards zero-emission by means of blending or 100% of bio-fuels (e.g. BioLNG). The barrier is however that the business case is negative or weak for emission reduction technologies and fuels. As a result, most of the ship-owners will delay the replacement of engines in order to avoid higher investment and operational costs. The business as usual situation is that a polluting vessel will remain cheaper to operate compared to a clean vessel.

There is a growing awareness about the air pollution by inland waterway transport as well at local governments (e.g. cities along the Rhine river) which negatively influences the public support for inland waterway transport. More are more cities are installing measurement equipment along waterways to measure the levels of concentration of PM and NOx in relation to traffic on the waterways.
Without any intervention, the reduction of PM and NOx reduction by the total inland fleet will decrease very slowly resulting in an increasing gap with road haulage. It shall be noted that this situation will get worse over the next years since trucks have more strict emission standards (Euro VI) and the replacement rate is much higher (each 6 years a new state-of-the-art truck).

The issue of oversized engines is acknowledged by some ship-owners and some engine suppliers. However oversized engines are still appearing on the market. A mathematical cost benefit model has been published.
Hybrid vessels are appearing on the market, but their claimed increased fuel efficiency has not been independently verified. In PROMINENT a mathematical model is published that calculates the most important costs. The model takes the most important factors into account, but being a model, not all effects are taken into account perfectly.

The lack of independent measurements gives room for speculation about potential savings, and fierce discussions between stakeholders while lacking facts as a basis. Ship-owners who invested in hybridization have a strong interest in claiming to be environmentally friendly, while others who do not experience fuel benefits stay silent. For the discussion about hybridizations their experiences are vital in the search for more better hybrid vessels.

The real world emissions or real sailing emissions will be dependent on right engine sizing (minimize installed power) and the avoidance of engines running idle or at low stand by power. Hybrid propulsion systems without or with batteries can be a method to realise true low real sailing emissions. Also more conventional direct propulsion systems can be optimised for low real sailing emissions.

Despite the disappointing results from the cost benefit study for vessels appearing on the market now, electric propulsion is a promising technology contributing to zero-emission sailing. More effective, and more costly technologies such as batteries and fuel cells are suggested. Their capability to bring green energy on board is expected to overcome the disadvantages of diesel electric vessels. However, the investment in these technologies is out of reach for conventional ship-owners and it is unknown if and when fuels/technologies such as hydrogen fuel cells and battery power will be offered to the market at competing prices. The competition with untaxed diesel fuel is difficult for alternative fuels and drivetrains. Only for LNG there is currently a business case, depending on the ship size and level of fuel consumption.

It can be concluded that from a technological viewpoint the options to reduce the air pollutant emissions to Stage V equivalent levels is now well developed and validated by PROMINENT. The TRL level can be rated to level 8 or 9. The key issue is the business case and the framework conditions that do not provide a 'stick and carrot' approach for greening the fleet.

c. Main barriers for Roll-Out

Innovation uptake needs a positive business case for the decision maker. In other words, there needs to be a positive impact for the company active in IWT in order to invest in an innovation in the engine room. It can be concluded from the analyses in PROMINENT that for the Greening the Fleet innovations there is often no business case for the ship-owner/operator. The biggest challenge for Greening the Fleet is the development of a business case for the ship-owner/operator. This is needed to invest in greening technologies and alternative fuels. One of the drivers is the legal framework which is not giving the right incentives. There is no internalisation of external costs of air pollution and greenhouse gas emissions in IWT with the consequence that the 'polluter pays' principle is not valid for IWT. Green vessels are in general more expensive to operate compared to vessels with conventional diesel engines. In comparison with road haulage for example the fuel in IWT is cheap as there is no excise duty applicable. Lack of instruments and incentives make it more difficult for the IWT sector to apply alternative (clean) fuels such as GTL, (Bio)LNG or HVO or after-treatment systems such as SCR and DPF. Application of hydrogen or battery power is even more out of reach for the average ship-owner/operator. Especially for existing vessels and their engines the situation is difficult with the current framework conditions. The engines have a lifetime of around 20 years and retrofitting is expensive. In general there is no significant incentive to reduce air pollutant emissions such as NOx and PM. The only exemption is the application of LNG, which has a lower price compared to diesel and therefore can provide a win-win situation for large energy consumers in IWT.

Despite plans and options made in NAIADES II communication to set standards for existing engines and to develop a financing scheme (using the Reserve Fund, CEF), it can be concluded that there is no stick and neither a carrot in relation to greening the fleet. This situation clearly gives an opportunity. There is momentum and growing sense-of-urgency and support to develop and implement new policies and regulations to close this gap. Greening of the existing fleet shall be addressed by means of intervention measures with respect to air pollutant emissions (NOx and PM). Moreover, the low carbon footprint of IWT compared to road haulage is an opportunity to further exploit and to attract more cargo flows and clients to usage of the inland waterway network.

Furthermore, despite the low CO2 emission per container or tonkilometre also IWT needs to reduce the fossil fuel consumption. But there is not yet a clear EU policy or objective the reduction of the carbon footprint of IWT in light of the COP 21 agreement made in Paris to limit global warming. While the long term challenge is clear (zero-emission), there is a need for policy targets for IWT concerning CO2 and air pollutant emissions and related policy interventions for the sector.

There is a need for ship-owner/operators to have a clear target as regards emission levels. This will help them to make decisions on the fuel and technology to be applied on their existing or new vessel. It will also help the technology provides to make investments in R&D and deployment for innovative and green drivetrains and fuels for the IWT sector. The current lack of inceptives and targets cause a situation where the sector is waiting. The resulting behaviour is postponing of investments and/or choosing for the conventional diesel-engines (CCR stage 2) without after-treatment. Such engines are cheaper than the Stage V engines which will be required from 2019/2020 onwards. Also the wide range of alternative fuels and technical options which are being discussed makes it not easier for the ship-owner to make a choice as well as for policy makers who need to decide on co-funding of fuel infrastructure for example (e.g. Clean Power directive).

Considering right sizing of engines, the engine size is one of the many choices that have to be made in the design process. Additional operational expenses associated with a larger (more expensive) engine are not easily considered in the design process. In the design process, ship buyers do not have independent sources to which they can benchmark the vessel they are about to build. Although this project has published power requirements for 19 vessels, this is not yet enough to cover all different hull shapes, cargo types and sailing routes. Such a database could be filled with anonymous data from engine suppliers, from which many do keep archives. Information about stopping tests and minimum power requirements is available at certification societies and institutes that perform stopping tests on model scale.

There are several factors that the slow down the roll-out of emissions savings using hybrid vessels:

- Higher fuel consumption and CO2 emissions due to loss of efficiency in the conversion from mechanical to electric power;
- Unavailability of independent studies on the fuel efficiency of such vessels;
- Hybrid vessels are still a niche, there a not many suppliers;
- Costs of electric components are very high;
- Diesel electric vessels are seen as a transition towards zero-emission, but technologies to bring green energy on board are not yet market ready nor affordable. Apart from using biodiesel blends (which can be used for conventional or hybrid drivelines), there are no pilot vessels with full battery electric or H2 electric drivelines.

Another barrier is the lack of understanding and awareness within the sector about the feasibility and maturity of the options. Moreover, some promising technologies which can be classified as ‘zero-emission’ such as full-electric and in particular hydrogen. However, despite small initiatives, these are not yet mature for a broad market uptake. These need further development before commercial exploitation is feasible. In addition, for biofuels, there are concerns about the price, availability and the suitability to apply these in existing engines. HVO and BioLNG seem to be the most appropriate solutions for the next decade(s), while there are also rumours concerning (bio)methanol to be a possible fuel which may contribute to the zero-emission development of IWT.

This illustrates also the need for neutral platforms to act as a platform for knowledge exchange and dissemination of information about greening innovations (such as EIBIP ICs, EICB, etc.) to provide clear and up-to-date information to the IWT sector.

In addition to the barriers regarding the legal framework (missing legislation for existing engines/vessels to comply with low air pollutant emission levels), the following barriers are additionally identified as regards the engine room:

- Barrier 1: Lack of a medium and long term EU policy towards zero-emission inland waterway transport;
- Barrier 2: No business case for greening the fleet on business economic level for the ship-owner/operator as well as difficult access to finance (loans);
- Barrier 3: No mature zero-emission technology available and commercially viable for 70% of the market. Unclear how the market position can be of these zero-emission technologies and what will be the time-frame for the market implementation;
- Barrier 4: Missing capacity at the large number of (small) companies to investigate the possible technologies/fuels for their specific business situation (vessel characteristics and sailing profile).

d. Roadmap for Roll Out

Actions for the Engine Room category of innovations aim in particular on:

- Barrier 1: Lack of a medium and long term EU policy towards zero-emission inland waterway transport
- Action 1: Development of an updated EU policy with realistic targets on reduction on greenhouse gas emissions and air pollutants for IWT specifically (CO2, NOx and PM);

- Barrier 2: No business case for greening the fleet on business economic level for the ship-owner/operator as well as difficult access to finance (loans);
- Action 2: Development of a European wide financial support scheme and an internal funding regime linked to (fossil) fuel consumption to provide the business case and funding for supporting 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.

- Barrier 3: No mature zero-emission technology available and commercially viable for 70% of the market. Unclear how the market position can be of these zero-emission technologies and what will be the time-frame for the market implementation;
- Action 3: Initiating Research and Development projects dedicated to IWT for promising technologies to be applied in IWT in period 2020 onwards such as hydrogen/fuel cells, biofuels and full electric, e.g. new R&D projects funded by the European Commission (FP9); This includes research on energy requirements on board of vessels (including auxiliary systems) and perform in-depth measurement campaigns on hybrid vessels. Determine and explain the results found in fuel use for sailing electrically and conventionally;

- Barrier 4: Missing capacity and low awareness at the large number of (small) companies to investigate the possible technologies/fuels and right sized power for their specific business situation (vessel characteristics and sailing profile);
- Action 4: Supporting platforms such as EIBIP and development of tools and dissemination work to bring more awareness and sharing information on the various technical options and alternative fuels. Develop tools and awareness for installation and operation of engines in a vessel. Engine fit to vessel and engine operation have big influence on engine efficiency and pollutant emission level as well as on reliable operation. Increase awareness among ship-owners about the benefits that can be gained from right sizing by publications and presentations.

i. ER - Action 1: Updated EU policy on greening the fleet

The first action is the development of an updated EU policy on greening the fleet with realistic targets on reduction of greenhouse gas emissions and air pollutants for IWT specifically (CO2, NOx and PM). Specific policy targets for IWT shall be formulated to contribute to the Paris goals (COP21) to limit global warming, indicating pathways with timelines towards zero-emission. This shall take into account the different fuel and power options in relation to the fleet families and operational profiles. For example, on short distances and shuttle container services, the electrified vessels using batteries charged with green electricity can be a viable option (e.g. Port-liner concept), while for long distances the BioLNG is probably a logical technology to reach zero-emission transport.

