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CONTRIBUTION TO IMPACT ASSESSMENT

of measures for reducing emissions of inland navigation

Partners:

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Contents

1 Introduction and scope of this study

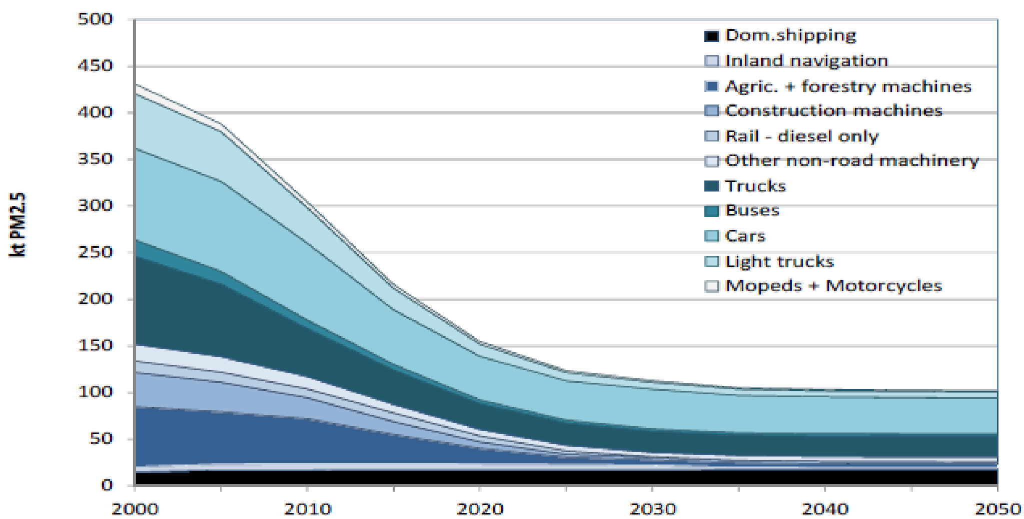
1.1 IWT emission levels

Inland Waterway Transport (IWT) is an efficient, safe and environmentally friendly mode of transport. However, the previously undisputed competitive position of IWT in the field of emissions, in comparison to air, is increasingly being contested. The gap – regarding emissions to air – between road transport and IWT is rapidly becoming smaller. A major concern thereby, is the poor progress made on the emission of air pollutants with in particular, the emission of nitrogen oxides (NOx) and particulate matter (PM).

Air pollution due to emission of NOx and PM makes asthma worse and exacerbates heart disease and respiratory illness. This results in premature deaths amongst EU inhabitants. Therefore, addressing the emission levels of IWT is aimed at significantly reducing premature deaths caused by air pollution, whilst simultaneously resolving environmental impacts, such as acidification and associated losses in biodiversity.

In contrast to the road haulage sector the emission standards for new engines are much less stringent and the average lifetime of engines in inland vessels is very long. As a consequence, inland waterway transport already has higher air pollutant emission levels than road transport per tonne kilometre for certain vessel types. Without specific action this situation will further deteriorate in the future and the air pollutant emission will remain high for IWT. Figure 1.1 shows the development of emissions of particles smaller than 2.5 micrometer (PM2.5) from mobile sources in the EU27.

Figure 1.1 Development of PM2.5 emissions from mobile sources in EU27



Source: EU and the Review of Air Quality the Thematic Strategy on Air Pollution (State of Play and Outlook), AECC Seminar 27 November 2012 on Emissions from Non-Road Mobile Machinery, presentation by Mr Thomas VERHEYE, DG ENVIRONMENT

Engines used in IWT have been subject to Stage IIIA emission requirements (Directive 97/68/EC on emissions from non-road mobile machinery engines) since 2007. Despite this measure the atmospheric pollution from inland shipping remains significant with 17% of the overall non-road emissions and with high concentration levels in certain harbours and cities. It should also be noted that around 9 out of 10 inland waterway vessels in the EU are registered in Belgium, the Netherlands, Germany and France, where the environmental impacts are more intense, due to a higher concentration of the population along waterways.

The Europe 2020 Strategy and the White Paper 2011 'Roadmap to a Single European Transport Area', sets out clear environmental objectives for the transport system. As an overall objective of the White Paper on Transport, the impact of transport on the environment should be lowered by reducing the dependency upon oil and thereby, cutting carbon emissions in transport by 60% by the year 2050. If current trends persist, IWT will not contribute sufficiently towards the achievement of the sustainability objectives of the White Paper on Transport.

The technical assistance provided in this study is a contribution to the revision of the NAIADES programme and to various measures that affect the environmental performance of inland navigation, including the revision of Directive 97/68/EC. Along with an assessment of the various technologies which would allow achieving these standards, various options for emission standards for the inland navigation sector have been analysed.

The analysis of the 'Business as Usual' (BAU) scenario confirms that the most persistent problem in relation to external costs of IWT (especially when compared to road transport) is to be found in the air pollutants NOx and PM, while IWT still has a clear advantage compared to road haulage in the performance of carbon dioxide (CO2) emissions. The focus of this study therefore, lies on the reduction of the air pollutants NOx and PM in order to reduce the related external costs. This study concludes that addressing the emission standards for engines used in IWT is the most effective approach towards the reduction of these emissions.

1.2 Technical assistance and consultation of interested parties

1.2.1 Technical assistance

The technical assistance for this study has been provided under the Marco Polo accompanying measure MOVE/B3/2011/548-1 concerning 'Provision of support services in the field of inland waterway transport'. The technical assistance was provided by experts from a consortium that was composed of the following partners:

- Panteia/NEA (leading partner)
- Stichting Projecten Binnenvaart (SPB)/ Expertise- en InnovatieCentrum Binnenvaart (EICB)
- Planco
- via donau
- Central Commission for the Navigation of the Rhine (CCNR)

1.2.2 Common Expert Group

The initiative directly affects the IWT industry (ship owners, as well as skippers), the engine and equipment manufacturing industry, the shipbuilding industry, the fuel production industry, infrastructure authorities, ports, cities and communities. Indirectly, the initiative could possibly affect the freight forwarding industry and customers (shippers).

A dedicated Common Expert Group on emission reduction of the inland waterway transport fleet was set up by the Commission in the summer of 2012, involving Member State authorities, engine and ship manufacturers, the engine retrofitting industry and independent experts and representatives of the IWT sector and ports.

The Common Expert Group met for the first time on the 18th of September 2012, followed by meetings on the 23rd of October 2012, the 22nd of November 2012, the 17th of December 2012 and the 12th of March 2013. All meetings took place in Brussels and demonstrated a high and increasing degree of participation and involvement from the stakeholders.

As defined in the Terms of Reference for the Common Expert Group, the purpose of the group was threefold:

- To advise the Commission from a technological point of view in the preparation of the necessary legislative initiative to reduce the emission of air pollutants originating from the inland waterway transport fleet;
- To advise the Commission on possible flanking measures, such as transitional provisions or financial assistance;
- To exchange experience and information on existing activities, initiatives and good practices in different Member States of the EU and in River Commissions in the field of emission reduction in inland waterway transport.

Participants of the expert group meetings included:

European Commission

- European Commission DG MOVE
- European Commission DG ENVIRONMENT
- European Commission DG ENTERPRISE
- European Commission Joint Research Centre - Institute for Energy and Transport
- European Commission Trans-European Transport Network Executive Agency

Member States

- Austria – Federal Ministry of Transport
- France – Ministère de l'Ecologie, du Développement, durable et de l'Energie
- The Netherlands - Ministry of Infrastructure and the Environment
- Croatia - Ministry of the Sea, Transport and Infrastructure, Inland Navigation Authority
- Belgium – Federal Public Service Mobility and Transport

International organisations

- Central Commission for the Navigation of the Rhine (CCNR)

Associations
- European Skippers' Organisation (ESO-OEB)
- European Shippers Council (ESC)
- European Barge Union (EBU)
- Inland Navigation Europe (INE)
- Promotie Binnenvaart Vlaanderen (PBV)
- European Association of Internal Combustion Engine Manufacturers (Euromot)
- Association for Emissions Control by Catalyst (AECC)
- Community of European Shipyards Associations (CESA)
- European Federation for Inland Ports (EFIP)
- European Sea Ports Organisation (ESPO)
- European Marine Equipment Council (EMEC)

Individual companies
- Development Centre for Ship Technology and Transport Systems (DST)
- Imperial Shipping Service
- CE Delft
- ECORYS
- LLOYD's Register EMEA

1.2.3 Opinions, concerns and views of stakeholders

The **first meeting** of the Common Expert Group on emission reduction of the inland waterway transport fleet took place on the 18th of September 2012. DG MOVE presented the contents of the staff working document 'Towards NAIADES' (published in May 2012) and the Terms of Reference of the Common Expert Group on emission reduction of the inland waterway transport fleet was presented and discussed. Furthermore, preparatory work under the PLATINA 7RFP project was presented. Generally, the stakeholders stressed the need for a close linkage of the work with the revision of the NRMM Directive (97/68/EC). Unit prices of technical measures were subsequently discussed and assessed with the stakeholders bilaterally. Amongst other issues, unit prices were evaluated in a first questionnaire sent to the stakeholders (see Annex 2).

During the **second meeting** of the Common Expert Group on the 23rd of October 2012, the Terms of Reference (ToR) were officially adopted. Further preparatory work under the PLATINA 7RFP project was presented and a discussion on provisional cost-benefit calculation outcomes, modelling assumptions, limitations and implications for policy options took place. Regarding follow-up investigations in the 'Marco Polo support measure' project, the stakeholders recommended to use existing studies to estimate the expected fuel costs in the long-term. Furthermore, the investment costs of the different technologies should be reviewed again, since the investment costs used in PLATINA seem rather generous. The number of operating hours should also be taken into account (i.e. the higher the number, the faster the return on investment). Several experts in the Group offered to provide information on this subject. The follow-up investigations should look into funding schemes, especially given the limited timeline. Stakeholders found it important to avoid changing the emission standards in the IWT sector on a regular basis. Setting the emission requirements – possibly more ambitious – for a long-term horizon will stimulate investments.

The **third meeting** of the Common Expert Group on emission reduction of the inland waterway transport fleet took place on the 22nd of November 2012. The results of a second questionnaire (see Annex 2) and the feedback given by the stakeholders were discussed. Stakeholders generally found that the required transition periods of new emission limits must depend on the level of the standards chosen. Usually this timeline is five years. From a perspective of technology and experience, a short transition time should not be a problem. Stakeholders also stated that the unit prices and the R&D costs are expected to decrease over a longer period and with higher production volumes. For the former NRMM Stage IV[1] proposal, no additional R&D is needed, as it follows the US Tier 4[2] emission standard and IMO Tier 3. Some of the technical limits mentioned towards the installation of engines and other equipment on existing vessels remain: the available space (e.g. limiting LNG use on small vessels), the possibility of having oil in the exhaust gasses of old engines (causing problems for the use of after-treatment systems) and the low amount of maximum allowable back pressure. The application of Fuel-Water Emulsion should further be investigated as one of the possible technologies, however, only for existing vessels. The further answers to the questions on the second questionnaire are provided in Annex 2.

The **fourth meeting** of the Common Expert Group on emission reduction of the inland waterway transport fleet took place on the 17th of December 2012. The main points on the agenda were several technical questions and an updated cost-benefit analysis for different policy options. The technical questions elaborated and answered by the stakeholders included themes, such as test cycles and applicability of (marinised) truck engines, Fuel-Water Emulsion, passenger vessels, updated cost figures for technical measures and the number of engines and vessels to be installed, adapted and replaced. Generally, it was stressed by the stakeholders that there is a need to be ‘technology neutral’ as much as possible.

The **fifth** and final **meeting** of the Common Expert Group took place on the 12th of March 2013. The draft report prepared by the consultants was presented and discussed and presentations by the European Commission were made on the Clean Power strategy and possible financing instruments from the Connecting Europe Facility, as well as Horizon 2020. A discussion took place on the updated policy objective and the assumptions on the Marco Polo external cost calculations. Some stakeholders expressed their views on their preference regarding the policy options and highlighted the pros and cons from several viewpoints. Issues discussed, concerned measures for existing engines and smaller vessels and level playing field considerations. The Common Expert Group meeting was finalised with a presentation on the next steps which included a view on the process of the revision of the Non-Road Mobile Machinery Directive 97/68/EC and the NAIADES II Communication and Staff working document on greening the fleet. The members of the Common Expert Group were requested to send short statements by the end of March.
The minutes of the meetings of the Common Expert Group and position papers and statements of stakeholders are included in Annex 2.

[1] This former NRMM stage IV proposal is equivalent to stage 3B in this report
[2] US Tier 4 is equivalent to stage 3B in this report

1.3 Scope of this study

The aim of this study was to provide information that can be be used in impact assessments (IA) for measures aimed at reducing the emissions of inland navigation. For a number of policy options, the impacts have been determined and analysed. The focus of this study was on the main engines for propulsion of the vessel.

Auxiliary engines (e.g. for power generation) are not within the scope of this study. Based on interviews held with around 100 owners of vessels of up to 110 metres, it was learned that the average fuel consumption of a freight barge in 2003 was 228 m^3 per year (about 200 tonnes)[1]. In addition, the fuel consumption of auxiliary engines was on average 15 tonnes per year, of which 10 tonnes on average by bow thrusters and 5 tonnes by generator sets. This resulted in a contribution of about 13% to the total fuel consumption (on average) of a freight barge. Since 2003, the average installed power of bow thrusters has increased. Therefore, more research is needed on the effects of auxiliary engines towards the emission of air pollutants.

For the most part however, the emissions to air and the related external costs are caused by the main propulsion system of a vessel. Therefore, the focus of this study was on the technical measures towards the reduction of the emissions of the main propulsion engines only.

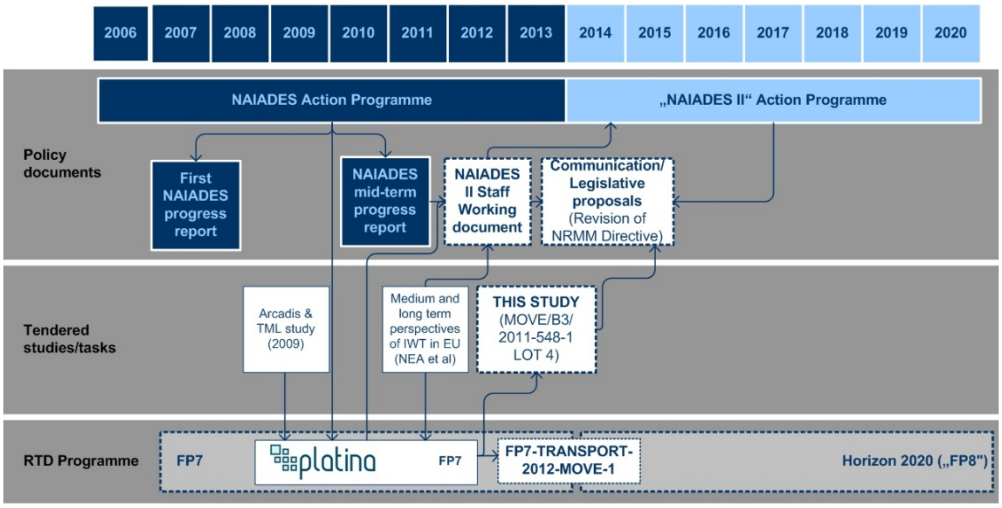
[1] EMS-protocol Emissies door Binnenvaart: Verbrandingsmotoren (2003)

2 Context, problem definition and existing legislation

2.1 Context

In regards to the topic of greening the fleet, a number of relevant policy plans and studies have been published in recent years (see Figure 2.1).

Figure 2.1 Policy plan and studies greening of the fleet



2.1.1 NAIADES 2006-2013

This study examines one of the aspects of the NAIADES Action Programme 2006-2013 which refers to concrete measures to be enacted at an appropriate level to introduce technologies to further reduce fuel consumption and harmful emissions from new and existing vessels. It is also one of the actions put forward in the Commission Staff Working Document 'Towards NAIADES II' that was adopted on the 31st of May 2012. The study contributes to the greening of the IWT fleet and is one of the main objectives expected for the NAIADES II Communication.

2.1.2 Reviewing Directive 97/68/EC Emissions from non-road mobile machinery (2009)

An earlier impact assessment study on possible policy options for the review of the Non-Road Mobile Machinery (NRMM) Directive was performed by Arcadis and Transport & Mobility Leuven (TML) in 2009. This study compared the impacts of the different options. Nine different types of equipment were under review, including equipment on inland waterway vessels.

The Central Commission for Navigation on the Rhine, as well as Euromot, who represents a part of the industry, suggested possible stage IV limits. These limits were investigated by Arcadis & TML, which concluded that IWT emissions could reach 10% of NRMM emissions in 2020. The reason is that other NRMM emissions decrease faster than IWT emissions due to the stricter emission limits. The highest compliance costs associated with the CCNR proposal[1] were due to the development of a new type of engine at the edge of what was technically feasible at the time of the study. Alternatively, the development costs of the diesel engines that are in alignment with IMO Tier 3/ EPA Tier 4 are considered to be already done by the industry as these engines were developed for the US market.

The basic assumptions in the Arcadis & TML study determining the analysis outcomes, pertain to the number of average vessels used (one vessel type with 1400 kW engine power), the number of assumed engines sold per year (270 engines sold/year in EU-27) and the transport volume prognoses (baseline scenario (tkm) based on TREMOVE). The overall analysis showed that no significant modal shift from IWT to road impacts can be expected as a result of additional compliance costs.

In this study conducted by Arcadis & TML no detailed fleet or engine model was used for inland navigation. A rather general approach was used to calculate the emissions to air and the related external costs. The shadow prices that were applied by Arcadis & TML for calculating the avoided external costs of NOx and PM emissions for the policy options are based on outdated reports, seen from the viewpoint of the current state-of-the-art options. Since 2009, the shadow prices for NOx and PM emissions has increased. Moreover, the external costs mentioned in the main results of the Arcadis report are based on average values of the EU, not taking into account the large differences between the transport performance of IWT between various countries and the differences between shadow prices for those countries involved. As a result, the external cost estimates provided by Arcadis & TML in 2009 are much lower compared to the external cost estimates that are provided in this report.

The study by Arcadis & TML did not take into account a policy option to have emission standards for existing vessels. In addition, it did not take into account the recent technologies, such as dual fuel LNG engines for IWT.

2.1.3 Medium and Long Term Perspectives of Inland Waterway Transport in the European Union (2012)

The study 'Medium and Long Term Perspectives of Inland Waterway Transport in the European Union' provided the European Commission with a comprehensive basis to define the inland waterway transport policy within the general transport policy for the medium and long-term. It therefore, provides recommendations for actions to be taken up in the NAIADES II programme (2014-2020).

A major concern was expressed in this study regarding the poor progress made on reducing the emission of air pollutants and in particular the emission of nitrogen oxides (NOx) and particulate matter (PM2.5). It was concluded that the trend towards 2020 shows an increasing gap between emission performance of

[1] The CCNR proposal mentioned in the Arcadis study (2009) is equivalent to stage 5 in this report (NOx 0.4 g/kWh, PM 0.01 g/kWh), but did not yet take into account a standard for PN .

engines in barges and trucks. The EC was advised to adopt a policy package providing push and pull measures to reduce the air pollutant emissions up to 2020.

Considering the most important determinants of the external costs of inland waterway transport operations, the following measures are expected to have an effective and direct impact on external costs:

- Investigate and invest in the appropriate incentives and retrofit programmes to reduce pollutant emissions of existing engines;
- Revise engine emission standards for the future;
- Promote access to capital and funding programmes;
- Improve and implement education and training programmes related to fuel-saving, sailing behaviour and safety.

These proposed policy measures would have a direct impact on the reduction of external effects.

2.1.4 PLATINA (2008-2012)

In the summer of 2012, the PLATINA platform was asked by the European Commission to provide technical assistance in the preparation of steps towards greening the fleet. This resulted in a Working Paper summarising the status quo and a first analysis.

The analysis by PLATINA was ultimately aimed at achieving insight into the most effective technical measures to make IWT as competitive as road transport in terms of emissions to air by 2020 and beyond. The PLATINA analysis demonstrated that a reduction of fuel consumption and emissions to air can mainly be realised by means of infrastructural, technical, operational or organisational measures. A selection of measures was made, which would have sufficient effectiveness to contribute to the policy objective (close the gap with road haulage external costs of emissions to air by 2020).

This resulted in a long list of technical interventions that could help achieve the policy objective as specified in the previous sections. The analysis was ultimately aimed at achieving insight into the most effective technologies and behaviours to make IWT as competitive as road transport in terms of emissions to air by 2020 and beyond. In order to identify the most promising technical measures from this perspective, the following criteria were used by the PLATINA working group:

- Significant emission reduction potential
- Technical feasibility
- Temporal feasibility
- Cost-effectiveness

The application of the above mentioned criteria leads to a focus on combinations of ship-related technical measures, ship-operational and -organisational measures, which could have a high emission reduction potential, which could be applied on a short to medium term and which could be applied to a large proportion of the inland vessels. The following list presents the results of a quick evaluation on the basis of the criteria as presented above.

- Use larger vessel units
- Use LNG
- Apply dual fuel
- Exchange of main diesel engines
- Overhaul of existing engines
- Apply diesel-electric engines
- Apply selective catalytic reduction (SCR), a diesel particulate filter (DPF) or a combination
- Apply smart and eco-efficient steaming
- Reduce empty runs
- Increase load factor of loaded trips

Next, a monetised estimation on the economic and environmental impacts of the selected measures was provided.

Table 2.1 Preliminary options analysed

Option	Emission standard for NO_x/PM	Applies to new vessels	Year of entry into force	Applies to existing vessels	Year of entry into force
0 (BAU)	CCNR-II/NRRM Stage IIIA (6-11 g/kWh NO_x and 0.2-0.8 g/kWh PM)[1]	Yes	2007	No	-
1	EURO-6 (0.40 g/kWh NO_x and 0.01 g/kWh PM)	Yes	2015	No	-
2	Intermediate norms (1.8 g/kWh NO_x and 0.045 g/kWh PM)	Yes	2020	Yes	2020
3	Intermediate norms (1.8 g/kWh NO_x and 0.045 g/kWh PM)	Yes	2020	Yes	2035
4	EURO-VI (0.40 g/kWh NO_x and 0.01 g/kWh PM)	Yes	2020	Yes	2020
5	EURO-VI (0.40 g/kWh NO_x and 0.01 g/kWh PM)	Yes	2020	Yes	2035

Source: PLATINA, 2012

A number of preliminary options were analysed (see Table 2.1). The main costs of the options depend on the technology mix chosen (improved conventional diesel, LNG, SCR+DPF and/or econometers), whereas, the calculated benefits can be divided in four main reduction categories:

- External costs through reduced fuel consumption per tkm
- Transport costs for skippers

[1] For the BAU option the NOx emission standard was based on CCNR II

- Logistics costs for shippers
- External costs through a modal shift from road to IWT

The PLATINA analysis selected four representative vessels for the detailed calculations (two self-propelled vessels, one pusher combination and a coupled formation), which represent a large proportion of the total population. Transport volume prognoses were based on the study 'Medium and Long Term Perspectives of IWT in the European Union'[1].

In summary, the preliminary cost-benefit analyses of PLATINA showed that:

- The net present value (NPV) of the balance of costs and benefits is significantly higher for all options than in the BAU option;
- All policy options have a significantly higher and positive benefit-cost ratio (BCR) than the BAU option;
- The balance between costs and benefits is positive as of 2014 for all options, whereas, in the BAU option benefits only exceed costs as of the year 2029;
- As in the earlier discussed study conducted by Arcadis & TML, the PLATINA study found that expected impacts on modal shift are not significant.

2.2 Problem definition

Inland waterway transport has unquestionably been the most environmentally friendly mode of inland transport for decades. However, this advantage has steadily been eroding due to the rapid improvement of emissions from other transport modes. In particular, the road haulage sector has been confronted by stricter emission standards combined with strong incentives for road haulage operators (e.g. environmental zoning, differentiated infrastructure charges). In contrast to the road haulage sector the replacement rate of engines used in inland waterway vessels is very low and the emission standards for new engines are much less strict regarding NOx and PM emissions. As a consequence, inland waterway transport for certain routes, cargo types and vessel sizes already has higher air pollutant emission levels than road transport per tonne kilometre. Without specific action on the legacy fleet, the traditional environmental advantages of IWT will further deteriorate in the future. This will lead to IWT losing its environmentally favourable position in comparison to road transport, resulting in reduced public support to use IWT. Such a development would also be in conflict of interest with shippers that request environmentally friendly transport solutions and with national programmes to stimulate IWT on environmental and public health related grounds.

2.3 Underlying drivers of the problem

The main drivers behind this specific problem of the IWT sector are compulsory emission standards lagging behind, the long lifetime of inland vessels, as well as the small and specific market for inland vessels and their engines.

1. Compulsory emission standards lagging behind those of road transport

[1] Medium and Long Term Perspective of IWT in the European Union, NEA et al, 2011

Inland navigation still holds a pole position in terms of relative fuel consumption and related greenhouse gas (GHG) emissions per tonne kilometre (tkm). However, a continuous investment process needs to be maintained in order to retain this competitive advantage. The existing regulations have only a limited effect on fleet modernisation and innovation since standards are only applicable to new engines. The size of the active motorised cargo fleet is approximately 11.500 vessels[1]. In general, all vessels are subject to emission requirements, meaning that if an existing vessel is equipped with a new engine, the engine has to comply with the current emission standards. However, since the year 2003, only 17% of these vessels have been equipped with new engines[2]. As a result, only 17% needed to install new engines that comply with the emission standards. The number of new engines entering the market is too small to have a significant effect on the emissions of the total fleet population. As of 2007, new engines are required to meet the criteria of emission Stage IIIA according to Directive 2004/26/EC (Non-Road Mobile Machinery) or Stage II of the Rhine Vessel Inspection Regulations.

2. Long serviceable lifetime of IWT engines compared to road transport

The reduction of emission levels of IWT is stagnating in comparison to other modes, because the innovation rate of engines for those modes is faster. The long lifetime of inland barge engines (30,000 to over 200,000 hours, depending on the engine type) results in a slow uptake of the new engines in the fleet. Breakthrough and large-scale innovations are introduced at a relatively slow pace. The transport vehicles used in inland waterways are self-propelled dry cargo and tank vessels, push boats, tugs and non-motorised barges. Inland vessels thereby, have a longer life span than maritime vessels. Bulk vessels on the Rhine are on average about 50 years old; the average age of liquid cargo ships is about 35 years. A pushed convoy on the Danube has an average age of 20 years, with the exception of Serbia and Croatia, where the average age of vessel units is more than 25 years. The pushed convoys of Romania and in particular Ukraine are by far the largest and youngest on the Danube. In addition, engines of inland vessels have a longer lifespan in comparison to other modes. According to the IVR register 83% of the vessels is equipped with an engine built before the year 2003 and therefore, has no limits with respect to emission characteristics. CCNR norms on emissions apply since 2003 (CCNR-I) for new engines, while in road freight transport emission restrictions have been in force since 1992 (Euro I) and Euro VI will be in force from 2014. Directive 2004/26/EC established emission restrictions for new engines for inland navigation vessels in the European Union installed after 2007. Based on the long serviceable lifetime of inland vessels, these regulations currently leave the existing engines of the majority of older vessels, or legacy fleet, unaffected. As a result, there is a gap in the emission performance of average engines in IWT in comparison to road haulage.

3. Lack of incentives for vessel operators/owners to increase the environmental performance of the engines

Retrofitting a vessel causes significant additional investment costs without clear returns on investment for the vessel owner/operator. Lacking a system of

[1] This number does not include dumb or non-motorised barges
[2] Source: IVR database

internalisation of external costs, operators of greener and cleaner vessels are generally not rewarded in business economic terms. Whereas CO2 reduction strategies usually go hand in hand with the interests of IWT operators (accompanying fuel reduction), operators have little or no own financial interest to invest in after-treatment or end-of-pipe devices to reduce NOx or PM. On the contrary however, operational costs usually rise through the use of these technologies. There are also little or no incentives from shippers to operate more environmentally friendly vessels.

4. Small market for inland vessels
The relatively small and specific market for inland vessels causes disadvantages of scale. In the EU27 the number of companies involved in IWT does not exceed 10,000. Engine manufacturers prefer to concentrate their research and development activities on larger and potentially more profitable markets and need to take foreign standards into account (such as the US Environmental Protection Agency (US EPA)). The IWT sector lacks joint development and co-operation in the field of innovation and consequently fails to build up countervailing buying power for specific and cutting edge applications specifically developed for inland navigation.

2.4 Existing legal framework for addressing emissions

The first Union-wide compulsory emission limits for inland waterway vessels were introduced with the Directive 97/68/EC on non-road mobile machinery (NRMM Directive), which applies to new vessels as of 2004, whereas the first EURO I emission standards for road transport were introduced in 1992. The currently applicable Stage IIIA standards within this framework are now under revision. The Commission is preparing a proposal for a revision of Directive 97/68/EC, which should ultimately result in more stringent emission limits for new vessels.

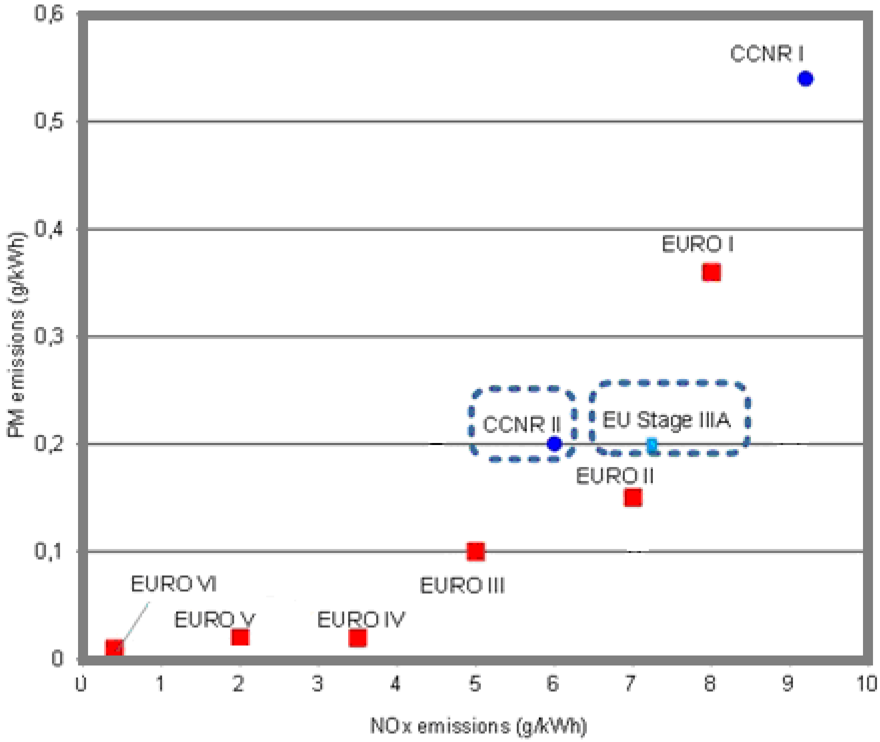
The quality of gasoil used in inland navigation is governed by Directive 2009/30/EC. The Directive stipulates amongst others, the maximum sulphur content and has implications for the pollutant emissions. Since January 2011, the fuel used in inland waterway transport also contains a maximum amount of sulphur of 10mg/kg fuel and therefore, has the same maximum sulphur content as fuel for road haulage, resulting in a strong reduction of the emission of SO2 (sulphur dioxide). As a result, as demonstrated in the BAU analysis of this report, SO2 emissions are no longer a real issue for IWT.

With respect to the emissions of CO2 and other greenhouse gases, there are no explicit or specific regulations for the inland shipping sector.

Emission limits under the NRMM regime are different for different engine classes. The above emission limits are given for a standard engine, a Type 8V 4000 M60 with a cylinder capacity of about four cubic decimetres per cylinder and an engine-output between 660 and 3300kW. The currently effective regulations (EU Stage IIIA and CCNR II for IWT, EURO V for road transport) are marked by the blue boxes with dotted lines (see Figure 2.2).

The EURO VI standard will come into force on the 1st of September 2014 for the approval of vehicles and from the 1st of January 2015 for the registration and sale of new types of road vehicles. The new emission limits resulting from the ongoing revision of the NRMM Directive will in any case apply only to new engines. If emission limits as considered in the Arcadis study were introduced, emission factors for EURO VI trucks would still be lower than those of inland barge engines.

Figure 2.2 Current emission standards for road transport and IWT: NOx/PM



Source: PLATINA, 2012

Only engines using gasoil are currently allowed, according to the technical requirements for inland navigation vessels. There is also no type approval procedure for engines other than those running on gasoil. However, CCNR is currently granting exemptions for engines using LNG on a limited trial basis and the development is foreseen for regulations allowing LNG fuelled engines on inland navigation vessels.

2.5 Who is affected and how?

Major stakeholder groups affected include the general population, the IWT industry (ship owners as well as skippers), the engine and equipment manufacturing industry, the shipbuilding industry, the fuel production industry, authorities managing infrastructure, ports, cities and communities. Indirectly, the initiative could possibly affect the freight forwarding industry and customers.

- The EU population is increasingly affected by the emission of substances that are harmful to human health, in particular, NO_x and PM.
- Inland shipping companies, individual skippers and employed personnel: a facilitating policy framework and a business-friendly climate with adequate capitalisation mechanisms to attract new entrepreneurs and invest in an eco-innovative fleet will have impacts on the competitiveness of operators that are directly involved in inland waterway transport.
- Shipowners as well as skippers are also affected by increases in the price of vessel engines and equipment as well as increased running costs. For a particular category of vessels, running costs may also decrease due to fuel savings.
- Engine manufacturers will be affected by the obligation to reduce emissions and will have to introduce measures to reduce emissions. In the short-term this could result in increased R&D and production costs. However, the demand for low-emission engines is increasing throughout the world and as other countries introduce their standards, the increased costs may be distributed over more markets. In other cases, manufacturers may have an opportunity to gain first mover advantage and the potential to sell low-emission engines in other markets.
- Equipment manufacturers are expected to benefit from the higher demand for their products. The engine manufacturers will benefit from the possibility to export their technology to other markets.
- Shipbuilding industry will benefit from new building and/or an impulse in the retrofit of vessels.
- Fuel production industry will be affected in case of measures that influence fuel consumption. Fuel demand will decline in case of measures that save on fuel.
- In addition, a policy to promote inland navigation and to address the identified problems and their drivers requires the active involvement of administrations at European level, at Member State level and at the level of River Commissions.
- Ports, cities and communities depend on a combination of energy-efficient and congestion-free transport solutions to secure an effective supply of goods without creating additional nuisances. Targeted measures to promote inland waterways which cross many European cities and towns help to create better mobility and accessibility combined with lower negative externalities caused by harmful substances and carbon emissions, in case of measures that also save fuel.

3 Methodology and assumptions

3.1 Calculating external effects and their costs of emissions to air

The emissions and the related external costs produced by the inland waterway transportation (IWT) sector depend on different parameters. For example: the type and volume of goods carried, the transport distance, the vessel type and loading capacity, loading factor, loaded kilometre factor, transportation speed, the specific energy consumption and emission profile of the engine used and the region where the vessel sails.

The environmental impacts of IWT concern in particular, the climate change emission CO_2 and the air pollutants NO_x and PM. The Council Directive 1999/32/EC aimed to bring the sulphur content down to 1000 parts per million (ppm). The air pollutant emission SO2 has been further reduced since the introduction of low sulphur fuel to a maximum of 10 ppm in the IWT sector as of the 1st of January 2011 (Directive 2009/30/EC). The environmental impacts of the air pollutant Non-Methane Volatile Organic Compounds (NMVOC) are also negligible[1]. However, in order to obtain a comprehensive representation of the external costs in the IWT sector, these have also been taken into account in the calculations. The impact is rather limited (0.6% of the average air pollution external costs).

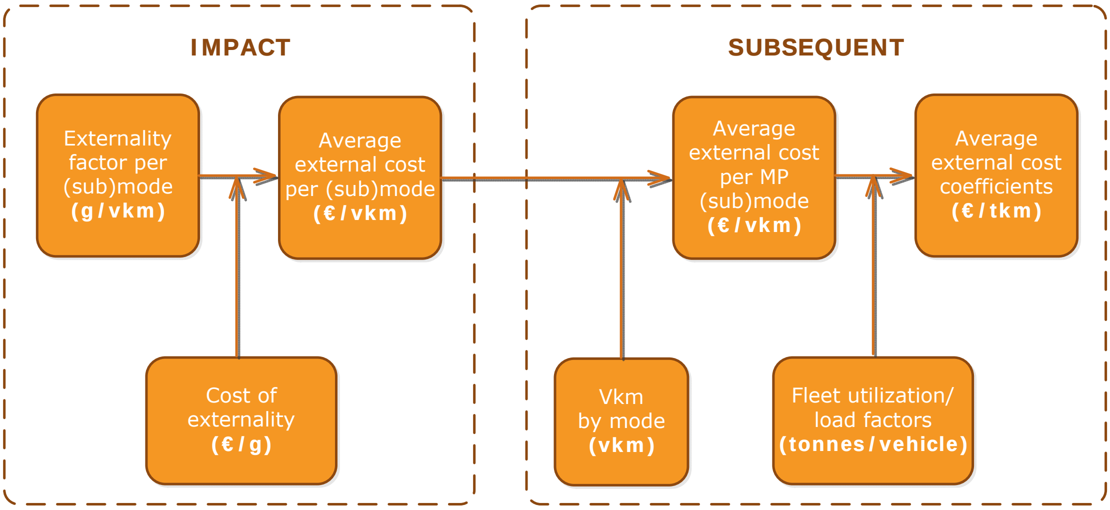
Each of the emissions presented above can be expressed in units, such as grams per vehicle kilometre (vkm) or grams per tonne kilometre (tkm). Nevertheless, each substance has a different impact on the human health and the ecosystem and therefore, is valued differently. In order to compare the impacts, these externalities need to be presented in monetary values. A common monetary unit makes it possible to compare results and use this information for the design of policy instruments for the transport sector.