Moreover, a further reduction of NOx is possible compared to Stage V, for example by means of via lower limit values in combination with improvements in type approval procedure and reduced Not-to-Exceed levels.

The barrier addressed by this action is that there is a lack of a medium and long term EU policy towards zero-emission inland waterway transport. The Staff Working Document from the EU on Greening the fleet from 2013 (SWD/2013/0324 final) resulted in the Stage V regulation for new engines only. However, the ambition to address also existing engines (the so called “Innovative Option” in the SWD) was not implemented. Moreover, the staff working document does only address air pollutant emissions and does not target the climate change emissions. However, since the Paris Agreement (Cop 21) there is an obvious need to also provide a policy on how to reduce the greenhouse gas emissions emitted by inland waterway transport on a well-to-propeller basis.

The lifetime of vessels and engines is long. For that reason, investments are done based on current information. The ship-owner/operator wants to have certainty that the right choice is made for the vessel and the drive train on the longer term. This requires a vessel which is ready for the medium and long term. This supports the residual value of the vessel. Yet, it is unclear what the requirements will be with respect to energy use and emissions and there are no further requirements for existing engines. As a result of higher costs (CAPEX and OPEX) for a Stage V engines it is expected that many existing engines will remain operational (overhauling to extent lifetime) and existing vessels will hardly reduce their emission levels.

The European Commission DG MOVE is therefore recommended to develop an updated policy document, addressing the challenge to keep pace with air pollutant emissions levels compared to road haulage and to address the need to reduce greenhouse gas emissions. This policy shall involve

announcement of a package of measures, such as legislative actions such as possible revision of Stage V (including also existing engines), infrastructure development (e.g. alternative fuel supply), R&D actions, funding and financing contributions from the side of the EU and budgets to support awareness and promotion of green transport.

The launching of a study (CEF-PSA) is probably needed to support the EC DG MOVE in the preparation of this document, e.g. 500 K Euro for external support (consultants) and of course the resources at the EC DG MOVE to guide this process (e.g. 2 FTE policy officers). Obviously Member States as well as industry associations such as EBU, ESO, EFIP, EUROMOT. The Common Expert Group from 2011-2012 which was consulted for the SWD Greening the fleet development may be revitalised.

The policy shall lead to a strong and accelerated reduction of air pollution and also climate change caused by inland waterway transport. The avoided external costs sum up to around 900 million euro per year as soon as Stage V is implemented in parallel with energy saving measures (ENAT, right sizing). This means a reduction of 85-90% of the external costs for emissions to air (NOx, PM, CO2). In case of achieving complete zero-emission, the reduction of external costs is 1.1 billion euro.

Furthermore, the development of these innovations and the deployment will bring jobs and turnover in Europe. Moreover, it will strengthen the position of Europe's transport system and answers the need for low carbon and green transport. Because of the strong international market on IWT it is a must to address to topic from the European viewpoint. This ensures the level playing field. In particular also incorporating the existing fleet in the policy will support a level playing field and will remove the barrier to invest in new technologies.

ii. ER - Action 2: European wide financial support scheme and funding regime

This action proposed by PROMINENT concerns the development of a European wide financial support scheme and an internal funding regime linked to (fossil) fuel consumption to provide the business case and funding for supporting 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.

This action addresses the barrier that there is hardly any business case for greening the fleet on business economic level for the ship-owner/operator as well as difficult access to finance (loans). As indicated, only for LNG there is a business case, depending on the price difference between LNG and diesel and the willingness of banks to provide loans to cover the investment.

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 be provided by means of resources from the Reserve Fund as well as introducing differentiated environmental surcharge on fuel used in IWT. 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.

This dedicated greening fund shall eliminate the barrier to invest in after-treatment systems (SCR-DPF) or LNG conversion (CAPEX) to address air pollution emissions. At the same time it gives an incentive as well to CO2 reduction and low/zero carbon drivetrains. Revenues from the surcharge

shall be earmarked to feed this fund, blended with grants from governments. The ratio to be applied between public and private contributions will be a political choice.

The idea is to piggy pack on the already existing international CDNI agreement for IWT to generate revenues for a system of waste collection from IWT (7.50 euro to be paid on each 1000 litres of fuel). There is already a system in place with payment cards, administration, governance etc.
The idea is to introduce in addition a surcharge which will be differentiated to the emission class of the engines and carbon intensity of the fuel or energy source. The surcharge can have an air pollution component (NOx, PM) and a greenhouse gas component (CO2). Taking into account the external cost structure of emission to air, the short term focus shall be to reduce NOx and PM, while on medium/long term the focus shall be on CO2, as soon as alternative energies such as bio-fuels, battery electric sailing and hydrogen fuel cell are further developed. This differentiation shall provide a competitive advantage on operational costs (OPEX) for green vessels through a reduction of the surcharge to be paid.

In this way, a sustainable instrument is provided to address the policy objective to internalise external costs and to implement the 'polluter pays principle' and to reach zero-emission on longer term. Moreover, it will lead to increase awareness among forwarders and shippers about the actual costs of greening inland waterway transport. It shall introduce the currently missing market mechanism to promote green vessels from a business economic viewpoint.

At first stage the development of the fund will require resources at Member States, River Commissions and European Commission to develop the legal base, the structure and governance. The process probably needs to be supported by independent experts and consultants. Questions to be further addressed will be:

- What shall be the scope of the fund:
    - all inland vessels in Europe, or the focus on the vessels with a certain ship size/length or a minimum fuel consumption (more cost-effective)? This will be a political choice between aspects of weighing level playing field and cost-effectiveness of grants and All
    - all waterways in Europe (including isolated waterways in Italy, UK, Sweden, Finland,..) or a selection, e.g. CDNI area, connected waterways Rhine-Danube?;
- What will be the share between public and private contributions?;
- What shall be the timeline and duration of the fund:
    - When to start, when to end?
    - What will be the duration for providing grants from the fund to support investments?
    - What will be the duration for the surcharge to generate revenues for the sector contribution to reach Stage V? A longer duration (e.g. 15 or 20 years instead of 10years) will allow a lower surcharge to be applied;
- What will be the level of the surcharge and the policy for the surcharge in relation to differentiation and timewise development of the surcharge?

It was concluded from the work carried out in SWP 6.2 (See Deliverables 6.3 and 6.5) that a fund with a size of 1050 million euro is needed to provide grants to the ship-owners for investing in Stage V solution in case all passenger vessels and cargo vessels would be part of this scheme. Assuming a

50:50 split between public and private funding and a duration of 10 years, the average surcharge rate for the IWT fuel would be 40 euro for 1000 liters (4 eurocents per liter).

It is recommended to set-up a joint working group, consisting of:

- Sector representatives EBU and ESO;
- EC DG MOVE;
- Member State representatives.

The group shall be supported by experts and consultants to develop and assess various options and scenarios (Impact Assessment study). Relevant legal documents to take into account are the CDNI agreement and the Act of Mannheim.

Seen the share of vessels and fuel consumption, the key actor is the Dutch sector and government as promotor of this action. Because of the strong international market in IWT it is a must to address to topic from the European viewpoint. This ensures the level playing field. In particular also incorporating the existing fleet in the policy will support a level playing field and will remove the barrier to invest in new technologies.

iii. ER - Action 3: New R&D projects for zero-emission IWT

This action calls for initiating Research and Development projects dedicated to IWT for promising technologies to be applied in IWT in period 2020 onwards. It shall be noted that PROMINENT aimed specifically on technologies for the short term, aiming on reaching low emission levels (Stage V equivalent) ready for implementation by 2020. Technologies with low maturity were therefore excluded. Moreover, PROMINENT focussed on technologies suitable to be used by a large share of the market (in terms of fuel consumption/emissions and tonkilometres) and therefore specific solutions for small market niches were excluded as well by PROMINENT (e.g. CNG, electric canal boats and ferries).

Since there are no European projecst addressing the further time-horizon and neither smaller applications, there is a need for R&D on future technologies. Taking into account the Paris agreement (COP 21) to limit global warming, there is a need for strong carbon dioxide reduction emissions by 2030. The Dutch government recently set a target of 60% reduction of GHG emissions to be reached by 2030 and zero-emission to be reached by IWT in 2050. Three major transition paths are distinguished:

- Biofuels or renewable fuels (e.g. power to gas) applied on combustion engines (with after-treatment to reach negligible air pollutant levels);
- Hydrogen fuel cells applied on electrified vessels;
- Battery power applied on electrified vessels.

However, there is no mature zero-emission fuel or technology available and commercially viable for the overall market:

- Biofuels such as Biodiesel/HVO and BioLNG are not yet widely available in the volumes needed and they are also more expensive than fossil fuels;
- There are concepts for full electric sailing (e.g. Port-liner) which are 20% co-funded by CEF, but they have limited operating ranges and rely on infrastructure to recharge batteries. Moreover, the price of (green) electricity is yet higher than the price for diesel, if the net

value of diesel is expressed in the price per kWh. As a result, there is only a business case for full electric sailing in case there is a subsidy and if it concerns small distances, fixes routes. Besides willingness is needed from the shippers/forwarders to provide long term contracts. Moreover, a network of recharging batteries would be needed and/or a concept to exchange container batteries;

- As regards hydrogen fuel cell technology: the costs and prices of hydrogen which is green (e.g. from solar or wind energy) is quite high and therefore seems quite far from being competitive with biofuels, electric energy. Moreover, the storage of hydrogen on board is a challenge due to the high pressure needed (350/700 bar). Furthermore, there is no fuelling infrastructure.

Interesting is however the option to have a separate business case for the power (e.g. a container with batteries or fuel cell) which can also be applied for other purposes (e.g. power generator at events, construction sites and batteries to be used as storage and peak shaver in the electricity network). As a result such units might not require investments from ship-owner/operators, but only the power could be purchased in terms of the kWh used.

The growing challenge and urgency to reach zero emission, the various pathways which are being discussed, Research and Development projects shall be initiated dedicated to IWT for promising technologies to be applied in IWT in period 2020 onwards. This concerns technologies such as hydrogen/fuel cells, biofuels and full electric. It is recommended to EC DG Research, DG MOVE and INEA to programme new large scale innovation and R&D projects funded by the European Commission (H2020/FP9 and CEF). This shall also include research on energy requirements on board of vessels (including auxiliary systems) and perform in depth measurement campaigns on hybrid/electrified vessels to determine and explain the results found in fuel use for sailing electrically and conventionally.

As indicated the total potential to reduce external costs of emissions is at this moment 1.1 billion euro. This is based on a shadow price of CO2 of 33 euro per ton, which is expected to increase to much higher levels, since the urgency to reduce CO2 emissions will increase in order to stay within the Paris agreements of COP 21.

iv. ER - Action 4: supporting platforms for expertise and dissemination

The action 4 proposed by PROMINENT addresses the need for supporting platforms such as EIBIP and the development of tools and dissemination work to increase awareness and share information on the various technical options and alternative fuels. Awareness will also be created on adopting engines fit to the vessel and engine operations, which has a large influence on engine efficiency and pollutant emission levels as well as on reliable operation. This will be done by increasing awareness among ship-owners about the benefits that can be gained from right sizing by publications and presentations.

The supporting platforms can address the various issues/barriers for the implementation and market uptake of innovations by the companies in the sector. It can solve the lack of capacity and low awareness among a large share of the small and medium-sized companies. This can be done by providing them tools to investigate the possible technologies/fuels and right sized power for their specific business situation (vessel characteristics and sailing profile). At the other side, there are

also some larger operators working in the international environment, which may be well aware of the technical and financial possibilities on the market. However, the support to these operators can be focussed on adequate funding and financial schemes for the uptake of innovations.

All these together can enable the further improvement and innovation in the IWT sector, which definitely requires consultations between the stakeholders on various levels. Supporting platforms might contribute on different levels:

- Know-how transfer of best practices by the use of studies, dissemination tools and the interaction between the stakeholders;
- The introduction, blending and dissemination of funding and financing solutions;
- The cooperation with financing institutes in customising their proven methodologies to new fields and regions;
- Raising awareness and cooperation in general together with other modes of transport.

The existing supporting platforms need to be continued and tools shall be maintained, updated and expanded. Awareness shall be improved about the technological possibilities and the total cost of ownership of greening technologies as well as right sizing of the engines.

The required budget is estimated at 1 million euro per year, to be funded by CEF-PSA. It is suggested that the EIBIP partners will continue and expand their work based on this funding.

4. Energy efficient navigation

Energy-efficient navigation reduces the fuel consumption of a vessel and therefore contributes to lower greenhouse gas emissions (CO2) and at the same time air pollutant emissions. It addresses mainly the behaviour of the skippers to set the speed of sailing. Raising awareness and providing advice on the relation between speed and fuel consumption was addressed by PROMINENT, by means of education and training to crew and students (e-learning) and full bridge simulators and operational tools for planning the speed on the specific sections of the route (ENAT).

Notably the ENAT tool and the simulations applied for full bridge simulations and model simulations (e.g. by DST) require a complex and comprehensive approach for reduction of the energy demand of a vessel based on knowledge of interactions between vessel and engine characteristics (e.g. vessel size, hydrodynamic characteristics, etc.), fairway parameters (e.g. frequently changing waterway depths, current), vessel speed and the resulting fuel consumption.

The core approach of ENAT is to reduce energy consumption by adaption of the speed (power) profile to the waterway profile, considering the following measures:

- speed (power) adaption in dependence of water depth, fairway width and current;
- choice of the optimum sailing track;
- provision of the needed information to the boatmaster in an efficient and user-friendly way in adequate time intervals, avoiding overloading due to excess of information.

Respective developments relating to this topic were carried out in the course of the H2020 EU project PROMINENT. More in detail, the following issues were considered:

- evaluation of the fuel saving potential of a vessel by simulations;
- development of dedicated tools for energy-efficient sailing and evaluation of ship performance;
- collection of waterway data (water depth and flow velocity) by commercial vessels as possible input to energy-efficient sailing, as well as for improved utilisation of the waterway.

As a conclusion it can be stated that energy savings of 10% are feasible for the overall fleet. Therefore, an annual saving of 65 million euro of fuel costs can be realised for the EU IWT sector as well as 110 million euro each year of external costs for NOx, PM and CO2 emissions.

It therefore provides a business case, not only for the inland navigation industry and shippers, but also for society to save energy where possible and feasible. The requested budgets and resources for supporting and funding roll-out actions required for energy saving, are characterised by high return on investments. Moreover, they contribute directly to the Paris agreement (COP 21) to limit global warming.

a. Main results of deliverables and transferability of results

i. Findings from the simulations

For the Rhine, DST's simulation environment was adapted and used to quantify the influence of different sailing policies on fuel consumption. The vessels considered were the passenger vessel FGS Symphony and the motor cargo vessel Monika Deymann. Five different sailing policies were investigated comprising:

- sailing with constant speed through water;
- sailing with constant speed over ground;
- sailing with constant delivered power;
- sailing with constant rate of revolutions (rpm);
- sailing with minimised average Froude number based on the water depth (Fnh).

The simulations revealed that sailing with constant rpm or delivered power results in the most significant fuel savings, depending on the sailing duration permitted. For the Monika Deymann, the simulations revealed also that sailing 10 % longer than the minimum possible time results in a reduction of fuel consumption by 30 %.

Further, an assessment of the fuel-consumption-reduction potential was carried out for a Danube vessel sailing between Regensburg and Budapest on the Upper Danube, using the modelling approach of Via Donau. The operational cases comprised:

- operation of a Johann Welker vessel (extended) as pushed convoy consisting of the motor cargo vessel under consideration and a lighter;
- operation of the motor cargo vessel as single vessel.

In all cases considered, the reduction of the brake power and the speed over ground lead to a significant reduction in fuel consumption, ranging from 8.7 % up to 25.5 %.

The motor cargo vessel in single operation showed an excellent relationship between increase in sailing time and reduction of fuel consumption. Roughly, one may say that 1 % increase in sailing time leads to a reduction in fuel consumption by 4 %. The relationship becomes little less favourable for sailing at the highest navigable water level (HNWL).

For the pushed convoy comprising the motor cargo vessel and the lighter, the reductions in fuel consumption could be achieved only by rather high increases in sailing time, becoming highest for sailing at HNWL. 1 % increase in sailing time lead to approximately 1.5 % reduction in fuel consumption at the low navigable water level (LNWL) and an artificial mean water level (MWL).

Simulation is no measure to increase the energy-efficiency of inland waterway transport by itself. However, it can serve raising the awareness of fuel-saving potentials associated with different sailing strategies. If this awareness is used in daily practice, the result can be achievement of reduced fuel consumption.

In general, the procedures of setting up and performing the simulations as done are applicable to other vessel types and waterways too, provided the power-speed relations at different water depths and navigation conditions (flow velocities and water depths) are known and no canal effects are expected.

ii. Tool for energy-efficient navigation (ENAT)

A user friendly web interface was developed and tested in order to help boatmasters on board or trip planners estimate fuel use and NOX emissions for an upcoming trip, including alternative arrival times for corresponding fuel savings. Boatmasters can be provided with track advice in real time. The basis for ENAT is a simulation model that combines the technical specifications of the vessel with the water conditions along the track, and optimises the operation of the vessel along the track based on fuel consumption.

A tool for the evaluation of the ship performance has also been developed with interrelation to the on-board tool. This tool can be used in combination with the on-board monitoring (OBM) system for fuel consumption, as well as CO2 and NOX emissions.

Application of ENAT model shows that optimization of lock scheduling and ship waiting times can reduce fuel consumption by 13%. This result was obtained by comparing actual and optimal voyage planning on the lock abundant Rotterdam-Maastricht route, using maps provided by Rijkswaterstaat. Fuel use was minimized when all waiting time is eliminated, leading to lower sailing speed. This exercise has shown both the applicability of ENAT as an impact assessment tool, as well as the importance of voyage planning and the role of infrastructure in the emissions reduction.

At this stage, the tool may be applied for sailing only on the German Rhine. However, it can be extended to other waterways e.g.in the Netherlands or the Danube, provided the navigation conditions demanded are available. Further, the amount of vessel types which may be considered can be increased by provision of dedicated model test results for the power-speed relations or alternatively the usage or further development of generic evaluation methods for obtaining the afore mentioned relationships. Up to now only three vessels are considered.

iii. Shipborne measurements on Rhine and Danube

For provision of navigation conditions, the first time, a highly accurate single beam echo-sounder technology was applied in commercial vessels navigating on the Rhine, using the technology and following the principles of professional surveying.

The echo sounding results derived deliver reliable data of the river bed topography. After only one year of operation of one vessel an average coverage of the fairway with echo sounding data in the German part of the river Rhine of 70 % was achieved. It was validated in PROMINENT that the methodology developed in PROMINENT and applied in the pilot provides highly accurate and up-to-date data on bed elevation in the fairway. Taking into account corrections for pitch and roll, the overall averaged difference between the on-board measurements and multi-beam soundings of the year 2014 amounts to 2 cm. If several vessels are equipped with appropriate measurement techniques, navigational relevant data can be collected in short time periods and over large areas of the fairway.

Both acoustic Doppler current profilers (ADCP, 1D: one-dimensional and 2D: two-dimensional) provide flow velocities within the vessel's path. Using 2D-ADCPs for this task improves the data accuracy especially in bends. The quality of the flow velocity results is affected by the immersion

depth of the device, the distance between the ADCP and the bottom, the velocity against water and the beam spreading. At mean water level, a rather good agreement of the on-board measurements with the ones derived from a 2D-HN-model is obtained. The results obtained at the equivalent water level (GlW) show greater deviations from the modelled ones, due to unreliable results for the magnitude of the flow velocities because of small under keel clearances together with a small immersion depth of the ADCP. Plausibility checks and post-processing of ADCP data are more complex and time-consuming than the ones of the echo sounding data.