The starting point for the calculations of the external costs for road transport and IWT are the official Marco Polo freight transport external cost coefficients, as reflected in the report and calculations provided by The European Commission Joint Research Centre (JRC)[2]. Figure 3.1 shows the main approach used for the calculation of the external cost in the Marco Polo calculator. The data on emissions provided by JRC are based on the cost of tank-to-wheel emissions.

The Marco Polo approach follows the methodology presented in the handbook on the estimation of external costs in the transport sector 'IMPACT' (2008)[3]. The general approach of the IMPACT handbook consists of the calculation of the *emissions factors* and its multiplication by the *unit costs per externality*.

[1] Source: Handbook on estimation of external costs in the transport sector. Internalisation Measures and Policies for All external Cost of Transport (IMPACT). Version 1.1. Delft, CE, 2008.
[2] External cost calculator for Marco Polo freight transport project proposals (call 2012), JRC Martijn Brons, Panayotis Christidis, Report EUR 25455 EN
[3] Source: Handbook on estimation of external costs in the transport sector. Internalisation Measures and Policies for All external Cost of Transport (IMPACT). Version 1.1. Delft, CE, 2008.

Figure 3.1 General overview of the methodological approach for the calculation of external cost coefficients



Source: External cost calculator for Marco Polo (MP) freight transport project proposals (call 2012), JRC

The average *emission factors* of air pollutants and climate change per sub mode were derived by JRC from the TREMOVE model[1]. The *unit costs per externality* have been obtained from two studies:

- The IMPACT (2008) study for the external costs of *air pollutants*.
  These unit costs are expressed in year 2000 prices (see Annex 3). The values have been updated to year 2011 prices, based on the GDP growth between 2000 and 2011 (adjusted for inflation and willingness-to-pay)[2].

- A study by Kuik et al. (2009)[3] for the external costs of *climate change*.
  The study by Kuik et al. presents the (avoidance) costs of climate change for policies that aim at the long-term. The study by Kuik et al. has been chosen, because the external costs presented here are more suitable for studies with policies that have a longer time horizon. The climate change costs are based entirely on the unit costs per tonne emission of CO2. The applied shadow price per tonne emission of CO2 is based on the medium value provided by Kuik (2009). Extrapolating the cost values from Kuik (2009) back to 2011 prices, results in a medium value of € 86.60 per tonne of CO2 for the year 2011 (for more information, see Annex 3).

[1] TREMOVE is a transport and emissions simulation model that estimates the transport demand, modal split, vehicle fleets, emissions of air pollutants and the welfare level under different policy scenarios. For detailed information refer to TREMOVE 2006.

[2] The update has been carried out at the member state level based on the annual average rate of change in Harmonized Indices of Consumer Prices (Eurostat). In addition, a correction at the member state level has been applied to account for the impact of changes in real GDP per capita (Eurostat) on the relative valuation of externalities compared to that of other goods. This correction is based on the assumption that the elasticity of willingness-to-pay with respect to real GDP per capita is equal to one for all external cost categories.

[3] Marginal abatement costs of greenhouse gas emissions : A meta-analysis. O. Kuik, L. Brander, R.S.J. Tol, 2009. Energy Policy, vol. 37, Iss. 4 (2009); p. 1395-1403).

The approach mentioned above was applied to both road transport and IWT.
For road transport the external costs of the largest trucks and heavy goods category has been chosen, as these usually compete with inland shipping (>32 tonnes truck, travelling mostly on motorways and with an average load factor of 11.7 tonnes). Please note that for road haulage there are also other external cost categories which are significant. These are the costs that are related to noise, accidents and congestion.

In order to take the operational differences and engine characteristics into account, a distinction was made between various IWT vessel types. Broadly, three vessel categories have been discerned, according to three length class groups of vessels:

- ≤ 55 metre length
- Between 55 and 110 metre length
- ≥ 110 metre length

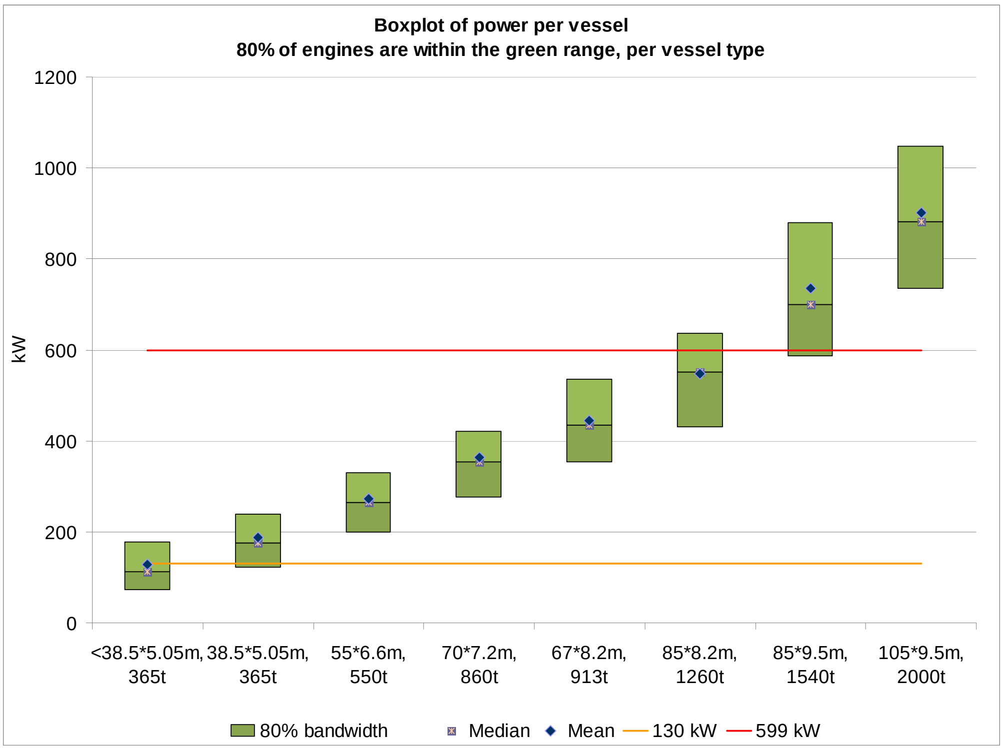
These three different vessel categories form aggregates of a more differentiated set of vessel types. Model calculations were performed, based on a selection of representative vessel types from this set. Table 3.1 shows this selection (length x beam in metres, load capacity). Vessel types that were not selected, were included afterwards by scaling up the calculation results.

Table 3.1 Types of vessels selected

Cat. ≤ 55 m	*Cat. between 55 and 110 m*	*Cat. ≥ 110 m*
• 38.5x5.05 (365 t.) • 55x6.6 (550 t.)	• 70x7.2 (860 t.) • 67x8.2 (913 t.) • 85x8.2 (1260 t.) • 85x9.5 (1540 t.)	• 110x11.4 (2750 t.) • 135x14.2 (5600 t.) • 2 barges, 1 pusher (4600 t., 1000-2000 kW) • 4 barges, 1 pusher (9200 t., > 2000 kW)

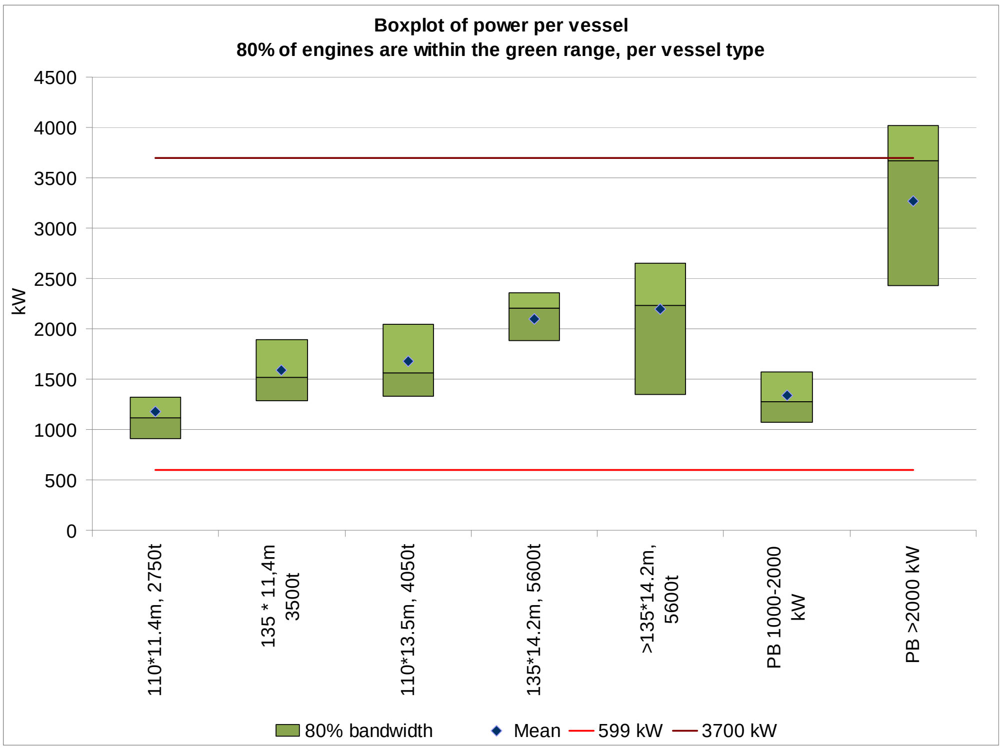
As legislation is primarily based on the net power of the propulsion engines the relation between the type of vessels and the size of the installed power of the engines also needs to be clear. This relation has been shown for all vessel types in Figures 3.2 and 3.3. These figures present the bandwidth, mean and median of the propulsion power per vessel. Annex 4 contains an overview of the engine power for all vessel classes discerned. Moreover, it must be noted that within some vessel classes it is common to use multiple engines for the propulsion, i.e. for 135 metre large motor vessels and for large push boats. Therefore, Annex 5 also provides more details on the engine power per vessel per propulsion engine.

Figure 3.2 Propulsion power per vessel, small and medium vessels



Source: IVR database

Figure 3.3 Box plot of propulsion power per vessel, large vessels



Source: IVR database

A weighted average based on the market segment (dry cargo, liquid cargo or push barge) and an estimation of the tkm performance in EU-27 has been calculated using the external costs estimated for each type of IWT vessel. The Table 3.2 presents the weighted average external costs (in $euro_{2011}$/tonne) for EU-27 for the emissions to air. These are divided into the costs for climate change and the air pollutant.

Table 3.2 Weighted average external costs for the emissions to air (in $Euro_{2011}$ / 1,000 tkm) for EU-27

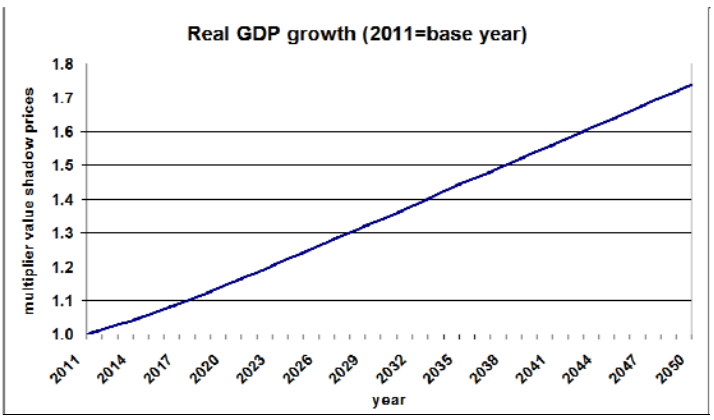
2011	Climate change costs	Air pollution costs	Total external costs of emissions to air
Road	€ 6.95	€ 7.00	€ 13.95
IWT	€ 3.06	€ 10.47	€ 13.53

The weighted average air pollution costs in EU-27 for IWT is divided as follows:

- NOx: 65.5%
- PM: 33.9%
- SO2: 0.0%
- NMVOC: 0.6%

The external costs for CO2, NOx and PM are calculated for future years. The shadow prices are estimated based on the expected long-term Real GDP development per capita in the European Union. In order to estimate expected external costs up until the year 2050 (shadow prices for emissions), an index on GDP development was derived from Prognos (2010)[1] that provided a forecast up until 2035. The trend between 2020 and 2035 was extrapolated in order to make a quantitative assessment for the remaining period (2035-2050). The real GDP per capita is thereby, assumed to develop as displayed below in Figure 3.4.

Figure 3.4 Real GDP growth per capita



Source: Prognos World report 2010, Industrial Countries 1995-2035, Facts, figures, forecasts

[1] Prognos World report 2010, Industrial Countries 1995-2035, Facts, figures, forecasts

3.2 Modelling the evolution of the fleet and fleet engines

Over time, the external effects depend on the development of the fleet. To determine these effects it is necessary to model how the fleet evolves. For various policy options, including BAU, the impacts can then be calculated. Simulation results for the BAU option will be shown. The fleets/engine renewal model has been set up for vessels carrying freight. Lastly, the contribution of the external effects caused by passenger vessels will be discussed.

3.2.1 Input data

The actual performance of inland vessels is not precisely known, since precise and comprehensive data on the engine composition of the fleet is not registered at European level. Furthermore, actual emission profiles depend on a large variety of operational characteristics (flow velocity, cruising speed, travel direction, etc.).

An issue at the start of the research work for this study was the general lack of reliable and complete data on IWT engines, their lifetime and emission profiles. Therefore, based on the available data sets (notably the IVR database 2012), Panteia/NEA developed a dedicated fleet/engine renewal and emission model, which allowed estimates on engine renewal rates and the evolution of emission levels between 2012 and 2050. Table 3.3 shows some characteristics of the IVR database.

Table 3.3 Characteristics of the IVR database

IVR database	*Number*
Total number of vessels (all vessels, barges included)	20,884
Motor vessels, push and tug boats and passenger ships (excluding barges)	14,803
Motor vessels, push and tug boats (excluding passenger vessels)	11,459
Freight motor vessels only (excluding push boats, tug boats and passenger vessels)	10,136
Size of average propulsion engine in freight vessels	555 kW
Size of average propulsion engine in freight motor vessels only (excluding push boats, tug boats and passenger vessels)	473 kW

The data was based on the IVR database and adjusted in 2012 based on interviews with ship owners and by means of consistency checks with fleet registers from the Netherlands. In depth analyses by Panteia/NEA on the IVR database and additional consistency checks with ship owners and engine manufacturers, led to a further approximation of the business as usual scenario for IWT. This was done in order to produce a clear reference option that would allow comparison of further policy options. These analyses have produced the BAU scenario for the development of the emission profile of IWT between 2011 and 2050.

Based on the methodology described in section 3.1, the weighted average values were calculated for EU27 and for 10 typical vessel types. These vessel types were categorised and the number of vessels was checked against a database containing the

European inland fleet[1]. Subsequently, these vessels were approximated using a scale factor on the existing vessel types of the IVR database in order to make an assessment of the emission performance and the related external costs for the active cargo vessels in the European Union.

Therefore, the fleet/engine renewal model contains 10 different representative vessel types, as shown in Table 3.4.

Table 3.4 Vessel types in vessel / engine renewal model

CEMT class	Beam (m)	Length (m)	Draught (m)	Load capacity (t)	Average installed propulsion Power (kW)
I	5.05	38.5	2.5	251-400	189
II	6.6	50-55	2.6	401-650	274
III	7.2	55-70	2.6	651-800	363
III	8.2	67-73	2.7	801-1050	447
III	8.2	80-85	2.7	1051-1250	547
IV	9.5	80-85	2.9	1251-1750	737
V	11.4	110	3.5	2051-3300	1178
VI	14.2	135	4.0	4301-5600	2097
V/VI	11.4/22.8	170-190/95-145	3.5-4.0	3951-7050	1331
VI	22.8	185-195	3.5-4.0	7051-12000	3264

Input data from PLATINA[2] was used with regards to the evolution of road transport emissions. It was thereby, assumed that EURO VI standards will be fully implemented in road transport by the year 2030 and that there are no further improvements on the emissions of road haulage beyond EURO VI.

For each type of vessel the following characteristics have been specified:

- Age structure of hulls
- Age structure of engines
- Structure of type of engines (low, medium and high rpm)
- Engine power (kW)
- Number of engines

3.2.2 Assumptions

In setting up the vessel/engine model, the following assumptions have been used.

Assumptions on engine hours

Depending on the type of vessel an estimate was made on the average engine hours per year. Small vessels operate fewer hours per year and therefore, the engines have a longer total lifetime. Larger vessels that operate in semi-continuous or full continuous (24/7) operation have a high amount of engines hours and therefore,

[1] Data on European fleet is based on the IVR 2012 database, which was verified and adjusted based on comparison with other publications and checks with Dutch ship owners.

[2] The estimation for the evolution of road transport comes from the PLATINA study (SWP 6.4) and was carried out by CE Delft in August 2012.

engines are reconditioned or replaced much sooner. Moreover, the modern engines have a shorter lifetime than the older engines. Reconditioning occurs more frequently for older (low RPM) engines.

Assumptions on scale increase and engine renewal rates

For the business as usual scenario the renewal rate of engines is determined by a statistic function that, based on the engine hours of engines in a year, calculates the probability that an engine will be renewed in a subsequent year. This is done for each type of vessel for the period 2012-2050.

The trend towards scale increase (increasing average size of vessels) was separately taken into account. The model takes into account that smaller vessels with older engines are being scrapped[1] and new buildings of larger vessels with new engines will be entering the market. Specifically, the BAU scenario takes the following into account:

- Access regime by the port of Rotterdam as of 2025: only NRMM Stage IIIA engines are allowed;
- Scrapping of all single hull tankers in the period between 2012 and 2019 due to ADR regulations;
- Dutch Green Deal Initiative: 50 LNG vessels deployed in the Netherlands by 2015, largest vessel classes (110/135 metre motor vessels, push barges);
- Increase of transport flows according to medium baseline scenario[2];
- Low renewal rates on short term as a result of postponed investments for new engines and new vessels to 2018. (see Figure 3.5).

It was therefore, assumed that in the BAU scenario, without additional regulatory or economic incentives, the large majority of engines will be replaced by conventional diesel engines which meet the NRMM Stage IIIA or CCNR 2 emission standards.

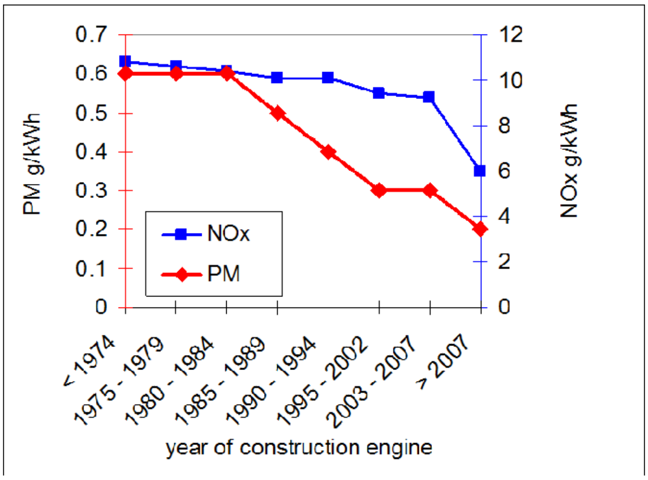
Assumptions on emission profiles

The emission profile may depend on the year of construction of an engine. Therefore, based on the number of engines in a certain construction year interval, the weighted average of the emission profile was determined for that interval. In particular the emission of NOx and Particulate Matter (PM) is relevant for external costs. The emission profiles[3] applied in the simulation model are presented in Figure 3.5.

[1] Newbuildings and engine renewal of smaller vessels are considered. However, these do not outweigh the number of scrapped vessels.
[2] Medium and Long Term Perspectives of IWT in the European Union, NEA et al, 2011
[3] Emission profiles for engines <1974-2003 were based on figures from report TNO 2010 Denier van der Gon, H., Hulskotte, J. Methodologies for estimating shipping emissions in the Netherlands. A documentation of currently used emission factors and related activity data. BOP Report, 2010

Figure 3.5 Relation between engine year of construction and emission profile

Year of construction of main engine	*NOx [g/kWh]*	*PM [g/kWh]*
<1974	10.8	0.6
1975-1979	10.6	0.6
1980-1984	10.4	0.6
1985-1989	10.1	0.5
1990-1994	10.1	0.4
1995-2002	9.4	0.3
2003-2007*	9.2	0.3
>2007*	6	0.2



** CCNR I from 2002, NRMM Stage IIIA / CCNR II from 2007*

3.2.3 Simulation results

Based on the above assumptions, the simulated development of the number of vessel types in the fleet/engine simulation model yield the following results (see Figure 3.6 and Table 3.5).

Figure 3.6 Evolution of the inland motorised fleet for freight transport

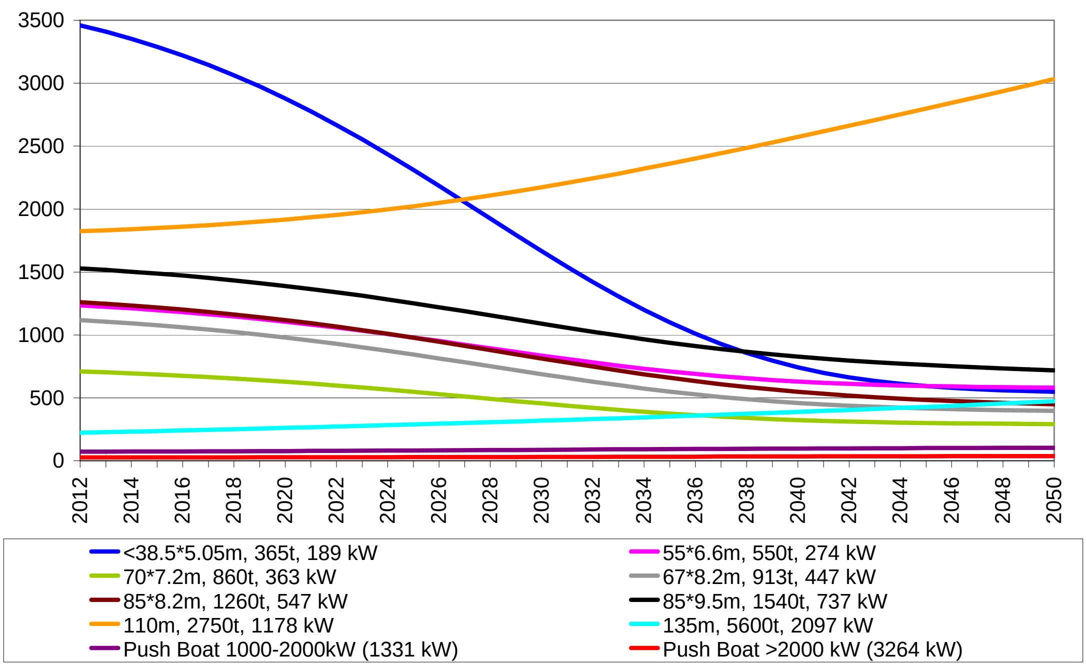
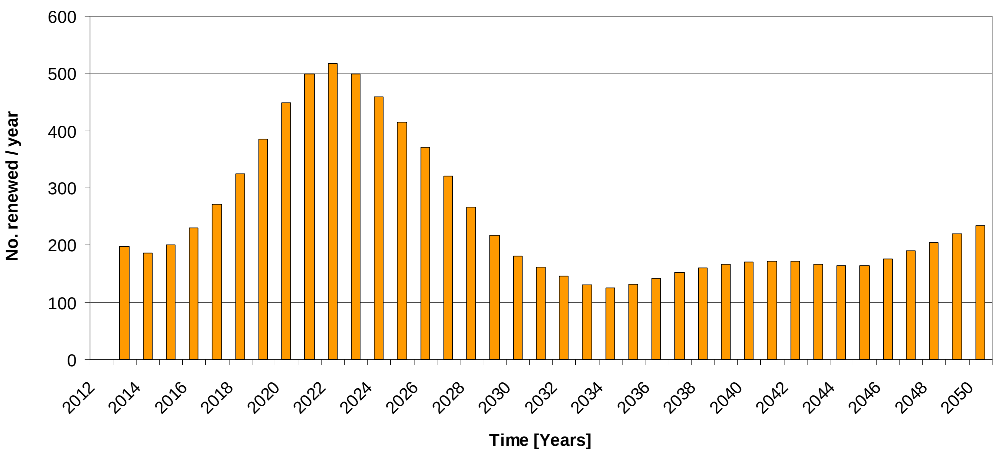


Table 3.5 Evolution of the inland vessel fleet for freight transport

CEMT	*I*	*II*	*III*	*III*	*III*	*IV*	*V*	*VI*	*V*	*VI*
Length (m) or Power (kW)	*≤38.5*	*55*	*70*	*67*	*85*	*85*	*110*	*135*	*Push boat 1000-2000 kW*	*Push boat ≥2000 kW*
Power (kW)	*189*	*274*	*363*	*447*	*547*	*737*	*1.178*	*2.097*	*1.331*	*3.264*
Length (m)	*≤38.5*	*55*	*70*	*67*	*85*	*85*	*110*	*135*		
Beam (m)	*5.05*	*6.6*	*7.2*	*8.2*	*8.2*	*9.5*				
Tonnage (t)	*365*	*550*	*860*	*913*	*1.260*	*1.540*	*2.750*	*5.600*		
2012	3.461	1.235	711	1.118	1.260	1.528	1.824	223	73	27
2030	1.666	836	456	689	814	1090	2.173	319	88	31
2050	548	581	292	397	450	719	3.033	474	104	38

The growth figures have been checked for consistency with historical growth per vessel type between 2002 and 2012, as well as with the expected increase of freight volumes according to the medium growth scenario. It was, for example, observed that the class of 110*11.4 metre vessels (1178 kW, 2750t) had a higher growth rate in the period 2002-2012 in comparison to the expected growth rate for 2012-2050. This difference is in line with the current market situation as it is expected that there will be an overcapacity of these vessels in the near future. Figure 3.6 clearly demonstrates that the smallest vessel categories show the sharpest decline between 2012 and 2050, whereas the larger vessel types are steadily growing. The estimated number of vessels with new engines in the BAU scenario (the sum of new buildings and replacements) is displayed below.

Figure 3.7 Renewal of engines – Totals per year



In Figure 3.7 the first peak reflects the effects of the aftermath of the economic crisis (postponed investments), as well as the need for a group of vessels to renew the engines in order to continue to gain access to the port of Rotterdam by the year 2025.

3.3 Number of ships to be adapted

The vessel/engine model was used to derive the number and type of freight vessels to be adapted. Table 3.6 shows a fleet overview in numbers for the year 2012, based on the break-down of freight vessel types in the model. Table 3.7 shows the number of new engines in the period from 2018-2050.

Table 3.6 Fleet overview in numbers, situation year 2012

Fleet category by motor vessel dimensions and/or kW installed	Number of vessels	Number of propulsion engines
<38.5*5.05m, 365t, 189 kW	3,461	3,535
55*6.6m, 550t, 274 kW	1,235	1,310
70*7.2m, 860t, 363 kW	711	770
67*8.2m, 913t, 447 kW	1,118	1,209
85*8.2m, 1260t, 547 kW	1,260	1,312
85*9.5m, 1540t, 737 kW	1,528	1,697
110m, 2750t, 1178 kW	1,824	2,087
135m, 5600t, 2097 kW	223	412
Push Boat 1000-2000kW (1331 kW)	73	137
Push Boat >2000 kW (3264 kW)	27	73
Total number in Europe	11,459	12,542

Table 3.7 Numbers of vessels with new engines installed from 2018 to 2050

Fleet category by motor vessel dimensions and/or kW installed net propulsion power	Engine replacement existing vessels	New vessels	Total number of vessels with new engines
<38.5*5.05m, 365t, 189 kW	220	198	418
55*6.6m, 550t, 274 kW	553	31	584
70*7.2m, 860t, 363 kW	271	19	290
67*8.2m, 913t, 447 kW	355	92	447
85*8.2m, 1260t, 547 kW	522	39	561
85*9.5m, 1540t, 737 kW	263	583	846
110m, 2750t, 1178 kW	3,164	1,199	4,363
135m, 5600t, 2097 kW	992	228	1,220
Push Boat 1000-2000kW (1331 kW)	178	28	206
Push Boat >2000 kW (3264 kW)	76	9	85
Total	6,594	2,426	9,020

Aside from the number of engines that need engine replacement, the existing vessels with existing engines are also relevant for this study. This study also takes a possible policy to bring the emissions down of existing vessels and their engines into account. As will be explained in Chapter 4, there are options that assume a gradual adaptation process in the period 2017-2026 for existing engines. In that respect, Table 3.8 shows the number of freight vessels that would need an obligatory retrofitting of the existing engines.

Table 3.8 Number of vessels in case of obligatory retrofitting from 2017 to 2026

Fleet category by motor vessel dimensions and/or kW installed net propulsion power	*Retrofit existing vessels (2017-2026)*
<38.5*5.05m, 365t, 189 kW	2,043
55*6.6m, 550t, 274 kW	614
70*7.2m, 860t, 363 kW	432
67*8.2m, 913t, 447 kW	423
85*8.2m, 1260t, 547 kW	408
85*9.5m, 1540t, 737 kW	493
110m, 2750t, 1178 kW	579
135m, 5600t, 2097 kW	48
Push Boat 1000-2000kW (1331 kW)	30
Push Boat >2000 kW (3264 kW)	12
Total	5,082

3.4 Business as Usual scenario

The impact assessment study compares policy options with the business as usual reference scenario in which no targeted policy measures are taken. The developments that are assumed in this business as usual (BAU) scenario can be summarised as follows.

With regards to general developments in IWT:
- Increase of transport flows according to the medium baseline scenario[1]
- Continued implementation of voluntary measures at the current level to promote fuel efficiency and emission reduction;
- Current situation in terms of emission standards (NRMM Stage IIIA and CCNR II);
- Access regime port of Rotterdam in 2025: only NRMM Stage IIIA engines will be allowed.

With regards to fleet specific developments:
- Scrapping of all single hull tankers within the period 2012-2019, as a result of ADR regulation;
- Dutch Green Deal Initiative: 50 LNG vessels deployed in the Netherlands by 2015, largest vessel classes (110/135 metre motor vessels, push barges);
- Low renewal rates on short-term as a result of postponed investments for new engines and new vessels to 2018 (see Figure 3.7).

Furthermore, it is assumed that in the BAU scenario, without additional regulatory or economic incentives, the large majority of engines will be replaced by conventional diesel engines that comply with the CCNR II standard.

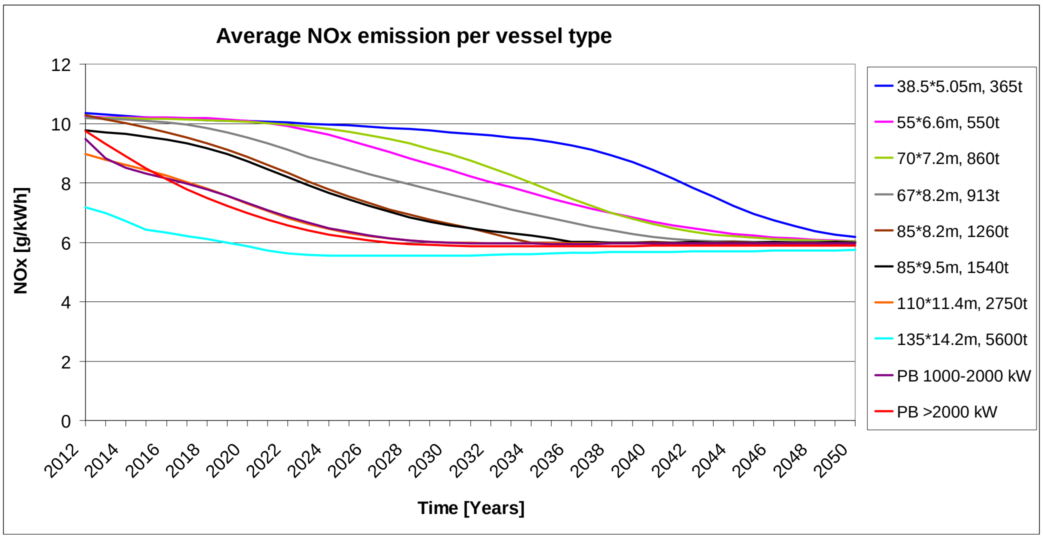
3.5 Evolution of emissions

With the assumptions on fleet/engine populations and their development over the years, as well as on their key emission characteristics, the evolution of the most

[1] Medium and Long Term Perspective of IWT in the European Union, NEA et al, 2011

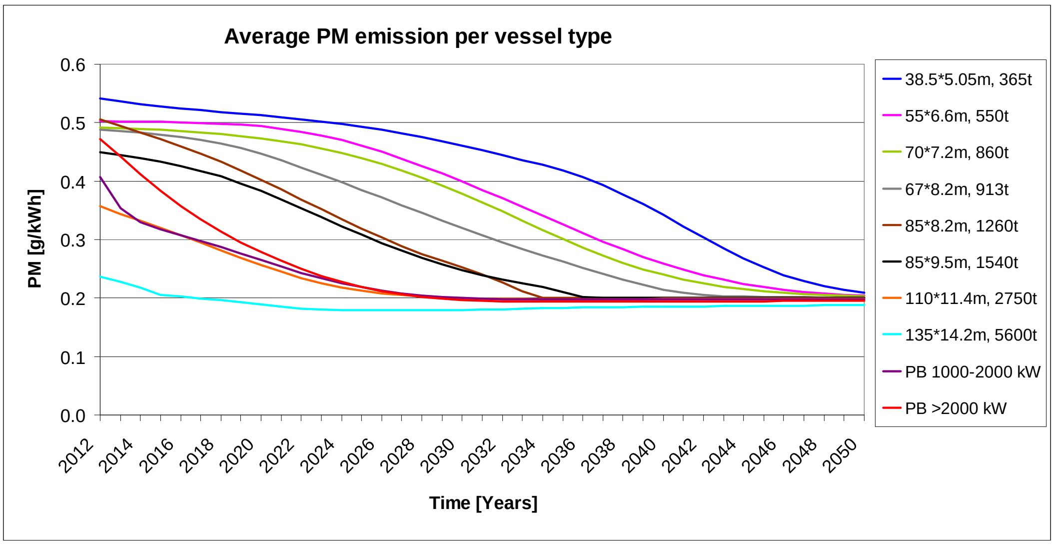
critical emissions for air quality (NOx and PM) was established. Results for the evolution of emissions are shown in Figure 3.8 for NOx and in Figure 3.9 for PM. Both the values of NOx and PM are expected to stabilise in the long run at the levels that are prescribed by the existing legal regime on emission standards for new engines. For NOx emissions, it was assumed that future engine deliveries would mainly consist of high RPM engines. From interviews held, it followed that this assumption is supported by engine manufacturers.

Figure 3.8 Evolution of NOx emission in BAU scenario



Using the expected emission levels as shown in Figures 3.8 and 3.9 and monetising them according to the earlier described methodology (see section 3.1); the BAU gap between road and inland waterway transport can be calculated for the external costs of air pollutant emissions. Aggregation to EU27 provides the average external costs for air pollutants in euro per 1000 tkm for an average vessel or heavy goods vehicle.

Figure 3.9 Evolution of PM emission in BAU scenario

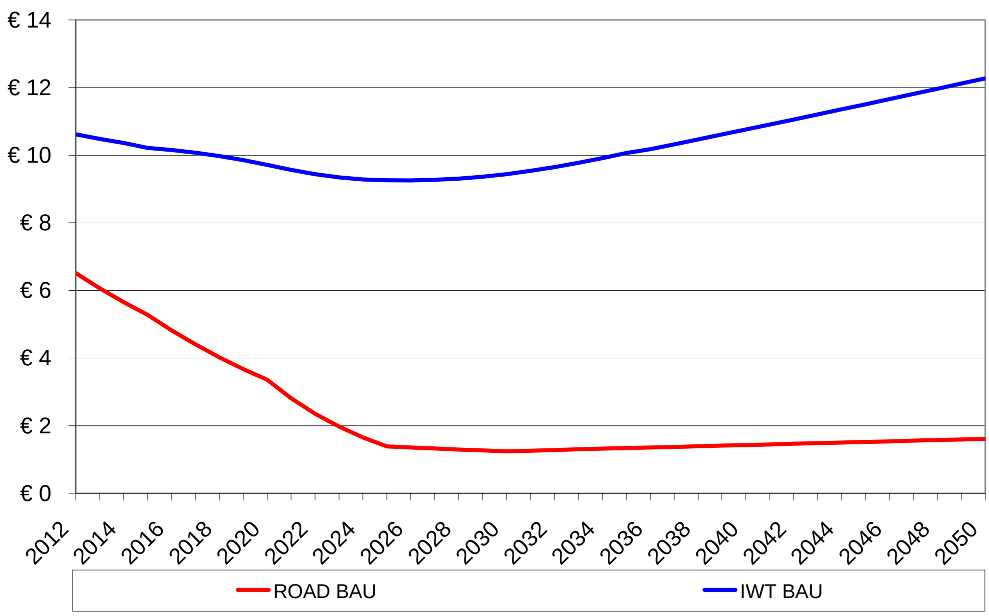


The present value for the year 2011 of the external costs of air pollutants for the period between 2012 and 2050 have been calculated by means of discounting[1]. The future environmental external costs depend on:

- The age structure of the engines and the fleet and the concerning emission factors:
  - For IWT: the average lifetime of both vessel and engine has been taken into account to make an estimation of the expected age structure for the engine for each vessel class and the renewal rate which is based on the type of engine (low, mid, high speed) and the number of sailing hours / engine hours per year.
  - For road transport: the introduction of Euro VI vehicles from 2013/14 onwards, (Reg. 595/2009) has been assumed. From the year 2030 onwards, only Euro VI trucks are expected to be present in the fleet.
- The real GDP development per capita per country in EU-27, based on the forecasted development of the real GDP per capita forecast in Prognos, 2010[2], see Figure 3.4.

The air pollutant costs for 2012-2050 are based on 2011 price levels. Figure 3.10 shows that air pollution costs for IWT are significantly higher than for road transport and this gap will only increase in absence of additional policy measures and is only partly compensated for by the higher energy-efficiency of IWT in comparison with road. Figure 3.10 shows the external costs of IWT main propulsion engines excluding the auxiliary engines. Consequently, the air pollutant emissions costs for IWT are in reality slightly higher than what is presented in the figure. Please note that the category of 'Air Pollution emission cost' excludes the CO2 emissions to air.