The costs associated with the implementation of the developed system and further developments to be carried out are too high in order to be covered by the ship-owner solely, therefore, demanding dedicated financing solutions.

Since January 2016, on-board monitoring has been taking place for a group of ten vessels of the Romanian shipping company NAVROM sailing mainly on the Middle and Lower Danube. The measurements performed aimed at analysing the engine performance of the vessels and navigation conditions such as waterway depth and flow velocities. The measurements collected were stored in a database with over 100,000 hours of data utilised in this pilot for estimation of the waterway depths at the city of Corabia in Romania, which is considered a bottleneck due to the shallowness of the Danube there.

In general, the on-board measurements give plausible results. The agreement with the surveying results (single beam) is good at several points, although at some points maximum deviations of up to 1 m occur. The deviations may be explained by lack of consideration of sinkage and trim of the vessels, different densities of measurement points across the fairway as well as different time periods between the on-board measurements and the surveying results.

The costs to be covered by the ship-owner (based on pilot costs for Romanian Shipping company NAVROM) amount to 30,000 euro per vessel for installation and around 400 euro per month for maintenance, handling of mobile equipment and transmission of the data. Before the pilot took place there was a large uncertainty on the price levels of this equipment.

The usefulness of the data and the quality of the depth estimates indicate that the method developed may be suitable to be used in other bottlenecks of the Danube as well. In a further step, it may be thought of extending the procedure for the creation of a waterway map with depth contours, demanding, however, a significant amount of efforts and resources. A meaningful processing of the flow-velocity measurements could not be performed.

For the Rhine and Danube cases, a specific quantification of the impact on fuel consumption is not possible at this stage. The systems developed provide an improved knowledge of the fairway conditions as well as at which locations significant changes of the river-bottom topography occur, demanding maintenance works. Thereby, the system contributes to an improved waterway infrastructure and usage of it by vessels, resulting in more reliable services, better choice of the route and loading of the vessel and reduced fuel consumption related to tonne kilometre.

In addition, the systems can be used for the provision of input to tools like the ENAT, giving advice on efficient ways of sailing the vessel, affecting this way the reduction of fuel consumption. However, for this purpose more accurate information on the flow velocities or usage of flow

velocities averaged over dedicated stretches seems to be necessary e.g. in order to allow for a rather accurate estimation of the time of arrival. ENAT showed that significant energy savings are possible.

b. Where are we now?

i. Findings from the simulations

Energy-efficient navigation can be investigated by dedicated case studies using simulations or simulations. In PROMINENT, simulations were used for this purpose, and, in addition, an e-learning tool was developed providing basic knowledge with respect to this matter, Hoyer et al. (2017).

There are no legal constraints. However, the intellectual property right and right to use the simulation environment of DST used in PROMINENT is at DST.

It contains the performance characteristics of a large variety of different vessel types derived from model tests, which were partly validated under trial conditions. It can be applied to any waterway, provided the respective navigation conditions are made available as input to the simulations. The system is rated as full commercial application with TRL 9.

ii. Tool for energy-efficient navigation (ENAT)

The on-board tool for energy-efficient navigation aims at providing the boatmaster with proper operational advice for reduction of fuel consumption. The land-based tool allows for evaluation of ship performance depending on the operation of the vessel and the vessel type. To a great extent it is identical to the on-board tool.

The intellectual property right is at TNO. At this stage, the application of the tool is limited to the German Rhine. However, it is planned to include also the Dutch waterways.

The tool runs using the consolidated database, and considers the three vessels tested in the towing tank of DST. Validation of the energy model using the on-board measurements showed an underestimation of the required power to obtain the necessary speed. The gap was explained by the lack of detail in local conditions in flow velocity and bottom topography, which were not represented by the river simulations. Because these effects are very local, no straight-forward correction method could be derived as a solution. For the special case of the lock planning, additional river data for the Dutch Waal was retrieved, and ENAT showed useful to quantify the benefits of efficient navigation.

A real-life prototype is operational in a relevant environment (German Rhine). However, it lacks a real-time validation through a real-life demonstration in a relevant environment. The tool needs still additional research and development. As a result the TRL is rated as 5.

iii. Shipborne measurements – Rhine

The conduction of on-board measurements of river-bottom heights or water depths and flow velocities improves the knowledge of navigation conditions, serving efficient and safer navigation, as well as a better maintenance of the fairway. For this purpose, a system following the principles of professional surveying to be applied on commercial vessels was successfully developed.

From a legal perspective, issues relating to data protection are relevant as positioning data of dedicated vessels are collected and stored, as well as liability matters relating to the correctness and usage of the information provided have to be considered.

The system demands a positioning system providing accurate values also for the vertical position of the GPS-transceiver, in addition to the ones for the lateral and longitudinal position. The positioning services used were limited for use only in Germany (SAPOS HEPS) or Germany, Austria and the Czech Republic (AgCelNet). For coverage of a greater area, the availability of similar high-accuracy position services will be necessary. Similar vessels to the ones used in the pilot tests can be equipped with the system developed. However, the costs for the ship-owner will be most likely too high in order to be covered by him. The centre where all the data are collected and processed is at BAW in Germany. For a further market development of this system, the consideration of more vessels for collection of navigation conditions in a short time, as well as the limitation of the location of the server to Germany for collection and processing of the data can be considered as short-time perspective.

Between the measurements of river cross-sections performed on board and the ones conducted using the multibeam technology, a time difference of a few years was present, meaning that the multibeam measurements do not necessarily fully represent the river profile at the time of the on-board measurements. However, the longitudinal profile of the river bed was measured in 2016 using the on-board system, and it was compared with multibeam measurements of the same year, giving a very good agreement and a convincing validation.

The system itself demands further developments relating to automatic plausibility check and processing of the collected data, as well as provision of it in a suitable manner to the boatmaster or shipping company. A demonstration of the prototype was successfully carried out under real-life conditions. Some additional research and development is still needed. Therefore, the TRL is rated as 7.

iv. Shipborne measurements – Danube

Pursuing the same objective as described for the shipborne measurements carried out on the Rhine, an alternative approach was implemented and tested on a test stretch close to the Romanian city Corabia at the Danube. It gave less accurate results with respect to the water depth, and none which could be processed for the flow velocities. However, the system developed for the Danube is rather simple and does not need such expensive and high-accurate positioning systems like the ones used for the pilots on the Rhine. Instead, the water depths estimated are referred to the respective gauge readings. The approach can be applied basically everywhere where gauges are available, and the changes of water levels in the fairway and gauge readings accept similar values.

From a legal perspective, the same applies as for the shipborne measurements performed on the Rhine.

Due to its simplicity, the system can be rolled out relatively easily for the entire Danube. If only the longitudinal fairway profile is of main interest, e.g. in order to detect locations where maintenance is necessary, and the NAVROM vessels equipped with the measurement devices stay in operation performing regularly measurements of the water depth, a roll-out can be realised within a rather short time, provided the respective financial and personnel resources are available in order to cope with the consideration of a relatively great number of gauges. However, legal issues relating to sharing the data publicly will have to be clarified with the shipping company. In addition, it will become necessary to equip some additional vessels with respective measurement devices in order to increase the geographical coverage as the NAVROM vessels are currently sailing mostly on the Middle and Lower Danube and very seldom on the Upper Danube.

The intellectual property right is at TNO. Only this organisation can interfere with the software and algorithms developed. Therefore, for a further roll-out of the system TNO has to be involved.
A prototype was successfully realised under real-life conditions, and it is being used by the sipping company NAVROM. Nevertheless, the system can be still improved, demanding some additional research and development, e.g. with respect to presentation of the results, automatic detection of the distance between the echosounder and the water level, inclusion of further gauges, treatment of stretches between gauges, inclusion of information on flow velocities and validation of the measurements amongst others. Therefore, the TRL is rated as 7.

c. Main barriers for Roll Out

i. Simulations

The conduction of successful simulations relies on knowledge of the ship performance under certain navigation conditions, as well as the availability of these conditions as input. The simulation environment of DST can deal with a great number of different vessel types, as well as the navigation conditions for the German Rhine are known.

In addition to improving the knowledge on ship performance of the implemented vessel types, the remaining technical barrier for a wider roll-out of using this environment, e.g. to the Danube region, is the lack of consideration of Danube specific vessels, in particular larger convoys comprising up to nine lighters in different formations. Further, the lack of up-to-date information on navigation conditions in the required format constitutes an additional technical barrier. Finally, the lack of publicly available validation of the results decreases the confidence in these.

Relating to the market, only minor barriers can be detected with respect to willingness to pay for simulations. Some ship-owners, mostly the ones interested in innovations, are using the simulations offered for evaluation of their potential undertakings. Also, on political level, simulations are used for evaluation of certain measures, e.g. their impact on the environment, etc.

The listed technical developments demand financial investments, constituting also a barrier for roll-out of the simulation environment used in PROMINENT.

ii. Tool for energy-efficient navigation (ENAT)

ENAT as a advice tool provides the boatmaster or the trip planner with information on ship operation for reduced fuel consumption. The hardware and software is in place. However, still a greater amount of research and development work is needed.

The main technical barriers relate to the very limited amount of vessels which can be considered, the availability of proper navigation conditions, up to now only the German Rhine was considered, as well as a proper validation of the tool and advice provided.

Setting up the tool requires several actions before an advice can be given. The first is the technical specification of the vessel, which contains the interaction of the vessel with the environment via the speed-resistance curves for different depths. These curves need to be determined individually for each distinct ship type, for example by tank test for different depths. However, tank tests are expensive and rarely performed for inland navigation vessels. Therefore, the consideration of alternative ways of estimating the requested resistance curves (or even power curves) should be taken also into account.
The complexity of ENAT is increased by the demand to deliverer an accurate rpm advice to the boatmaster. To translate ship speed to rpm, technical specifications for the propellers, gearboxes and engine need to be determined, and calculations with those components have to be done. In case of a hybrid vessel, additional parameters for the electrical driveline are needed as well, including electromotor and generator sets. If it is the first time that a vessel (type) is used in ENAT, a comparison needs to be made of the predicted ship performance and propeller speed with observations of on-board measurements or the boatmaster's experience. This can be used as a validation of the implementation.

Relating to the usage of waterway data, improved input relating to at least the water depth and flow velocities seems to be necessary. The usage of one-dimensional (1D) data is simple, but it introduces local errors in the ship performance evaluations, demanding further examinations of the causes. Currently, two-dimensional fairway data including currents and water depths are simply not available, limiting the exploitation of ENATs potential. If the sailing area of the ship is not yet available in ENAT, detailed parameters for this data need to be retrieved. Accordingly, waypoints and routing need to be added to the user interface. Currently, ENAT is specialised in the German Rhine, while it is desirable to add other waterways like the Dutch and Belgian ones, as well as the Danube. If water levels are not constant, such as in rivers, real time coupling to the navigation conditions may be made using gauges or otherwise. This is of course unnecessary if they are constant such as in lakes or canals.

In addition it is important to facilitate in ENAT the inclusion of waiting times at locks and waiting times at terminals or the slot times. By means of more specific information on lock passage and the process of loading/unloading at terminals it may be possible to use the 'slack' to optimise the fuel economy. Slower sailing shall be applied were possible to reduce fuel consumption. Too early arrivals causing waiting at locks or terminals shall be avoided.

iii. Shipborne measurements – Rhine

The system developed provides the waterway authority or manager with information on river-bed elevation as well as flow velocities derived from measurements performed on board commercial vessels.

The main technical barrier comprises the availability of high-accuracy positioning systems like the ones used in PROMINENT. The applicability of the shipborne measurements performed was limited to Germany or Germany, Austria and the Czech Republic, depending on the positioning system used. For conduction and processing of similar measurements in other areas than the test stretch in Germany, the availability of respective high-accuracy positioning systems is a precondition. The knowledge on river bottom heights is only of little use to the boatmaster or the ship-owner if no information on the associated water depths is given. Therefore, a relationship between river-bottom heights and water depths must be available. Further technical barriers relate to automatic plausibility checks and processing of the collected data, as well as provision of it in a suitable manner to the boatmaster or shipping company, allowing the proper use of it, as well as raising the awareness and knowledge of the relevant benefits. In particular, when a greater number of vessels will be involved in the measurement programme, the automated handling of big data volumes becomes important. At low water levels, unreliable results were derived for flow velocity, demanding further actions in order to improve the quality of the information provided.

Limited legal barriers relate to data protection and liability with respect to the usage of the information provided, e.g. who is going to be held liable if an accident occurs as a result of using the data.

Currently, the geographical scope is limited to the German Rhine. An extension of the system to other waterways demands the willingness and ability of the organisation running the data acquisition centre to deal with the data collected from other waterways. In order to obtain a full picture of the river-bed elevations in a much shorter time than the one of the pilots, more vessels have to be included, demanding further cooperation activities with ship-owners, as well as their consent to share the data collected.

The high costs relating to the acquisition, installation and operation of the measurement system is a major barrier, demanding dedicated financial solutions.

iv. Shipborne measurements – Danube

The system developed provides the waterway authority or manager, as well as the ship-owner with an approximate overview of the longitudinal water-depth profile of the Danube at the Romanian city Corabia.

Initial technical barriers relating to the application of echosounders and flow-velocity measurement devices in pushed convoys could be overcome partly. A meaningful measurement and processing of the water depth was achieved. Deriving meaningful information on flow velocities poses still a technical barrier. However, depending on the purpose of applying the system developed, the collection of information on flow velocities could be neglected, e.g. if bottlenecks with respect to low water depths are to be detected.

The measurement device has to be handled manually, and it is exposed to external impacts, e.g. ice. Through handling of the mobile measurement equipment, errors in estimating the distance from the echosounder to the free surface around the vessel in rest might occur, resulting in false information on the water depths measured. External impacts may destroy the devices and limit their timewise operation as they have to be taken out of the water.

Currently, only a limited area in the vicinity of one gauge (Corabia) can be considered. For a meaningful roll-out, a great number of gauges has to be considered, leading to a big amount of data to be processed, which becomes even bigger when more vessels are to be included in the measurement programme. Further, it is not yet known how well the developed procedure applies to the river stretches between the gauges. If the respective procedure turns out to be not sufficient, then the availability of dedicated water-level models or alternative approaches relating the water level changes in the waterway to the ones at a reference point, e.g. a gauge, will become necessary.

Up to now, only a plausibility check of the results was carried out. For more information on the accuracy of the measurements, a proper validation is still necessary, which in turn will increase the confidence of e.g. ship-owners in using the system developed.

Limited legal barriers relate to data protection and liability with respect to the usage of the information provided, see also the sub-section on shipborne measurements on the Rhine. An organisational barrier results from the circumstance that the data acquisition centre where all the incoming data is analysed and processed is at TNO in the Netherlands. Legally and organisationally, it will be necessary to find solutions which guarantee the future operation of the system, as well as the involvement of ship-owners in the measurement programme.

The further development and roll-out of the system to the entire Danube, as well as the acquisition of and operation of the equipment is associated with significant costs which will be reduced once the system is fully operational and if the currently used expensive echosounders can be replaced by ordinary and cheaper ones commonly used on board of vessels.

d. Roadmap for Roll-Out

i. EEN - Action 1: Development of simulation environment

Addressing the barriers relating to the roll-out of simulations, the following actions are proposed, pursuing the objectives listed below:

- investigation of transport solutions and operational strategies;
- evaluation of the impact of new technical solutions.

The hardware and software for conduction of successful simulations are already in place, constituting a good basis for further developments.

Being able to deal already with a great amount of vessel types, the simulation environment of DST shall be extended for consideration of Danube specific vessels, e.g. large pushed convoys in different formations, as well as different technological modifications of the vessel types implemented in order to account for particular vessel specific characteristics.

As input to the simulations, up-to-date information on navigation conditions shall be compiled in the required format for the Rhine, Main, Main-Danube canal and the Danube, displaying water depths and flow velocities at different water levels, e.g. low navigable water level, mean water level and highest navigable water level. The navigation conditions compiled shall be made available also to the public in order to allow other organisations to perform respective investigations where such data is needed. Special care is to be taken regarding the correct interpretation of the data, as well as liability issues.

With respect to correct evaluation of ship performance, the tool shall be validated against full-scale measurements performed on board of vessels corresponding to the implemented ones. The results of the validations, as well as successful applications showing the benefits of simulations shall be made public, and comprehensive promotion activities shall be carried out in order to convince potential users of the quality and benefits of using the tool.

The required budget covering technical development, implementation and validation of the system, as well as project management, dissemination and interaction with stakeholders amounts to 2 million EUR.

The activity shall be led by the technology developer or an organisation with very good relationships to the technology developer, as well as waterway authorities or managers and shipping companies operating in the Rhine-Danube corridor.

Organisations to be involved comprise DST as developer and current operator of the system, as well as relevant waterway managers of the Rhine-Danube corridor, being able to collect and provide the waterway data requested. In addition, several ship-owners are to be included for validation purposes.

The action shall be started from 2019+. The duration shall be 2 years.

The action shall be embedded in and funded by the H2020 programme of the EU or other relevant programmes. Due to the relatively small budget, it can also be considered a subproject within a comprehensive project of e.g. 10 million EUR funding.

The success of the action is depending on the involvement of ship-owners and waterway managers, as well as the availability of suitable waterway data. In order to achieve a widespread use of the tool, convincing results relating to the validation of the tool and benefits achieved are a precondition.

The action contributes to reduced energy consumption and emissions, as well as external costs. Further, it serves the introduction of new technologies and transport solutions.

The societies and economies of all countries with the waterways of the simulations will benefit from the action. In first instance, these will be the ones in the Rhine-Danube corridor. In the transportation sector, the ship-owners will profit from reduced fuel consumption or new transport solutions improving the competitiveness. Basically, the majority of all common ship types can be investigated.

ii. EEN - Action 2 Further development of the tool for energy-efficient navigation (ENAT)

Addressing the barriers relating to the roll-out of the tool for energy-efficient navigation (ENAT), the following actions are proposed, pursuing the objectives listed below:

- provision of operational advice for reduced fuel consumption and emissions of inland waterway vessels to the boatmaster or ship-owner;
- Inclusion of information on waiting times (or slot times) at locks and terminals;
- provision of waterway conditions, linked to and legally embedded in Good Navigation Status and River Information Services;
- evaluation of ship performance, e.g. for improved waterborne transport operations on inland waterways, with respect to environmental performance, cost-efficiency and service quality.

Boatmasters have extensive experience on the routes they sail, therefore ENAT has to obtain a high level of quality to add value on top of this experience. Skippers consulted in this project stressed that this information is needed to optimize navigation and loading of the vessel, but that they cannot find it on the market. To obtain this minimum level of accuracy, accurate depth and current data needs to become available in 2D, in centimetre resolution. To enable planners and boatmasters to plan their journey from start to end, important shipping routes must be made available and be kept up to date. While waterway authorities often possess detailed bottom topography maps, other parties can enrich this data with the local currents and water depths. Preparing this data and bringing it on board, requires cooperation of both waterway authorities with commercial parties specialized in navigation.

The hardware and software are already in place, forming the basis for further developments.

The amount of vessels to be considered shall be increased such that the most common ship types operating in the Rhine-Danube corridor are represented. Respective approaches and methods giving proper information on the ship performance, e.g. power versus speed or fuel consumption versus speed, shall be developed and implemented. Costs and time may be saved by utilizing existing and developing tools for water depth, if they are sufficiently reliable and accurate.

In addition to validation of the part solutions, e.g. power-speed relations or optimization algorithms, the technical developments shall be validated. This is preferably done by dedicated real-life tests under controlled conditions, where the results of the operational advices are compared with real-life values. Important parameters for comparison are fuel consumption, savings in fuel consumption, vessel speed, estimated time of arrival.

For a practical roll out, boatmasters and ship-owners have to be convinced of the reliability and benefits of the tool ENAT. Therefore, comprehensive promotion activities shall be carried out, involving a great number of boatmasters,ship-owners and other relevant stakeholders by on-board demonstrations.