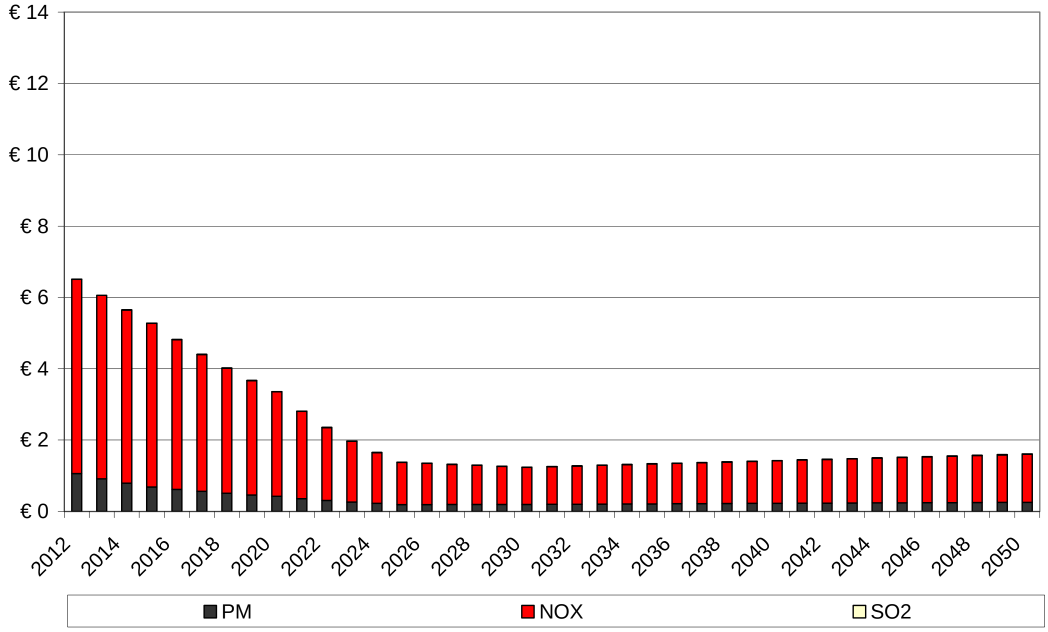
Figure 3.10 Air Pollution emission cost in euro/1000 tkm: business as usual scenario



[1] For more information on discounting and parameters used, see Chapter 5
[2] Prognos World report 2010, Industrial Countries 1995-2035, Facts, figures, forecasts

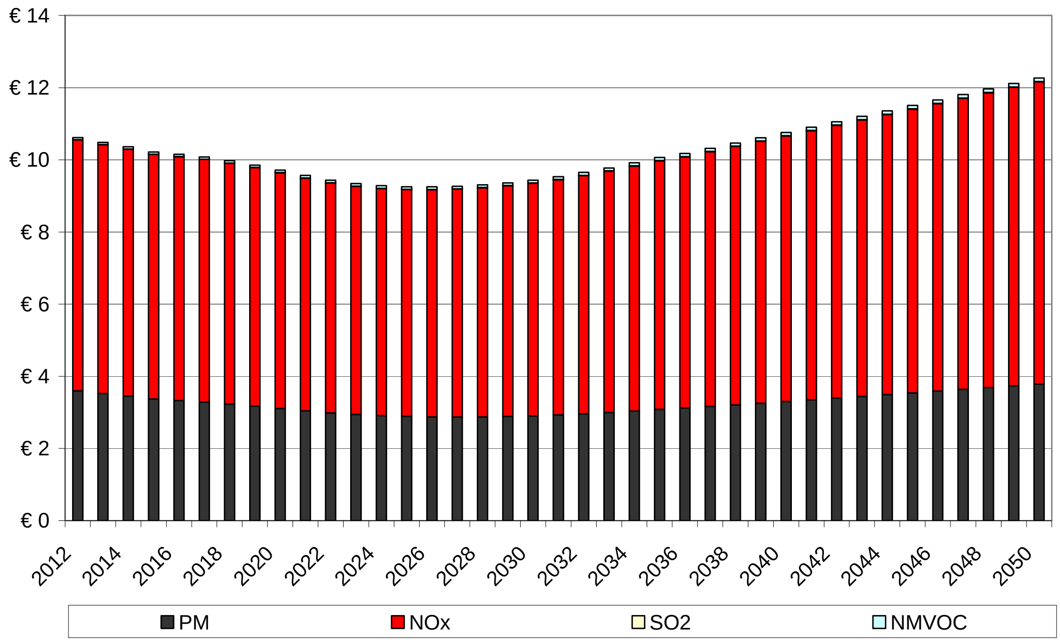
A breakdown of the air pollutant emissions of road transport shows that the emission of NOx and – to a lesser extent – PM have the largest share in the total external costs (see Figure 3.11).

Figure 3.11 BAU Road (in euro per 1000 tkm) EU27 average, breakdown of air pollutant emissions



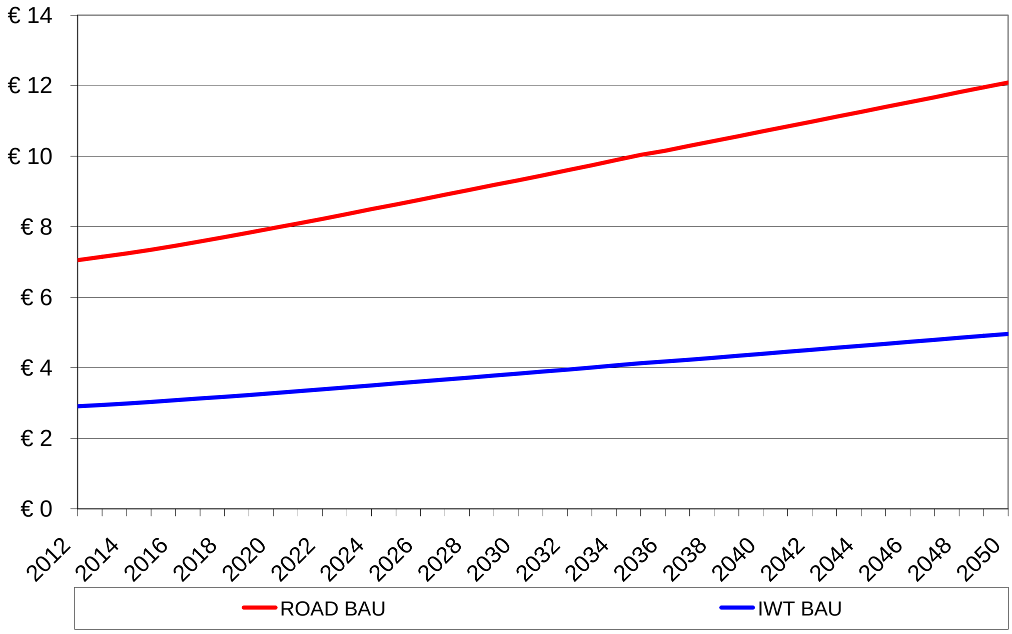
A breakdown of the air pollutant emissions of IWT makes clear that the most persistent problem of IWT is the emission of NOx and – to a smaller extent – PM. Emissions of SO2 and NMVOC are not an issue in the field of IWT (see Figure 3.12).

Figure 3.12 BAU IWT (in euro per 1000 tkm) EU27 average, breakdown of air pollutant emissions



Additionally, the Climate Change costs were calculated by way of the external costs for CO2. Figure 3.13 shows the development for freight transport by inland waterways and road.

Figure 3.13 Climate Change emission cost in euro/1000 tkm: business as usual scenario

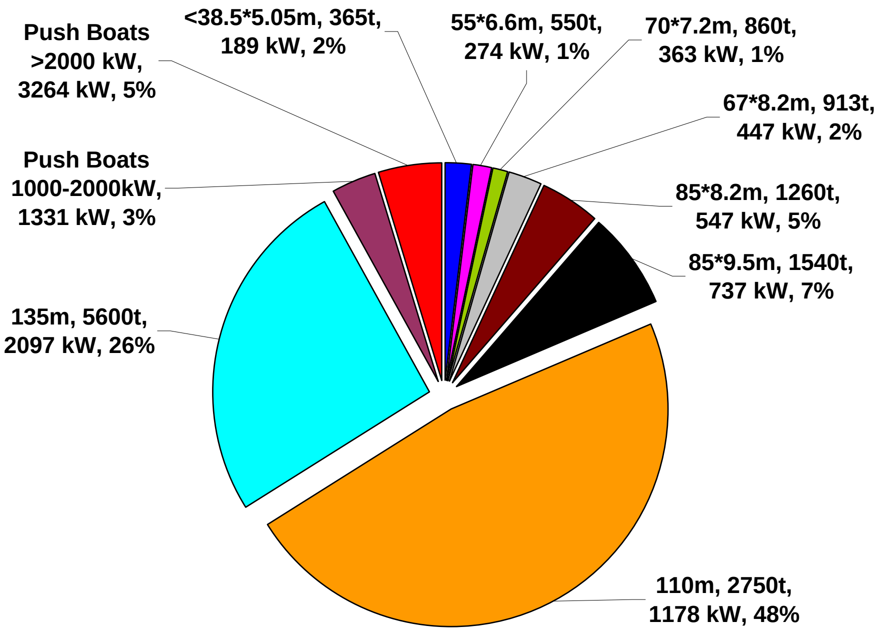


It can be concluded that inland waterway transport has a strong advantage on the climate change costs. The average emission of CO_2 per tonne kilometre is significantly lower and this situation will persist in the future.

A more detailed analysis was done in order to investigate the relative share of the various vessel types in the external costs of the emissions to air. Figure 3.14 shows the discounted external costs for the total of emissions to air: sum of the air pollutant costs (mainly NOx and PM) and climate change costs (CO2) in the period 2011-2050 by IWT, split by types of vessels in the business as usual scenario.

From the pie chart shown in Figure 3.15 it can be seen that vessels larger then 110 metres and push boats account for 82% of the external costs related to the emissions to air. Vessels up to 70 metres in length account for 6% of this part of the external costs.

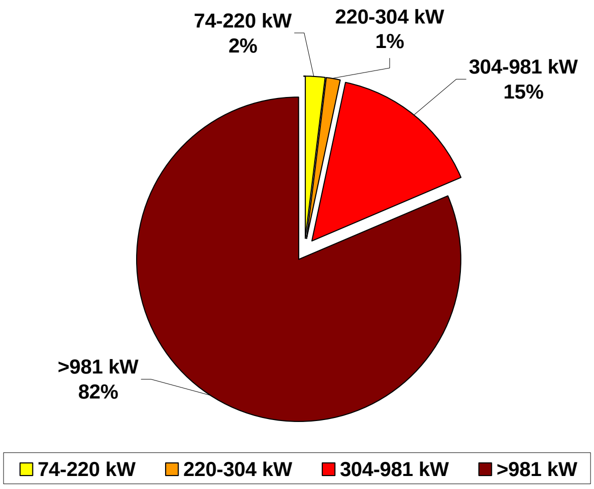
Figure 3.14 Discounted external costs in the period 2011-2050 by IWT, split by type of vessel in the business as usual scenario



A similar analysis has been done for the discounted external costs of emissions to air in the period 2011-2050 by IWT, split by the net installed power of propulsion engines per vessel. The pie chart in Figure 3.14 shows that the largest share of the external costs for emissions to air is caused by engines over 981 kW (82%). Engines below 304 kW have a share of only 3%.

Figure 3.15 Discounted external costs of emissions to air in the period 2011-2050 by IWT, split by net installed power of propulsion engines per vessel

Fleet category by motor vessel dimensions and/or kW installed	
38.5*5.05m, 365t	74-220 kW
55*6.6m, 550t	220-304 kW
70*7.2m, 860t	304-981 kW
67*8.2m, 913t	
85*8.2m, 1260t	
85*9.5m, 1540t	
110m, 2750t	> 981 kW
135m, 5600t	
Push Boat 1000-2000 kW	
Push Boat ≥2000 kW	



In summary, the analysis of the baseline scenario shows that – given the long lifetime of IWT engines and the limited applicability of the current legal regime on emissions to air – in IWT engines are currently being phased out relatively slowly in comparison to road transport. Therefore, emission levels for air pollutants are already exceeding those of road transport. The gap of air pollutant emissions between road transport and IWT will further widen between 2012 and 2050. This will lead to IWT losing its environmentally favourable position in comparison to road transport. The largest part of the external costs is caused by the emission of NOx and PM, which in turn are emitted by the largest vessel categories that have installed the largest propulsion engines and make relatively many sailing hours per year.

3.6 Inclusion of passenger vessels

From the IVR database it can be learned that passenger vessels amount to around 25% of the total fleet (excluding push barges). In broader lines, the data shows that passenger vessels would have a share of 8% to 9% in the total fuel consumption and external costs between 2012 and 2050 (excluding push barges). Passenger vessels most often operate seasonally and therefore, on average the annual operating hours are estimated to be sufficiently lower than cargo vessels. The fuel consumption of passenger vessels varies greatly, possibly more than cargo vessels. However, available data is rather weak for a proper impact assessment on the emission regulations. Technical and operational differences between passenger and cargo vessels demonstrate the need for a different approach to determine emissions and possible measures to reduce emissions.

Furthermore, it should be noted that emission reduction options that are feasible for cargo vessels may pose a problem for passenger vessels due to size, space or weight constraints. However, for passenger vessels, we assume that the same emission reduction options can be applied. In addition to these reduction options, daytrip vessels operating locally can make use of additional options: CNG or battery powered electric propulsion.

Table 3.9 Freight motor vessels and passenger vessels compared

	Freight motor vessels (push boats excluded)	*Passenger vessels*
No. IVR database 2012	10,136	3,344
Average construction year of engine	1981 1979 (dry cargo vessels) and 1987 (tankers)	1977
Average installed motor power per vessel	473 kW	497 kW
Estimated share in total fuel consumption IWT in period 2012 - 2050 (push boats excl.)	Between 90 – 91%	Between 8 – 9%

Table 3.9 shows a comparison of freight motor vessels and passenger vessels. In summary, the following can be concluded.

- Compared to freight, the numbers are significant, namely 25%.
- The average age of passenger vessels tends to be higher than in the case of cargo vessels. The average engine power is roughly the same.
- The installed engine power per cargo and passenger vessel is on average more or less the same, based on IVR fleet data analyses.
- The fuel consumption is about 8% to 9% of the total amount of fuel consumption by cargo and passenger vessels together.

The approach in which to make an estimate of the fuel consumption is a suitable way to estimate the impact of passenger vessels in terms of the output compared to the cargo vessels model. Passenger vessels are around 25% of total amount of vessels (push boats excluded), based on the IVR database. The estimations show that passenger vessels would have a share of 8% to 9% in the external costs between 2012 and 2050, with push barges being excluded.

Please note that the cost benefit calculations in this report (see Chapter 6) exclude costs and benefits for the passenger vessels. If one would make a cost benefit analyses for the passenger vessels the costs would be comparable based on the number of vessels. However the benefits would be smaller per vessel compared to freight vessels since the sailing hours are smaller compared to the freight vessels.

4 Policy Objective and Identification of Policy Options

In this chapter, the policy options for the impact assessment of the legal initiative are presented. A step-by-step approach has been applied to develop the policy options regarding more stringent future emission standards. A preliminary investigation was made on the issue of effectiveness, efficiency and technical feasibility. This preliminary investigation provided insight on the possible timing of the policy objective, as well as the need to focus on a revision of emission standards and the scope and the level of stringency regarding vessels and engine types (power range). Subsequently, policy options are derived that qualify for an in-depth analysis.

4.1 Preliminary analysis of policy objective, policy options and possible measures

An important aspect in formulating the policy options is the time horizon. The study started based on the policy objective formulated in the Staff Working Document 'Towards NAIADES II' with the objective to review the business as usual scenario and investigate options for achieving an overall performance regarding emissions levels for inland waterway transport that is better or at least comparable to the performance of road transport by **2020**.

However, preliminary analyses of various options showed that measures addressing the emission levels could be implemented from 2017 onwards. The preliminary analyses also made clear that the year **2030** would be the first instance that a break-even of IWT and road transport external costs of air pollutant emissions would become realistic. Therefore, the time horizon of 2020 as set out in the Staff Working Document 'Towards NAIADES II' for IWT to catch up with road in regards to air pollutant emissions, shifted to 2030, in order to provide a feasible horizon towards which policy options in the context of this study can be worked.

The policy objective for 2030 targetting the air pollutant emissions also fits well with the requested longer term framework for improvement of the environmental performance of the fleet, including innovative propulsion systems and in particular, with more stringent measures which are also applicable to the existing fleet[1].

This new time horizon is aligned with the target years of 2030 and 2050 for the main EC initiatives and programmes referred to in the White Paper 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system', including the revised TEN-T guidelines which set the target of 2030 for the completion of the TEN-T core network.

[1] See page 8/9 Commission staff working document, Towards 'NAIADES II', Promoting, greening and integrating inland waterway transport in the single EU, transport area, SWD(2012) 168 final, 31.5.2012

From September to December 2012, preliminary options were investigated. One of these preliminary options was to reinforce voluntary options by means of supporting measures at European level. Several possibilities for reinforcing these voluntary options were investigated and discussed with external experts and within the Common Expert Group. In particular the 'Smart Steaming' scheme that was implemented in the Netherlands was investigated and also the promotion of the use of 'econometers' was studied. Information is included in Annex 5 of this report.

The investigation showed that measures, aiming at reducing fuel consumption by promoting behavioural change within the IWT sector[1] are by far insufficient to bridge the external costs gap between IWT and road transport. Therefore, there is no significant impact to be expected in case the European Commission would take action to reinforce such voluntary measures. Given the difficult economic circumstances, the inland waterway transport operators already have a very strong own interest to save on fuel costs as much as possible. Only an insignificant part of the inland waterway transport operators would most likely be interested in such additional actions. Therefore, reinforcing actions to raise additional awareness on fuel consumption are not expected to provide significant reductions on emissions either. Furthermore, no convincing proof was found that was based on reliable data to determine the impact of current voluntary practices to save fuel.

Preliminary analyses therefore, made clear that imposing stricter emission standards is the only way to achieve the policy objective. For this reason, the selected policy measures focus on a revision of emission standards for vessel engines and in particular on setting maximum emission levels of NOx and PM in gram per kWh with the pollutants having the highest external costs.

[1] The Dutch programme 'Smart Steaming' and the application of econometers, voluntary or not, have been investigated. For a detailed description see Annex 5

4.2 Developing policy options focused on a revision of emission standards

Policy options that are focused on a revision of emission standards, are hereafter formulated and screened in order to select options for in-depth analyses. The approach that was followed has been illustrated in Figure 4.1.

Figure 4.1 Schematic overview of development of policy options

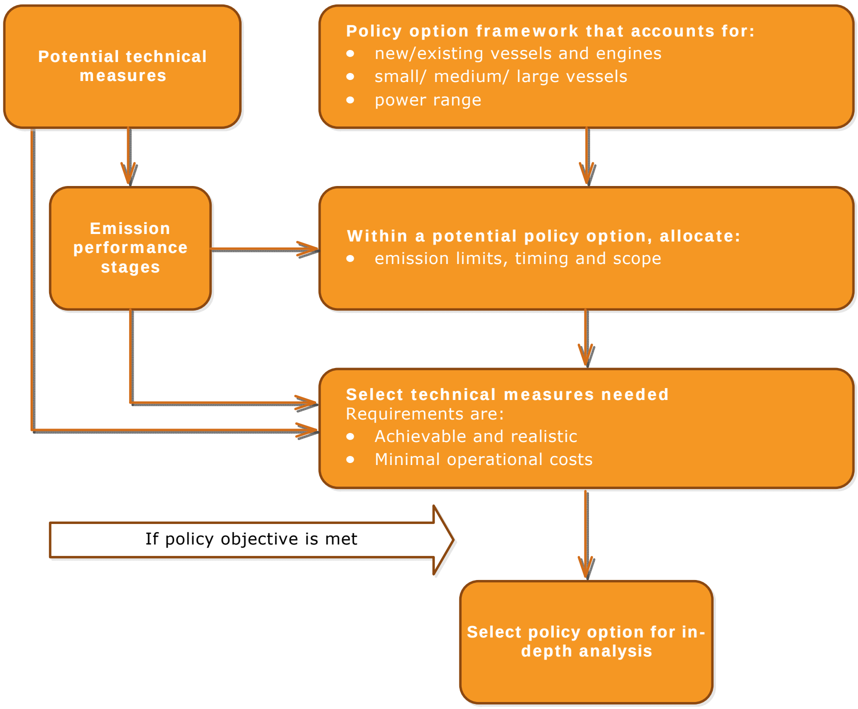


Figure 4.1 provides a schematic overview of all important input and steps in the development of policy options:

- Formulation of policy options in which different emission performance standards may be imposed on different types of vessels.
- Identification of the potential emission reduction of technical measures that are available in order to bring down emissions.
- Specification of emission performance stages that are related to available technical measures
- Allocation of emission performance standards and timing based on:
  - application of realistic and achievable techniques;
  - minimising the compliance costs for the IWT industry;
  - avoiding disturbance of the level playing field in the IWT sector.
- Screening of options regarding the compliance with the overall objective to be achieved by the year 2030 air pollutant cost equivalent to road or better. Final selection of options that will be assessed in-depth.

4.3 Formulating a general set-up for policy options

Within the IWT sector there is a wide range in vessel characteristics, as has been explained in Chapter 3. In this chapter policy options will be generated that address the following vessel/engine characteristics for freight transport:

- New and /or existing vessels/engines;
- Small, medium and large vessels/propulsion power ranges (as in Table 3.1).

It is important to be able to differentiate the emission performance standards and their timing for these catagories, as each of them are different in terms of numbers, feasibility of technical measures, business economic performance, market structure, etc. As a result of this, the policy options to be formulated will all show a similar structure that has been shown in table 4.1. For each engine power or vessel length category, emission level requirements are set, as well as the timing when the requirement should be in force.

Table 4.1 General structure of policy options (P = installed net propulsion power of the vessel in kW, L = length of the vessel that is most representative for the installed power)

		Option
New Engines		
75 ≤ P ≤ 220	L ≤ 38	Emission level requirement & timing
220 < P ≤ 304	38 < L ≤ 55	
304 < P < 600	55 < L ≤ 85 (85*8.2 m)	
600 ≤ P <981	85 ≤ L <110 (85*9.5 m)	
P ≥ 981	L ≥ 110	
Existing engines		
75 ≤ P ≤ 220	L ≤ 38	Emission level requirement & timing
220 < P ≤ 304	38 < L ≤ 55	
304 < P < 600	55 < L ≤ 85 (85*8.2 m)	
600 ≤ P <981	85 ≤ L <110 (85*9.5 m)	
P ≥ 981	L ≥ 110	

4.4 Technological options for reducing emissions

Technical measures will need to be taken in order to reduce the emissions. Based on the performance that is to be expected from these technical measures, emission stages are derived. In this study, the following mainstream technical measures have been taken into account.

- In particular to further reduce NOx: application of selective catalyst reduction (SCR) possibly combined with a diesel oxidation catalyst (DOC) to reduce also the HC and CO levels.

- In particular to further reduce PM: application of (diesel) particulate filters (DPF). This study takes the closed wall flow filters that have a high effectiveness and reliability into account.
- Engines running on liquefied natural gas: Dual Fuel LNG (DF LNG)[1].

Moreover, other possible solutions could be available, such as:
- Fuel-Water Emulsion (FWE);
- Methanol instead of LNG as fuel;
- Hydrogen fuel emulsification;
- Diesel electric configurations;
- Monofuel LNG application.

In the next sections of this report, a number of important issues regarding applicability of measures are dealt with. For more background information about technical solutions, see Annex 6.

4.4.1 Issues regarding applicability of SCR/DPF

The mainstream technology for adapting existing diesel engines to reach more strict emission standards is based on SCR and DPF. There are some constraints that need to be taken into account or that may require further technological development:

- The engine cannot be too polluting for the application of DPF, a maximum limit is 350 mg PM per kWh. Furthermore, the exhaust gas should not contain too much oil. This implies that the most 'dirty' engines would need to be replaced first or would need a FWE device to reduce the engine-out PM levels.
- Application of SCR/DPF increases the exhaust backpressure. For low RPM engines this may require the application of larger after-treatment systems or – if insufficient space is available – the replacement of the engine.
- On smaller vessels, available space may be a problem due to small engine rooms and small exhaust systems.
- The SCR and DPF usually require a volume of two or three times the volume of displacement of the engine. Since engine rooms and engines are in different configurations, the application of SCR and DPF for existing engines will often require a case-by-case / tailor made approach. First the condition of the base engine and engine room needs to be verified with respect to the restrictions described above. The engine-out emissions of PM may vary strongly, depending on engine type, size and maintenance and operation history of the engine. After mounting the retrofit devices, the effectiveness in terms of the reduction levels of the devices (-80%, -90%) needs to be verified. For unregulated engines, the emission levels at engine-out and also at the end of the exhaust system need to be measured and compared. This can also be done for regulated engines (e.g. CCNR 1, CCNR 2, Stage 3A) by means of a standard in terms of a limit value on the maximum emission to air in grams per kWh and will need to be verified based on the measurement at the end of the exhaust system.

[1] This measure accomplishes also a reduction in fuel consumption in addition to the lowering of NOx and PM emissions.

4.4.2 Issues regarding applicability of LNG

The criteria to choose a technical measure to achieve certain emission limits are different for new and existing vessels. The design of new vessels is based on optimisation of total lifetime. This means that the installation of LNG fuel facilities can be incorporated into in the vessel design without further complications. Preliminary calculations have shown that for all new vessels in the vessel class from 110 metre onwards and operating on Dual Fuel LNG, there are positive impacts for ship owners in terms of the operational costs, in addition to an increase in the performance regarding emissions.

The ability to make use of Dual Fuel LNG for existing ships is more complicated. Annex 10 clarifies for what type of existing large vessels a conversion or shift to LNG may be expected. In general, it can be concluded that the feasibility depends on the share of fuel costs in the overall operational costs, as well as the available space to place the LNG tank on board of the vessel. The level of fuel consumption is crucial here as this influences the payback time needed to recoup high investment costs.

Regarding the pay-back period, the IWT sector is expected to benefit from experience gained in the maritime sector and from favourable incentives and framework conditions established at EU level. Examples of this are financial instruments to promote access to financing for the significant investments needed to upgrade the fleet, deployment of bunkering facilities as envisaged by the EU clean fuel strategy, the development of the regulatory framework and standards regarding the application of LNG in IWT vessels. In view of these expected favourable conditions, a time horizon of 20 years is used in order to determine the compliance cost for the industry that is consistent with the expected economic lifetime of the investments. The selection of the technology is based on the lowest overall costs for the shipowner/operator over a time span of 20 years after the initial investment. In view of the expected increase in residual value of the LNG vessels over their entire lifetime and given the long-term operational savings perspective, this time-horizon is significantly expanded in comparison to other types of investments. Furthermore, the strong signal given by the European Commission through the recently adopted clean fuel strategy in favour of the deployment of LNG is expected to trigger policies that will have lasting favourable conditions for LNG uptake at various levels in Member States.

It is noted that the actual real life performance of Dual Fuel or Mono Fuel engines running on LNG is not yet known in IWT. The only real life data for application on IWT comes from the MTS Argonon however, the technology has not yet sufficiently matured to provide a solid basis to make final conclusions on the emission performance of Dual Fuel LNG engines applied in IWT. However, experience from applying LNG on maritime ships leaves sufficient confidence that in IWT similar emission reduction levels are also within reach.

In maritime transport the most widely used marine fuel is heavy fuel oil and marine diesel oil. However, the use of LNG has recently gained more attention. Three key drivers for expanding the use of LNG as a marine fuel are[1]:

- The reduction of sulphur oxide (SOx) emissions by 90-95% in order to comply with the emission limits that are being implemented in coastal areas known as Emission Control Areas (ECAs) by 2015. A similar reduction will be enforced for worldwide shipping by 2020.
- The reduction of 20-25% of CO2 emissions.
- The current low LNG prices in Europe and the USA compared to traditional fuel types.

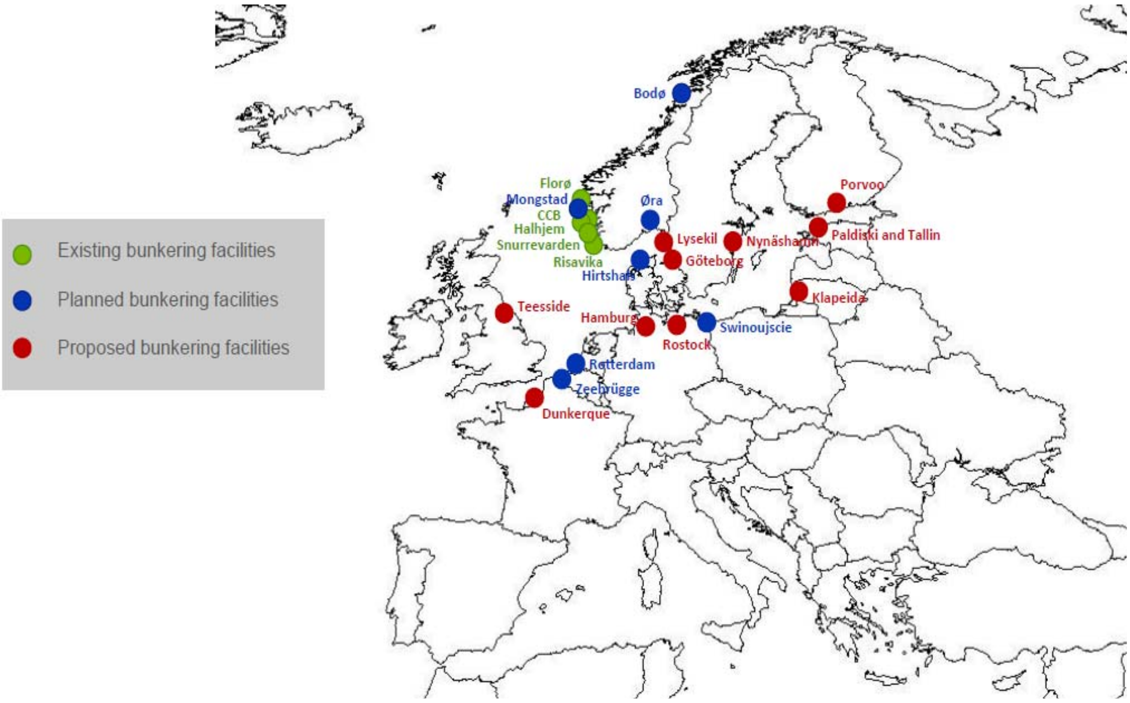
In 2012, a total of 30 LNG fuelled maritime ships were in operation on a worldwide scale[2]. Furthermore, there are around 32 confirmed orders for LNG newbuildings. These are mainly car or passenger ferries and platform supply vessels (PSV).

Most of the LNG fuelled ships are operating in Norway. This is mainly due to the lack of infrastructure bunkering facilities that are available elsewhere (see Figure 4.2). This is also one of the main barriers for the further development of LNG as a maritime fuel. Det Norske Veritas (DNV) carried out a market forecast on the expected LNG shipping situation in 2020. By this year a total of 1.000 LNG fuelled ships are expected (see Figure 4.3).

[1] Source: Costs and Benefits of LNG as Ship Fuel for Container Vessels, GL and MAN Diesel & Turbo (2011).

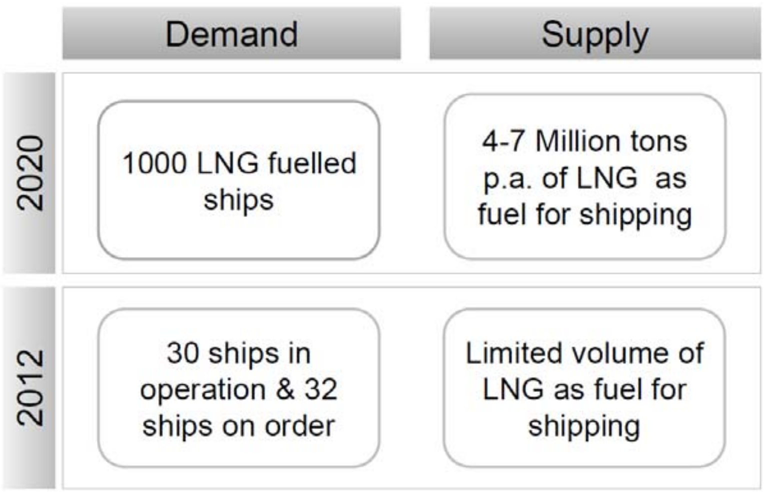
[2] Source: 'What are the market options for LNG and what can The Netherlands learn from the Norwegian safety requirements?'. Presentation by DNV (M. Bekaert) at the LNG seminar Rotterdam (January 2013).

Figure 4.2 The European LNG bunkering grid



Source: 'What are the market options for LNG and what can The Netherlands learn from the Norwegian safety requirements?'. Presentation by DNV (M. Bekaert) at the LNG seminar Rotterdam (January 2013).

Figure 4.3 LNG forecast based on DNV shipping 2020 study



Source: 'What are the market options for LNG and what can The Netherlands learn from the Norwegian safety requirements?'. Presentation by DNV (M. Bekaert) at the LNG seminar Rotterdam (January 2013).

In addition, around 20 to 25 plans are currently known for new vessels in inland waterway transport on LNG, including several vessels running monofuel LNG with gas-electric configuration.

With regards to the payback time, the tanker vessels have a high number of operational hours and consume a lot of fuel. Safety regulations and the placing of the LNG fuel tank are more straightforward, since vessels and crew are already adapted/trained to cope with dangerous goods. Dry cargo vessels accumulate on average less operational hours and have a lower fuel consumption in comparison to tankers, although there are exceptions (e.g. container vessels operating on the Rhine). The fuel tank will have to be placed at the cost of loss of some of the payload. The level of fuel consumption here is also crucial. However, the analyses have made clear that LNG provides the technology that gives the lowest compliance costs for the ship owner over a time period of 20 years. In several cases it can even provide cost reductions when compared to the business as usual scenario. It is therefore, expected that existing motor vessels will convert to LNG.

Push boats also have a high number of operational hours and have a high fuel consumption, however, existing push boats do not have room to place an LNG tank. Therefore, it is assumed that existing push boats can not be adapted to LNG. The key problem here is to find space for the fuel tank as for reasons of stability it has to be placed in the gravitational centre of the vessel where the engine room is already situated. The only solution therefore, is to replace existing (large) push boats with new push boats designed to run on LNG. The analyses have made clear that this can be expected for the largest class of push boats, thus taking the additional costs into account for writing off the existing push boats. The smaller category push boats (1000-2000 kW) is however expected to remain operating with diesel engines. Based on the above, it can be concluded that for the majority of vessels, LNG can be applied while for some existing vessel categories (i.e. smaller push boats) a diesel engine capable to reach the new emission standards is the better solution, due to the physical inability to apply LNG (lack of space, safety regulations, stability of the vessel).

Another technical issue is the impact of methane (CH_4) slip. As a result, an emission limit needs to be in place to prevent an increase of the climate change impact as a result of methane emissions. The current vessel MTS Argonon running on DF LNG has a methane slip catalyst on board in order to eliminate this problem. There are however, questions on the durability of such devices. The need to renew these devices can be considered a cost issue. Costs have been taken into account in the marginal costs estimation for Dual Fuel LNG compared to the business as usual situation for the methane slip catalyst.

Moreover, the legal framework for LNG would need further development. This requires some lead time for standardisation authorities which need to take experience from pilot projects with vessels running on LNG in different configurations into account.

Lastly, LNG vessels need bunkering stations in order to organise refuelling. A high density of bunkering points could have the benefit that the LNG fuel tank could be made smaller. Problems with the availability of space on board vessels could then be reduced. In this context, the recent adoption of a Commission proposal on the deployment of alternative fuels infrastructure is a major step forward.

4.4.3 Issues regarding applicability of Stage 5 diesel engine

In the previous section it was pointed out that the use of LNG may be very difficult for a number of the existing large vessels and an alternative would be needed, based on a diesel engine that could reach the same emission performance. It was concluded that a 'Stage 5' performance is feasible after a review of the performance of LNG dual fuel combined with SCR and DPF. This Stage 5 performance shows similarities with the Euro VI emission limits applied in Heavy Duty Vehicles on the road that will be in force from the year 2014 onwards (0.4 gram NOx and 10 mg PM per kWh).

In order to be able to set standards on the performance that can be expected with a large part of the fleet running on LNG, it is necessary to also develop an engine reaching stage 5 based on diesel fuel. We note that this stage 5 diesel engine is not yet being developed. Members of Euromot state that they as of yet do not have plans to develop such an engine and that it is unclear if it will be possible to develop a stage 5 diesel engine.

There is a risk that the engine manufacturers may leave the market if they would have to invest in R&D programmes for developing stage 5 engines in applications with the expected sales volume being relatively small. Therefore, alignment with other larger markets, such as the USA would require the EU to engage in discussions with the USA and Japan on emission standards for the longer term. As the USA has not yet engaged on preparatory work on longer term standards, this may be an interesting possibility. More background information on expected emission standards for the short-term can be found in Annex 8 (standards IMO Tier 3 and US EPA Tier 4).

It may also be considered to reap the benefits from economies of scale with other large engine applications, such as rail and tractor engines by establishing longer term limits for a broader range of applications. In order to counter the 'small market' risk, it could also be considered to follow different pathways for the development of a diesel based stage 5 diesel engine. Integrators, who are used to operating on a smaller scale, could develop such an engine with a combined application of techniques (e.g. Fuel Water Emulsion (FWE) + SCR + DPF or Hydrogen emulsification + SCR + DPF possibly combined in diesel-electric configurations).

It can be concluded that it is yet unclear how long the actual lead time will be for R&D work needed to develop a stage 5 diesel engine for a small population of large vessels (≥ 981 kW) that is not able to shift to LNG, but would still need a new engine to be installed on the vessel. In view of this uncertainty, a lead time of five years appears appropriate. The actual costs that are involved are also unclear. In this study the cost assessment for a diesel engine with stage 5 performance was therefore, largely based on the study by Arcadis & TML that provided cost figures on the additional price of a stage 5 engine. Moreover, the necessary R&D work is estimated as 15 million euro and based on a more recent estimate from a questionnaire amongst Euromot members held in December

2012/January 2013 (see Annex 2). Given the small size of the expected market for a stage 5 diesel engine, it is assumed that only one manufacturer will enter the market and will develop such an engine. This figure is consistent with the Arcadis & TML study from 2009 as they assumed an R&D budget of 75 million euro for 5 manufacturers for the development of a full range of stage 5 diesel engines for all vessels. In view of the possibility to engage in discussions on this matter at a global level and of the existence of alternative pathways for achieving the corresponding limits, the figure of 15 million euro for R&D appears to be a realistic amount. In Chapter 5 a sensitivity analyses is also presented with a focus on how much the R&D budget is.

4.5 Possible emission limits for new and existing engines

Two categories of vessel engines are to be addressed in regards to the emission standards for IWT engines:

- New engines for new and/or existing vessels;
- Existing engines for existing vessels.

In the case of new vessel engines, imposing requirements work differently in comparison to existing engines. For existing engines, the emission reduction is determined by:

- A minimum performance level of the reduction compared to the engine-out emission of at least:
  - 80% for NOx and
  - 90% for PM as a result of devices applied to reduce the emissions.

Therefore, a certain threshold can be derived in terms of gram per kWh based on the 80% and 90% reduction levels for NOx and PM for the regulated engines (CCNR 1 and 2).

This implies that the actual performance level that can be reached on retrofitting existing engines (e.g. with SCR and DPF) depends on the engine-out emission level. On existing vessels there are still engines in use that comply with emission stages CCNR I, CCNR II or that are unregulated. Based on ongoing developments in the area of heavy duty vehicles (HDV) at UNECE (REC[1]), a scheme of a similar type is being considered for existing IWT engines. Under the REC scheme, Retrofit Emission Control devices need to be applied that show an improvement in emissions by an 80% reduction for NOx and 90% reduction for PM to be able to at least meet the next emission stage. It has to be noted that these values (-80% and -90%) are minimum thresholds and that the actual performance of the devices is generally much higher. For example, the NOx reduction could be close to 90% while the reduction of PM could be 98% or more[2].

The actual emission performance largely depends on the engine load and exhaust gas temperature. Test cycles are used to estimate the expected performance of the engine and after-treatment systems in the real world. The test cycle protocols linked to the emission standard allow reproducible and comparable measurements

[1] REC stands for Retrofit Emission Control

2 See presentation by Mr Dr Raimund Müller, Chairman of AECC NRMM & REC sub-group on the AECC Test Program for Emissions from Non-Road Mobile Machinery Engines, Brussels – 27 November 2012, http://www.aecc.be/en/Publications/NRMM_Technical_Seminar.html

of exhaust emissions for different engines or vehicles. Test cycles specify the specific conditions under which the engine or vehicle is operated during the emission test. Specified parameters in a test cycle include a range of operating temperature, speed and load. Different test cycles show different results on the effectiveness of technologies such as SCR and DPF. More information on test cycles has been included in Annex 7.

In order to compare HDV Euro VI engines with NRMM engines, it is necessary to distinguish between the test cycles for both types of engines. The EURO VI-engines are used for heavy-duty road vehicles and are tested for this use, while the engines used for inland waterway transport application will be tested for use of marine application.

While road vehicles are used under different circumstances (urban areas, highway etc.), the road engines are tested with more modes than engines used for marine application. The stationary test cycle ISO 8178 is assumed[1] for deriving the emission standards for inland waterway transport.

The most important components in the emission standards are the levels of NOx and PM, as they strongly determine the performance of IWT on external costs. Therefore, the design of the stages for future emissions is driven by the reduction potential regarding the levels of PM and NOx and based on the mainstream technologies (SCR, DPF and Dual Fuel LNG). For SCR and DPF the REC scheme was taken into account which implies the following:

- 80% reduction of engine-out emissions of NOx
- 90% reduction of engine-out emissions of PM

In this respect the engine-out levels of base engines was the starting point for making assessments on the possible performance in case of application of technologies on new and existing engines. Moreover, the possible alignment was taken into account with the engines that will enter the market in 2016 and 2017 and be based on IMO and EPA standards. The engine performance that is expected in case of the alignment with IMO and EPA is called 'Stage 3B'.

It has become clear that it would be possible to design more stringent emission levels. According to REC principles and based on the current new CCNR 2 engines with 6.0 gram NOx per kWh and 0.2 gram PM per kWh, a performance is expected of 1.2 gram NOx (-80%) and 0.02 gram PM (-90%) per kWh in the case SCR and DPF is applied. This assumption provided the Stage 4B for new engines.

A standard for adaptation of regulated existing engines is based on the ability to adapt existing CCNR 1 engines which are expected to have an engine-out emission performance of 9 gram NOx and 0.3 gram PM per kWh. After application of the reductions of 80% and 90% according to REC, the result is an emission of 1.8 gram NOx and 0.03 gram PM per kWh. It has to be remarked that the 0.3 gram PM per kWh is close to the maximum engine-out level on which a DPF can successfully be applied.

[1] See for more information also http://www.dieselnet.com/standards/cycles/iso8178.php

Moreover, the level of 1.8 gram NOx per kWh is similar to the alignment with IMO and EPA that could enter the market in 2016. In order to increase the feasibility the 'Stage 3B' engine was also evaluated as a possible engine to retrofit. A performance below 0.03 gram PM per kWh is quite feasible in case of application of a DPF. Therefore, the standard for existing engines also included the possibility to retrofit the stage 3B engine by means of adding a DPF to the system.

Lastly, a Stage 5 was designed. This stage was driven by the opportunities provided by LNG in combination with SCR and DPF in order to reach a similar performance per kWh with heavy duty vehicles on the road. It is expected that LNG itself can result in low NOx and PM levels in the range of stages 4A and 4B. By means of application of SCR and DPF a further reduction is feasible which would bring down the emissions to similar limit values as applied in the Euro VI standard: 0.4 gram NOx and 0.01 gram PM per kWh. Moreover, a PN limit is also applied that is similar to the Euro VI HDV standard.

In order to implement the standards, feasible (combinations of) mainstream technical measures are shown in Table 4.2. A distinction is made between new vessel engines and existing engines. It also has to be noted that the emission standards defined shall remain technology-neutral and possibly new technologies could be developed that are more cost-effective or easier to install or apply.

Table 4.2 Technical measures

Technical measures for new engines		*Technical measures for existing engines*	
Stage 3B	Diesel engine in alignment with IMO Tier 3 / EPA Tier 4	Stage 4A	Retrofit with SCR+DPF
			Diesel engine in alignment with IMO Tier 3/ EPA Tier 4 (stage 3B) + DPF refit
			LNG DF +SCR+DPF
Stage 4B	CCNR 2 engine (stage IIIA NRMM)+SCR+DPF (refit)		
	LNG DF +SCR+DPF		
Stage 5	LNG DF +SCR+DPF		
	New marine diesel engine to be developed (Euro VI alike)		

The diesel engines in alignment with IMO Tier 3/ EPA Tier 4[1] (called stage 3B) are able to cope with types of fuel that contain higher sulphur contents in order to be able to function properly in maritime environments across the world. As a result however, a different type of SCR is used which is not as effective as an SCR that

[1] See Annex 8 for more background on emission standards for IMO Tier 3 and EPA Tier 4

could be used with low sulphur fuel used in IWT. Furthermore, the performance of such engines in terms of NOx emission cannot be further improved, as it would not be possible to equip these engines with additional SCR retrofit equipment.
Another technologically feasible and cost-effective approach to reducing emissions would be to equip CCNR 2 / Stage IIIA engines currently available on the market with SCR and DPF techniques according to REC principles. The corresponding emission limits are called Stage 4B.

EURO VI equivalent levels of emission limits (called Stage 5) could be achieved with LNG Dual Fuel with SCR and DPF to make sure that the required standard is reached. Currently, real world practice in IWT does not yet provide the evidence that LNG dual fuel engines are able to reach Stage 4B without DPF and SCR, even if further technological progress can be expected in this field (e.g. monofuel LNG engines in gas-electric configuration).

Retrofitting existing engines with SCR and DPF techniques according to REC principles allows for the reduction of emissions to the levels which are called Stage 4A.

The Figures 4.4 and 4.5 summarise the relations between the technologies and the emission stages for the new engines and existing engines.

Figure 4.4 Scheme on technologies for new engines to reach stage 3B, stage 4B, stage 5

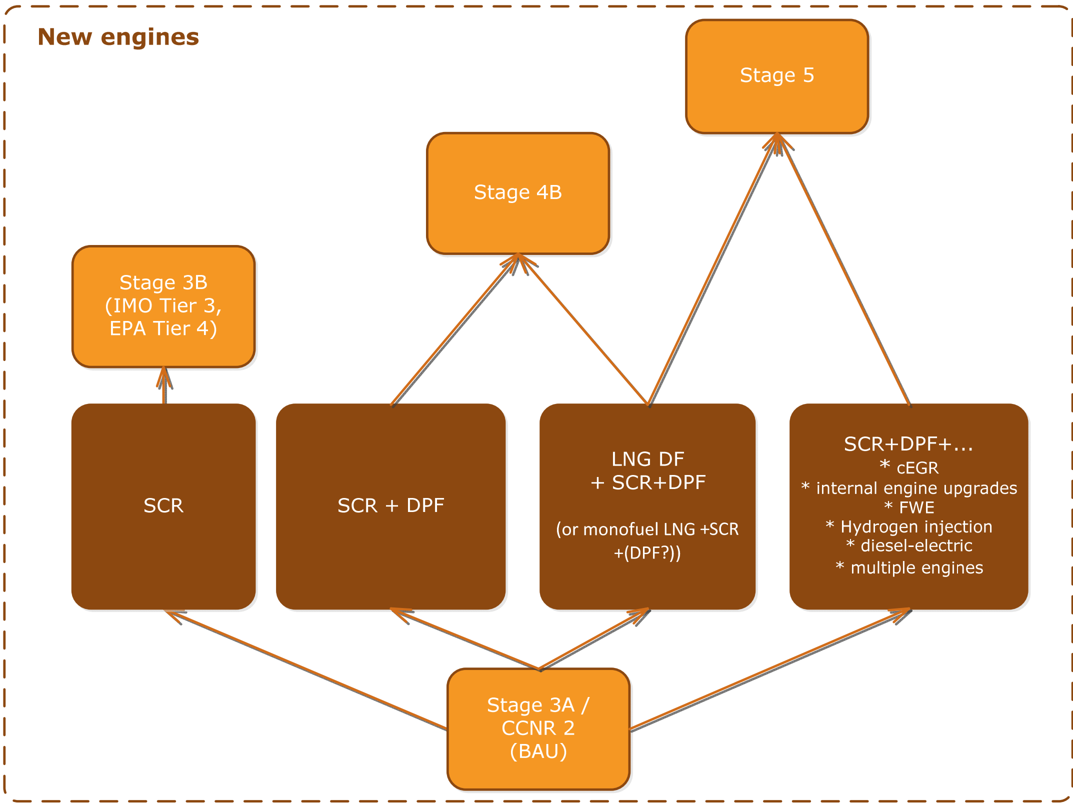
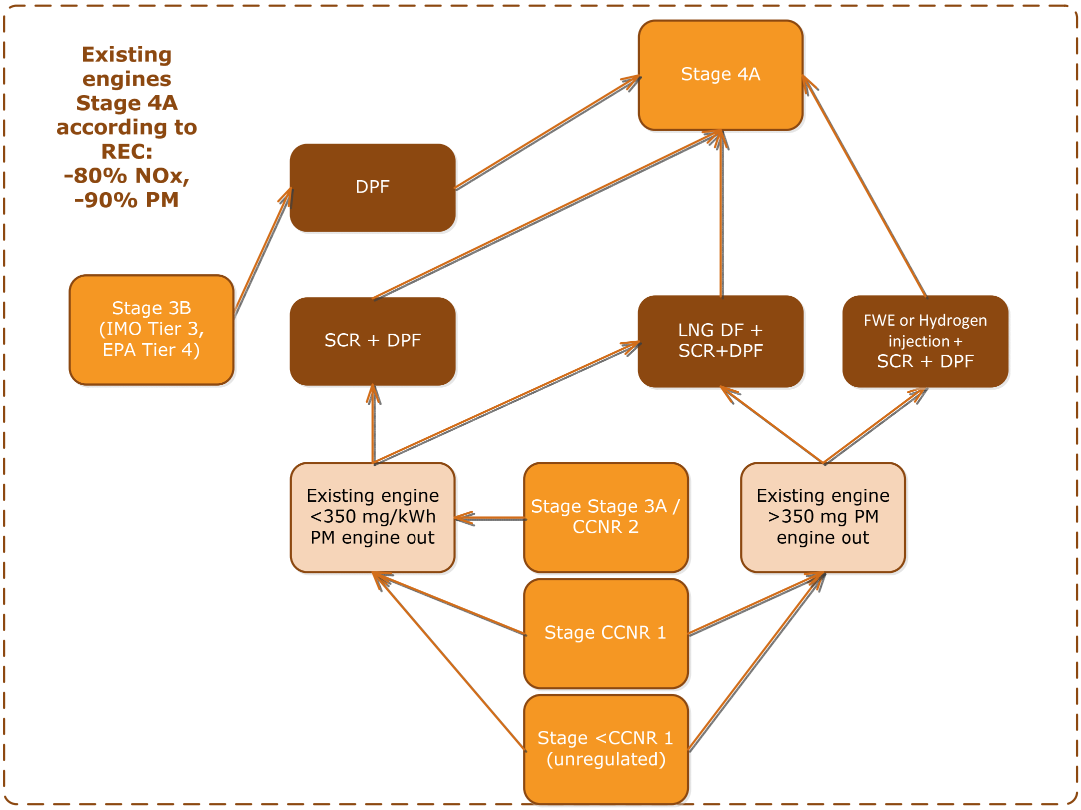


Figure 4.5 Scheme on technologies for existing engines to reach stage 4A



The stages for the policy options and the requirements for pollutants are shown in Table 4.3. The following pollutants are included in addition to PM and NOx:

- CO (carbon monoxide): colourless, odourless and poisonous gas produced by the incomplete burning of carbon fuels. CO reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with heart disease.
- HC (hydrocarbons): HC are produced by incomplete combustion of hydrocarbon fuels (e.g. gasoline and diesel). HC include many toxic compounds that can cause cancer and other adverse health effects. HC also react with NOx in the lower atmosphere to form ground-level ozone, a major component of smog. The application of a DOC will reduce the HC emission. The application of DOC is valid for the stage 3B and 4A for engines over 600 kW and for all engines in the stages 4B and 5,
- PN (particle number): a limit on the number of particles is introduced to also avoid the emission of small particles with the ability to deeply diffuse within the lungs and be absorbed into the bloodstream that causes a severe negative impact on health. The PN limit is a further development of regulations on the emission of particle matter and is additional to the limit expressed in gram per kWh for PM (mass). The PN limit is being introduced for heavy duty road vehicles at the Euro VI standard and is based on the steady state test cycle (see Annex 7).
- CH4 (methane): the main component of natural gas. This greenhouse gas emission is emitted when using, for example, engines running on LNG and could have an impact on global warming. A methane slip catalyst is assumed to be in place to make sure that emissions remain below the limit values. The

limit value of 0.5 gram per kWh CH4 was derived from the Euro VI standard for gas engines in heavy duty vehicles.

- NH3 (ammonia): Unreacted ammonia, referred to as ammonia slip, can be a by-product of certain NOx reduction processes. An ASC (Ammonia Slip Catalyst) can be applied to prevent ammonia slip in the exhaust and this is assumed to be in place to reach standards 4A, 4B and 5. The limit value of 10 ppm was derived from the Euro VI value for heavy duty vehicles.

Table 4.3 Emission performance stages (P = installed net propulsion power of the vessel in kW)

	CO	HC	NOx	PM	PN	CH4	NH3
New engines Stage 3B	g/kWh	g/kWh	g/kWh	g/kWh	1/kWh	g/kWh	ppm
75 ≤ P < 130	5	5.4 (NOx + HC)		0.14	-	-	-
130 ≤ P ≤ 220	3.5	1	2.1	0.11	-	-	-
220 < P ≤ 304	3.5	1	2.1	0.11	-	-	-
304 < P < 600	3.5	1.0	2.1	0.11	-	-	-
P ≥ 600	3.5	0.19	1.8	0.045	-	-	-
New engines Stage 4B	g/kWh	g/kWh	g/kWh	g/kWh	1/kWh	g/kWh	ppm
75 ≤ P ≤ 220	3.5	0.19	1.2	0.02	$8.0X10^{11}$	0.5	10
220 < P ≤ 304	3.5	0.19	1.2	0.02	$8.0X10^{11}$	0.5	10
304 < P < 600	3.5	0.19	1.2	0.02	$8.0X10^{11}$	0.5	10
600 ≤ P <981	3.5	0.19	1.2	0.02	$8.0X10^{11}$	0.5	10
P ≥ 981	3.5	0.19	1.2	0.02	$8.0X10^{11}$	0.5	10
New engines Stage 5	g/kWh	g/kWh	g/kWh	g/kWh	1/kWh	g/kWh	ppm
P ≥ 981	3.5	0.19	0.4	0.01	$8.0X10^{11}$	0.5	10
Existing engines Stage 4A	g/kWh	g/kWh	g/kWh (-80% on engine-out)	g/kWh (-90% on engine-out)	1/kWh	g/kWh	ppm
75 ≤ P < 130	5	1.0	-80%	-90%	-	0.5	10
130 ≤ P ≤ 220	3.5	1.0	-80%	-90%	-	0.5	10
220 < P ≤ 304	3.5	1.0	-80%	-90%	-	0.5	10
304 < P <600	3.5	1.0	-80%	-90%	-	0.5	10
600 ≤ P <981	3.5	0.19	-80%	-90%	-	0.5	10
P ≥ 981	3.5	0.19	-80%	-90%	-	0.5	10

Further background information on HC, CO, PN and CH4 emission can be found in Annex 9. A distinction is made between standards for new engines and standards for existing engines. For existing engines the policy options are limited. Stage 5 has been left out for existing engines, as this is considered to technically be unfeasible. It must be remarked that with regards to external costs, bringing down the level of PM and NOx below the level of the standard, as mentioned in Table 4.3, saves by far the largest amount of costs in comparison to the other pollutants. Therefore, PM and NOx will be dealt with in a quantitative way in the remainder of this study, while the other pollutants will be treated qualitatively.

With regards to the existing engines (Stage 4A), a specific limit value can only be provided for engines that were regulated, e.g. CCNR I and CCNR II / Stage 3A engines. Based on their original engine-out limit values for NOx and PM emissions per kWh, the 80% and 90% reduction rates can be applied.

For example:
SCR to reduce NOx according to REC principles, reduction -80%:
- 6.0 gram NOx per kWh engine-out for a CCNR II engine results in 1.2 gram NOx per kWh emission
- 9.2 gram NOx per kWh engine-out for a CCNR I engine results in 1.84 gram NOx per kWh exhaust

DPF to reduce PM according to REC principles, reduction -90%:
0.2 gram PM per kWh engine-out for CCNR II engine results in 0.02 gram PM per kWh exhaust.

Assumptions need to be made on the engine-out emission levels for model calculations. The assumptions that have been used in this study are based on TNO (2010)[1]. Table 4.4 presents the subsequent expected average emission levels for stage 4A on existing engines for NOx and PM levels:

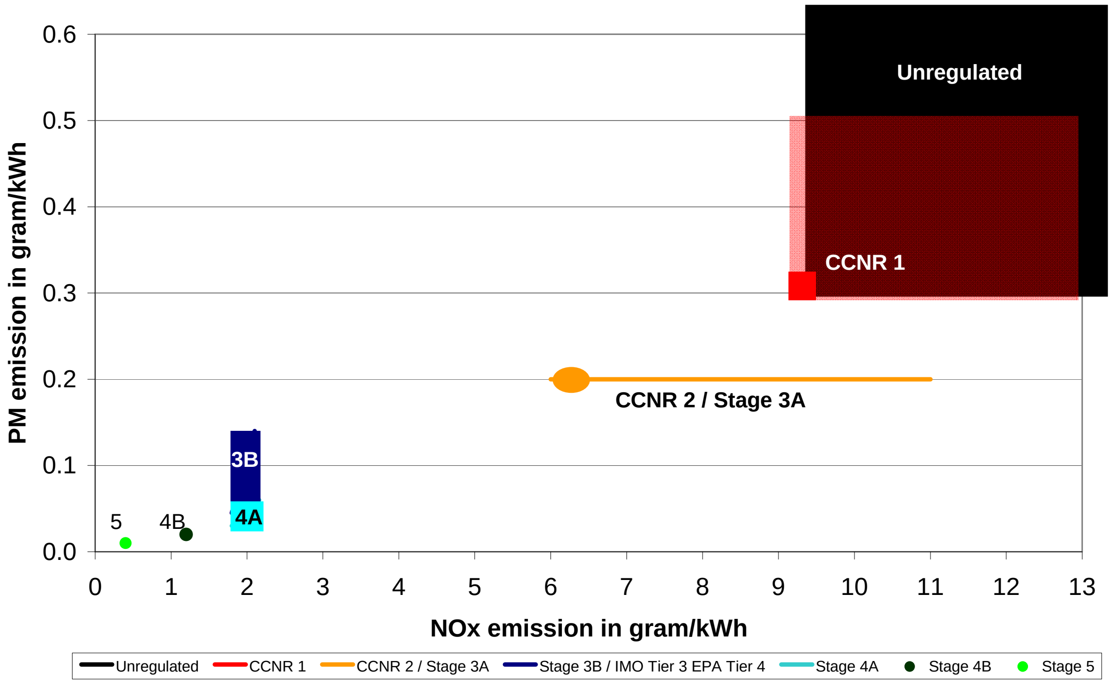
Table 4.4 Expected emission performance on NOx and PM levels for existing engines (Stage 4A) depending on the year of construction,

year of construction of engine	NOx gram per kWh, Engine-out base engine	PM gram per kWh, Engine-out base engine	Performance expected after REC - 80% for NOx in gram per kWh	Performance expected after REC - 90% for PM in gram per kWh
> 2007	6.0	0.20	1.2	0.02
2003 - 2007	9.2	0.30	1.8	0.03
1995 - 2002	9.4	0.30	1.9	0.03
1990 - 1994	10.1	0.40	2.0	0.04
1985 - 1989	10.1	0.50	2.0	0.05
1980 - 1984	10.4	0.60	2.1	0.06
1975 - 1979	10.6	0.60	2.1	0.06
< 1974	10.8	0.60	2.2	0.06

Figure 4.6 presents an overview of the NOx and PM levels for the different emission stages.

[1] TNO report 2010, Netherlands Environmental Assessment Agency, 'Methodologies for estimating shipping emissions in the Netherlands'

Figure 4.6 Emission performance for existing and optional stages in future (3B, 4A, 4B, 5) regarding NOx and PM emission in gram per kWh



4.6 Costs and level playing field

4.6.1 Costs of technical measures

The costs of technical measures have been determined to adapt new vessels/engines and existing vessels/engines. Cost components comprise:

- Initial investment
  - Costs of engines and/or equipment
  - Time needed for installation (vessel out of service)
  - Repair and maintenance costs

- Operational costs
  - Maintenance costs
  - Changes in fuel consumption
  - Consumption of urea for SCR
  - Reconditioning of equipment after lifetime

Please note that only the cost differences are presented in comparison to business as usual (BAU), which is the regular stage 3A or CCNR 2 engine. For various emission standards and technology combinations, costs have been determined compared to BAU. In this process, representatives from Euromot and AECC, as well as independent equipment manufacturers were consulted. Their input has been included in the cost data. Due to the fact that the cost data and price data of individual firms are strictly confidential, only aggregate data are presented in this report and its Annexes.

The cost data are used in order to calculate:
- Additional initial investment costs for the vessel owner
- Total operational impact for the vessel owner

As an example, Table 4.5 presents the additional initial investment costs for the hardware and installation for new freight vessels with new engines for the different stages in comparison to business as usual. Other situations, for which costs have been determined, are: existing vessels with engine replacement and existing vessels with existing engine adapted/retrofit. The cost data for all these situations are included in Annex 10.

The additional investment costs presented are undiscounted[1] and estimated costs for the year 2017 in $Euro_{2011}$, taking into account the spin-off of Euro VI heavy-duty vehicle after-treatment technologies (introduced in 2012), synergies with expected emission reduction developments in other Non-road Mobile Machinery segments and economies of scale in case of the combinations with addressing existing vessels (Stage 4B and Stage 4A).

A distinction has been made between the costs for a stage 5 diesel engine including R&D costs and costs for stage 5 diesel excluding the R&D costs.

Table 4.5 Additional initial investment cost for the hardware and installation for a single new vessel with new engines compared to business as usual

NEW ENGINES, NEW VESSELS				
Emission standards >	*Stage 3B Diesel*	*Stage 4B Diesel*	*Stage 4B / 5 LNG SCR DPF*	*Stage 5 DIESEL Excl R&D*
<38.5*5.05m, 365t, 189 kW	€ 17,758	€ 25,969		
55*6.6m, 550t, 274 kW	€ 20,213	€ 30,412		
70*7.2m, 860t, 363 kW	€ 21,714	€ 33,491		
67*8.2m, 913t, 447 kW	€ 21,979	€ 33,614		
85*8.2m, 1260t, 547 kW	€ 22,728	€ 34,908		
85*9.5m, 1540t, 737 kW	€ 25,835	€ 41,502		
110m, 2750t, 1178 kW	€ 35,001	€ 55,530	€ 591,148	€ 122,834
135m, 5600t, 2097 kW	€ 60,418	€ 96,494	€ 961,237	€ 216,325
Push Boat 1000-2000kW (1331 kW)	€ 45,366	€ 70,015	€ 947,515	€ 146,061
Push Boat >2000 kW (3264 kW)	€ 92,284	€ 147,991	€ 1,412,126	€ 334,484

The initial investment costs are only a part of the total economic impact for the vessel owner. Other cost components, such as impacts on fuel costs, urea consumption, repair and maintenance, reconditioning/replacement after lifetime also need to be taken into account in order to provide a view on the impact of the 'Total cost of ownership' compared to BAU. In several cases where the LNG option is selected the operational impact is beneficial, as the reduction of fuel costs compensates for the additional investment costs within the time horizon of 20 years. This is the case for instance for new large vessels operated on a 24/7 basis.

[1] More background on the discounting that is applied in this study can be found in Chapter 5.1

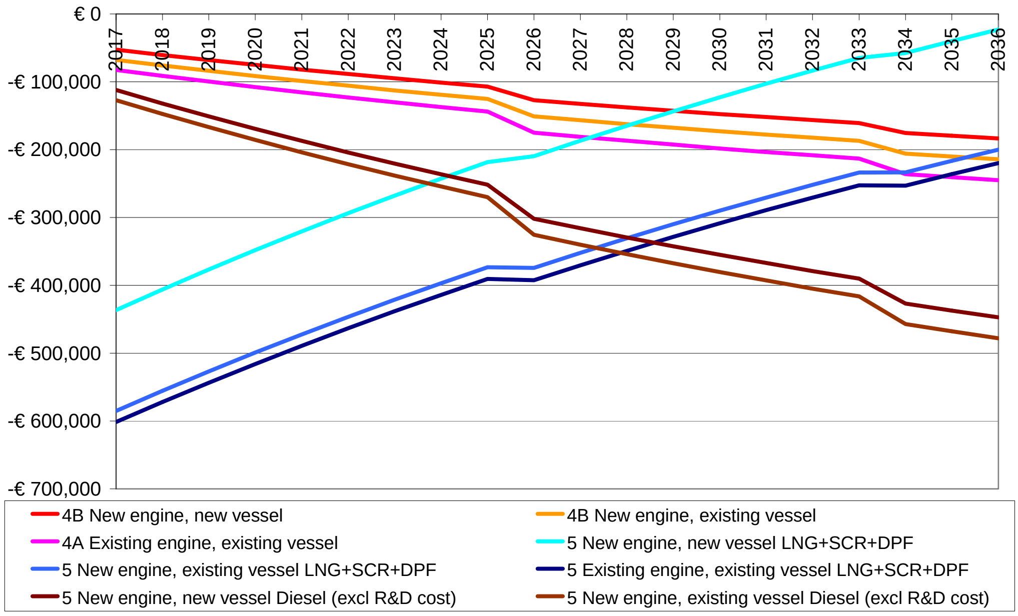
Table 4.6 presents the net present value for the operational impact for the freight vessel owner for a single vessel for the period 2017-2050. The financial figures have been discounted at a discount rate of 4%. Once again, the situation with new vessels with new engines is shown as an illustration. All other financial data are included in Annex 10.

Table 4.6 Net present value for the operational impact for the vessel owner for a single vessel compared to business as usual

NEW ENGINES, NEW VESSELS			
	Stage 3B Diesel	*Stage 4B Diesel*	*Stage 4B / 5 LNG SCR DPF*
<38.5*5.05m, 365t, 189 kW	-€ 22,422	-€ 36,117	-€ 361,979
55*6.6m, 550t, 274 kW	-€ 31,684	-€ 53,436	-€ 358,610
70*7.2m, 860t, 363 kW	-€ 36,113	-€ 62,609	-€ 355,238
67*8.2m, 913t, 447 kW	-€ 41,257	-€ 75,725	-€ 316,561
85*8.2m, 1260t, 547 kW	-€ 47,461	-€ 96,424	-€ 201,013
85*9.5m, 1540t, 737 kW	-€ 58,051	-€ 125,978	-€ 192,857
110m, 2750t, 1178 kW	-€ 116,296	-€ 230,499	€ 88,019
135m, 5600t, 2097 kW	-€ 277,559	-€ 547,075	€ 731,566
Push Boat 1000-2000kW (1331 kW)	-€ 153,637	-€ 360,212	€ 477,905
Push Boat >2000 kW (3264 kW)	-€ 460,296	-€ 1,077,617	€ 2,758,999

Figure 4.7 presents the cumulative discounted cash flows for 110 metre freight vessels for the relevant emission standards/technology (similar graphs for other vessel lengths are included in Annex 10) in comparison with the business as usual scenario. In order to illustrate the situation it is assumed that the implementation of (part of) the measures will start in 2017. A discount rate of 4% has been applied.

Figure 4.7 Cumulative discounted cash flows for 110 metre vessel length for the relevant emission standards/technology



It can be noted that while for a number of emission standards/technologies the cumulative discounted cash flow is increasingly negative with time, there are also emission standards/technologies where the cumulative discounted cash flow is becoming less negative.

For new 110 metre vessels that are based on Stage 5 LNG+SCR+DPF the cumulated discounted cash flow becomes positive after a number of years due to the savings on fuel costs in case of LNG. This illustrates what has earlier been described as a win-win situation: benefits for society, as well as benefits for the operator/owner in comparison to the business as usual scenario.

In particular, where there are benefits for both the society (reduced external costs) and the IWT industry the situation becomes very attractive and should be pursued. It has been concluded that the LNG option already brings 'win-win' opportunities for the largest vessel class. This obviously increases the overall economic feasibility for the introduction of stage 5 emission limits.

Moreover, the knowledge gained on the economic impact for the owners of different vessel types makes it possible to optimise the scope of the emission standards. In the design of the emission standard the aim was to minimise the compliance costs for the industry. Therefore, the information as presented in Annex 10 supports the development of cost-efficient options for new emission standards for the IWT fleet while reaching the policy objective (IWT reaching by the year 2030 equal or lower external costs for air pollutant emissions compared to road haulage).

4.6.2 Considerations on level playing field for IWT operators/owners

To account for different characteristics of vessel sizes and to secure a level playing field, the fleet was divided into different vessel size categories. Also, new and existing vessels (and vessel engines) were treated separately. This made it possible to avoid adverse effects that may affect specific groups of IWT operators and owners. However, at the same time it should be noted that a different treatment between groups may in itself, also give rise to adverse effects.

Smaller vessels are able to reach geographic areas that cannot be reached by larger vessels. On the other hand, larger vessels have clear economies of scale. Smaller vessels often operate on a smaller scale, not only due to the smaller size of the vessels, but also due to less working hours. In addition, the possibility of attracting financial resources differs. A different treatment of vessel categories is therefore, obvious. However, when differences in emission limits between vessel/engine categories are too big, owners/operators may decide to choose certain vessel or engine categories for the sole purpose that they have the least amount of restrictions, which would be counter-productive from a socio-economic point of view.

Owners of new vessels have the possibility to optimise their vessel and engine design with respect to emission regulations by making use of a broad spectrum of available technologies. When owners of existing vessels/engines would face the same constraints in terms of emission limits, they may have less technological options which could lead to higher costs, putting them at a disadvantage in comparison to those acquiring new vessels. A different treatment, in favour of existing engines, should account for this effect.

When emission limits for existing vessel/engines are not beneficial to the owner/operator, he/she may opt for the reconditioning of the existing engines/ships for as long as possible, instead of investing in new engines/ships. This would again distort the market, hamper innovation and lead to suboptimal economic and societal outcomes.

A third effect for specific groups could arise when the costs of measures would prove prohibitly high. IWT operators could then lose the competition with other modalities. In particular a loss of modal share to road transport would be an undesired impact from a societal viewpoint, as this is expected to increase the total external cost of transport. This could especially be a risk for smaller vessels, which are often more directly in competition with road transport.

The level playing field aspects will be further dealt with under Chapter 7.2 in this report. In order to find the right balance between specific groups of IWT operators/owners, the policy options should be formulated in such a way that:

- Every vessel type has a comparable proportional contribution to the reduction of emissions in order to avoid a preference for one vessel category on the sole ground of its emission limits. There should be limited differences in the requirements for the vessel categories.
- Limited total lifetime cost differences exist between requirements for new engines and existing engines in order to avoid repeated reconditioning instead of renewal.
- Keep impact on investment and operational costs limited to avoid reversed modal shift, meaning that technical measures such as LNG SCR would not be required for small vessels.

4.7 Screening policy options, selection for in depth analysis

A long list of combinations of emission reduction possibilities were reviewed and quantitatively investigated. From these analyses, the following conclusions have been drawn:

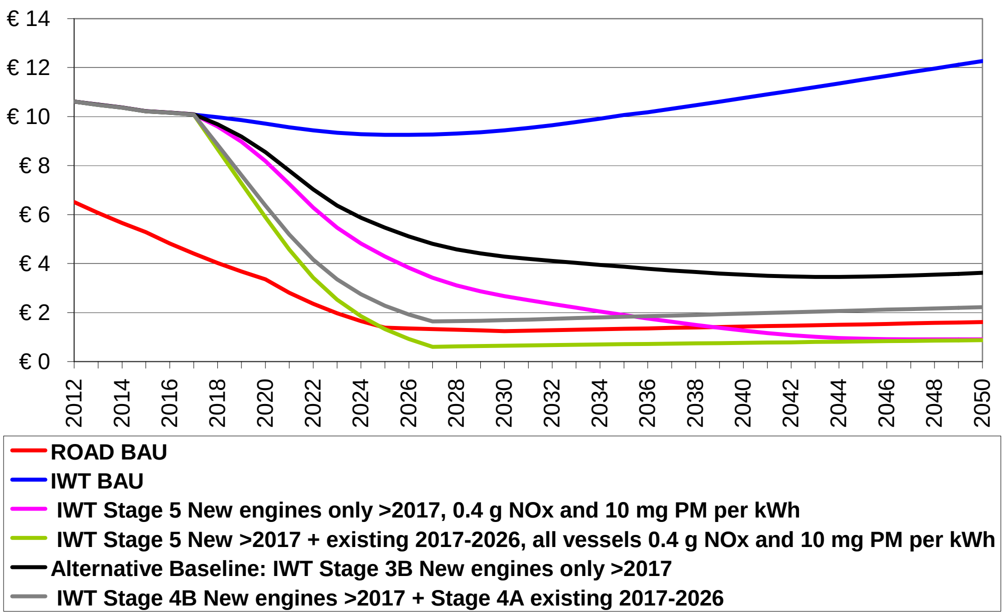
- Large vessels have the highest contribution to emissions and the highest benefit/cost ratio for measures, in particular as a result of the opportunity to apply LNG which also reduces fuel costs.
- Large vessels already have much higher engine renewal rates in comparison to small and medium sized vessels.
- Although initial investments for LNG+SCR+DPF technologies are relatively high, they could lead to a positive business case for new vessels in the largest vessel class (110 new, 135 metre, push boats). This would result in a win-win situation for the sector and society.
- Applying Stage 3B (diesel in alignment with IMO Tier 3/ EPA Tier 4) emission limits for new engines cannot achieve the overall objective for IWT to catch up with road transport as regards air pollutants and therefore is excluded as a policy option.

- In order to reach the objective, a certain share of Stage 5 engines (0.4 g NOx and 10 mg PM) will always be necessary.
- In order to reach the objective within a reasonable time horizon (2030), it is required to tackle emissions of existing engines (retrofit action), as well as render emission limits of new engines more stringently.

Model simulations on the impact of emission levels on the air pollutant performance expressed in external costs allows the conclusion that in order to achieve the objective for IWT to catch up with road transport with regards to air pollutants:
- Stage 5 is needed as a minimum for new engines for vessels ≥ 110 metre (1178 kW) in all cases.
- A certain level of retrofit is needed for existing engines, including for (at least) medium and large vessels.

This conclusion was drawn after making assessments using a number of different emission levels and applications only on new engines and applications where existing engines were also targeted. Figure 4.8 shows the results of preliminary assessments of various emission levels for the application on new and/or existing vessels in order to derive effective combinations of emission standards for various new vessel types and existing vessel types. From this figure it can be concluded that even when stage 5 is made mandatory for all new vessels then the objective will not be reached until 2040, which is too late. It can also be seen that a complete retrofit of all existing vessels to stage 4A and for new engines to stage 4B, will not reduce emissions enough to meet the objective.