Once the tool has reached a TRL such that it can be put in commercial operation, organisational, legal and financial actions are to be elaborated and initiated in order to guarantee a continuous availability of the services the tool is going to provide.

The required budget covering technical development, implementation and operation of the system, as well as project management, dissemination and interaction with stakeholders amounts to 5 million EUR.
The activity shall be led by an organisation with very good relationships to the technology developers, as well as waterway authorities or managers and shipping companies operating in the Rhine-Danube corridor, including the Dutch and Belgian waterways.
Organisations to be involved comprise TNO as developer and current operator of the system, as well as companies with experience in the creation of power-speed relationships for inland waterway vessels (e.g. DST, MARIN). A greater number of test vessels provided by respective shipping companies shall be included, in addition to organisations being able to provide waterway data for the waterways in the Rhine-Danube corridor, as well as the Dutch and Belgian waterways.

The action shall be undertaken as soon as possible, starting 2019. The duration shall be three years.

The results will have an impact on the following policy documents: the ES-TRIN standard, referred to by the Directive (EU) 2016/1629, as well as the RIS Directive (Directive (EU) 2005/44) and also the Good Navigation Status concept as described in a recent study by DG MOVE in view of the legal requirements in the TEN-T Guidelines Regulation 1315/2013 EC.

The action shall be embedded in and funded by the H2020 programme for further R&D works of the EU (e.g. integration of lock and port waiting times) and/or in the innovation deployment program of the Connecting Europe Facility for further application along TEN-T waterways.

The success of the action is depending on the involvement of ship-owners and waterway managers, the availability of suitable waterway data, as well as possibilities for further use of the PROMINENT system developed by TNO. In order to achieve a widespread use of the tool, convincing results relating to the validation of the tool are a precondition.

The action contributes to reduced energy consumption and emissions, as well as external costs. In PROMINENT, it was shown that for a typical Rhine vessel, a time increase by 1 % derived by sailing slower can result in a reduction of fuel consumption by 3 %. For a Danube vessel in single operation, a time increase by 1 % may result even in 4 % reduction of fuel consumption, demonstrating very well the importance of smart steaming as part of voyage planning and the accurate estimation of the arrival time based on detailed knowledge of vessel and waterway condition, avoiding sailing too fast.

The societies and economies of all countries where the tool will be applied will benefit from the action. In first instance, these will be the ones in the Rhine-Danube corridor. In the transportation sector, the ship-owners will immediately profit from the reduced fuel consumption. Basically, all ship types will be affected. However, either the ones with a high fuel consumption, e.g. pushed convoys, or the ones with very steep power-speed characteristics and high operational power, e.g. single vessels sailing rather fast, will show the greatest benefits.

iii. EEN - Action 3: Complete the system for shipborne measurements on the Rhine and Danube

Addressing the barriers relating to the shipborne measurements on the Rhine and Danube, the following actions are proposed, pursuing the objectives listed below:

- provision of a longitudinal river-bed profile of the entire Rhine and Danube including information on water depths;
- automated detection of locations where the river profile shows changes;
- creation of river-bed-elevation information across the waterway where vessels have been sailing (two-dimensional waterway map with depth information, e.g. depth contours) including information on water depths;
- provision of information on flow velocities for different water levels.

Rhine specification:

The system in use in PROMINENT shall be further developed such that also information on water depths associated with river-bed elevation and water levels is given, demanding the application of suitable relationships. Automated procedures for dealing with a big amount of data and plausibility checks of the results shall be established. Means for provision and visualisation of the information compiled in a suitable manner, e.g. ECDIS applications, to the boatmaster or shipping company shall be developed. The respective information shall be made available in real-time, or if this is not possible, it shall be updated within rather short time intervals e.g. every hour, four times a day, etc. The waterway information shall be made available to the public as one-dimensional and two-dimensional data. This shall be addressed as well in view of requirements to reach Good Navigation Status by 2030 on the TEN-T waterways.

The PROMINENT cargo vessels active on the Rhine will stay in operation for further acquisition of data. The project can be started with these. For obtaining a full picture of the river-bed elevations in a much shorter time than the one of the pilots in PROMINENT, being important for capturing short-time river-bed changes, more vessels have to be included. Therefore, further cooperation activities with ship-owners shall be established, as well as an agreement with respect to sharing the data collected shall be found.

Danube specification:

The system developed shall be extended to the entire Danube by consideration of all gauges providing water-level information which may be automatically processed. The respective information shall be made available in real-time, or if this is not possible, it shall be updated within rather short time intervals e.g. every hour, four times a day, etc. This shall be addressed as well in view of requirements to reach Good Navigation Status by 2030 on the TEN-T waterways.

Building upon the algorithms of the existing system, the data collected shall be processed and visualised automatically. Further developments with respect to dealing with a big amount of data, meaningful processing and presentation of the data, as well as validation of the results the system is going to deliver are to be carried out. If the current procedure turns out to be not sufficient for dealing with locations farther away from the reference gauges, then the usage of dedicated water-level models or alternative approaches relating the water level changes in the waterway to the ones at a reference point, e.g. a gauge, will become necessary.

At this stage, the measurement device has to be handled manually, and it is exposed to external impacts, e.g. ice. Through handling of the mobile measurement equipment, errors in estimating the distance from the echosounder to the free surface around the vessel in rest might occur, resulting in false information on the water depths measured. External impacts may destroy the devices and limit their timewise operation as they have to be taken out of the water. The possibility of human errors with respect to the determination of the distance between the echosounder and the free surface of the vessel in rest shall be minimised e.g. through automated provision of this information by depth gauges, and solutions shall be found in order to minimise the danger of external impacts.

Currently, rather expensive devices for measurement of the distance between the location of the respective device and the river bottom, as well as the flow velocity are used. For fulfilment of the objectives listed above, the information on flow velocities can be neglected, and the usage of cheaper devices to be used for provision of water depth information only might be sufficient, e.g. the echosounders already installed on board the vessels sailing on the Danube or additional ones to be installed at favourable locations on board. Therefore, investigations shall be carried out in order to determine the most cost-efficient technical solution giving results of sufficient quality in order to cope properly with the objectives set. Once the final technical solutions are known, then a greater amount of vessels sailing all over the Danube shall be equipped with the respective devices for successful participation in the measurement programme. The measurement programme itself can be started prior to the investigation of the most cost-efficient technical solution by the Navrom vessels, being already fully equipped and active with respect to this matter in PROMINENT, provided the vessels will be involved the respective programme.

Rhine and Danube:
Legal and organisational solutions for continuous running of the system and involvement of new ship-owners shall be developed and put in place. The required budget covering technical development, implementation and operation of the system, as well as project management, dissemination and interaction with stakeholders (regulative and legal bodies, shipping companies) amounts to 4 million EUR for the Rhine and 4 mln EUR for the Danube.

The activity shall be led by an organisation with very good relationships to the technology developers, as well as waterway authorities or managers and shipping companies operating on the Rhine and Danube. Organisations to be involved comprise TNO as developer and current operator of the system, as well as the shipping company Navrom with ten vessels already successfully equipped for the fulfilment of the objectives set.

The action shall be undertaken as soon as possible, starting 2019. The duration shall be three years.

The results may have an impact on the following policy documents: the ES-TRIN standard, referred to by the Directive (EU) 2016/1629, as well as the RIS Directive (Directive (EU) 2005/44) also the Good Navigation Status concept and updates of the GNS Guidelines as described in a recent study by DG MOVE in view of the legal requirements in the TEN-T Guidelines Regulation 1315/2013 EC.

The action shall be embedded in and funded by the CEF programme of the EU, allowing for EU-cohesion countries funding rates of up to 85 %.

The success of the action is depending on the involvement of waterway managers and ship-owners, as well as possibilities for further use of the PROMINENT system developed by BAW. For the Danube, the availability of information on gauge readings, possibilities for further use of the PROMINENT system developed by TNO, as well as how well the stretches between the gauges can be dealt with the original approach used at the gauge Corabia in PROMINENT.

The action contributes to removal of bottlenecks and an improved waterway infrastructure, resulting in better utilisation of it, more reliable services, more cargo transported, less fuel consumed, reduced emissions and external costs per tonne kilometre.

Assuming 5000 active vessels (approximately 40 % of the EU fleet) with an average yearly fuel consumption of 300 000 kg each and a minimum impact of 1 % on reduction of fuel consumption per tonne kilometre, as well as 1 EUR external costs per kg fuel consumed, the reduction in external costs per year will be approximately 15 million EUR. Probably, the impact will be greater, meaning that the funding provided will be earned back within less than one year. Thereafter, the society is starting to make only profit, provided the operational costs of running the system remain low, which will be most likely the case.

The societies and economies of all Rhine and Danube countries will benefit from the action. In the transportation sector, the ship-owners will immediately profit from the improved infrastructure and information available. Basically, all vessel types will be affected. However, the ones carrying heavy cargo, e.g. iron ore, resulting in great draughts, will be mostly affected, at least by the infrastructure measures.

iv. EEN - Action 4: carry out comprehensive promotion activities for energy-efficient navigation

For an efficient roll out of the toolset, awareness campaigns are required, both for aimed at vessel operators and at other stakeholders in the logistics chain, such as cargo owners, freight forwarders, terminal operators and infrastructure managers. This action shall be combined with Action 9 of the Engine Room (promotion and dissemination platforms such as EIBIP) and has also close links to feeding education programmes for students and crew working on vessels (e.g. full bridge simulator training facilities).

5. Skilled workforce and quality jobs

Options are developed and reviewed and recommendations are made for actions and measures resulting in a roadmap for Roll-Out of:

A) Use of simulators and digital tools for crew of vessels;
B) e-SRB and e-Logbook;
c) Integration of IWT in logistics.

i. Full bridge simulations and e-learning tools

The effectiveness of the use of ship-handling simulators for the purposes of education, assessment and examination, especially in relation to Knowledge of Specific Situations (KSS) and practical examinations, was investigated under SWP4.1. A comparison between simulator-based education and training on the one hand and real-life applications on the other showed the advantages and disadvantages of the use of ship-handling simulators, resulting in recommendations for the standardized use of simulators in education and exams.

In the course of the PROMINENT project CESNI/QP has installed a working group on the use of simulators. The aim is to develop a draft standard for minimum technical requirements of the Vessel Handling Inland Navigation Simulator, as well as its features, used as examination tool for the navigation, including navigation with radar[3].