Figure 4.8 Developments of main variants assessed



A number of iterative assessments took place, where both the year of introduction of stage 5 and the scope of the retrofit obligation were varied. The precondition regarding the outcome is to ensure that the key policy objective is reached. Moreover, there are several feasibility aspects to take into account:

- Postponement of Stage 5 introduction until 2022 would be possible, allowing more time for reaching maturity on the application of LNG on existing vessels/engines and/or for developing diesel-based stage 5 engine technologies (either by large engine manufacturers or smaller sized integrators).
- Introducing Stage 4B emission limits (1.2 g NOx and 0.02 g PM per kWh) for new engines (implying the application of LNG or retrofit equipment) is most cost-effective when this is combined with retrofit requirements for existing engines as larger market volumes will help to offset R&D costs to develop standardised retrofit packages (e.g. SCR, DPF) for certain engine types and power ranges.
- In case of applying emission limits for existing small vessels<55m[1] (or <304 kW) technical difficulties are expected because of old engines and lack of space. Moreover, the cost-effectiveness in this case is relatively small in comparison to other vessel classes, because of the relatively low number of annual sailing hours (fuel consumption and related emissions), while the number of vessels is quite large as a share of the total fleet. Therefore, there are arguments that point towards the consideration of exempting smaller vessels from an obligatory retrofit of emission control devices (e.g. SCR, DPF, FWE) on existing engines.

From the iterative screening exercise three policy options could be derived, those are listed in Table 4.7 and can be characterised as follows:

- Option 1: Maximised time to develop Stage 5 engine combined with level playing field
- Option 2: Optimised cost-effectiveness
- Option 3: Mix between cost-effectiveness and level playing field

[1] A positive exception may be passenger vessels. Daytrip passenger vessels are seldom longer than 55m. However, passenger vessels may be able to use LNG or CNG. As these vessels often sail in urban areas, local legislation as well as maintaining a clean image towards passengers create a necessity to seek for clean technologies.

Table 4.7 Policy options (P = installed net propulsion power of the vessel in kW, L = length of the vessel that is most representative for the installed power)

		Option 1 *Maximised time to develop Stage 5 engine combined with level playing field*	Option 2 *Optimised cost-effectiveness*	Option 3 *Mix between cost-effectiveness and level playing field*
New Engines				
75 ≤ P ≤ 220	L ≤ 38	4B by 2017	3B by 2017	3B by 2017
220 < P ≤ 304	38 < L ≤ 55	4B by 2017	3B by 2017	4B by 2017
304 < P < 600	55 < L ≤ 85 (85*8.2 m)	4B by 2017	4B by 2017	4B by 2017
600 ≤ P <981	85 ≤ L <110 (85*9.5 m)	4B by 2017	4B by 2017	4B by 2017
P ≥ 981	L ≥ 110	4B by 2017, 5 by 2022	4B by 2017, 5 by **2020**	4B by 2017, 5 by **2020**
Existing engines				
75 ≤ P ≤ 220	L ≤ 38	4A between 2017-2027	-	-
220 < P ≤ 304	38 < L ≤ 55	4A between 2017-2027	-	4A between 2017-2027
304 < P < 600	55 < L ≤ 85 (85*8.2 m)	4A between 2017-2027	4A between 2017-2027	4A between 2017-2027
600 ≤ P <981	85 ≤ L <110 (85*9.5 m)	4A between 2017-2027	4A between 2017-2027	4A between 2017-2027
P ≥ 981	L ≥ 110	4A between 2017-2027	4A between 2017-2027	4A between 2017-2027

It should be noted that all these options achieve the objective of IWT catching up to road transport in regards to air pollutant external costs by the year 2030. Option 1 provides more time (until 2022) for the development of Stage 5 technologies. As a consequence however, all existing vessel engines will need to be retrofitted, including the smallest vessels in order to reach the policy objective.

The options 2 and 3 assume an earlier introduction of Stage 5 (by 2020) which provides room to relax requirements for the small and medium categories of vessels. As a result of this, existing small vessels are exempt for option 2, as well as option 3 which increases the cost-efficiency. New engines for small vessels need to comply with stage 3B. This is the standard with the lowest compliance costs while still an improvement on the emission performance for this class of vessel. However, for option 3 the small vessel range only concerns vessels of 38 m or smaller (or with a maximum of 220 kW installed net power).

In addition to the above mentioned policy options, an alternative emission limit (stage 3B) has been added, which corresponds to a diesel engine aligned with IMO Tier 3/ EPA Tier 4 emission limits. As indicated above, this cannot be seen as a policy option, because it does not reach the policy objective. It is therefore, taken into the analysis as an Alternative Baseline scenario (see also Table 4.8). This Alternative Baseline scenario allows for the comparison of the present study with the Arcadis study conducted in 2009 in the framework of earlier stages of the

NRMM revision. In the Alternative Baseline scenario it is assumed that there will be no further development of LNG as fuel beyond the business as usual scenario.

Table 4.8 Alternative baseline

		Alternative baseline
New Engines		
75 ≤ P ≤ 220	L ≤ 38	3B by 2017
220 < P ≤ 304	38 < L ≤ 55	3B by 2017
304 < P < 600	55 < L ≤ 85 (85*8.2 m)	3B by 2017
600 ≤ P <981	85 ≤ L <110 (85*9.5 m)	3B by 2017
P ≥ 981	L ≥ 110	3B by 2017
Existing engines		
75 ≤ P ≤ 220	L ≤ 38	-
220 < P ≤ 304	38 < L ≤ 55	-
304 < P < 600	55 < L ≤ 85 (85*8.2 m)	-
600 ≤ P <981	85 ≤ L <110 (85*9.5 m)	-
P ≥ 981	L ≥ 110	-

5 Environmental impact analysis

5.1 Introduction

Air pollution caused by transport activities leads to various types of external costs. The most important external costs are health costs due to cardiovascular and respiratory diseases caused by air pollutants. Other external costs of air pollution include building and material damages, crop losses and impacts on biodiversity and ecosystems.

The most important transport related air pollutants are particulate matter (PM), nitrogen oxide (NOx), sulphur dioxide (SO2), volatile organic compounds (VOC) and Ozone (O3) as an indirect pollutant. Greenhouse gases (GHG) are treated separately since they do not have any direct toxic effects and are therefore, covered within the climate change cost category.

As mentioned above, external costs due to air pollution costs consist of several cost elements[1 2]:

- Health effects: The aspiration of air transport emissions increases the risk of respiratory and cardiovascular diseases. The main source of disease is particulate matter.
- Building and material damages: Air pollutants can cause damages to buildings and materials in two ways: a) soiling of building surfaces by particles and dust; b) degradation of facades and materials through corrosive processes due to acidifying pollutants (NOx, SO2).
- Crop losses: Ozone as a secondary air pollutant (formed due to the emission of VOC and NOx) and acidifying substances (NOx, SO2) cause crop damages. This means that an enhanced concentration of these substances leads to a decrease in the amount of crop.
- Impacts on ecosystems and biodiversity: Ecosystem damages are caused by air pollutants leading to acidification (NOx, SO2) and eutrophication (NOx, NH3). Acidification and eutrophication have a mainly negative impact on biodiversity. These effects are not yet included in most external cost studies and are excluded in the external cost calculations. Here, the NEEDS[3] project is a first study in this area that provides reliable cost factors for ecosystem and biodiversity damages due to air pollution.

In this chapter the emissions will be presented for NOx, PM and CO_2 for inland waterway freight transport. Please note that the emission of auxiliary engines is

[1] Handbook on estimation of external costs in the transport sector Produced within the study Internalisation Measures and Policies for All external Cost of Transport (IMPACT), CE Delft 2011

[2] External Costs of Transport in Europe, Update Study for 2008, CE Delft, 2011

[3] New Energy Externalities Developments for Sustainability, Integrated Project 6th Framework Programme

not within the scope of this study. Possible environmental savings in passenger transport are not presented in this chapter,

5.2 Impacts of policy options compared to business as usual

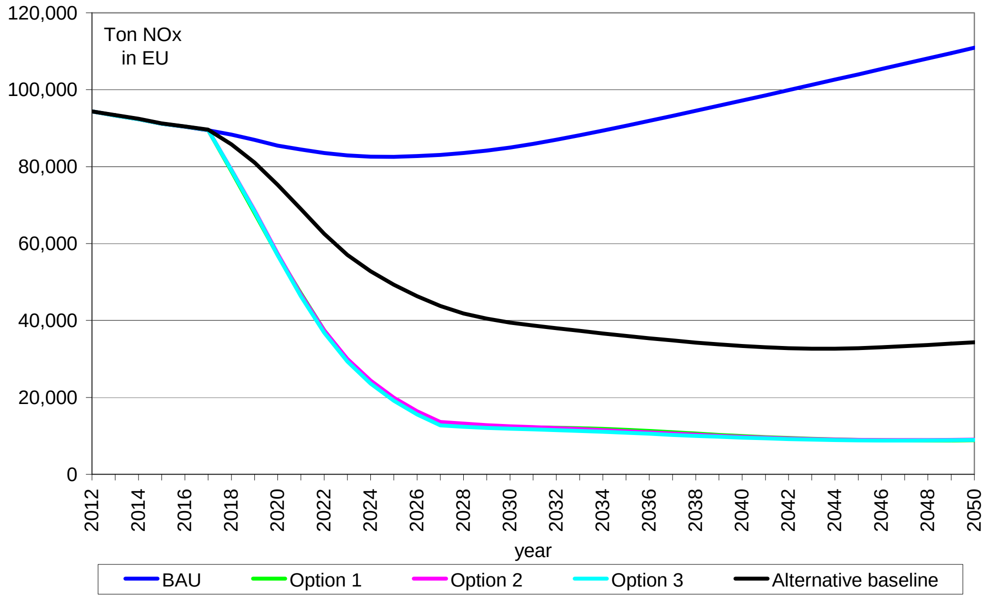
5.2.1 Absolute emission levels in EU by inland waterway freight transport

Table 5.1 and 5.2, as well as the graph in Figure 5.1 show the development of the NOx emission in Europe related to the transport of goods by inland waterway transport in terms of tonnes of emission[1].

Table 5.1 Absolute level of NOx production by IWT in Europe in tonnes per year

year	Business As Usual (BAU)	Option 1	Option 2	Option 3	Alternative baseline
2012	94,350	94,350	94,350	94,350	94,350
2020	85,422	57,033	57,323	56,955	75,246
2030	84,965	12,318	12,524	11,875	39,480
2040	97,201	9,959	9,774	9,565	33,382
2050	110,910	8,853	9,034	8,943	34,354

Figure 5.1 Absolute level of NOx production by IWT in Europe in tonnes per year



[1] Emissions are calculated for the main propulsion engines, emissions of auxiliary engines are not taken into account.

Table 5.2 Reduction of NOx production by IWT in Europe in tonnes per year and in relative terms of policy options and alternative baseline compared to business as usual

Year	Option 1	Option 2	Option 3	Alternative baseline
2020	28,389	28,099	28,468	10,177
2030	72,647	72,441	73,090	45,484
2040	87,242	87,428	87,636	63,819
2050	102,057	101,876	101,967	76,556
2020	33%	33%	33%	12%
2030	86%	85%	86%	54%
2040	90%	90%	90%	66%
2050	92%	92%	92%	69%

Table 5.3 and 5.4, as well as the graph in Figure 5.2 show the development of the PM emission in Europe related to the transport of goods by inland waterway transport[1].

Table 5.3 Absolute level of PM production by IWT in Europe in tonnes per year

year	Business As Usual (BAU)	Option 1	Option 2	Option 3	Alternative baseline
2012	5,271	5,271	5,271	5,271	5,271
2020	4,383	2,744	2,792	2,771	3,838
2030	4,129	318	407	363	1,718
2040	4,704	286	313	296	1,313
2050	5,411	286	302	293	1,310

[1] Emissions are calculated for the main propulsion engines, emissions of auxiliary engines are not taken into account

Figure 5.2 Absolute level of PM production by IWT in Europe in tonnes per year

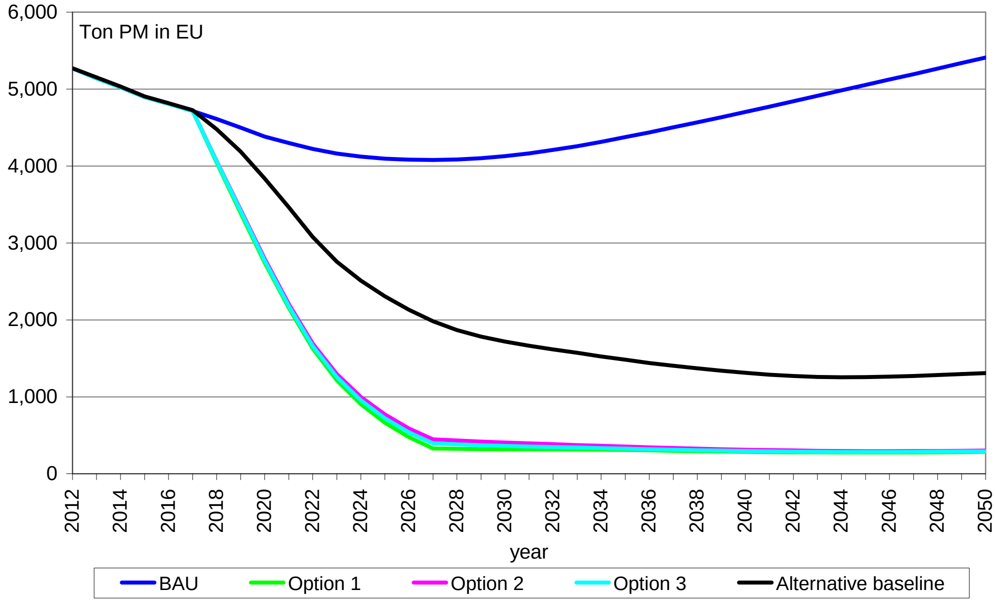


Table 5.4 Reduction of PM production by inland waterway freight transport Europe in tonnes per year and in relative terms of policy options and alternative baseline compared to business as usual

Year	Option 1	Option 2	Option 3	Alternative baseline
2020	1,639	1,590	1,612	544
2030	3,811	3,722	3,766	2,411
2040	4,418	4,391	4,408	3,391
2050	5,125	5,109	5,118	4,101
2020	37%	36%	37%	12%
2030	92%	90%	91%	58%
2040	94%	93%	94%	72%
2050	95%	94%	95%	76%

5.2.2 External costs of air pollutants

The PM and NOx emissions are strongly reduced as a result of the policy options in comparison to the business as usual scenario. The following shadow prices were applied based on the Marco Polo external cost calculator:

- 11,252 $euro_{2011}$ per tonne NOx (prices current in 2011)
- 104,291 $euro_{2011}$ per tonne PM

It can be concluded from Figure 3.12 that NOx emissions have the highest share in the external costs of IWT for the air pollutants.

5.2.3 Biodiversity losses

The external cost calculation, as presented in the previous section does not include biodiversity losses due to air pollution, as this was not included in the Marco Polo external costs calculator.

Airborne emissions, however, lead to the eutrophication and acidification of natural ecosystems, which can have negative effects on biodiversity.

Within NEEDS, the external cost of biodiversity losses due to transport activities have been analysed and quantified (NEEDS, 2006)[1]. In this study, the negative impact of air pollutants on biodiversity was quantified using dose-response-relationships that lead to a so-called 'Potentially Disappeared Fraction' (PDF) of species affected. The PDF can be interpreted as the fraction of species that has a high probability of non-occurrence in a region due to unfavourable conditions caused by acidification and eutrophication. In NEEDS, the PDF of species is then valuated in monetary terms by a restoration cost approach. This is done by valuing the restoration cost for the reconversion of acidified and eutrophic land to a natural state with high biodiversity. The NEEDS project reports cost factors for biodiversity losses due to airborne emissions in euro per tonne of air pollutant (SOx, NOx, NH3) for all EU-27 countries as well as Norway and Switzerland.

These cost factors have been used in the present study to calculate biodiversity losses due to the airborne emissions of transport. The cost factors derived from NEEDS were adjusted from price levels in 2004 to prices current in 2011 (with GDP per capita) and then multiplied with the total emissions of the corresponding pollutants. The calculation was focussed on nitrogen oxide (NOx).

According to NEEDS, the average figure on external costs for biodiversity losses is 1293 $euro_{2011}$ per tonne NOx. The cost of biodiversity losses is additional to the air pollutant costs that have been presented in section 3.5 based on the Marco Polo external cost calculator methodology (health costs, building & material damages, crop losses).

[1] NEEDS project documentation, Deliverable D.4.2.- RS 1b/WP4 – July 2006, 'Assessment of Biodiversity Losses', http://www.needs-project.org

The total external cost of air pollution is the sum of both cost aspects. In case the costs would be added to the NOx shadow price that was used based on the Marco Polo cost calculator, this would result in an increase of 11.5% on the external cost savings for NOx, resulting in a sum of shadow price of 12,545 euro per tonne NOx (1,293 $euro_{2011}$ + 11,252 $euro_{2011}$ per tonne NOx)

5.2.4 Impact on climate change, external costs savings on CO2

In 2007 about 19.5% of the total greenhouse gas (GHG) emissions in Europe were caused by transport[1]. These emissions contribute to global warming resulting in various effects, such as sea level rise, agricultural impacts (due to changes in temperature and rainfall), health impacts (increase in heat stress, reduction in cold stress, expansion of areas amenable to parasitic and vector borne disease burdens (e.g. malaria, etc.), ecosystems and biodiversity impacts, increase in extreme weather effects, etc.

The main greenhouse gases with respect to transport are carbon dioxide (CO2), nitrous oxide (N2O) and methane (CH4). To a smaller extent emissions of refrigerants (hydrofluorocarbons) from Mobile Air Conditioners also contribute to global warming.

The climate change costs have been estimated based on a study by Kuik et al. (2009)[2]. Through a meta-analysis of 62 studies, the study by Kuik et al. presents the avoidance costs of policies that aim at the long-term stabilisation of greenhouse gases in the atmosphere (in € 2005 value per tonne CO2). There can be a large bandwidth in the external climate change (avoidance) costs. With regards to a long-term target of 450 ppm CO2 eq. (in order to keep global temperature rise below 2°C) the avoidance cost in 2025 is estimated to be €129 per tonne CO2 (bandwidth: €69-€241). For 2050 the central value is estimated to be €225 per tonne CO2 (bandwidth: €128-€396). Due to the uncertainties in forecasting long-term climate change costs (e.g. due to changes in oil price and discount rates), the middle value has been selected for this study. It is generally assumed that climate costs increase over time. Extrapolating the cost values of 2025 and 2050 from Kuik (2009) back to 2011 and adjusting the cost values from price levels in 2005 to levels current in 2011, results in a value of €86.60 per tonne CO2 (price level 2011).

For this study it is assumed that LNG Dual Fuel vessels save 20% of their CO2 emission in comparison to the conventional diesel engines. Moreover, it is assumed that the new diesel engines for stage 3B have a slightly better fuel consumption performance with a saving of 2% on fuel consumption and CO2 emission. Table 5.5 and 5.6 as well as Figure 5.3 show the development of the CO2 emission in Europe related to the transport of goods by inland waterways[3]. It can be seen that the policy options will have an impact on CO2 reduction of 11% by 2030, 14.5% by 2040 and 17% by 2050.

[1] EU Energy and Transport in Figures 2010
[2] Marginal abatement costs of greenhouse gas emissions: A meta-analysis. O. Kuik, L. Brander, R.S.J. Tol, 2009. Energy Policy, vol. 37, Iss. 4 (2009); p. 1395-1403).
[3] Excluding emissions of auxiliary engines

Table 5.5 Absolute level of CO_2 production by inland waterway freight transport in Europe in Ktonnes per year

year	Business As Usual (BAU)	Option 1	Option 2	Option 3	Alternative baseline
2012	5,119	5,119	5,119	5,119	5,119
2020	5,559	5,518	5,518	5,518	5,537
2030	6,547	5,809	5,808	5,809	6,447
2040	7,534	6,441	6,440	6,441	7,395
2050	8,518	7,059	7,058	7,059	8,352

Figure 5.3 Absolute level of CO_2 production by IWT in Europe in tonnes per year

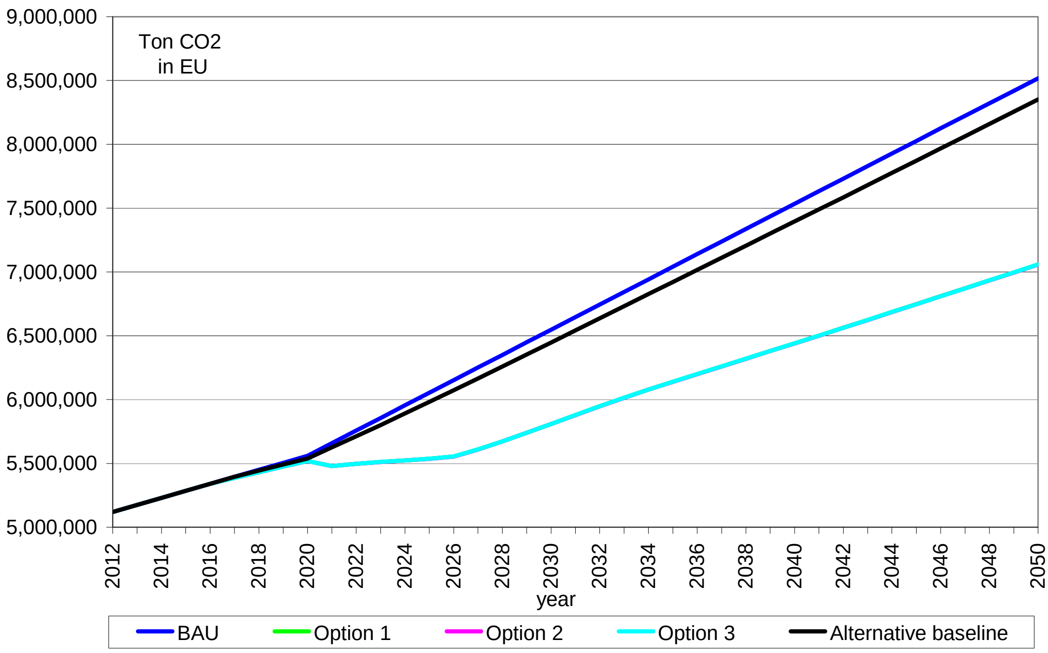


Table 5.6 Reduction of CO_2 production by inland waterway freight transport in Europe in Ktonnes per year and in relative terms of policy options and alternative baseline compared to business as usual

Year	Option 1	Option 2	Option 3	Alternative baseline
2020	41	41	41	22
2030	738	739	738	100
2040	1,093	1,094	1,093	139
2050	1,458	1,460	1,459	166
2020	0.7%	0.7%	0.7%	0.4%
2030	11.3%	11.3%	11.3%	1.5%
2040	14.5%	14.5%	14.5%	1.8%
2050	17.1%	17.1%	17.1%	1.9%

6 Cost-benefit analysis

6.1 Parameters and definitions for Cost-Benefit Analysis calculations

In this chapter, costs and benefits of the policy options and of the alternative baseline will be expressed in terms of:

- Net Present value (NPV): the value that results from present costs minus present benefits;
- Benefit-Cost ratio (B/C ratio): the ratio of the present value of social benefit to the present value of social costs over the time horizon.

The EC Guide to Cost-Benefit Analysis of Investment Projects[1] refers to the NPV as the most important and reliable social Cost-Benefit Analysis (CBA) indicator and should be used as the main reference economic performance signal for project appraisal.

In order to determine NPV and B/C ratio, the choice of the discount rate is essential. The European Commission suggests a social discount rate of 5.5% for Cohesion and IPA countries and for convergence regions elsewhere with a high growth outlook. For other regions, a discount rate of 3.5% is advised. Therefore, for the calculations in this study an intermediate discount rate of 4% was applied. The calculations are made for a time span ranging from 2012 to 2050. All benefits and costs are discounted in order to determine the present value for the year 2011.

The NPV of the total external costs for the BAU scenario for the period 2012-2050 are calculated as 51.5 billion euro for the EU27 while the NPV of investments for the BAU scenario for the period 2017-2050 sums up to 1.3 billion euro. Table 6.1 presents a breakdown of the total external costs for the BAU scenario over different engine power ranges.

Please note that in this chapter the cost and benefits for auxiliary engines and passenger transport have not been taken into account. The cost benefit analyses does focus on commercial freight transport and the policy options for emission limits to main propulsion engines of freight vessels.

[1] Guide to Cost-Benefit Analysis of Investment Projects, Structural Funds, Cohesion Fund and Instrument for Pre-Accession, European Commission DG Regional Policy, 2008

Table 6.1 total of external costs for BAU between 2012-2050 and total of investments in new stage IIIA engines between 2017-2050, in mln euro

	NPV INVESTMENTS BY IWT	NPV EXTERNAL COSTS BY IWT
74-220 kW	7.5	1,053
220-304 kW	23.8	659
304 kW - 600 kW	85.3	4,220
600 kW- 981 kW	64.6	3,685
>981 KW	1,080	41,908
TOTAL	1,262	51,526

The impact of the policy options as well as the alternative baseline will be determined relatively to the BAU scenario.

In the CBA the following definitions are used:
- NPV External costs: NPV of emission savings (relative to business as usual, always ≥ 0);
- NPV IWT industry: NPV of impact on investments and operational costs such as changes in fuel costs, consumption of urea, repair and maintenance costs (marginal costs compared to business as usual);
- NPV IWT Investments: NPV of investments for hardware and installation costs;
- NPV Society = NPV external costs + NPV IWT industry.

In this study, efficiency and effectiveness of the policy options or the alternative baseline are important assessment parameters. Efficiency and effectiveness are defined as follows.

Efficiency is the result attained per € invested. Or, in terms of the above mentioned definitions, it is the Benefit/Cost ratio (B/C ratio), determined by:

$$\frac{NPV_{society}}{-NPV_{IWT.Industry}}$$

Effectiveness is when the alternative baseline or the policy options comply with the policy objective[1].

6.2 Results of financial calculations

Table 6.2 shows the results of the financial calculations for the alternative baseline and the policy options. Net Present Values for the IWT sector as well as society are given, as well as efficiency ratios and the reduction of the external costs compared to the BAU scenario. The results are shown for both the individual engine categories and all engine and vessel categories together.

[1] In this report, effectiveness is measured by comparing the monetised performance of the policy options or the alternative baseline against the BAU scenario. For graphs of the performance in terms of NOx or particle exhaust, see Annex 11

Table 6.2 Results of the financial calculations for the policy options and the alternative baseline

OPTION 1 - Maximised time for development Stage 5 large vessels	*4B NEW / 4A Existing*	*4B NEW / 4A EXISTING*	*4B NEW / 4A EXISTING + Stage 5 from 2022*	
Net propulsion power	*≤ 304 kW*	*> 304-981 kW*	*≥ 981 kW*	*Total*
Total costs IWT (NPV)	174 mln €	316 mln €	180 mln €	670 mln €
Investments by IWT (NPV)	133 mln €	184 mln €	1,570 mln €	1,886 mln €
Reduction external costs compared to BAU (NPV)	499 mln €	2,337 mln €	20,533 mln €	23,369 mln €
Net impact for society (NPV)	324 mln €	2,021 mln €	20,353 mln €	22,698 mln €
Reduction of external costs compared to BAU	47.3%	30%	49%	45%
Benefit/Cost ratio (efficiency)	1.9	6.4	113.1	33.9
Benefit/Investment ratio	3.7	12.8	13.1	12.4

OPTION 2 - Optimised cost-effectiveness	*3B NEW ONLY*	*4B NEW / 4A EXISTING*	*4B NEW / 4A EXISTING + Stage 5 from 2020*	
Net propulsion power	*≤ 304 kW*	*> 304-981 kW*	*≥ 981 kW*	*Total*
Total costs IWT (NPV)	16 mln €	316 mln €	160 mln €	492 mln €
Investments by IWT (NPV)	13 mln €	184 mln €	1,739 mln €	1,935 mln €
Reduction external costs compared to BAU (NPV)	66 mln €	2,337 mln €	20,829 mln €,	23,233 mln €
Net impact for society (NPV)	50 mln €	2,021 mln €	20,669 mln €	22,741 mln €
Reduction of external costs compared to BAU	6.3%	30%	50%	45%
Benefit/Cost ratio (efficiency)	3.1	6.4	129.1	46.2
Benefit/Investment ratio	5.1	12.8	12.0	12.0

OPTION 3 - Mix of cost-effectiveness and level playing field	*≤ 38m: 3B NEW*	*4B NEW / 4A EXISTING*	*4B NEW / 4A EXISTING + Stage 5 from 2020*	
Net propulsion power	*≤ 220 kW*	*> 220-981 kW*	*≥ 981 kW*	*Total*
Total costs IWT (NPV)	4 mln €	€ 381 mln €	160 mln €	545 mln €
Investments by IWT (NPV)	3 mln €	€ 231 mln €	1,739 mln €	1,972 mln €
Reduction external costs compared to BAU (NPV)	10 mln €	€ 2,543 mln €	20,829 mln €,	23,383 mln €
Net impact for society (NPV)	6 mln €	€ 2,032 mln €	20,669 mln €	22,707 mln €
Reduction of external costs compared to BAU	1.0%	32%	50%	45%
Benefit/Cost ratio (efficiency)	1.5	5.3	129.1	41.6
Benefit/Investment ratio	3.1	11.0	12.0	11.9

Alternative baseline - Stage 3B New engines only	*3B NEW ONLY*	*3B NEW ONLY*	*3B NEW ONLY*	*3B NEW ONLY*
Net propulsion power	*≤ 304 kW*	*> 304-981 kW*	*≥ 981 kW*	*Total*
Total costs IWT (NPV)	16 mln €	57 mln €	330 mln €	403 mln €
Investments by IWT (NPV)	13 mln €	35 mln €	163 mln €	211 mln €
Reduction external costs compared to BAU (NPV)	66 mln €	1,044 mln €	13,369 mln €	14,480 mln €
Net impact for society (NPV)	50 mln €	986 mln €	13,039 mln €	14,076 mln €
Reduction of external costs compared to BAU	6.3%	13%	32%	28%
Benefit/Cost ratio (efficiency)	3.1	17.2	39.5	34.9
Benefit/Investment ratio	5.1	29.8	82.1	68.6

In the Figures 6.1 to 6.4, the NPV results as in Table 6.2 are shown graphically for the three policy options and the alternative baseline. The results are shown for both the individual engine/vessel categories and all categories together. The CBA results per vessel type have been included in Annex 12 as well as the specific CBA results for existing engines. Figure 6.5 compares the results for the alternative baseline and the policy options of all engine/vessel categories together.

Figure 6.1 NPV for IWT sector and society in case of option 1

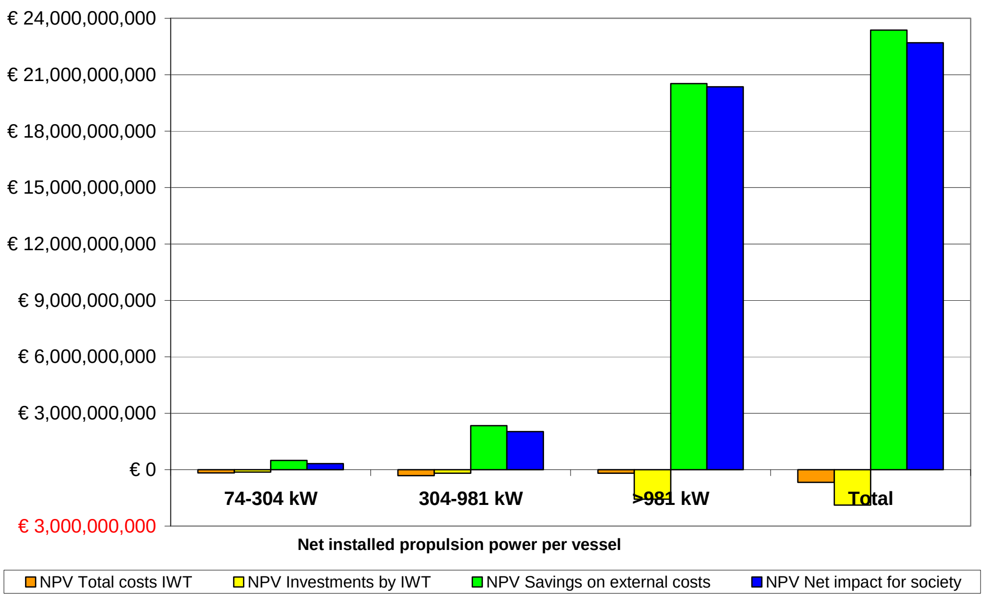


Figure 6.2 NPV for IWT sector and society in case of option 2

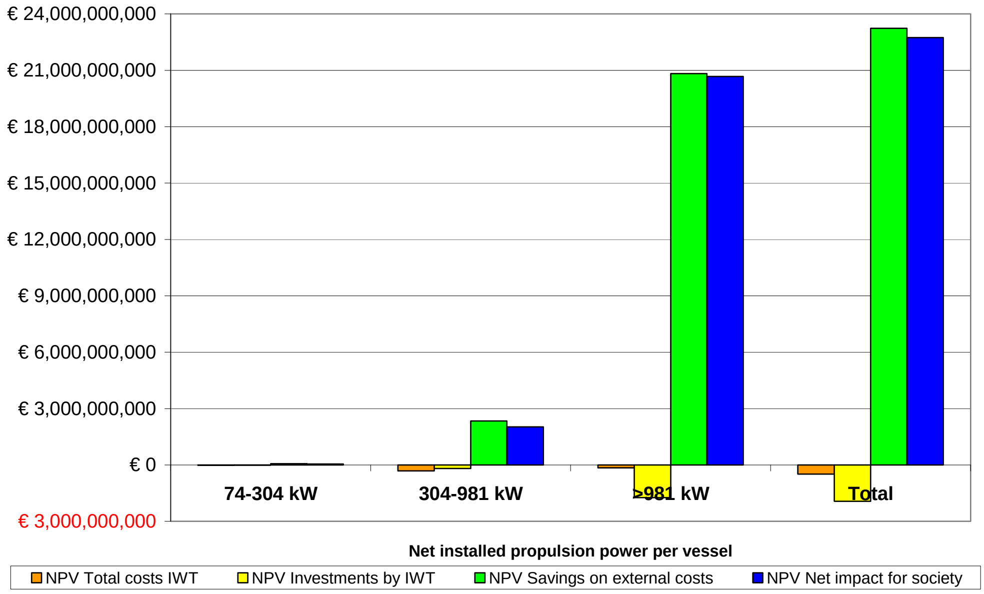


Figure 6.3 NPV for IWT sector and society in case of option 3

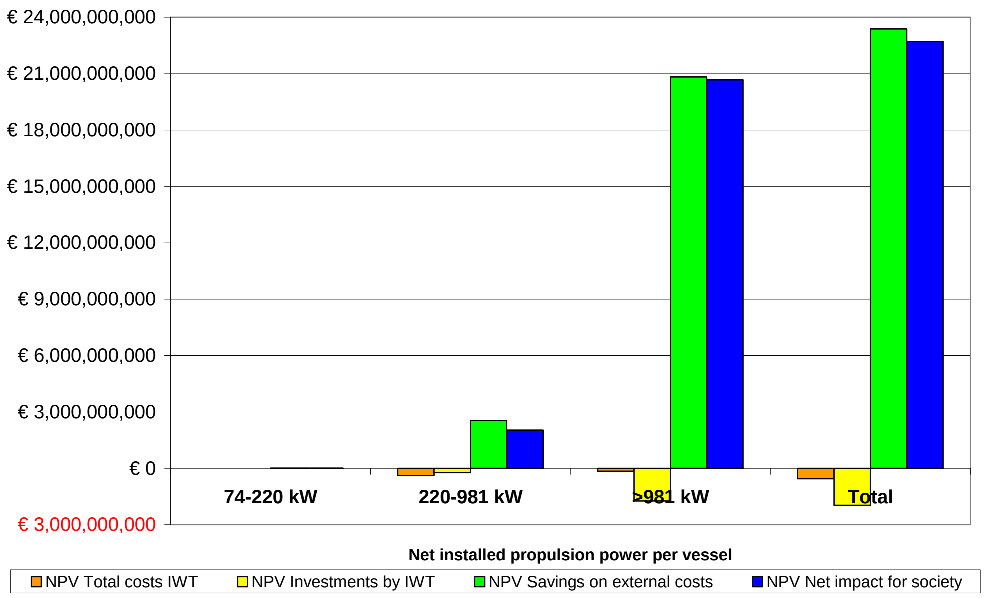


Figure 6.4 NPV for IWT sector and society in case of alternative baseline

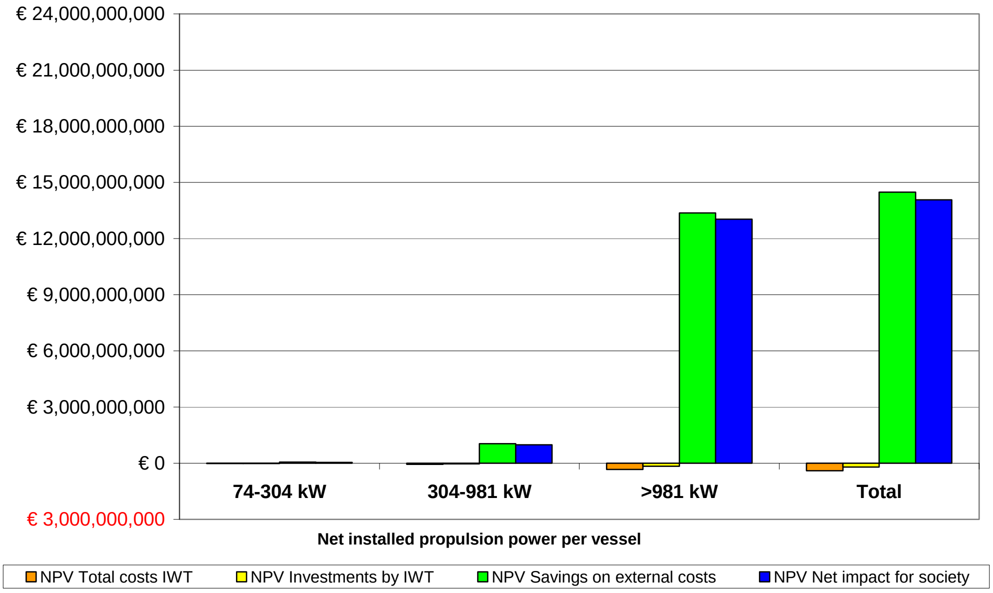
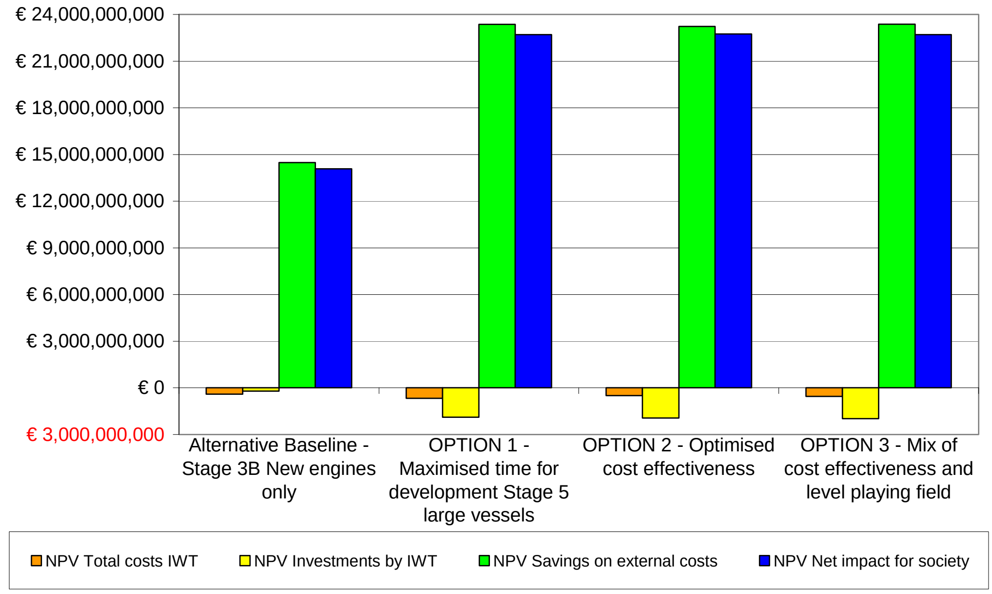


Figure 6.5 Comparing NPV outcomes for alternative baseline and policy options



Based on the results in Table 6.2 it can be observed that the Net Present Value for society for freight transport by inland waterways is estimated at 22.7 billion euro for the options 1, 2 and 3. The Net Present Value for Society for the alternative baseline (3B only new engines) is estimated at 14.1 billion euro. Therefore, it can be concluded that compliance with the policy objective (equal or lower air pollutant cost compared with road haulage by 2030) generates an additional 8.6 billion euro of savings for society in comparison to the alternative baseline (3B). It can also be concluded that in particular, the class of large vessels/large engines (>981 kW) has a strong influence on the results. This class shows a rather high benefit/cost ratio (113 to 129) and also a strong reduction of external costs of 50% when compared to the business as usual scenario (BAU). Moreover, in this class all new vessels added to the fleet show 'win-win' situations, as they reduce both the internal transport cost for the shipowner/operator and shippers and also a reduction on the external costs compared to BAU. More information on the impact for the ship owner/operator is presented in Annex 9 of this report.