Further, digital tools can bridge the gap between the increasing requirements to adjust the necessary skills to navigate in an efficient manner and the high barrier to enter conventional onshore learning classes.
Prominent developed the following prototypes of digital tools (e-learning modules) for education and training:

- energy and cost-efficient navigation;
- handling of (alternative) fuel and cargo, especially dangerous goods;
- vessel stability

It is mostly a matter of further usage within the curricula to apply the e-learning tools and contents in the education of students and crew already working in IWT.

ii. European electronic service record book and logbook

Public authorities, shippers and crew members face high costs, notably administrative and enforcement costs, to comply with IWT legislations, in particular with respect to professional qualifications, crewing requirements and working time. This is caused by the multiple reporting of data on crew/personnel and on vessel stemming from various legal acts, the difficult validation of these data by the competent authorities (cross-check) as well as the difficult or ineffective check of these data by enforcement authorities.

[3] See also the CESNI working programme 2016-2018, notably page 10
https://www.cesni.eu/wp-content/uploads/2016/07/Prog_Tr_CESNI_en.pdf

These difficulties are also inherent to the fact that currently the service record books and logbooks as well as other official documents and data related to crew members or to the vessels exist mainly in paper format as that version is necessary for controls by authorities. Aquapol and the European Transport Workers' Federation also report as a problem the gradual increase of unlawful practices, which has a correlation with the difficult check by enforcement authorities and to the fact that manipulation of documents is easy.

These problems seem particularly salient on the IWT network where cross-border activities and mobility of workers are frequent resulting in the diversity of documents required to comply with legislations. The negative consequences of these problems are inefficiency, deterioration of working conditions and attractiveness of the profession, decreasing of human and capital resources for controlling capacity and risk for safety of navigation. Ultimately, these represent an obstacle for the competitiveness of the IWT sector and its better integration in the value chain.

Based upon the outcomes of PLATINA-II and eIWT, which design an initial architecture of an e-SRB and an e-Logbook, PROMINENT developed and tested a prototype of an e-SRB and e-Logbook. Within PROMINENT pilots were executed in real world environment with the prototypes. The gained experiences are important inputs for the further process to introduce and roll-out e-SRB and e-Logbook in the IWT sector.

iii. Integration of inland navigation in general logistics education

A web-based community of practice (CoP) with learning modules was developed in order to create a sustainable tool for the integration of IWT knowledge into general logistics education. An open access learning management system (LMS) was used for content management and an accessible and responsive web-platform was developed. The e-learning modules developed in SWP4.1 are also available on the web-based community of practice. To foster the use of the web-based CoP developed, dissemination activities were conducted to make people aware of its existence as well as its handling.

a. Main results of deliverables and transferability of results

i. Use of simulators for the crew of vessels

In general two methods can be used for the education of the practical sailing skills of nautical personnel on inland waterway vessels: the training on board a vessel and the training on a simulator. While the vessel provides the real situations, environment and behaviour of a vessel on inland waterways there are several disadvantages like the costs, the time needed and the difficulty to provide special situations and weather conditions on demand. This can be overcome by the application of a nautical simulator as training platform because it is cheaper regarding the costs, can change scenarios very fast and can provide any situation with any risk level without the danger of serious damage. The work within Prominent focussed on the development of a procedure to assess the quality of an existing simulator in comparison to reality. Participating simulators were: Sandra (DST), Simulator STC (STC) and Nautis (MAH).

An estimation of costs for assessments on a simulator and assessments on a real vessel was performed and both were compared. Costs for the assessment on the simulator are mainly calculated by the fixed costs, given by investment costs, the depreciation and maintenance costs. Additionally, costs for lecturers, assessors and classrooms for briefing and debriefing have to be considered. For an assessment on a real vessel, it is assumed that all operational costs including labour costs for the crew as well as costs for lecturer and assessor have to be taken into account.

Since there is a variety of simulators with different functionalities and scopes, the investment costs differ over a wide range. For the calculation, two exemplary simulators were used: A single bridge simulator with investment costs of 400,000 euro and a multiple bridge simulator with investment costs of 1 million euro. Yearly costs are given by depreciation and maintenance costs. Maintenance costs may vary within a range of 5 -10 %. An average of 7 % was used in the calculation. The depreciation was based on a period of seven years.

The costs of a training vessel are estimated as 2295 euro per day, including all operational costs. Further, days for travelling to a certain area have to be taken into account. In conclusion, the total costs for an assessment on the simulator were estimated to be cheaper than the assessment on a vessel, in case a minimum of 800 assessments per year are performed. An additional benefit of a simulator is that environmental conditions and traffic can be trained more or less at the push of a button with far less time effort and without any additional costs in case of accidents.

ii. E-learning modules

As regarding the e-learning modules, the first topic is the energy and cost-efficient navigation, which covers the knowledge on interactions between water depth, current and sailing speed on resulting fuel consumption. The second topic is handling of dangerous cargo, divided in modules for crew not having an ADN certificate, crew not sailing on ADN vessels and crew sailing with LNG cargo. The third topic is Vessel stability, in which basic and advanced calculation schemes for the stability of inland vessels are provided with focus on container and liquid bulk cargo vessels. This tool helps to create awareness and sensitivity for vessel stability. In addition, the CESNI working group on competences is currently discussing voluntary standards in certain areas, where the e-learning modules could support the work of CESNI.

iii. e-SRB and e-Logbook

Aim of the work under Prominent was to design a prototype of a European electronic service record book and logbook, based upon legislative requirements, requirements from the industry and the results of the first pilots executed. The functional specifications, were defined in close cooperation with the Joint Research Centre of the European Commission. The system consists of a database and should have, as a minimum, the following basic building blocks:

- An extended electronic logbook (e-LBK). It would serve as a registry of all data associated with the vessel characteristics (like: owner, tonnage, dimensions, capacity, licences, manning requirements, eventual modifications etc.) and activities (like: navigation time, position and speed history, boat-master and crew).
    - An electronic Inland Worker's Card (eIWC), uniquely associated to each IWT worker;
    - Electronic service record book (e-SRB): it should be based on a non-volatile on-chip memory, where the acquired information would be stored for later use;

- A connection with the European Hull Database (EHDB), to which all vessel document updates are being pushed by the inspection bodies, in order to exchange necessary vessel data.

Additionally some centralized procedures, such as the issuing or update of certificates can be facilitated. The prime benefit lies in the necessary harmonization of the reporting and the terminology and, to a lesser extent, to the accuracy and efficiency of the document compilation.

iv. Integration of IWT in logistics

Logistics education faces the challenge to prepare logistics students for the challenges of tomorrow and should be able to offer training which is relevant for the industry. An online web-based Community of Practice (CoP) was developed in order to provide free up-to-date learning materials on the topic of IWT for general logistics education on an international basis. The developed CoP provides various types of learning materials, covering the aforementioned important topics of inland navigation which are currently underrepresented in general logistics education. Since the topic of inland navigation is often not included in general logistics education, the provided learning materials can be seen as a first step in order to close the identified gap in logistics education.

By conducting various dissemination activities such as attending international conferences, organizing special events and collaborating with relevant projects and stakeholders, involved partners made sure, that relevant stakeholders were aware of the web-based CoP. Positive feedback from the educational sector and the industry gives reason to believe that the web-based CoP will be utilized.

b. Where are we now?

Recognition and modernisation of professional qualifications in inland navigation is one of the measures required to accomplish the single market in the inland waterway transport (IWT) sector and is as such also included in the Commission Communication 'Towards quality inland waterways transport - NAIADES II'. It aims at reducing barriers to labour access and mobility, valorise qualifications and careers in the sector, and create a level playing field.

c. Main barriers for Roll-Out

i. Use of simulators and digital tools for the crew of vessels

The main barrier is that a legal basis is missing for the recognition of simulators for inland waterway transport (as in the maritime field). Since simulations have advantages in preparing crew members, education and training institutes need to invest in simulations. The set-up of a financial incentive scheme would support the roll-out of simulators. However, this financial incentive scheme is not available. Moreover, lecturers need to be trained how to use the simulator in their daily teaching practices which needs to be stimulated and supported as well.

ii. e-SRB and e-logbook

The main barrier for the Roll-Out is the lack of the legal basis and system architecture for e-SRB and e-Logbook. Digital tools for recording sailing times and qualifications are a next step in the implementation of the new legal framework on professional qualifications. In a number of policy-

setting documents as the White Paper on Transport; the Digital Single Market Strategy; the EU e-Government Action Plan 2016-2020, the Commission recognised the need for measures fostering the acceptance and use of electronic documents, including transport documents. Within the EU Directive harmonised procedures and models for SRBs and LBKs are foreseen in order to facilitate the electronic exchange of information through the setting up of a central database. However, first an assessment is needed in order to pave the way for the European introduction of these electronic tools. This needs to be seen within the wider frame of the development of the Digital Inland Navigation Area (DINA).

i. Integration of IWT in logistics

The main barrier is that there are differences in curricula of European-wide IWT education and there is a lack of an internationally recognised certification system for IWT schools.

d. Roadmap for Roll-Out

i. SKQJ – Action 1: Certification of simulators and funding

CESNI develops the draft standard for minimum technical requirements of the VHINS (Vessel Handling Inland Navigation Simulator), as well as its features, used as examination tool for the navigation, including navigation with radar.

The next steps needed is the legal adoption of the standard, including the scheme for certification of the simulators and supporting the funding for building/purchasing simulators by the education and training institutes in the EU. This will require legal actions from the side of the EU DG MOVE in close cooperation with CESNI/MQ. Furthermore, supporting funding instruments will be needed to facilitate the roll-out of VHINS across Europe to enable effective and efficient training and education.

ii. SKQJ – Action 2: Impact Assessment for e-SRB and e-Logbook

An impact assessment procedure was already started by European Commission DG MOVE. This is the required first step to take. A study is tendered and results of the Impact Assessment study are expected by end of 2018.