In regards to the required investments the options 1, 2 and 3 have a Net Present Value of investments in the range of 1.9-2.0 billion euro, while the alternative baseline has a Net Present Value of 211 million euro.

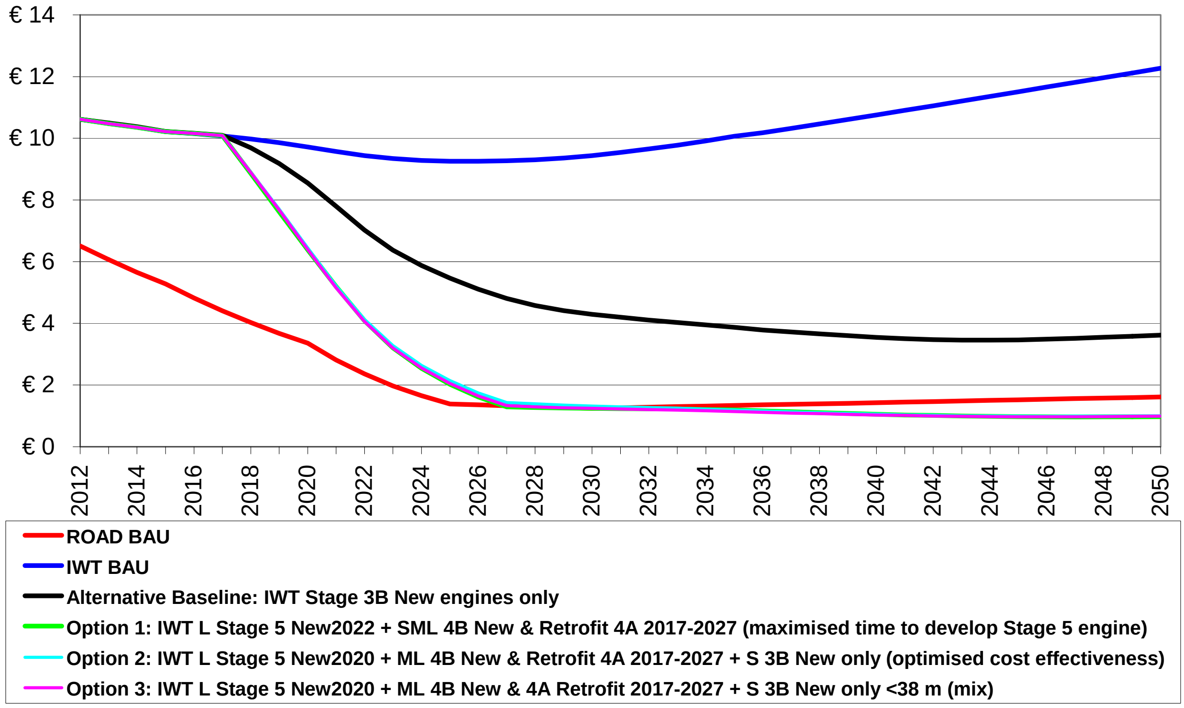
With regards to the overall compliance costs for options for the inland waterway transport sector, the costs are lowest for the option 2 at 492 million euro (NPV IWT Industry). These compliance costs also take the impact on maintenance and fuel and urea consumption into account. The compliance costs for the option 1 is 670 million euro and for option 3 the value is 546 million euro. The alternative baseline has a compliance cost of 403 million euro.

Despite the large difference in the investments between the options and the alternative baseline it can be concluded that the differences on the net present value of the overall compliance costs are much more limited. Here the advantage of the technology option LNG is providing clear benefits for the shipowner/operators, as operational costs for the industry are reduced due to a strong reduction of fuel costs.

Moreover, it should be noted that the alternative baseline is not effective, i.e. does not meet the policy objective as stated in Chapter 4. The alternative baseline will result in a reduction of external costs by approximately 28%, while the options 1, 2 and 3 will result in approximately a 45% reduction and in particular, equal or lower air pollutant costs in comparison to road haulage by 2030. This is shown graphically in Figure 6.6. In addition, it should be kept in mind that the LNG technologies that are assumed for stage 5 provide additional benefits to society, because of the reduction of CO2 emissions which results in a reduction of the costs for climate change.

Lastly, an important socio-economic indicator for assessing the merits of options is the benefit/cost ratio: the NPV of savings for society divided by the -NPV of compliance costs for the sector. Here the highest benefit/cost ratio is seen at the option 2 with a value of 46.2. This means that on average, every euro for compliance costs for the IWT industry generates 46.2 euro of savings for society. The value for option 1 is a ratio of 33.9 and the benefit/cost ratio for Option 3 is 41.6. The value for the alternative baseline is 34.9.

Figure 6.6 Evolution in time of external cost in Euro / 1.000 tkm of air pollutants for BAU IWT and road haulage, alternative baseline and policy options 1, 2 and 3



6.3 Sensitivity analysis

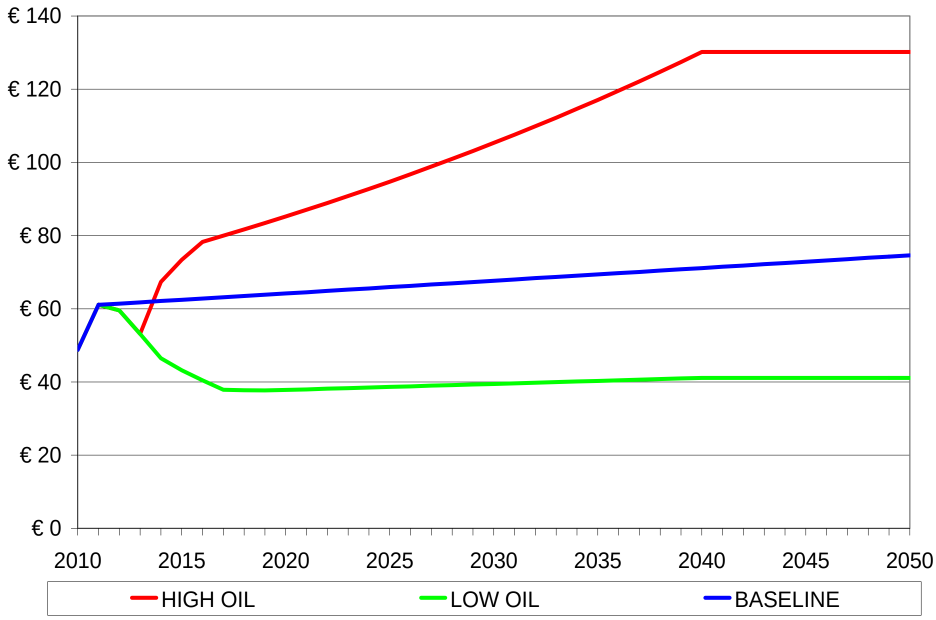
A number of sensitivity tests have been run to investigate how the results of the financial calculations vary according to changes in important assumptions. In order to do so, the following cases have been analysed:

- Level of fuel prices and fuel price differences between LNG and diesel;
- Use of methanol instead of LNG as fuel;
- CO2 shadow price;
- Research and development costs of stage 5 diesel engine.

6.3.1 Level of fuel prices and fuel price difference between LNG and diesel

The price of the fuel and the price difference between LNG and diesel is important for the decision making of vessel owners when deciding what technology to use. The general assumption on the diesel fuel price development is derived from the World Energy Outlook from November 2012. Secondly, the price difference between diesel and LNG is set at 20%, based on various interviews with experts. On top of the environmental benefits, LNG also provides an additional gain with regards to the external costs, because of the reduction of CO_2 emission. Therefore, it is important to investigate the sensitivity for the fuel price of LNG versus the price of diesel. Figure 6.7 presents the variation of the fuel price for diesel.

Figure 6.7 Variation of the fuel price for diesel



A favourable situation for the LNG business case would be a high oil price in combination with a larger relative gap between diesel and LNG, e.g. 30% instead of the 20% in the baseline. On the other hand, a low oil price and a smaller gap (10%) would result in lower fuel cost savings per year.

Table 6.3 NPV total operational costs for a single new vessel with technology LNG+SCR+DPF

Vessel type	Average power kW	Worst case LNG 10% price difference at low oil price	Baseline LNG 20% price difference, medium oil price	Best case LNG 30% price difference at high oil price
67*8.2m, 913t	447 kW	€ 431,112-	€ 316,561-	€ 104,541-
85*8.2m, 1260t	547 kW	€ 402,924-	€ 201,013-	€ 172,696
85*9.5m, 1540t	737 kW	€ 440,208-	€ 192,857-	€ 264,958
110*11.4m, 2750t	1178 kW	€ 494,573-	€ 88,019	€ 1,166,319
135*14.2m, 5600t	2097 kW	€ 792,393-	€ 731,566	€ 3,552,207
Push boat 1000-2000kW	1331 kW	€ 704,131-	€ 477,905	€ 2,665,694
Push boat> 2000kW	3264 kW	€ 884,420-	€ 2,758,999	€ 9,502,475

Table 6.3 presents the results of the NPV of the total operational costs for one new vessel for the LNG-SCR-DPF technology application for different assumptions on the fuel price and the price difference between LNG and diesel. It can be concluded that the attractiveness of the LNG business case depends, to a large extent, on the fuel price development. In case of high oil prices and a larger gap, the LNG business case would also become positive for the 85 metre vessels operated in daytime services. However, in case of a low oil price and a smaller gap (10%), even the most fuel consuming vessels, such as the large push boats operating on a 24/7 basis, would no longer have a financial gain in comparison to BAU. In regards to the the comparison however, it should be remarked that

the reference should be an alternative technology that would also meet the stage 5 emission limit.

6.3.2 Use of methanol instead of LNG as fuel

An important cost element for the LNG technology is the tank for storage of the fuel. Methanol technology is further described in Annex 6. An advantage of methanol in comparison to LNG would be that the storage of fuel on board the vessel would be less complicated. The expensive cryogenic tank needed for LNG storage can then be replaced by a standard tank container. This would lead to lower costs and an improved business case. Table 6.4 shows the influence on the Net Present Value of the total operational costs, as well as the required investment in case of new vessels for five different vessel types.

Table 6.4 Methanol versus LNG for new vessel with Stage 5 emission limit

		Methanol (+SCR+DPF)		LNG (+SCR+DPF)	
Vessel type	Power kW	NPV Total cost	NPV Investment	NPV Total cost	NPV Investment
85*9.5m, 1540t	737 kW	€ 34,794-	€ 316,175-	€ 192,857-	€ 474,238-
110*11.4m, 2750t	1178 kW	€ 271,424	€ 393,435-	€ 88,019	€ 576,839-
135*14.2m, 5600t	2097 KW	€ 925,698	€ 823,094-	€ 731,566	€ 1,017,225-
Push boat 1000-2000kW	1331 kW	€ 661,310	€ 735,567-	€ 477,905	€ 918,971-
Push boat> 2000kW	3264 kW	€ 2,953,131	€ 1,336,132-	€ 2,758,999	€ 1,530,264-

6.3.3 CO2 shadow price

The applied shadow price is 86.8 euro per tonne emission of CO2 based on the medium value provided by Kuik (2009) and as described in Chapter 3 of this report for the year 2011 and based on the 2011 price levels. This is the central or medium value. Literature indicates that there can be a large bandwidth in the external climate change costs (avoidance costs). The IMPACT study[1] provides a broad overview of damage cost estimates from the literature showing values between 20 and 200 euro per tonne.

Therefore, in order to get a view on the sensitivity of the results for the CO2 shadow price level, analyses were made on the business as usual scenario and the external cost savings for the alternative baseline and the three options with the following factors on the CO2 price for the year 2011:

- Low value: 0.23
- High value: 2.3

The CO2 price for future years is then multiplied with the expected development of the real GDP development per capita.

[1] CE/INFRAS/ISI, 2008a, M. Maibach, C. Schreyer, D. Sutter (INFRAS), H.P. van Essen, B.H. Boon, R. Smokers, A. Schroten (CE Delft), C. Doll (Fraunhofer Gesellschaft – ISI), B. Pawlowska, M. Bak (University of Gdansk). Handbook on estimation of external costs in the transport sector Internalisation Measures and Policies for All external Cost of Transport (IMPACT), Delft : CE Delft, 2008

Table 6.5 presents the results for the business as usual scenario, as well as the overall impact on the alternative baseline and three options.

Table 6.5 Sensitivity of external cost calculations for CO2 shadow price, in mln euro

	NPV external costs 2012-2050 at low value, 20 euro per tonne CO2	NPV external costs 2012-2050 at applied baseline value: 86.8 euro per tonne CO2	NPV external costs 2012-2050 at high value: 200 euro per tonne CO2
74-220 kW	854	1,053	1,471
220-304 kW	526	659	912
304-600 kW	3,331	4,220	5,942
600-981 kW	2,875	3,685	5,608
>981 kW	32,498	41,908	69,095
Total	40,084	51,526	83,028

	NPV external costs 2012-2050 at low value, 20 euro per tonne CO2	NPV external costs 2012-2050 at applied baseline value: 86.8 euro per tonne CO2	NPV external costs 2012-2050 at high value: 200 euro per tonne CO2
Option 1	17,741	28,157	56,747
Option 2	17,878	28,293	56,881
Option 3	17,728	28,143	56,733
Alternative Baseline	25,654	37,047	68,090

	NPV external cost savings 2012-2050 at low value, 20 euro per tonne CO2	NPV external cost savings 2012-2050 at applied baseline value: 86.8 euro per tonne CO2	NPV external cost savings 2012-2050 at high value: 200 euro per tonne CO2
Option 1	22,343	23,370	26,282,
Option 2	22,206	23,233	26,147
Option 3	22,357	23,383	26,296
Alternative Baseline	14,430	14,480	14,938

6.3.4 Development costs of Stage 5 diesel engine

As was described in Chapter 4 it is not clear what the actual costs will be in order to develop a stage 5 diesel engine. The cost estimates were based on the indications provided by members of Euromot. A required R&D budget of 15 million euro was expected for one manufacturer to be required to develop a range of stage 5 diesel engines. Alternatively, the integrators could also take action to provide services for reducing the emission limits to stage 5. The calculation is however, based on the scenario that an engine manufacturer will take the risk to develop stage 5 diesel engines.

It should be noted however, that the required stage 5 emission standard is limited to a certain class of engines linked to the existing push boats that will not be converted to LNG and therefore, would need a stage 5 engine in case the existing vessel needs new engines. On average these vessels use two engines with a power of around 700 kW. Therefore, it probably would not be necessary to develop smaller stage 5 diesel engine sizes. Manufacturers and after-market service providers could focus on the development of larger engines: e.g. the range between 700 to 1400 kW.

In order to illustrate the impact of a higher or lower budget, a sensitivity assessment was made with revised R&D budgets:

- 50% R&D cost reduction: 7.5 million euro instead of 15 million euro;
- 200% increase of R&D costs: 30 million euro instead of 15 million euro.

Table 6.6 presents the results of the costs for the IWT industry, as well as the investment costs for the large vessels.

Table 6.6 R&D costs for the IWT industry as well as the Investment costs for the large vessels, options with introduction of stage 5 in the year 2020 in mln euro

	At R&D costs: 7.5 million euro	*At R&D costs: 15 million euro (baseline)*	*At R&D costs: 30 million euro*
Total NPV Investments by IWT class ≥981 kW	-1,733	-1,739	-1,751
Total NPV IWT Industry class ≥981 kW	- 154	-160	-172
Difference of NPV Investments compared to baseline	-0.3%		0.7%
Difference of NPV Industry compared to baseline	-3.7%		7.4%

It can be concluded that the required R&D costs do not have a major impact on the overall economic impact. The majority of the impact consists of other costs, such as investments for hardware and operational costs (urea, fuel consumption, etc.). From Table 6.6 it can be seen that the total impact for the IWT industry is most sensitive towards a change in R&D costs.

7 Financing and operational effects for stakeholders

The effects of the policy options with regards to the stakeholders may be two-sided. On the one hand, stakeholder groups may be confronted with the direct consequences of the policy options. On the other hand, the policy options also may create incentives for stakeholder groups to act in ways that are not originally meant by the legislative action. In the first part of this chapter, the direct impact is dealt with. In the second part, attention is paid to possible unintended side effects.

7.1 Impact for stakeholders

In the following sections the impact for the stakeholders will be further assessed along two different lines: financing capacity and operational effects. The two most relevant stakeholder groups in this respect are:
- Vessel owners/operators
- Engine manufacturers, equipment suppliers and ship wharfs

For the vessel owners/operators, the most important issues lie with the financial aspects. Operational effects play a lesser role. A vessel engine refit will cause a limited amount of downtime. This effect has already been incorporated in the CBA in Chapter 5.

For engine manufacturers, equipment suppliers and ship wharfs, the most important issues lie with possible capacity bottlenecks in case a large amount of ships need a refit within a short time span. Further, in order to arrive at a stage 5 diesel engine, the engine manufacturers and/or integrator companies must do R&D.

Lastly, the labour market effects are described. The labour market effects are strongly related to the impact of the policy options for the vessel owners/operators and the resulting measures that need to be taken in addition to the BAU scenario.

7.1.1 Vessel operators/owners: financing impact

The basis for the assessment of the economic impact and the effect on vessel operators/owners is:
- Size of fleet affected and number of engines to be renewed or adapted;
- Compliance cost: investment and operational impact ;
- Financial capacity of sector/banks.

The policy options will have the effect that investments will need to be made by most ship owners. Policy options cause changes to the cost structure of the operations of inland vessels and the impact may vary for different types of vessels. In addition, the most suitable technology can be different for existing vessels and new vessels. An important factor is the number of engine running hours and the share of fuel consumption in the overall exploitation costs of a vessel.

Based on interviews with engine manufacturers and distributors it becomes clear that the LNG technology could be economically feasible for new vessels already sailing 5000 engine hours per year as the payback time would be around 5 years, based on a 20% price advantage for LNG fuel compared to diesel fuel. In particular, for the new larger vessels that operate on a 24/7 basis, investments in LNG would then be attractive from an economic viewpoint, irrespective of any environmental benefits. The current LNG dual fuel solutions with 80% LNG and 20% diesel as a fuel mix are expected to result in fuel consumption cost savings of at least 20% in comparison with conventional diesel engines. This generates benefits that compensate the higher investments in LNG technology and in particular, investments in the fuel tanks and the engine. Moreover, further developments are expected in the field of engines using LNG fuel. These developments will further reduce the fuel costs, such as higher shares of LNG (95% LNG, 5% Diesel fuel mix) and also monofuel LNG engines in gas-electric configurations. The time horizon that needs to be bridged is however, an important issue for deciding on the type of technology. The assessments made in this study take into account a time horizon of 20 years in order to derive the best option from an economical viewpoint. This long time horizon is in favour of LNG and will be enabled by the European Commission by means of financial instruments and other measures to support the implementation of LNG in the future (bunkering, R&D support, demonstration and pilots). These accompanying measures will also be part of the NAIADES II programme for 2014-2020, based on the opportunities provided by the Connecting Europe Facility/TEN-T and the Horizon 2020 programme.

In addition, the application of after treatment techniques will add costs to the operation. Along with depreciation and interest for investment costs for SCR and DPF, there will also be higher maintenance costs and consumption of urea, as well as a small increase of fuel consumption. Therefore, the ship owner is currently quite reluctant to invest in such techniques as there is no return of investment and no obligation to apply such technologies in order to meet emission standards. Differentiated port dues for example, by far, do not provide sufficient financial compensation to offset the investments and additional operational costs. For this reason, many ship owners are currently reconditioning the existing engines instead of investing additional money in a replacement with a CCNR 2 engine and/or application of after treatment techniques.

Several ship owners that actually did invest in CCNR 2 engines and new techniques highlight that there is no level playing field in this respect and that these pioneers have a disadvantage in the market when compared to the competitors that are still opting for the reconditioning of existing engines. A more general emission standard that also includes more strict emission standards for existing engines could therefore, result in a better level playing field.

Moreover, financial means shall also be available to enable investments. These financial means primarily can come from:

- Own capital within the company
- Debt capital (e.g. expanding loans from banks)

Therefore, it is necessary to analyse the level of financing that can be expected from the vessel owners and banks. In this respect the share of own capital and the profitability of inland waterway transport companies is important.

Due to the financial and economic crisis the revenues of inland waterway transport companies dropped significantly in 2009 and 2010, while the variable costs (fuel price) showed record levels. The profitability was therefore, under great pressure. It has to be remarked that the supply structure of the market mainly consists of small family owned companies that operate one vessel. Often these companies do not have employees. Many entrepreneurs have reacted to this by awarding themselves less salary and making an agreement with the banks to postpone payments. Based on a study by Panteia/NEA in the Netherlands, in the summer of 2011, approximately 10% of the companies had postponed payments to banks for the payback of loans and interest. In addition, investments were cancelled and/or postponed, e.g. in new building projects and new engines. In 2011 the low water conditions caused a temporal recovery of the revenues. However, the situation for entrepreneurs was worse again in 2012 and in particular, on the Rhine, caused by the overcapacity in the IWT sector.

There have been relatively few bankruptcies. In the Netherlands, 29 bankruptcies were counted in 2012. The reason being that it is of no interest to the banks to sell the vessels. The result would be a re-entry of these vessels into the market, with an increased pressure on lower fares leading to even less earnings, more bankruptcies and a reduced value of vessels which would cause losses for banks, as well as depreciation of loans.

Given the current financial state of the majority of entrepreneurs in inland waterway transport, the overcapacity in parts of the market and the current economic situation banks expect (e.g. ING report 2012) that the financial recovery of the sector will not start until 2018 at the earliest.

The Dutch fleet has a high share in the total EU fleet. Panteia/NEA monitored a group of 75 entrepreneurs in the Netherlands which have been active in the years 2007 to 2011. According to the IVR database the following shares are valid for the Netherlands:

- Class <86 metre: 51% of the motorised cargo vessels are registered in the Netherlands
- Class >86 metre and push boats> 1000 kW: 57% of the motorised cargo vessels and push boats are registered in the Netherlands

Figures 7.1 and 7.2 present the development of the key indicators 'share of own capital' and 'book profits' based on their financial performance in these years for the sample from the Netherlands. Please note, that the majority of these companies operate as family companies without payments of salaries for the family members that often work on board of the vessel.

In Figure 7.1 it can be seen that the average share of own capital significantly reduced over the years. In particular, the situation for the group of larger vessel owners is weakened as they have a negative own capital. The situation for smaller vessel owners is however, better. Their own capital increased again in the years 2010 and 2011. It has to be remarked however, that the value of smaller vessels is much lower in comparison to larger vessels. In the sample the average value of small vessels is approximately 100.000 euro, while the average value of large vessels in the sample was approximately 1.000,000 euro in the year 2011. Furthermore, it has to be emphasised that the figures shown above relate to the Dutch sector situation. Although the Dutch fleet accounts for roughly 53% of the European fleet, the Dutch situation does not necessarily reflect the IWT situation in the whole of the EU.

Figure 7.1 Share of own capital in the Dutch fleet

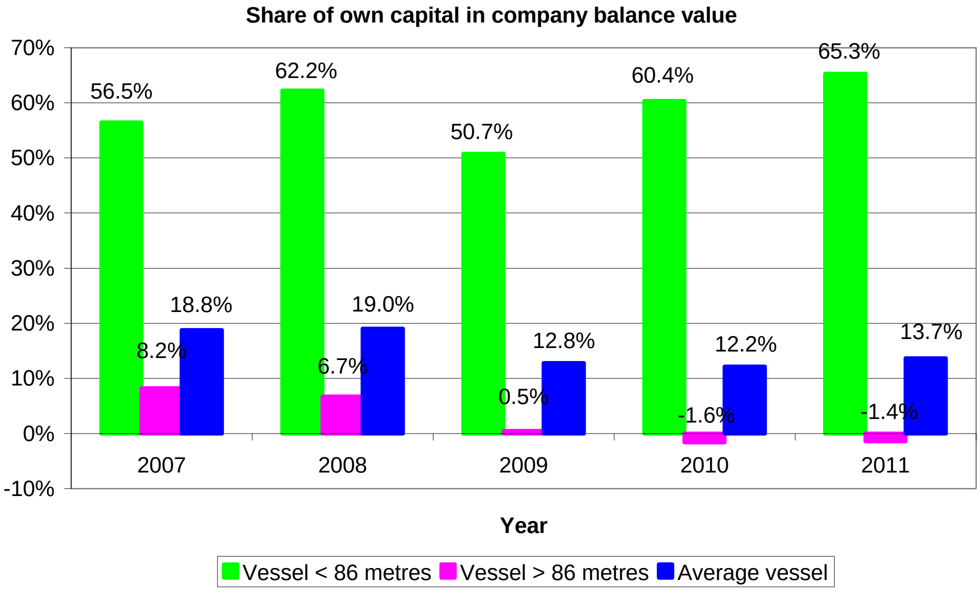
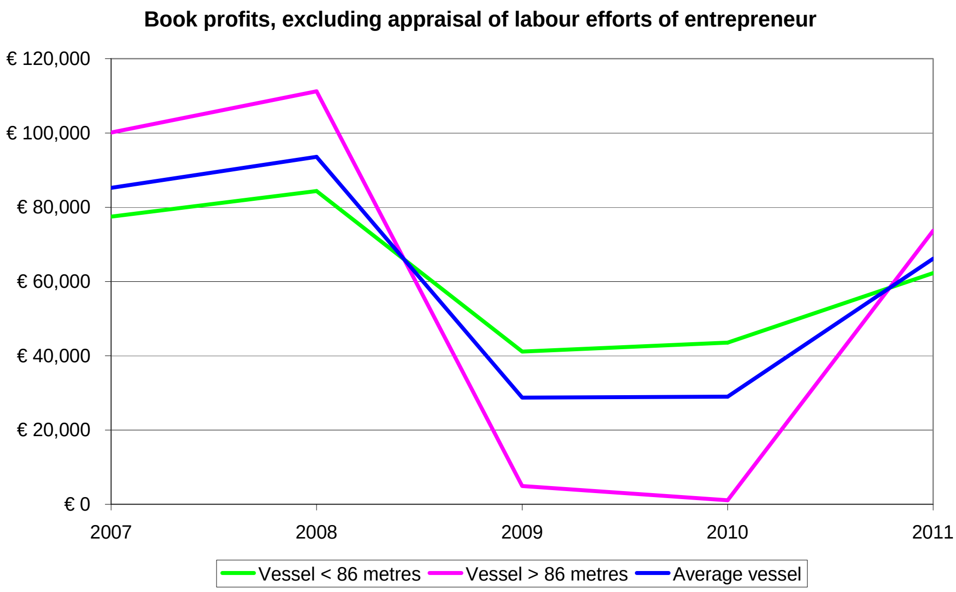


Figure 7.2 Average book profits in the Dutch fleet per vessel, 2007-2011



7.1.2 Engine manufacturers, equipment suppliers and ship wharfs: operational and financing impact

The policy options could give rise to a peak in capacity demand for engines and emission control/after treatment devices. The height of this demand peak differs per option: when legislation is also imposed on the smaller vessels, the demand peak will be steeper.

This demand peak could cause a capacity bottleneck for engine manufacturers, equipment suppliers or ship wharfs. Consultation with the relevant stakeholder groups has however pointed out that this is not expected to be a problem. A demand peak can be absorbed by the service suppliers and ship wharfs.

With regards to the financing aspect, development of a stage 5 diesel engine will require an upfront investment in R&D by the engine manufacturers and/or integrator companies. This investment has to be recouped within a reasonable period after it has been made. In this respect, it must be noted that the IWT market is a rather small market for engines and that it is expected that a large share of the fleet will opt for LNG. This limited number will cause additional costs per engine if this engine is only made for the IWT European sector . The smaller the estimated engine sales, the higher the extra costs per engine will need to be.

7.1.3 Labour market effects

If eco-efficient investments lead to a better and more sustainable competitive position of inland waterway transport, then positive labour market effects for onboard personnel are to be expected.

However, in case the costs of compliance are too high the ship owners could decide to leave the market and to scrap the vessel. This could in particular, be an effect of option 1 as also the smallest vessel categories with a low financing capacity would be subjected to a retrofit obligation. However, the cargo will still need to be transported. The loss of labour for these smaller vessels would therefore, be compensated by the need for personnel for larger vessels and/or the need for more truck drivers in case a reverse modal shift would take place.

Suppliers of equipment and engine manufacturers will also benefit from a demand peak, leading to an increased turnover. Employment would increase accordingly, especially when retrofitting of the large number of smaller vessels is included in the options. The quality of jobs would also improve, as the higher standards would evoke the development of cutting edge applications.

7.2 Possible side effects of legislative action

The policy initiatives aim to improve the overall environmental performance of the IWT fleet. This may also bring about unintended effects. Four of these possible side effects are briefly described in this section.

7.2.1 Reverse modal shift

Almost all technical options identified require large investments or at least additional investments than would have been the case in the BAU scenario. These investment costs ultimately translate into higher standby (i.e. interest and depreciation) costs for inland waterway transport operators. For LNG however the reduction of fuel cost brings strong reductions of the variable costs. It can be seen in Annex 10 that in several cases this would even result in an overall reduction of the cost price of transport. The issue of modal shift therefore, depends on the specific impact that the emission stage would have on the total costs. In case of cost savings the IWT operator can provide the transport services at lower rates to their clients. However, in case of a cost increase the IWT operators will need to calculate the additional costs into the prices offered to customers in order to remain financially sound. Moreover, a better environmental performance of IWT will also be an argument for a group of shippers to increase the use of inland waterway transport.

Both PLATINA (2012) and Arcadis & TML (2009)[1] estimate that the modal shift away from IWT will be marginal, though the compliance cost could be significant for individual self-employed skippers. Arcadis and TML conclude that, when assuming the totality of compliance costs translated in the inland navigation tkm price, the increase in road transport is still negligible. The PLATINA working group concluded that price elasticities for IWT services are generally low, causing a relatively low modal shift effect in case of changes in the transport prices.

In general, PLATINA concluded that transport services are relatively insensitive to changes in prices (direct elasticity between 0 and -1). Transport over longer distances is concluded to be (on average) even less price sensitive than transport over shorter distances. Most studies conclude that the transport of bulk goods is less price sensitive than the transport of general cargo and containers.

- The study conducted by Arcadis et al (2009) used elasticities that were based on model results of the TREMOVE-model. The study applied a direct elasticity of -0.25 for inland waterway transport as an average for all commodities, whereas for bulk transport a value of -0.15 was applicable. This means that a cost increase of 10% would lead to a decrease of IWT transport volume by 1.5%.
- Sys and Vanelslander (2011)[2] identified a direct price elasticity for IWT on Flemish waterways of -0.34 (a cost increase IWT by 10% leads to 3.4% decline of IWT (tkm) and a cross-mode elasticity between road and IWT of 0.19 (Cost increase road by 10% leads to 1.9% growth of IWT).
- The study of CE et al. (2010)[3] on the corridor Amsterdam-Paris applied elasticities that ranged between -0.2 and -0.6. The range of elasticities to be used is -0.2 to -0.8 (direct price elasticity for IWT). This means that if total costs per tkm increased by 10%, demand for tkm would decrease by 2 to

[1] Reviewing Directive 97/68/EC Emissions from non-road mobile machinery, ARCADIS and Transport & Mobility Leuven (TML), 2009

[2] Sys, C. and T. Vanelslander (eds.) (2011), Future Challenges for Inland Navigation: A Scientific Appraisal of the Consequences of Possible Strategic and Economic Developments up to 2030, University Press Antwerp.

[3] CE Delft, Alenium, Herry and Infras (2010), External cost based pricing on the corridor Paris-Amsterdam: Deliverable 2 – Scenarios and impact analysis Final report Delft, Delft.

8%. In the cost-benefit analyses performed in the framework of this study, a price elasticity of -0.5 was assumed, meaning that a 1% price increase would lead to a decrease of transport performance by 0.5%.

Taking note of the conclusions of PLATINA and Arcadis & TML concerning the relatively low modal shift effects that are to be expected, the issue of a reverse modal shift is dealt with in this study in a qualitative way.

7.2.2 Distortion of level playing field

Three different elements can be distinguished regarding level playing field:
- Level playing field between vessel classes
- Level playing field between vessel with new engines and vessels with existing engines
- Level playing field between modes of transport, in particular the position of road haulage in comparison to inland waterway transport

Forced and accelerated phasing out of IWT engines, on the basis of more stringent emission standards that are also applicable to existing vessels, might lead to a distortion of the level playing field between vessel classes and ages. In this respect the rationale behind the options 2 and 3 is to avoid disproportionate compliance costs for small vessels. In option 1 the compliance and investment costs do not discriminate against vessel size; the basic investment costs have to be borne by both small and large vessels, but also for the existing vessels. At the same time, the cost-benefit analyses demonstrated that the high investment does not yield the same societal gains in comparison to other vessel types (see Chapter 6 and Annex 12).

Forced phasing out of relatively new engines could also lead to another adverse effect. For relatively new engines it may show that they do not comply with new emission standards while at the same time the normal depreciation period has not yet passed. When adjustments need be made, the owner/operators would be affected in a disproportionate manner. Entrepreneurs that have invested in new vessels/engines just before any possible new emission regime is announced would have to bear the highest compliance costs, namely the additional investment costs and the lost interest/depreciation costs. Entrepreneurs that wait with investments until the deadline would then even be rewarded in such a situation. Therefore, in the design of the measure for existing vessels a transition period of 10 years is taken into account (2017-2026) after the emission limit would be in force. Moreover, the design of the Stage 4A limit was based on a possible adaptation of CCNR 1 (>2003) and Stage IIIA/CCNR 2 (>2007) engines in order to adapt existing engines to new emission standards based on REC principles (-80% NOx and -90% PM). Therefore, in case of proper maintenance the engines that were sold before CCNR 1 came into force would be introduced and could be faced with the need to replace the existing engines. However, there is a lack of information on the actual distribution of the engine-out emission performance of these older engines. At present it is not possible to make a quantitative assessment of the possible additional cost for replacing the older engines. Moreover, other techniques such as Fuel Water Emulsification that could be installed on engines with higher engine-out emissions where DPF is not an option could also be applied.

Comparison with road haulage the position of inland waterway transport is also a matter to take into account. The level playing field between modes can be seen from the viewpoint of the environmental performance. While there is strict emission regulation in force in road haulage (Euro VI), the inland waterway transport has not yet been subjected to such stringent measures. The policy options therefore, close this gap in the level playing field and in particular, the option 1 that also includes the smallest vessels.

7.2.3 Slow-down of investments

If policy initiatives or legislative prescriptions were to concentrate only on new engines, a slow-down of investments in new engines could be the result. In such a situation, ship owners could be expected to keep on working with reconditioned older engines, in order to avoid having to invest in more expensive new engines and to avoid possible additional operational costs for urea consumption and maintenance on the catalysts and filters. This could for example, occur in case of the alternative baseline. This possible adverse effect – the greening initiative is aimed at speeding up investments rather than slowing them down – provides a strong argument for aiming policy and/or legislative initiatives at the legacy fleet as well, or for restricted transitional procedures for existing vessels and their engines.

However, for the existing push boats in the category 1000-2000 kW there could be an impact of slowed down investments. The R&D costs for the development of the stage 5 engine could result in high additional costs for the vessel owner. The vessel owner could therefore, decide to avoid these high additional costs and to opt for adapting the existing engine and to comply with Stage 4A instead of Stage 5. It should be remarked that the number of existing push boats is small in comparison to motor vessels in the class over 981 kW net installed propulsion power. The share in the total discounted external costs in the business as usual scenario for the push boats 1000-2000 kW is limited to less than 3%, as can be seen in the pie chart in Figure 3.13 (only existing vessels as new push boats would opt for LNG). Since the step towards 4A also means quite a significant reduction of emissions, a very limited difference would be expected between stage 5 and stage 4A for the existing 1000-2000kW push boats.

7.2.4 Acceleration of company closures

The inland waterway transport industry has not only been faced with an economic crisis but also with an ageing working population, who have problems in finding successors. Being faced with compliance costs of more stringent emission standards, these financially weak and/or older entrepreneurs might be pushed to go out of business at an earlier point in time than in the BAU scenario. In addition, they may be faced with a lack of their own financial re-investment capacity, a lack of external financing opportunities, or a lack of willingness to invest high sums shortly before a planned retirement.

The possible results of such a situation could be that they go out of business, sell or scrap their vessels, and/or leave the sector for other business industries.

Smaller vessels in particular, are expected to leave the market in an accelerated manner.

This possible adverse effect means that a trade-off will need to be made between the need for stringent environmental standards and the wish to retain jobs in the inland waterway transport industry. These possible adverse effects may justify the following:

- Exemption of smaller vessels for more stringent standards on the existing engines as included in options 2 and 3;
- A long transition periods for technical adaptations (2017-2026);
- The use of dedicated financial support for a limited period to overcome the financial barriers.

8 Legal implications, enforcement and administrative burden

In this chapter we will further describe, the legal implications, enforcement issues and administrative burdens that follow from the policy options. The description is based on the identified relevant European Union legislation that is currently in force. In the fields where European Union legislation lacks, the legislation that is established within the framework of other international organisations, such as the CCNR and Danube Commission, has been called in.

8.1 Legal implications

A scan of relevant legislation was done to determine possible legal implications related to the policy options. In this paragraph the legal feasibility of the eligible options or components thereof will be analysed, including the compatibility with the Treaty and international agreements in terms of the stated objectives pursued. To this end the options and components thereof, have been examined against the background of current law and legislation that is considered being of relevance. Legal obstacles will be identified and legal implications pointed out. In this perspective Table 8.1 shows the legislation that is considered relevant.

Table 8.1 Summary of relevant legislation

Legislation	*Description*
Directive 97/68/EC	DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (OJ L 59, 27.2.98)
Directive 2004/26/EC	DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 April 2004 amending Directive 97/68/EC on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate pollutants from internal combustion engines to be installed in non-road mobile machinery (OJ L 146, 30.4.2004). Corrigendum to Directive 2004/26/EC (OJ L 146, 30.4.2004)
Directive 2006/87/EC	DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006 laying down technical requirements for inland waterway vessels and repealing Council Directive 82/714/EEC (OJ L 389, 30.12.2006, p. 1)
Directive 2008/68/EC	DIRECTIVE 2008/68/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 September 2008 on the inland transport of dangerous goods (OJ L 260/13)
Convention for Rhine Navigation	Convention of Mannheim of 1868 on the Regime of Navigation on the river Rhine
Convention regarding the regime of navigation on the Danube	Convention of Belgrade of 1948 on the Regime of Navigation on the Danube
Police Regulations	Police Regulations established by the Rhine and Danube Commission

In the following paragraphs, the possible legal implications are identified with regards to the revision of emission standards.

8.1.1 Directive 2006/87/EC

Directive 2006/87 lays down the technical requirements for inland waterway vessels as regards to construction and equipment. A Community Inland Navigation Certificate is issued for vessels which comply with these requirements. This certificate allows operation on all European inland waterways. Vessels brought into service after the 31st of December 2008 must comply in full however, transitional provisions may be applied to vessels brought into service prior to that date.

With regard to engines, Chapter 8a of Annex II of the directive stipulates that the engines must comply with Directive 97/68/EC. Existing engines, installed onboard vessels and which carry a community certificate, enjoy the transitional provisions as laid down in the Chapters 24 and 24a; they can be used without a deadline.

Options making use of LNG

Legal implications of revision of emission standards arise from the proposed variations in regards to technology, where it concerns the introduction of LNG. Regarding the deployment of LNG, Directive 2006/87/EC contains an obstacle as Article 8.01(3) of Annex II of the directive prescribes that only internal-combustion engines burning fuels with a flashpoint of more than 55°C may be installed. In individual cases derogations may be granted over Article 2.19 of Annex II - Equivalences and derogations. Four such derogations have been granted already according to the RVIR (the Rhine inspection rules) for vessels using LNG as fuel. More are to be expected. However, this case by case approach undermines the long-term legal certainty. Therefore, conditions for engines burning LNG should be elaborated and embedded in the legal system.

Another topic related to LNG where legal issues may arise concerns the possibility that for reasons of safety, certain vessels are excluded from the deployment of LNG. Examples of such vessels could be:

- Passenger vessels and vessels carrying dangerous goods;
- Vessels not being built according to classification rules.

New vessels/ engines combined with retrofit

All policy options foresee a gradual mandatory introduction between 2017 and 2027 for existing engines, when a revision of the engines (e.g. after 30,000 hours of operation) will occur. Option 1 involves the full range of vessels while options 2 and 3 exempt smaller engines from a mandatory retrofit. Against the background of the present transitional provisions, the possible legal implications may depend on the time span that allows ship owners to adapt to the new situation. Most likely, the renewal of certificates for the vessel will be the occasion to introduce regulations for new engines.

According to current EU legislation, existing engines installed onboard inland waterway vessels may continue to be used without a deadline. However, in other industries directives have also been implemented that aimed at the introduction of emission restrictions for existing installations. Clear examples of this are mentioned in Table 8.2. If a measure were to be communicated in 2013 and applicable in the year 2027 at the latest, this would allow ship owners a maximum time for adaptation of 14 years. Whether this period allows the ship owner sufficient time to prepare for adaptation by the transitional regime, can be studied by way of comparing it with similar cases (as in table 7.2) where a policy change was implemented within a certain limited time span.

Table 8.2 Cases where a policy change was implemented within a certain limited time span.

Topic	*Short explanation*
Directive 2010/75EC, Directive 2010/75/EC on industrial emissions (integrated pollution prevention and control)	BEMS example of implementation of directive in the Netherlands: April 2010 strict emission limit values (ELVs) on mid-size combustion plants have come into force. New plants are to comply with these regulations immediately. For the existing plants there is a transitional period until 2017. BEMS sets emission limit values for NOx, SO2, PM and CxHy.
Single hull tanker phase-out	EC proposed to introduce a phase out scheme for single hull tankers with final date set on 2015. The phase-out of any particular single hull tanker was based upon its year of build, its gross tonnage and whether it had been fitted with either double bottoms or double sides.

With regards to the concept of 'revision', a clearer and unequivocal interpretation would be desired. Accordingly, a link should be made with the Community Inland Navigation certificates. The validity period of Community certificates issued to newly built vessels in accordance with the provisions of this Directive will be determined by the competent authority up to a maximum of (a) five years in the case of passenger vessels and (b) ten years in case of all other craft (including transport of goods).

8.1.2 Directive 2008/68/EC

Directive 2008/68/EC on the inland transport of dangerous goods is a so-called framework directive. In regards to to the substance, it refers to the ADN, the European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways, concluded at Geneva on the 26th of May 2000. Regulations regarding the construction and equipment of the vessels can be found in the Annexes (B2).

With regards to LNG a similar obstacle that is also in Directive 2006/87/EC has been created by Directive 2008/68/EC. The paragraphs 7.2.3.31.1 and 9.3.2.31.1 of the respective Annex to the ADN also prescribe that only engines burning fuels with a flashpoint of more than 55°C may be installed. Pursuant to paragraph 1.5.3.2 of the Regulations annexed to the ADN, derogations may be granted by the ADN Administrative Committee of the UNECE. Derogations for vessels using LNG as fuel have already been granted.

8.1.3 Directive 97/68/EC and Directive 2004/26/EC

Directive 97/68/EC stipulates that as from July 2007, engines for inland waterway vessels which are placed on the market have to meet the requirements of the directive (NRMM). The engine type or engine family has to be type approved with regard to the level of emission of gaseous and particulate pollutants. Furthermore, the directive obliges Member States to issue the Community Inland Water Navigation certificate as established by Directive 82/714/EC only to vessels whose engines meet the requirements of this Directive (97/68).

Directive 2004/26/EC is amending Directive 97/68/EC. Since then engines in Inland Waterway Transport are also addressed. The directive 2004/26/EC covers diesel fuelled engines from 19 kW to 560kW for common NRMM and regulates the emission in 3 further stages. The directive includes railcars, locomotives and inland waterway vessels. For the 2 latter categories there are no upper limits concerning engine power.

The different stages in the 2004/26/EC directive are as follows:

- Stage III A covers engines from 19 to 560 kW including constant speed engines, railcars, locomotives and inland waterway vessels.
- Stage III B covers engines from 37 to 560 kW including, railcars and locomotives.
- Stage IV covers engines between 56 and 560 kW.

The stage III A is effective (placed on the market) from 1 January 2006 for certain types of engines, stage III B from 1 January 2011 and stage IV from 1 January 2014. In the directive there is a flexibility scheme that allows manufacturers to place engines on the market that only fulfil the previous stage when a new stage is in force.

The directive 2004/26/EC is aligned with the US proposal TIER IV of further stages of emission limit values.

As the directive applies to new engines, i.e. engines which are placed on the market, it would not be the best instrument to accommodate emission levels for existing engines. Directive 2006/87/EC, Chapter 8a, seems to be appropriate as the present version already contains provisions for engines with after-treatment systems.

Due to Directive 82/714/EC being repealed and the requirement for engines to comply with Directive 97/68/EC set out in Directive 2006/87/EC, it may be considered whether it still makes sense to maintain the relevant article (8.2.a) of the Directive 97/68/EC.

8.1.4 Police Regulations

The Police Regulations contain the rules for navigation and behaviour of the vessels on inland waterways. Within the Union the police regulations, as established by the CCNR and the Danube Commission, can be considered as the leading instruments. They are applicable on a substantial part of the European Union waterway network.

In regards to the conditions for navigation, neither the Police Regulations currently in force on the Rhine, nor those in force on the Danube, create an obstacle for navigation conditions, such as mooring and berthing. In addition, the derogations recently granted for vessels whose engines burn LNG do not mention these topics. Within the CCNR Member States have decided to allow, on a case by case basis, certain specific vessels using LNG for propulsion. However, where the risk may be too high, certain vessels could be excluded in future regulations that are to be set up. For the sake of long-term certainty, clarity should be sought with regards to this topic.

Other topics related to LNG where legal implications/obstacles may arise:
- Possibility that for reasons of safety certain areas are excluded from the deployment of LNG;
- Passing locks;
- Bunkering facilities.

8.2 Certification and enforcement

With regards to the use of tuning/after-treatment technology, conditions for appropriate systems should be developed, accompanied by type approvals and monitoring. Details of the systems should also be entered in the ship's certificate. These requirements could be incorporated in Directive 2006/87/EC.

After-treatment and other technologies may require specific modes or conditions for their operation, such as use of additives. In addition, tempering with these technologies with the aim of reducing fuel consumption and avoiding maintenance costs, shall be prevented. Police regulations may be used to create the legal basis for enforcement of the correct operation of these technologies. For example, attention shall be paid to the illegal use of a by-pass of DPF. Such a by-pass would be requested, as a safety measure to ensure manoeuvring for vessels with single propulsion engines without powerful bowthrusters.

It is not expected that new emission standards will lead to changes with regards to type approval. However, low emission limits may require after-treatment applications for new engines. This would possibly extend the scope of type approval for combinations of engines and after-treatment applications. Engines, as well as combinations of engines with after-treatment technologies would be approved, if they fulfill emission standards and other relevant criteria. The combination of an after-treatment technology application with an engine would have to be approved by certification authorities. As practised and with regards to engines the approval of the compatibility with one engine of a family might be sufficient for approval of all engines belonging to one family. With regards to the retrofit of existing engines, the same certification issues would apply as they do for new engines and the combination of engines with after-treatment application has to be approved.

The functionality of engines and after-treatment technology will be checked in the ship certification, which is according to Directive 2006/87/EC and Rhine Vessel Inspection Regulation, required before any new vessel start operation (installation test). A check is also required when the engine has been changed significantly, e.g. by retrofit of after-treatment applications. The ship's certificate has a limited validity and subsequently checks are required at least every 10 years.

The inspection covers emission relevant components, adjustments and parameters. It is based on instructions by the manufacturer, which has been approved by the certification authority. The regulation states explicitly that the functionality of after-treatment technologies has to be checked. However, after-treatment technologies might require additional verficiation mechanisms, for instance by foreseeing shorter test intervals than 10 years, by administrative checks or by taking appropriate provisions in the framework of the policy regulation (CEVNI). This might be required, as the functionality of after-treatment technologies depends on adequate maintenance of systems, e.g. sufficient urea supply of SCR applications and replacement/cleaning of filters. In order to ensure a proper functioning of the device, another possibility is to allow only officially registered system components in case of repair or service to the device. This implies that the components need to be kept in stock.

Failure could not only lead to too high emission levels, but may also affect the functionality of the entire engine. The latter is regarded as critical on board of vessels, as there are risks in case of non-manoeuvrability. Such risks are perceived to be lower in other areas such as road applications. As contribution to easy maintenance and its control, regulations require manufacturers to provide maintenance/control instructions and engine conception, which allows easy control.

The relevance for new emission levels and related risks may require regular controls in the field to enforce proper maintenance and functionality of applications. This refers to a measurement by a certified authority including staff and equipment. Until recently however, field measurements of emission levels are regarded as costly. Due to the high cost, other ways of enforcement could be considered. Instead of field measurement, criteria such as engine parameters with a clear relation to functionality and emission levels could be determined. These criteria require unambiguous application and checking. Parameters should be observable by skippers. Moreover, authorities should be able to collect these parameters easily during control and read-out of electronic logs could be used for checks. An interface for the read-out of parameters and failure memory by authorities has to be defined and its installation should be obligatory. Indicator values might, in particular, be a viable option for DPF systems (e.g. regarding conductivity) application. With regards to SCR applications the emission level is not the major concern, as it is expected to only marginally worsen over time. However, functionality concerns exist. Therefore, skippers could be required for the documentation of periodic coating and urea controls. Generally, skippers could be required to prove that maintenance of applications follow the instructions given by the manufacturer, which are approved by authorities. These could be done by documentation of regular functionality controls of catalysts and filters, as well as a documentation of required actions, such as urea addition and filter renewal.

As the emission level of retrofitted engines has to be tested on an individual basis, the total administrative burden for retrofit is high. However, measurement of emission level with certified equipment could become more affordable in the near future. There is certified portable measurement equipment available for around € 20,000. This device might allow an easy on-site control of emission levels, e.g. during planned engine overhaul. Supplier Testo has developed a mobile measurement device, which has been approved by Germanischer Lloyd. The use of this device would broaden the options for enforcement. Conditional to the diffusion of the technology, the documentation of emission measurements during engine overhaul could be used to prove the compliance with emission standards.

Regular controls will be required regarding LNG applications, due to safety requirements (preventing gas leaks and explosions due to uncontrolled combustion in the exhaust). These inspections need to show that owner/operators of LNG powered vessels follow the required safety regulations and maintain the installation properly. As LNG applications not only have to fulfil regulations with regards to their emissions, similar to diesel engines, they also have to fulfil sophisticated safety requirements. The costs for certification and control of LNG powered vessels are expected to exceed those for vessels using conventional fuel systems.

The conditions for control of emission level and functionality for certain technologies and applications should be embedded in the legal systems and should include procedures, equipment, interval and criteria.

8.3 Administrative burden

An administrative burden refers to anything that businesses must do to comply with regulations, which they would otherwise not do. Typically, this involves activities, such as filling out forms, keeping records or responding to information requests also related to enforcement (see previous section 8.2).

An administrative burden may arise from regulations to provide information and data to the public sector or third parties and these information obligations may lead to administrative costs. These are the costs incurred in meeting legal obligations to provide information on its action or production, either to public authorities or to private parties (labelling, reporting, registration, monitoring and assessment needed to provide the information). Administrative burdens are the part of the administrative costs resulting from collecting and processing information which would not be collected or processed by an undertaking in the absence of legislation.

The size of registers of compentent authorities will increase related to an increasing number of different technologies and applications. Due to stricter emission standards the scope of the information obligation from the IWT companies may increase. With relation to the safety requirements, e.g. with respect to LNG, further obligations will probably arise. The increase of information obligations will lead to additional administrative work by both public authorities and private parties. For instance, with regards to LNG engines, authorities are required to develop a new regulation. The emergence of new technologies and growth of retrofit, which requires an approval of compatibility of engine and after-treatment applications, might increase the variety of approved engines and combinations. The approval and enforcement activity will increase and the obligation for an approval of compatibility of after-treatment applications with the extensive range of existing engines would primarily cause additional costs for manufacturers of after-treatment applications.

Administrative costs related to approval of new engines, respectively equipment, are mainly one-off costs made for launch or installation. However, manufacturers need to adjust the registration or even renew an approval in case of modifications, which require additional costs. Moreover, regulation may require certain intervals for information provision. In relation to technology, the requirements and administrative costs may be different. The administrative burden is determined by different factors, such as the amount of information required, collection effort, processing workload and interval for information provision. For example, the interval of information obligation may be related to the required interval between engine certification.

Corresponding to the manufacturer's/ship owner's obligation to provide information, public authorities are forced to collect, control and register a larger extent of information. The approved new technology engines and combinations of engine with after-treatment applications have to be registered and registers have to be distributed amongst authorities. This will increase the administrative workload for authorities, as well as vessel owners and equipment providers. However, the administrative costs of public authorities will be partly passed through to the private sector in terms of fees for certification and other related services.

Depending on the specific regulation, the additional administrative burden at business level is rather small for measures related to new engines, as approval and registration of engines would have been required anyway (business as usual). A joint approval of engines with after-treatment technologies, however, would cause a larger increase of administrative requirements due to the variety of combinations, which require separate considerations. While suitable after-treatment applications for new engines will be provided by the engine manufacturer and approved jointly with rather low additional administrative efforts, the wide range of existing engines could require extensive certification in case of retrofit. A wide range of combinations would emerge, which all require individual certification. This would lead to additional administrative costs in the private and public sector.

The costs for additional inspection are a main component of administrative burden. If authorities were to request field measurements by official investigation bodies, then administrative burden would be significant[1]. However, for retrofit of existing engines with after-treatment applications, a field measurement and certification seems to be the only solution. The availability of portable emission measurement equipment and the resulting decrease of costs for such measurement devices contributes to the feasibility of field measurement and approval. For instance, the Dutch supplier Testo offers a certified measurement device for around € 20,000 covering modules for PM and NOx and this is currently being tested by the Dutch Inspection. This is far less than estimates for vessel application of other measurement equipment, which range up to € 250,000. The availability of low-cost measurement equipment contributes to a reduction of the administrative burden. Therefore, at the moment it is impossible to make a reliable cost estimate on the administrative burden. It is expected that costs will reduce, as a consequence of the larger volume of the market and the availability of mobile measurement equipment for the policy options.

In order to reduce the risk of increasing administrative burden, several actions could be pursued. For example, tests should refer to application families as much as possible, as this would reduce the number of required approvals. For instance, UNECE proposes a type approval according to German regulation XXVII STVZO for DPF applications. This includes the approval of all applications, whose characteristics do not deviate more than specified from those of the tested equipment. Compliance to emission limits could be checked with type approval certificates instead of on the field measurements. The development of general standards may avoid also unnecessary administrative burden for the companies and the competent authorities, by avoiding case by case decisions. Furthermore the entry into force of emission limits could also coincide with the renewal of European navigation certificate avoiding that an additional inspection of the vessels.

The specific costs for administrative burden have not been taken into account in the cost estimation of the policy options. However, the administrative burden will be addressed qualitatively in the next chapter.

[1] A first cost estimate based on current technologies and market volume points towards a cost of € 10,000 including 2 man days on board the vessel, preparation, wrap-up and travel.

9 How do the options compare

In this chapter, the policy options will be compared, based on the findings in the previous chapters and a list of evaluation criteria will be shown. Subsequently, these criteria will be briefly discussed and rated for each of the policy options. An overview will be presented in a multi-criteria score table containing all scores for the policy options. In all cases, the BAU scenario will be used as a reference. Lastly, and where possible, a number of preliminary conclusions will be drawn.

9.1 Criteria to compare the options

The multi-criteria score table contains the criteria as shown in Table 9.1. The relevant chapters providing input to score the criteria are indicated in this table. Furthermore, it is indicated whether the nature of a criterion is economic, environmental and/or social. Some criteria have been split into two or three main aspects. This is further explained in paragraph 9.2.

Table 9.1 Criteria for scoring the options

Input from	*Criterion*	*Economic*	*Environ mental*	*Social*
Chapter 4	Technical feasibility			
	New engines	x	x	
	Retrofit existing engines	x		
	Effectiveness	x	x	
Chapter 4/5	Environmental effects			
	CO2, NOx, PM reduction		x	
	PN/HC/CO reduction		x	
	CH4 reduction		x	
Chapter 6	Efficiency			
	Benefit/investment ratio	x		
	Benefit/cost ratio	x		
Chapter 6	Financing feasibility	x		
	Labour market effects			x
	Side effects			
	Level playing field issues	x		x
	Stimulation of new investments	x		
	Modal shift towards IWT	x	x	
Chapter 7	Legal issues			
	Stage 5 (LNG)	x	x	
	Retrofit (small) vessels	x		x
	Certification and enforcement efforts	x		
	Reduction of administrative burden	x		

9.2 Overview of scores per criterion

This section contains an overview of how, based on the information in the previous chapters, the score per criterion is determined for the options. It should be noted that the criteria may vary in importance if relative to each other. The economic criteria are covered quantitatively (ratios). The other parameters are described qualitatively. In this respect '+++' means very positive, '++' means positive, '+' rather positive, '0' is neutral, '-' is rather negative, '--' means negative and '---' means very negative. A short overview is given below of the motivation behind the criteria ratings. For more background on the criteria, see the relevant chapters in this report as indicated in Table 9.1.

Technical feasibility

Technical feasibility is split into two aspects:

- New engines
- Retrofit existing engines

Engine manufacturers are currently developing stage IIIB technology in order to comply with US standards for marine engines. As no stages 4A, 4B or 5 level requirements exist yet, engines would need to be retrofitted to comply with these more stringent standards. If engine manufacturers would not consider the market of IWT engines large enough to justify R&D investments to develop engines compliant with the emission standards, it is expected that integrators will adapt engines by adding, where necessary, SCR and/or DPF equipment.

Stage 5 standard of emission can be already reached with LNG dual-fuel combined with SCR and DPF or, probably, with LNG monofuel combined with SCR. For the large existing vessels that would be unable to convert to LNG, it would be necessary to develop a stage 5 diesel engine. In option 1, the stage 5 technologies are allowed more time for development, resulting in a higher score for technical feasibility than options 2 and 3, where less time is available.
Certain smaller vessels may face a problem of lack of space in the engine room, needed for the retrofitting equipment (filter, SCR, urea tank). This problem is only relevant for option 1, as in option 2 existing small vessels are exempt. Option 3 takes an intermediate position in this respect.
The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Technical feasibility			
New engines	-	-	--
Retrofit existing engines	---	0/-	-

Effectiveness
Effectiveness determines whether or not the policy objective is achieved. The options have an equal and positive score concerning effectiveness.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Effectiveness	yes	yes	yes

Environmental effects
The main environmental effects concern the emissions of NOx, PM and CO2. The absolute emission reduction levels have been presented in Chapter 5. Additional environmental effects to NOx and PM have been split into the following aspects:
- PN/HC/CO reduction
- CH4 reduction

For options 1 to 3 the emission of CO2 is reduced, as in all three options the application of LNG is assumed. Regarding NOx and PM the option 2 has a slightly lower performance, since the existing engines in smaller vessels are excluded from additional emission regulation measures. Option 1 has the widest application of SCR/DPF, therefore, having the highest score with regards to NOx and PM and PN/HC/CO reduction. Option 2 has the lowest score of the options, because there are no requirements for the category of vessels with smaller propulsion power (<304 kW). The option 3 score is between 1 and 2. The problem of CH4 slip only plays a role in the options where LNG is used. The options do not differ in their score with regards to CH4 reduction: it is assumed that in all cases a methane catalyst is applied.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Environmental effects			
NOx reduction in the year 2030 compared to BAU	86% +++	85% ++	85% ++
PM reduction in the year 2030 compared to BAU	92% +++	90% +	91% ++
CO2 reduction in the year 2030 compared to BAU	11% +	11% +	11% +
PN/HC/CO reduction	+++	+	++
CH4 reduction	0/-	0/-	0/-

Efficiency
Efficiency is expressed in monetary terms (discounted cash flows, against 4% discount rate). Efficiency is split into two aspects.
- Benefit/investment ratio
- Benefit/cost ratio

The benefit/investment ratio means the proportion between the result that can be obtained and the (upfront) investment that has to be made. The benefit/cost ratio includes all costs. The differences between options 1 to 3 are small for the benefit/investment ratios. However, regarding the benefit/cost ratio the option 2 illustrates with the value 46.2 the maximised cost-effectiveness to reach the key policy objective. The full table is presented in chapter 6 (see Table 6.2) and a further breakdown by vessel type can be found in Annex 12 including also the specific added value to include more strict emission standards for existing engines.

The scores of the options are included in the table below

	Option 1	Option 2	Option 3
Efficiency			
Benefit/investment ratio	12.4	12.0	11.9
Benefit/cost ratio	33.9	46.2	41.6

Financing feasibility

The ease with which debt capital can be attracted is a measure for the financial feasibility. Financing difficulties play a role within small, as well as larger vessel categories. Application of DPF and SCR and in particular LNG, requires major investments. Operators of smaller vessels often have a limited financing capacity because of the lower value of the ship, which serves as collateral in case of loans. Operators of larger vessels generally have a higher financing capacity due to a higher value of the ship. Unfortunately, in many cases this financing capacity is currently already utilised, making the room for expansion limited.

The options however, do show different impacts in the total costs for the IWT industry. Net Present Value for the IWT industry is as follows:
Option 1: -670 million euro
Option 2: -492 million euro
Option 3: -546 million euro

Therefore, the option 2 shows on aggregate, a less negative impact for the IWT sector which increases the feasibility to finance measures in comparison with option 1. Moreover, option 2 spares the smaller vessels from investments and operation costs for adaptation of existing diesel engines seen from the background of the low value of the smaller vessels.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Financing feasibility	---	-	--

The limited financing capacity from a business point of view underpins the need for financial instruments to be provided by the European Commission to support the industry to overcome the financing barriers.

Labour market effects

In option 1, due to the refitting of the existing engines in smaller vessels, employment will rise due to an increased demand for products and services from engine manufacturers, equipment suppliers and wharfs. In option 2 and 3, the existing engines in smaller vessels are exempted and there are less strict emission standards for new engines in smaller vessels. This causes lower positive employment effects.

Ship owners may decide to exit their business as IWT operator because of high investments and compliance costs. In case of this occurance, it is expected that the related transport operations will be taken over by other vessels or by trucks. Therefore, no significant impact on the labour market is expected. Smaller vessels in particular, could be sensitive to such effects given the limited financial resources.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Labour market effects	+++	++	++

Side effects

The side-effects are split into three different aspects:

- Level playing field:
  - between vessel classes
  - existing versus new engines
  - between transport modes
- Stimulation of new investments
- Modal shift towards IWT

With regards to the level playing field aspects between vessel classes, the impact for smaller vessels in case of measures on their existing engines is relatively large in financial terms when compared with business as usual and also because larger vessels can benefit from LNG. A disturbance on the level playing field between vessel classes could be expected as the cost price of transport would increase relatively more for smaller vessels when compared to the medium and larger vessels. In case of option 2, the owners/operators of existing small vessels are not faced with new regulations for existing engines, but still there are new regulations for new engines (stage 3B). Therefore, it is estimated that this provides a better balance in the level playing field between vessel classes when compared to option 1. Option 3 holds the middle ground between option 1 and 2.

With regards to the level playing field for vessels with existing, versus vessels with new engines, in the case of option 1, owners/operators of existing vessels are all confronted with requirements, irrespective of the size of the vessel. Stricter emission standards for existing engines improve the level playing field between the companies investing in new vessels and clean engines in comparison to the companies currently opting for reconditioning of existing and more polluting engines, as this is the case in the business as usual scenario. In case of option 2, the owners/operators of existing small vessels are not faced with new regulations for existing engines. In addition to this, option 3 holds the middle ground between option 1 and 2.

With regards to the level playing field between the transport modes it can be remarked that the policy options all close the environmental performance gap between IWT and road transport in the level playing field. However, in the case of option 1, additionally the smallest vessels are included while for option 2 this is not the case. Option 1 therefore, scores highest. Option 3 holds the middle ground between option 1 and 2.

With regards to the issue of stimulation of new investments, option 2 has a disadvantage for the smaller vessels, because the regulations only affect new engines. This would create an incentive for the owners/operators of existing engines to not consider renewal and to overhaul the engine time after time. For the other vessel classes this incentive does not exist, as both new and existing vessels/engines need to take measures to fulfil the emission standards. For option 1 this is not the case: all vessel categories, new and existing vessels/engines, need to fulfil the requirements. Once again, option 3 has an intermediate position between option 1 and 2.

Analyses have shown that the modal shift effects are generally small. However, in cases where small vessels are confronted with large investments, it is possible that they do not have the necessary financial capacity or the capacity to acquire a loan. In geographical areas that are only accessible by means of small vessels, transport could then be taken over by road transport in case these owners/operators of small vessels decide to leave the market. Option 1 is most vulnerable to this, followed by option 3. For option 2 this effect plays a lesser role, because the smaller vessels would be exempted.

On the other hand, the larger vessels can benefit from LNG which can reduce the overall price for IWT. Therefore, there can be a mixed situation on the modal shift impact: small vessels could lose, while larger vessels could win market share. Improved environmental performance could also be considered favourably by shippers.

The scores of the options are included in the table below.

	Option 1	***Option 2***	***Option 3***
Side effects			
Level playing field between vessel classes	+	+++	++
Level playing field between existing and new engines	+++	+	++
Level playing field between transport modes regarding emissions	+++	+	++
Stimulation of new investments	+++	+	++
Modal shift towards IWT	0/-	0	0

Legal issues

Legal issues are split into two aspects:

- LNG development
- Retrofit existing engines

In all options the framework for LNG needs to be in place before the year 2017 as it is assumed that for existing large vessels the conversion to LNG will start in

2017 and will end by 2026, linked to the renewal of certificates. This is a tight schedule for the authorities to make the necessary legal arrangements for issues, such as type approval, certification, bunkering, emission standards and enforcement.
In addition to the retrofitting of existing engines, the legal framework needs to be developed and completed before 2017. In this case, option 1 includes all vessel classes while option 2 and 3 would enable a focus on the medium and larger vessels.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Legal issues			
LNG development before 2017	-	-	-
Retrofit existing engines before 2017	---	-	--

Certification and enforcement
Inspections procedures for all vessels having a European navigation certificate is already applying; moreover, the procedures for engines' certification before entering the market is also in place.
If emission levels needed to be tested on site, the sheer number of vessels to be investigated would be a main measure for the scale of the certification and enforcement effort. The efforts are fewer in cases where small vessels are exempted, such as in option 2 and to a lesser degree option 3. In the case of option 1, the smaller vessels would also need to be refitted and the environmental performance of these smaller vessels will need to be enforced. This would cause the greatest effort.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Certification and enforcement efforts	--	0/-	-

Reduction of administrative burden
In case of the policy options that were considered, the administrative burden mirrors the efforts that have to be spent on certification and enforcement: where authorities have to spend considerable efforts, the same is required for the owners/operators. The scores of the options are closely related to the number of vessels concerned by the measures.

The scores of the options are included in the table below.

	Option 1	Option 2	Option 3
Reduction of administrative burden	--	0/-	-

Summary: multi-criteria scores for all options

The scores of the options are summarised in Table 8.2.

Table 9.2 Multi-criteria scores for the options

	Option 1	Option 2	Option 3
Technical feasibility			
new engines	-	--	--
Retrofit engines	---	-	--
Effective?	yes	yes	yes
Additional environmental effects			
PM/NOx reduction	+++	++	++
CO2 reduction	+	+	+
PN/HC/CO reduction	+++	+	++
CH4 reduction	0/-	0/-	0/-
Efficiency			
Benefit/investment ratio	12.4	12.0	11.9
Benefit/cost ratio	33.9	46.2	41.6
Financing feasibility	---	-	--
Labour market effects	+++	++	++
Side effects			
Level playing field vessel classes	+	+++	++
Level playing field existing/new engines	+++	+	++
Level playing field IWT vs road	+++	+	++
Stimulation of new investments	+++	+	++
Modal shift towards IWT	0/-	0	0
Legal issues			
LNG development before 2017	-	-	-
Retrofit existing engines before 2017	---	-	--
Certification and enforcement efforts	--	0/-	-
Reduction of administrative burden	--	0/-	-

9.3 Preliminary conclusions

In section 9.2 the multi-criteria table has been filled in for all criteria that are considered to be of importance towards the choice on how to best realise the policy objective. Therefore, in order to be able to prioritise the policy options, the various criteria need to be traded off and weighted. This would require a valued judgement and the political decision makers have the last word here.

Nevertheless, based on the consultant's findings, some preliminary conclusions and recommendations can be made. Initially, it can be concluded that:

- The three options all manage to close the emission gap with road transport with rather similar impacts on the overall level of investments and the external costs. However there are differences between the options on the total costs for the IWT industry and therefore, on the benefit/cost ratios.
- From the multi-criteria table it can be seen that the investment ratios do not differ significantly between the options 1 to 3. This implies that for a further prioritisation of the options criteria other than the investment ratios should be decisive. This puts more emphasis on the benefit/cost ratio and the scores on the qualitative assessment criteria.

The options 1 to 3 each vary whether or not the regulations also pertain to owners/operators of small vessels on the one hand and whether or not larger vessels are allowed more time to adapt to stricter stage 5 standards for new vessels on the other hand. This additional time would be needed for the development of a diesel based alternative.

Sparing the owners/operators of smaller vessels could be motivated by concerns about their (in)ability to finance measures as well as by technical difficulties (such as lack of space, old engines) and also by their limited impact on the external costs and relatively low benefit/cost ratios.

Allowing large vessels more time to adapt to stage 5 could be motivated by a widespread need for further R&D to develop a diesel engine with appropriate specifications, as well as resolving legal issues before essential new technologies can widely be introduced in the IWT sector.

10 Further steps

In this chapter further steps will be discussed that need to be taken on the way to realising the policy objective. Recommendations are made on how to make proceed here.

10.1 Need to strengthen R&D

In this study, a number of technical solutions have been considered that need further research and development. The following subjects could be investigated in this respect:

- Development of the LNG technology in the IWT context, not only as Dual Fuel, but also Mono Fuel and/or in gas-electric applications is required in order to further reduce fuel costs and also to reduce the engine-out performance regarding NOx and PM.

- Stage 5 diesel engines need to be developed. Possibly this could be realised by a combination of techniques that are currently still considered experimental. A few options could be selected in order to further research and develop to see if stage 5 performance would be within reach. As an example, one or more of the following techniques could be selected, possibly in combination with SCR/DPF.
  - Cooled exhaust gas recirculation (EGR)
  - Gas to liquid fuel (GTL)
  - Fuel-Water Emulsion (FWE)
  - Hydrogen emulsification/injection
  - Combinations of marinised Euro VI truck engines in diesel electric mode

  Further background information on these techniques can be found in Annex 7.

- Further research on the combination of LNG with SCR/DPF would prove useful. In particular, measurements concerning emissions in real-life situations with different types of dual fuel and monofuel LNG engines could shed light on the issue whether SCR and DPF are necessary to attain the required standards. Possibly, the compliance costs could be reduced in the case the engine-out emission levels are already much lower than assumed in this study.

- For the application of LNG, there is also the issue of methane-slip that needs to be resolved. Being a very intrusive greenhouse gas, the discharge of methane in the atmosphere needs to be avoided as much as possible. Technical solutions that could provide an answer to this, are high pressure LNG or the application of methane slip catalysts.

- Retrofitting of existing and new engines should be optimised further in order to reduce compliance costs including the administrative and enforcement burdens. It should be considered whether standard modules for certain SCR and DPF combinations could be developed that work well at certain power ranges of engine types and that only need little space or can be fitted well into the exhaust systems.

- Stage 4 and 5 engines, in particular if they are burning diesel only, will most likely be produced in small numbers by system integrators (companies that add on SCR and PDF) and not by the engine manufacturers that produce the core engine. Legally, that will not be a problem as this is nothing new and already covered in current legislation. However, it is important to consider that these integrators have a much smaller capital base and limited R&D capacity as they work in a relatively small niche market. They may need more advice and support from the competent authorities than larger engine manufacturers. Support from the public side of the R&D work could therefore, be necessary.

In general, the implementation of the above mentioned recommendations involve financial resources to be dedicated. As a possible instrument to enable these activities, the Horizon 2020 programme could be utilised to support the R&D for the above measures and techniques.

10.2 Financing issues

As was described in Chapter 6, the IWT sector is currently suffering from the effects of an economic crisis. It is necessary to examine the financing needs of the sector in order to comply with the emission standards as laid down in the policy options. This requires an analysis of the size and nature of the financial bottlenecks and how they can be resolved. Various financial instruments could be considered in this respect, ranging from direct subsidies to guarantees in order to mitigate risks.

10.2.1 European challenge

A faster transition to higher European emission standards for inland vessels will require accelerated and higher investments and depreciation from private parties. Aside from the largest vessel classes, the CBAs that were done in this study demonstrated that all policy options will generally produce negative net present values for these investments for most vessel classes. These negative financial impacts are however, clearly outweighed by the positive net present values of the external cost gains (high benefit/cost ratio). This outcome provides the basic rationale for public support for private parties, in order to stimulate faster transition to a greener and cleaner inland fleet. Based on the CBA results, it can be assumed that this transition will not materialise on the basis of market forces only and especially not in the segment of small and medium sized vessels and the existing push boats.

The empirical work of this study showed that entrepreneurs do not make extensive use of the current national funding programmes, as the funding rates are seen as insufficient to compensate for the investments and risks involved. In addition, given that support programmes only exist in a minority of the EU countries with navigable waterways, the existing funding landscape is not expected to be effective in terms of achievement of the European policy ambitions and objectives.