Public authorities, shippers and crew members face high costs, notably administrative and enforcement costs, to comply with IWT legislations, in particular with respect to professional qualifications, crewing requirements and working time. The problem of high costs to comply with the IWT legislations is mainly caused by the fact that the skilled workers' qualifications are not yet recognised throughout the European Union, resulting in multiple reporting of data on crew/personal and on vessel stemming. Although the costs related to a central registration and access are not yet exactly known, the benefits of introducing e-SRB and e-logbooks seem considerable, especially as important benefits can be realised with respect to the protection against loss or theft of service record books. Further, substantial gains may be realised in reducing the administrative burden for the stakeholders.

Also fraud is combated by using this approach. Reduction of fraud with SRBs creates a better level playing field. Furthermore, as unqualified workers are kept out, there also is an improvement of safety culture.

E-SRB and e-logbook should preferably be implemented together and the transition period should be short, in order to avoid unclear situations where paper and electronic systems co-exist. It is recommended to perform a more in-depth investigation of the investment costs needed for implementing e-SRB's or e-Logbooks. The impact assessment will review different policy options, within the framework of DINA (Digital Inland Navigation Area).
The impact of actions can be divided into 4 domains (social, economic, environment and level playing field). These will be elaborated below.

Meaningfulness and social work environment are key words here that prove a positive impact for job satisfaction. The likely result is much simpler and efficient interrelations between vessel owners, operators and crew, enforcing bodies and the public administration. Besides this, the social impact is concentrated on the employment and the working conditions by increased transparency and controllability that reduce the possibility of fraud and social dumping. This leads to more fairness in competition and more attractive working conditions.

E-SRB's and e-Logbooks are expected to provide increased efficiency in administrative procedures for all stakeholders involved. This results in saving time and costs. One of the most important impacts of the introduction of the proposed actions is that on the simplification of the bureaucratic procedures and the administrative burden. This will increase the efficiency and thus the competitiveness of the IWT sector. There is also a positive impact on SMEs both in what regards the SMEs of the IWT sector as well as the ICT SMEs. By enhancing the efficiency and competitiveness of the international IWT sector, the actions will contribute towards the achievement of the single market.

Moreover, with the e-SRB and the e-Logbook, fraud with SRBs is combated in a more efficient way. This diminishes unfair competition in employment and adds to a level playing field in the labour market, especially for countries that recently joined the EU. E-SRB's and e-Logbooks will likely lead to simpler and efficient interrelations between vessel owners, operators and crew and the public administration. This improves fair competition and working conditions within the sector.

iii. SKQJ – Action 3: Integration of IWT in logistics

Logistics curricula shall be adapted, and it shall be stimulated to use the web-based CoP as a source for learning materials, CoP for discussions on the topic of inland waterway transport. Funding is needed for training the teaching staff following the adaptations of the curricula.

Experience gained through past projects have shown four main requirements when providing content and information on IWT: provide up-to-date learning material which covers logistics contents; enhance the cooperation between industry and the educational sector; make simple and user-friendly offers accessible and available on an international level and broad train-the-trainer offer is needed.

It may be difficult to include the developed learning materials and the capstone course concept in the curriculum due to administrative barriers. In particular, it is noted in the case of Romania and

the Netherlands, which were under investigation in Prominent. This problematic transferability is likely to occur also in other institutes within Europe.

The action consists of adapting the logistics curricula (e.g. lesson materials and teaching aids) in order to integrate IWT into logistics training and harmonise this across the EU. The elaborated content should be integrated in general logistics education in Europe in order to raise awareness for inland waterway transport and equip the future logistics students with knowledge about this sustainable transport mode.

The future use of the CoP could be financed by a business model in order to finance further administrative costs of the web-based CoP and dissemination activities. In the business model it must be organized how the funding will be raised, how students and teachers can use the system and how the system will be maintained. Main funding partners to be considered are the European commission, National authorities, educational institutes and possibly regional authorities. Further international partners on European level may be integrated in these follow-up projects.

It shall lead to increased job quality and job satisfaction as education fits better to the needs on the job. Logistics/IWT workers are better geared to their tasks. The quality improvement within the sector creates more efficiency which in turn may raise the potential for modal shift. This in turn creates more jobs in the IWT sector.

References

Brüggemann, T. (2014). Leitfaden für die Einmessung von hydrographischen Messsystemen auf Vermessungsschiffen, BfG-Bericht 1822, 03/2014.

COM/2013/0623 final - COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Towards quality inland waterway transport NAIADES II.

Hervouet, J.A., Bates, P. (2000). The Telemac Modelling System. Special Issue of Hydrological Processes, 14, (13), pp. 2207-2363.

Hoyer, K., Friedhoff, B., van Eekeren, M., Jongkind, T. and Gebraad, J. (2017). D 4.4 Prototype of digital education and training tools. Technical report of the H2020 project Prominent.

Hulskotte, J. and Bolt, E. (2012). EMS-protocol: Emissies door Binnenvaart: Verbrandingsmotoren (Emissions of inland ships: combustion engines), Versie 4. 15 december 2012. TNO. Published by Taakgroep Verkeer en Vervoer (Emission registration).

Muilerman, G.-J., Quispel, M. and Gebraad, J. (2015). D6.1 Evaluation guidance report with methodology and templates. Deliverable of the H2020 project PROMINENT.

PROMINENT D1.1. (2015). List of operational profiles and fleet families. SPB, DST, PRO, STC, VIA. Deliverable of the H2020 project PROMINENT.

PROMINENT D3.2/D3.3. (2016). Assessment of certification procedures/Assessment of options for montoring and enforcement. Combined deliverables D3.2/D3.3 of the H2020 project PROMINENT.

PROMINENT D3.5. (2016). Ex-ante cost/benefit analysis of systems for certification, monitoring and enforcement. Deliverable of the H2020 project PROMINENT.

PROMINENT D5.7. (2017). Technical evaluation of the monitoring results. Monitoring results on Rhine, Danube and other vessels. TNO, Multronic, SGS, NAVRON, PRO. Deliverable of the H2020 project PROMINENT.

PROMINENT 5.8. (2017). Technical recommendations on options for specifications of monitoring equipment and database set-up. Deliverable of the H2020 project PROMINENT.

Regulation (EU) 2016/1628.of the European Parliament and of the Council of 14 September 2016 on requirements relating to gaseous and particulate pollutant emission limits and type-approval for internal combustion engines for non-road mobile machinery, amending Regulations (EU) No 1024/2012 and (EU) No 167/2013, and amending and repealing Directive 97/68/EC.

Schweighofer, J. et.al. (2013). MoVe IT: WP 7: System Integration & Assessment. D7.3 Environmental Impact. Final Report. Deliverable of the FP7 EU project MoVe IT!. : http://www.moveit-fp7.eu/assets/d7.3_move-it-final-report.pdf

Wurms, S., Schröder, P.M., Weichert, R.B., Wassermann, S. (2010). Strategies to overcome the possibly restricted utilization of fairways due to climate changes. River Flow 2010: proceedings of the International Conference on Fluvial Hydraulics, Braunschweig. pp. 1647-1654, ISBN: 978-3-939230-00-7.

Indexes

a. Figures

b. Tables

c. Abbreviations

AC	alternating current
ADCP	acoustic Doppler current profiler
ADN	European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways
AIS	Automatic Identification System
AR	Antwerp – Rotterdam
ARA	Antwerp – Rotterdam - Amsterdam
B	width, breadth
be	specific fuel consumption
BfG	Bundesanstalt für Gewässerkunde, Federal Institute of Hydrology
C	Celsius
CAN	Controller Area Network
CCNR	Central Commission for the Navigation of the Rhine
CFD	computational fluid dynamics
COG	centre of gravity
CoP	Community of Practice
csv	comma-separated values
CO	carbon monoxide
CO_2	carbon dioxide
DAQ	data acquisition system
DC	direct current
dGPS, DGPS	differential Global Positioning System
DOC	diesel oxidation catalyst
DPF	diesel particulate matter filter
DWT	deadweight tonnage
EAT	exhaust after-treatment
EC	European Commission

ENAT	Efficient NAvigation Tool
EPA	Environmental Protection Agency
EPM	Environmental Performance Monitoring
EU	European Union
EUR	euro
FGS	Fahrgastschiff
Fr_h	Froude number based on the water depth
FTP	file transfer protocol
GHG	greenhouse gas
GL	Germanischer Lloyd
GIW	equivalent water level, gleichwertiger Wasserstand
GMS	Großes Motorgüterschiff
GSM	Global System for Mobile Communications
GPS	Global Positioning System
GPRS	General Packet Radio Service
h	hour
H	height
HC	hydrocarbon
HDT	Heading, True
HSPA	High Speed Packet Access
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure
Hz	hertz
H2020	Horizon 2020
ID	identification
ISC	In Service Conformity
IWA	inland waterway auxiliary engine (NRMM Directive)
IWP	inland waterway propulsion engine (NRMM Directive)
IWT	inland waterway transport
JRC	Joint Research Centre
kHz	kilohertz
kN	kilonewton
km	kilometre
kW	kilowatt
l	litre
L	length
m	metre
MW	mean water level
NCD	NO_X Control Diagnostics
NHN	Normalhöhennull, standard geographical height system used in Germany
NRMM	non-road mobile machinery
NTE	not-to-exceed value
NTRIP	Networked Transport of RTCM via Internet Protocol
OBD	On-Board Diagnostics
OBM	On-Board Monitoring
OCE	Off-Cycle Emissions
OEM	Original Equipment Manufacturer

P_B	brake power
PC	personal computer
PD	delivered power
PEMS	portable emission measurement system
PLC	programmable logic controller
PM	particulate matter
PN	particulate number
PROMINENT	Promoting Innovation in the Inland Waterways Transport Sector
RDE	Real Driving Emissions
REC	Retrofit Emissions Control device
rkm	river kilometre
rpm, RPM	revolutions per minute
RSE	Real Sailing Emissions
R_{TS}	total resistance of ship
u	velocity
s	second
SAPOS HEPS	highly precise positioning service
SCR	selective catalytic reduction
SoG, SOG	speed over ground
SRB	service record book
SRM	standard reference material
StW, STW	speed through water
SWP	Sub-Work Package
t	tonne
T	draught, draft
TRL	Technology Readiness Level
V	volt
V_S	ship speed
wi-fi	local area wireless computer networking technology
WP	Work Package
xls	Microsoft Excel file format
1D	one-dimensional
2D	two-dimensional
∇	ship displacement volume
Δt	time (step)