Some yet unsolved, but important issues connected with the current European support and funding landscape in the field of emission reduction, are:

- Insufficient national incentives: Member States are not stimulated enough to provide sufficient funding means for IWT.
- Unclear delimitation: unclear delimitation between European and national funding schemes and consequently a potential risk of doubling of efforts.
- Duplication administrative efforts: potential duplication of the necessary administrative framework due to a complicated programme and awarding procedure.
- High coordination need: complicated coordination mechanisms between EC, MS and European IWT sector required to create an effective funding landscape.
- Dispersion of funding efforts: given the large scope of possible funding items in the current funding programmes (especially compared to the policy objectives), overall effectiveness could be blurred.

For an overview of existing funding mechanisms, see Annex 13.

10.2.2 Basic concept for a European support instrument

A way around these unsolved issues could be the creation of a so-called European add-on funding instrument with degressive annual funding rates.

European add-on facility
One core element of a new European instrument could be to use the existing national funding landscape whereby, existing national funding programmes would receive European funding on top of the existing national funding rates. It could build upon existing and notified national IWT funding programmes. It should thereby, also and in particular, stimulate the creation of dedicated national IWT funding programmes in Member States where these programmes are currently lacking and speed up implementation of national funding schemes. The idea of using the existing national programmes would reduce administrative efforts, as the basic programmes and procedures have already been notified and are in place. This approach would also have clear benefits from the applicants' perspective, as the application would still be processed via one national administrative stop.

Degressive funding rates over time to stimulate fast transition
The European add-on facility could be designed with a degressive annual funding rate, meaning that early innovators are awarded a higher financial contribution than those lagging behind. This basic principle should encourage the IWT sector to invest more rapidly in both logistically-efficient and environmentally-friendly equipment, certainly in the face of new technical requirements for vessels and emission norms.

The advantage of such a degressive European add-on facility would be:

- The European measure is based on already notified funding programmes, i.e. inherently in line with EC funding regulations;
- A trigger for Member States to set up dedicated IWT funding instruments;
- Use of existing administrative and allocation structures: decentralised and un-bureaucratic system;
- A clear relationship between European and national funding: no overlap between EC and Member States' funding instruments;
- Stimulation of early innovation through degressive funding rates over time, creating a critical mass for suppliers.

10.3 Legal issues

For some of the technical solutions that have been introduced in this study, the following legal issues need to be reflected upon and new regulations need to be adopted.

With regards to retrofitting of existing engines/use of after-treatment technology the conditions for appropriate after-treatment systems need to be developed, accompanied by type approvals and monitoring systems which, amongst others, keep track of consumed additives, such as urea and facilitate for reading data with respect to the operation of the installation (interface). This also includes procedures, equipment, interval and criteria.

The obligation to have the relevant information available on board should be included in the legislation. Furthermore, this can be integrated in the police regulations. Details of the systems must be entered in the ship's certificate. These requirements could be incorporated in Directive 2006/87/EC, since this directive contains already provisions as regards to after-treatment systems. Furthermore, provisions must be elaborated for the availability of adequate maintenance systems with regard to the functionality of after-treatment technologies.

In this study, the application of LNG as a fuel for IWT is an important condition to meet the policy objective. However, before LNG can be widely applied, the following requirements and technical guidance need to be worked out with regards to the following topics.

- Safe use of LNG on vessels

This concerns for example storage aboard and retrofitting of existing engines. Conditions for engines burning LNG and associated auxiliary systems need to be elaborated and embedded in the legal system, based on the experiences gained during the evaluation of the already granted derogations. Directive 2006/87/EC seems the appropriate directive for this. The conditions must also be included in the annexes to the ADN which are part of Directive 2008/68/EC.

- Bunkering and bunkering stations for LNG

Here the Member States can be supported in developing criteria for admission bunkering stations. In view of European Union wide deployment, further coordination could be provided by the European Commission.

- Operations of the vessels and training of crew

Here the elaboration of training programmes can be supported which could be embedded in the future legislation on manning.

- Regulations to account for existing engines that cannot be retrofitted for technical reasons

Taking into account the policy options, some vessels may have to replace engines after a service life of eleven or twelve years which could be shorter than the normal lifetime. This short period may be a burden to the operator/owner with high costs. Therefore, strict, clear and unambiguous conditions for deviations must be elaborated.

- Small propulsion engines

Small propulsion engines may derive from other NRMM applications. It should be further investigated if an alignment of the emission limits for IWT purposes and other applications would be useful. An inventory can be made of engine applications in IWT where engines may derive from emission levels (e.g. engines of life boats and windlasses).

- Auxiliary engines

Auxiliary engines are not within the scope of this study but are covered by the Non-road Mobile Machinery standards (Directive 97/68/EC). Modern IWT vessels often have several auxiliary engines on board which can be quite powerful. The largest of them, for example the bow thrusters, can easily have an output of a few hundred kW. It would be pertinent therefore to choose, for these engines, between either a type approval under the NRMM for the specific application or a type approval for IWT emission limits. Another issue is whether the requirements for retrofitting also should be applied to auxiliary engines. It is assumed that new auxiliary engines follow the requirements of the NRMM. Further investigation on the contribution of pollutant emissions from existing auxiliary engines should be considered.

10.4 Monitoring and evaluation

A system to monitor progress of the installation of emission friendly engines or after-treatment systems needs to be set up and effective around the time that it becomes mandatory to adapt to the new standards. The system could be based on the current monitoring system which consists of certification of vessels and subsequent periodical inspections. Changes in the current system could concern the information entered in the certificates and in the register rather than the monitoring scheme itself. Therefore, no significant additional administrative burden to that from setting up the monitoring and reporting scheme is expected.

Monitoring reports on the progress should be written yearly on the basis of the monitoring data gathered. These reports will provide measureable indications of progress towards targets, as well as provide information on other relevant parameters. Specific actions here are to revise Annex IV (Model Community Inland Navigation Certificate) and V (Model Register of Community Inland Navigation Certificates) of Directive 2006/87/EC by means of an addendum dedicated to the vessel’s engines and the designation of a body to which the data should be transmitted. Moreover, the European Hull Database could be expanded with additional records per vessel in order to provide also information on the installed engines. The relevant information would be entered when the vessel certificate is issued, renewed or amended after the installation of new or the retrofitting of existing engines.

In the light of further progressive insight, the Commission may propose to revise the monitoring scheme, i.e. to change the frequency of inspections for existing vessels. This is not considered at this stage.

Annex 1 Glossary

Technique/standard	Description
AND	International Carriage of Dangerous Goods by Inland Waterways
ASC	Ammonium Slip Catalyst
B/C ratio	benefit/cost ratio
BAU	business as usual
CBA	cost-benefit analysis
CCNR I	emission standard
CEF	Connecting Europe Facility
CH	hydrocarbon
CH4	methane
CH4 slip	methane in exhaust due to incomplete combustion
CO2	carbon dioxide
CxHy	general chemical formula of a hydrocarbon
DF LNG	Dual-Fuel LNG engines are standard diesel engine, which operates unchanged, except power is generated by mostly natural gas. A measured quantity of natural gas is mixed with the air just before it enters the cylinder and compressed to the same levels as the diesel engine to maintain efficiency. The natural gas mixture does not ignite spontaneously under compression, so the Dual-Fuel engine uses a small injection of diesel fuel to ignite the main charge of gas and air. This small 'pilot' injection acts like a multitude of microscopic spark-plugs, setting off clean and efficient combustion of the lean gas-air mixture.
Directive 1999/32/EC	Directive as regards the sulphur content of marine fuels
Directive 2009/30/EC	Directive sets environmental requirements for petrol and diesel fuel in order to reduce their air pollutant emissions. These requirements consist of technical specifications for fuel content and binding targets to reduce fuels' greenhouse gas emissions during their life cycle
Directive 97/68/EC	Directive 97/68/EC of the European Parliament and of the Council of 16 December 1997 on the approximation of the laws of the Member States relating to measures against the emission of gaseous and particulate

Technique/standard	***Description***
	pollutants from internal combustion engines to be installed in non-road mobile machinery
DOC	diesel oxidation catalyst
DPF	Diesel Particulate Filters (DPF) are used to trap the harmful particulate matter (PM) present in the exhaust of (diesel) engines. The particulate matter is trapped in and on a porous ceramic substrate to keep PM emissions low.
EC	European Commission
EGR	In internal combustion engines, exhaust gas recirculation (EGR) is a nitrogen oxide (NOx) emissions reduction technique. EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. In a diesel engine, the exhaust gas replaces some of the excess oxygen in the pre-combustion mixture. Because NOx forms primarily when a mixture of nitrogen and oxygen is subjected to high temperature, the lower combustion chamber temperatures caused by EGR reduces the amount of NOx the combustion generates.
EMS protocol	emission registration and monitoring protocol
EURO VI	emission standard
FEW	Fuel Water Emulsion: Emulsion Fuels are defined as emulsions of water in diesel fuel and are typically made of 10 to 20% mass/mass water mixed diesel fuels. The surfactant additives are used to stabilise the emulsion, so that the finely dispersed water droplets remain in suspension within the diesel fuel. This reduces simultaneously emissions of nitrogen oxides, particulates and carbon dioxide of diesel engines without the need for any mechanical modifications.
GDP	gross domestic product
GHG	greenhouse gas
GTL	gas to liquid
HDV	heavy duty vehicle
IA	impact assessment
IMO	international maritime organization
IVR	Internationale Vereniging het Rijnschepenregister
IWT	inland water transport

Technique/standard	***Description***
JRC	Joint Research Centre
kWh	kilowatt hour
LNG	Liquefied natural gas (LNG) is natural gas (predominantly methane, CH4) that has been converted to liquid form for ease of storage or transport. LNG takes up about 1/600th the volume of natural gas in the gaseous state.
methanol	type of alcohol
MF LNG	mono fuel LNG
MTS	motor ship
NMVOC	non-methane volatile organic compounds
NOx	nitrogen oxides
NPV	Net present value
NRMM	non-road mobile machinery
NRMM stage IV	emission standard
PM	particle matter
PM2.5	fine particles in the (ambient) air 2.5 micrometres or less in size
PN	particle number
ppm	Parts per million
R&D	research and development
REC	Retrofit Emission Control devices (REC). Typical emission control devices available for retrofit applications are Diesel Particulate Filters (DPF), Diesel Oxidation Catalysts (DOC), and Selective Catalytic Reduction (SCR) catalysts. They allow the reduction of Particulate Matter (PM) - soot particles - and NOx emissions from existing diesel engines
repowering	An Emissions Repower is an engine replacement repair option to reduce exhaust emissions from existing Cat® engines by replacing a current engine system with an updated version that achieves lower emissions levels. Repowering a vessels engine has the benefits of upgrading the system to use emission reduction technologies not available in the past (by including new fuel

Technique/standard	***Description***
	injection system, electronic controls, cooling systems, etc.)
SCR	Selective catalytic reduction (SCR) originally used in thermal power plants by using ammonia as a reducing agent, called ammonia-SCR, is a NOx reduction methodology. Fundamentally, NOx reacts catalytically with ammonia on the surfaces of a catalyst. Different precious metals (e.g. gold, silver, platinum, ruthenium, rhodium and palladium) and base metals (e.g. iron, nickel, lead, zinc and copper) coated on a porous medium in order to increase the chemically active surface are been used as catalysts.
SME	small and medium sized enterprises
SO2	sulphur dioxide
Stage IIIa base engine	EU Off Highway regulations are split between diesel (CI) and gasoline (SI) fuelled engine categories. Within the CI category, there is further differentiation between Non-road Vehicles and Machinery (NRMM) (including agricultural and forestry tractors), Inland water vessels, and rail traction engines. The legislation were introduced in stages, and inland water vessels currently conform to Stage III A limits, dependent on engine swept volume.
standard cost model	model used for calculating administrative costs
TEN-T	Trans-European Transport Network
Tkm	tonne kilometre
UNECE	United Nations Economic Commission for Europe
US EPA	US Environmental Protection Agency
US Tier 4	emission standard
Vkm	vehicle kilometre

Annex 2 Questionnaires and minutes of the Common Expert Group / statements from stakeholders

Common Expert Group on emission reduction of the inland waterway fleet
18 September 2012

Introduction

A working group of the PLATINA project was asked by the European Commission to analyse technical measures, which could result in a reduction of emissions to air by inland waterway vessels. Secondly, and based on the analysis of technical measures, policy options should also be developed. These policy options will ultimately be evaluated against their potential impacts (economic, societal, environmental, etc.).

Attached is a report on 'Greening the Inland Fleet' which contains the results of the first stage of the analysis, namely the identification of the technical measures to reduce emissions to air. As the analysis showed, key facts were often incomplete or missing and the stakeholders involved were invited to share their expert opinions and experiences.

Questions to the stakeholders

A. Questions regarding technical feasibility
The expert report contains an overview of technical measures which could contribute to a reduction of emissions by inland vessels.

1. Is this overview of technical measures complete or are important measures missing?
2. What are the most promising technical measures (in terms of emission reduction) based on your own experience?
3. What is the current number of engines that are renewed in Europe in inland vessels on a yearly basis?
4. Would there be practical limitations on the supply side of technical systems (maximum capacity in the supply and installation of new engines and/or equipment such as catalysts (SCR) and filters (DPF)?
5. How many catalysts (SCR) and filters (DPF) are actually being installed on a yearly basis and what type of vessels and engines of the legacy fleet would principally be suitable for application of SCR and DPF?
6. What further technical developments can be expected in the near future, which could also contribute to a reduction of emissions by inland vessels?

B. Questions regarding economics
The expert report contains an overview of unit prices for different technical measures, but generally empirical values are scarce.

1. Does the overview of unit prices for technical systems provide a range of realistic values?

2. If these technical systems were to be applied on a larger scale, what could be the development of the unit prices of technical equipment?
3. Could an 'economies of scale' impact on the prices be expected?

C. Questions regarding implementation

The expert report contains a first set of policy options with different emission norms and different time lines.

1. What would be a realistic transition period (e.g. 2020, 2025, 2030, 2035, etc.) for both suppliers and ship owners to be able to anticipate to new regulations?
2. What would be needed from the side of authorities to enforce possible new regulations on emission performance of engines, if also existing engines would need to be adapted to comply with new emission regulations?
3. What would be the main legal bottlenecks to be solved if also existing engines would be under a new emission regulation regime?

Questions presented at the Common Expert Group Meeting, October 23, 2012

This document contains all the questions that were presented at the Common Expert Group Meeting (23 October 2012), complemented with provisional answers and follow-up actions. Where indicated, input is required from all or from particular members of the Common Expert Group.

For easy reference we have applied the following colour codes:

No colour	no action is needed from the experts – issue not relevant or solved
Yellow	no action is needed from the expert group as a whole – issue will be addressed by the consultants or through bi-lateral contacts
Green	input is in principle available but confirmation by the experts would be appreciated
Blue	input is requested from the expert group

Legal	
Questions / issues to address	**Action required**
What other relevant legislation, additional to what was presented, could play a role?	Largely, the relevant legislation has been identified. CCNR further to contribute here.
Is it correct to assume that option 1 (voluntary measures) does not need a legal backbone provided by the EC?	Yes. No further information/action needed.
Is Directive 2006/87/EC the proper instrument for implementation of policy options 2b (mandatory emission standards for the whole fleet) and 3 (mandatory econometers)?	Yes. No further information/action needed.
Are there further cases known from other sectors where existing engines or equipment shall comply with new standards (similar to option 2b: mandatory emission standards for the whole fleet)?	The Consultant will identify case material from other modes. Input of case material regarding other modes/ sectors from Common Expert Group is welcome.
How to enforce the emission levels? What is needed in terms of registrations, on the spot checks, etc.?	Action: Dutch Inspectorate is preparing a pilot. Dutch Inspectorate/ Austria will be approached to discuss how enforcement activities can be further detailed.
Are there budget assessments available on the cost of enforcement (e.g. from existing authorities/inspection)?	

Administrative Burden	
Questions / issues to address	**Action required**
Would there be additional information obligations?	Dutch Inspectorate/ Austria will be approached to discus show enforcement activities can be further detailed.
Would there be additional time needed for inspection, e.g. hours of delay for vessel operators per year? If yes, quantifiable?	
There will be substantive costs in case of mandatory options. To calculate, the following data is collected. • size of the fleet in the EU • number of new engines • number of main and auxiliary engines serving for the vessel propulsion • economic life span • extent to which the engines have to be replaced earlier than the life span and the extra costs (in case of option 2b: mandatory emission standards for the whole fleet) • size of the fleet in the EU currently using econometers • costs of econometers	Action: 1) Econometer manufacturer/supplier has been contacted A matrix with cost information is circulated for validation, see spreadsheet. All expert group members are asked to provide input. See also 'economy', where same issues play.

Technical	
Questions / issues to address	**Action required**
Are important technical options missing in the overview (e.g. hybrid solutions)?	No. Further information/action not required.

Option 1 (voluntary measures)	
Technical feasibility to develop energy efficiency design index and ship emission index: can we apply examples from the maritime industry to IWT?	Action: to ask CESA, Lloyd's & shipyards to provide input
What would be the share of vessels that have oversized engines and could benefit from a 'right-sizing' campaign?	**It is unclear where to find data regarding oversized engines. Perhaps Dutch Inspectorate could contribute, but all experts are asked to provide input, where possible.**

Option 2a (stricter standards for new engines)	
What are the developments regarding worldwide standards (EPA, IMO) in terms of time lines and emission standards?	Source: Euromot position paper
How do they match with Stage IV and EURO VI? Should worldwide standards be followed or would Europe be pioneer?	Source: Euromot position paper
What would be the technical consequences with respect to research and development efforts in case IWT in Europe would be a frontrunner?	Source: Euromot position paper
Are there further requirements to fuel standards to reach emission limits, need for EN590, and possible contribution of Gas To Liquid? Is this a baseline or a possible policy option?	It was decided that GTL and other options can be mentioned, but should not be researched extensively.
What is needed to reach NRMM Stage IV: 1) LNG 2) SCR, DPF 3) Water emulsified fuels needed?	Water emulsified fuels seem not to be feasible because of the reduced lifetime of engines. Therefore, the mix can be narrowed to SCR/DPF and LNG. Can the Expert Group agree with this? If yes, the mix SCR/DPF and LNG that is needed will be determined based on efficiency/ effectiveness criteria. This will be an output of the assessment itself.

Further technical implications to reach Euro VI in comparison with Stage IV?	Euro VI requires application of SCR/DPF. Can application of LNG only also reach Euro VI or is this only possible combined with SCR/DPF? Question specifically directed to Euromot, EMEC and AECC.
What are the differences between test cycles NRMM, EURO VI in terms of the technology needed to stay below emission limits?	Not relevant anymore, as we will limit ourselves to the NRMM test cycle. No further action required
Can technologies be applied on new engines for all (existing) vessels? Are they mature?	Yes. No further action required. All engines can be equipped with SCR/DPF.
What are the technical restrictions with respect to size and type of vessels and power range?	In principle, all engines can be equipped with SCR/DPF.

Option 2b (mandatory emission standards for whole fleet)	
Are there technical limits to installation of 3 techniques for existing vessels?	Water emulsified fuels are considered not to be feasible. This narrows the applicable techniques to LNG and SCR/DPF. In principle, all engines can be equipped with SCR/DPF. For medium and high RPM engines this would be economically feasible. For low RPM engines, the application of SCR/DPF may not be an economically feasible option, due to the very limited space that is available in ships that run with these kind of engines. This would result in high installation costs. Question: could the Common Expert Group confirm this? All experts are asked to provide input. The Consultant is in contact with manufacturers/suppliers regarding the possibilities to retrofit smaller vessels with LNG
Into what extent can existing engines be adapted? Or is it needed to replace them with new engines?	
Are there reliable sources on the fuel consumption and emission performance of older engines?	As most reliable data source we have:

<table>
<tr>
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<tr><th>Engine yr of construction</th><th>Fuel consumtion g/kWh</th><th>NOx emission g/kWh</th><th>PM emission g/kWh</th></tr>
<tr><td>1900-1974</td><td>235</td><td>10.8</td><td>0.6</td></tr>
<tr><td>1975-1979</td><td>230</td><td>10.6</td><td>0.6</td></tr>
<tr><td>1980-1984</td><td>225</td><td>10.4</td><td>0.6</td></tr>
<tr><td>1985-1989</td><td>220</td><td>10.1</td><td>0.5</td></tr>
<tr><td>1990-1994</td><td>220</td><td>10.1</td><td>0.4</td></tr>
<tr><td>1995-2001</td><td>205</td><td>9.4</td><td>0.3</td></tr>
<tr><td>2002-2008</td><td>200</td><td>9.2</td><td>0.3</td></tr>
<tr><td>2009-2011</td><td>200</td><td>6</td><td>0.2</td></tr>
</table>
* TNO 2010 Denier van der Gon, H., Hulskotte, J. Methodologies for estimating shipping emissions in the Netherlands. A documentation of currently used emission factors and related activity data. BOP Report, 2010
This is confirmed in:
ifeu - Institut für Energie-und Umweltforschung Heidelberg GmbH, Aktualisierung der Emissionsfaktoren und Verkehrsleistungen von Binnenschiffen und Übertragung ins TREMOD-Programm; Im Auftrag des Umweltbundesamtes, 2011
Question: could the experts of the common expert group mention other/better data sources than the above ones?
</td>
</tr>
<tr><td>Would an implementation before 2027 be technically feasible?</td><td>Yes, this is technically feasible.</td></tr>
<tr><td>Would an implementation before 2020 be technically feasible?</td><td>Action: all experts are asked to provide input.</td></tr>
</table>

<table>
<tr><th colspan="2">Option 3 (mandatory econometer)</th></tr>
<tr><td>What are the different technical options and developments for econometers?</td><td rowspan="3">Action: Econometer manufacturer/supplier has been contacted</td></tr>
<tr><td>What are the requirements for installing an econometer, will this be possible for each vessel?</td></tr>
<tr><td>What would be the time needed for adaptation from a technical perspective?</td></tr>
</table>

Economy	
Questions / issues to address	**Action required**
What are the investment and installation costs of the technical options and emission levels?	A matrix with cost information is circulated for validation, see spreadsheet. All expert group members are asked to provide input. Please confirm validity and/or to add data in empty cells.
What is the lifetime of equipment?	
Where to find the accurate information for the different type of technical solutions, power ranges and application on new and existing engines (references, reports, examples from other engine applications, etc.)?	
What time is needed for installation (vessel out of service) for different options for installation?	
What are the operational impacts with respect to fuel and urea costs and consumption, maintenance and repair costs at the technical options?	
Where to find the accurate information for the different type of technical solutions, power ranges and application on new and existing engines?	
What are the limits and conditions for banks to provide loans to ship owners for making investments in new engines or new technologies?	Action: 1) to ask Banks for criteria in order to be able to provide loans 2) to ask ESO and EBU for input from stakeholders
Into what extent could public funding support the banks to provide loans and/or ship owners to invest?	
Is it realistic to assume that the existing fleet of old and small vessels with relatively low value of the vessels will be able to adapt to new regulations?	The answer to this question will follow from the information from banks, economic feasibility and technical feasibility.

Questions to individual Euromot members

In the last meeting of the Common Expert Group on Emission Reduction of the Inland Waterway Transport Fleet on December 17th in Brussels, Panteia presented the costs of the technical options based on cost estimations for the Euro VI alike technologies and mass production of SCR and DPF parts for trucks by the year 2018.

In order to respond to Euromot's concerns regarding the correctness of our assumptions regarding the technical scenarios and cost data, we kindly ask you to provide written feedback and information from your company on the cost estimations. In order to acquire the necessary cost data, Euromot has advised us to approach members individually. To follow this advice up, we now have a request to you as a representative of [redacted] if you could provide us with your expert estimate regarding:

1) Technical details of the emission options considered for NEW ENGINES (see slide 1): what would be the internal engine upgrades and/or after-treatment technologies that you would use to reach these emission standards (test cycle 8178, E3 using EN590 fuel) in case this would deviate from our assumptions? Can you please indicate this for the four emission stages:

Option	NOx g / kWh Exhaust	PM mg/ kWh Exhaust	Technology to reach standard	Investment costs, increase compared to NRMM Stage IIIA engine	Marginal other operational costs (repair & maintenance, urea, ...)	Fuel efficiency impact compared to baseline (Stage IIIA) (please check)	Investment costs (your R&D cost estimation)
2a1) diesel engine IMO Tier 3/ EPA Tier 4 130 < P <599 600< P < 3699	2.1 1.8	110 45	[please provide information]	...%	[please provide information]	-2%	[please provide information]
2a2) 130 < P <599 600< P < 3699	0.8 0.8	110 45	[please provide information]	...%	[please provide information]	0%	[please provide information]
2a3)	0.8	10	[please provide information]	….%	[please provide information]	+ 1.5%	[please provide information]
2a4)	0.4	10	[please provide information]	….%	[please provide information]	+2.5%	[please provide information]

2) Marginal costs (investment and operational (urea, fuel consumption, repair and maintenance)) of the technical options compared to the current NRMM Stage IIIA engines.

3) Rough estimation of the required additional R&D costs for your company for each option to develop the new engines.
If possible, we would like to receive your response by Wednesday January 9 the latest, so that we will be able to include this in the calculations for the final report.

Alternatively, if it is not possible to provide us with such an expert estimation, we envisage to use previous cost figures that we had based on current prices seen for SCR and DPF in the market (see attached MS Word report). In that case, please let us know how you would look at these figures.

For your convenience we have included the relevant slides of the working material of the December 17 meeting as well as the table above in MS Excel and a Word file with our cost information on the current prices for SCR and DPF applications.

Of course we will keep your information anonymous and confidential. We would propose to use only averaged figures from the information that we collect from various companies.

MINUTES
First meeting of the Common Expert Group on emission reduction of the inland waterway transport fleet

18 September 2012.

BREY, Avenue d'Auderghem 45, Room 5A, 1040 Brussels, 10.00-17.00 hrs.

Welcome and round table introduction, DG MOVE

DG MOVE welcomes the participants to this first meeting of the Common Expert Group on emission reduction of the inland waterway transport fleet. The emission reduction of IWT is a key challenge. There is an underperformance by IWT on this matter as demonstrated by the latest version of the Marco Polo calculator. Retrofitting to improve the emission performance of existing engines is at the heart of the discussion. This expert group also needs to focus on the deployment strategy. The revision of Directive 97/68/EC on emissions of Non Road Mobile Machinery (NRMM) has been under discussion since 2005. How to use this framework will be one of the discussion points of this expert group.

Staff working document "Towards NAIADES"

DG MOVE presents the contents of the staff working document. The staff working document dates from May 2012 and represents a stepping stone towards the Communication on NAIADES II. A stakeholder meeting on NAIADES II is planned for December 2012 and adoption of the Communication shall take place in 2013. It is, at this stage, not intended to prepare an impact assessment report for the whole action programme but for specific parts.

Terms of Reference of the Common Expert Group on emission reduction of the inland waterway transport fleet

This Common Expert Group will work in full transparency on concrete conclusions and a proposal aimed at a legislative measure for which an Impact Assessment procedure is required.

The Terms of Reference document states that the goal of the emission performance of IWT is to achieve by 2020 an overall performance regarding emission levels for inland waterway transport that is better or at least comparable to that of road transport. The European Commission explains that the objective was formulated to leave flexibility to approaches in order to determine the options and their emission performance. It is clear that there is a sense of urgency to improve the emission profile of IWT given the major progress made in the road haulage sector to reduce air pollutant emissions. The discussion of emission of IWT shall therefore focus on the air pollutants NOx and PM. Moreover, the reduction of GHG emissions is a major objective in the EU White Paper on Transport and possible impacts on CO2 emissions (positive or negative) will also be included in the Impact Assessment studies.

The financial aspects of the deployment strategy are crucial. A key topic for discussion is the financial support required to make the investments. Expertise and recommendations are needed on this matter.

Preparatory work under the PLATINA 7RFP project

The input provided by PLATINA is a good basis for discussion. PLATINA provides a first insight on regulatory (non voluntary) measures in the gap to bridge in terms of emissions from IWT. Voluntary measures are considered as providing insufficient impact on emission reduction in order to reach the objective.

The PLATINA report contains an overview of technical measures which could contribute to a reduction of emissions by inland vessels. The expert report also contains an overview of unit prices for different technical measures, but generally empirical values are scarce. Current estimation in the report on new technologies that could meet (more strict) future emission standards are often based on experimental projects. It is therefore expected that unit prices could drop if units are to be installed on a larger amount of vessels.

The expert report contains a first set of policy options with different emission norms and different time lines. The timing also depends on the current revision of NRMM Directive 97/68/EC as some time must be kept in between changes in emission regulation. In general stakeholders consider that a longer term and more ambitious regulation may be more appropriate that an intermediate stages on medium term. The year 2020 could be a realistic window.

Support under the Marco Polo accompanying measure

In addition to ongoing work in PLATINA, the Commission has contracted a new consortium that will work in parallel on the assessment of policy options for reducing emissions and in a first stage already start up activities focussing on: legal bottlenecks or limitations, financial capacity of ship owners and financers, administrative burden of measures, implementation and enforcement issues.

Future Planning

The main dates of the future calendar are: 1) second meeting of this Common Expert Group planned on October 23rd, 2) third meeting of this Common Expert Group foreseen for the end of November 2012, 3) discussion of impact assessment results in December 2012, 4) Finalisation of impact assessment work towards the end of 2012/beginning of 2013

The Communication will work in parallel on policy preparation.

Any other business and closing of meeting

The work is closely interlinked with the revision of the NRMM Directive (97/68/EC). The study for IWT follows the same timing compared to the general revision of the NRMM Directive. DG MOVE thanks the participants and closes the meeting.

List of participants

DG MOVE	DG ENVIRONMENT
JRC-ISPRA	DG ENTERPRISE
via donau	Austria – Federal Ministry of Transport
France – Ministère de l'Ecologie, du Développement, durable et de l'Energie	The Netherlands – Ministry of Infrastructure and the Environment
Federale Overheidsdienst Mobiliteit en Vervoer (Belgium)	EICB
ESC	Panteia/NEA
EUROMOT	CCNR
ESO	ESPO (also representing EFIP)
ECORYS	EBU
DST	AECC
Promotie Binnenvaart Vlaanderen (PBV)	INE
Imperial Shipping Service	

MINUTES
Second meeting of the Common Expert Group on emission reduction of the inland waterway transport fleet

23 October 2012
TENT-T Executive Agency (TEN-T EA)
Room 00/47
Chaussée de Wavre 910
B-1040 Brussels

List of Participating organisations

European Commission DG MOVE
European Commission DG ENVIRONMENT
European Commission DG ENTERPRISE
European Commission Joint Research Centre - Institute for the Protection and Security of the Citizen
European Commission The Trans-European Transport Network Executive Agency
Austrian Federal Ministry of Transport
Promotie Binnenvaart Vlaanderen (PBV)
France Ministère de l'Ecologie, du Développement durable et de l'Energie
European Marine Equipment Counsil (EMEC)
PANTEIA/NEA
Inland Navigation Europe (INE)
Community of European Shipyards Associations (CESA)
CE Delft
AECC (Association for Emissions Control by Catalyst)
Ecorys
European Barge Union (EBU)
LLOYD's Register EMEA
The Netherlands Ministry of Infrastructure and the Environment, Policy Programme Inland Waterway Transport
Via Donau
Central Commission for Rhine Navigation (CCNR)
European Shippers Council (ESC)
European Federation for Inland Ports (EFIP)
PLANCO
European Skippers' Organisation (ESO-OEB)

Agenda

Schedule: 10h00-17h00

Chairman: Mr Dimitrios Theologitis, Head of Unit Ports and Inland Navigation, DG MOVE

1. **Welcome (Dimitrios Theologitis, DG MOVE)**

2. **Summary and adoption of the minutes of the first meeting of the Common Expert Group of 18 September**

3. **Terms of Reference of the Common Expert Group on emission reduction of the inland waterway transport fleet**

   Adoption

4. **Research**

   4.1 Preparatory work under the PLATINA 7RFP project

   4.1.1 Presentation of PLATINA working group: Discussion on model outcomes and limitations, implications for policy options.

   4.1.2 Input from questionnaire

   4.2 Support under the Marco Polo accompanying measure

   Presentation of intermediate results

5. **Financing of greening of inland navigation**

6. **Next steps**

7. **Any other business and closing of meeting**

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Minutes

1.1. Welcome by the Chairman: Welcome and round table introduction.

1.2. Summary of the first meeting of the Common Expert Group of 18 September: The Common Expert Group has been publicly registered in view of maximum transparency. The main discussion points and conclusions taken during all the meetings will be documented.

1.3. Terms of Reference (ToR) of the Common Expert Group on emission reduction of the inland waterway transport fleet *(see also Terms of Reference document:* The ToR will be officially adopted, pending comments of one of the Group members.

1.4. Preparatory work under the PLATINA 7RFP project, presentation of results and discussion on model outcomes, limitations and implications for policy options *(see also attachments for the presentation slides):*

Assumptions of back-of-the-envelope calculations: The benefits for the operators are estimated based on savings in fuel consumption. The price level of LNG is assumed at 80% of the diesel costs. The forecasted transport volume growth is based on the baseline scenario of the study "Medium and long term perspectives of Inland Waterway Transport in the European Union" (January 2012). No further evolution of emission standards for road transport is assumed after 2025.

Comparison with other studies: For the external costs, the MARCO POLO (MP) figures are used from the external cost calculator. A sensitivity analysis was done using figures of other studies. The differences are limited. The MP figures will be assessed in the short term and improved were necessary. The 'Marco Polo support measure' project could assist with improvements in the basic assumptions. Regarding the engines, the study was compared with the Arcadis IA study. The basic outcomes go into the same direction.

Recommendations: It was recommended to perform the calculations on a well-to-wheel basis, instead of tank-to-wheel. In the 'Marco Polo support measure' project, studies from international energy organisations should be used to estimate the expected fuel costs in the long-term. A check should also be done on the total number of renewed engines in the BAU scenario for the total period. The investment costs of the different technologies should be reviewed in the 'Marco Polo support measure' project, since the investment costs used in PLATINA seem rather generous. This has an impact on the cost-benefit-ratio (e.g. a low ratio for LNG in PLATINA). The number of operating hours should also be taken into account (i.e. the higher the number, the faster the return-on-investment). Several experts in the Group offered to provide information on this subject. LNG could increase methane emission, but with after-treatment installations this emission could decrease to zero. The PLATINA study has concluded it activities. The 'Marco Polo support measure' will carry a more in-depth analysis and technical feasibility assessment of the different options.

1.5. **Support under the Marco Polo accompanying measure, presentation of intermediate results** *(see also attachments for the presentation slides):*

Part I "General introduction and presentation of policy options": The term EURO VI in one of the options needs to be changed to EURO VI *values* and refers only to the limit values and not the legislation and assumptions used for road transport. The option with a test cycle of EURO VI is not relevant for IWT. The policy options will be based on EURO VI maximum emission values in combination with the NRMM

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test cycle. In option 2a&b, the different standards for existing and new vessels should start at the same year. A missing scenario is EURO VI values for both the new and existing engines to be reached by 2020. It was pointed out that the chosen timeline of the option 2a for EURO VI is economically (for IWT companies) and technically (due to niche market of engine manufactures) probably not reachable. These values are only possible with after-treatment technologies. For option 3, different types of econometers can be distinguished, a mandatory basic version of an econometer would be preferred by some experts. The IWT companies should decide for themselves if they want a more expensive version. A mandatory switch to clean engines linked to the revision of the engine would be problematic since in practice there is no solid system for logging of engine hours. A solution would be to link it to the inspection of the vessel each 5 or 10 years according to Directive 2006/87/EC.

Part II "Data and modelling": Improvements in the waterways are taken into account through the trend of economies of scale. There is concern about the number of unknown building year of the engines versus the unknown building year of the vessels. It is necessary to differentiate between the type of particulate filter and to take into account its reliability. The model should also consider the phasing out process of the single hull tankers. The IVR database can be biased as it mainly contains data from mostly Dutch vessels. Data for other countries is not always complete. The study should also use information from other studies. The auxiliary engines are currently not taken into account. Given the deadline of the project, it is proposed to make the assumption of adding a percentage to the power of the main engine. Regarding technical measures, Gas-To-Liquid should be mentioned in the study, but not necessarily as one of the measures in the options. CNG for small vessels instead of LNG could be considered in a similar way, but eventually the choices should be narrowed for the policy options on a goal based approach. Only more mature technologies shall be taken into account in the assessment of the policy options. In theory any engine can be equipped with after-treatment systems. However, from a practical and economical point of view it might not always be viable. It is important to consider what the difference is in the compliance costs for adapting only the IWT market compared to the whole sector of NRMM.

1.6. **Financing of greening of inland navigation** *(see attached slides of presentation):* The age of the entrepreneur could also be relevant, as an entrepreneur that is almost retiring will not make major investments. The project should look into funding schemes, especially given the limited timeline. It is also important to avoid changing the emission standards in the IWT sector on a regular basis. Setting the emission requirements for a long term horizon will make investments more interesting.

1.7. **Next steps:** see schedule in the presentation slides of the 'Marco Polo support measure' project. The consultants will distribute a guided questionnaire (on legal instruments and enforcement issues; administrative burden and technical feasibility and impacts) and the Minutes of the meeting to the Group.

1.8. **Any other business and closing of meeting:** It was mentioned that a combination of measures is important. A differentiated approach regarding port dues depending on the market situation of the port needs to be considered and also the areas with smaller ports need to be taken into account. Chairman congratulates PLATINA for the successful work performed in the previous years.

MINUTES

Third meeting of the Common Expert Group on emission reduction of the inland waterway transport fleet

Thursday 22 November 2012
Meeting room G-6 SVD 11/1
Rue de Genève 6
Brussels

List of Participants

European Commission DG MOVE
European Commission DG ENVIRONMENT
European Commission DG ENTERPRISE
Austrian Federal Ministry of Transport
Promotie Binnenvaart Vlaanderen (PBV)
France Ministère de l'Ecologie, du Développement durable et de l'Energie
European Marine Equipment Counsil (EMEC)
PANTEIA/NEA
Inland Navigation Europe (INE)
Community of European Shipyards Associations (CESA)
AECC (Association for Emissions Control by Catalyst)
Ecorys
European Barge Union (EBU)
LLOYD's Register EMEA
The Netherlands Ministry of Infrastructure and the Environment, Policy Programme Inland Waterway Transport
Via Donau
Central Commission for Rhine Navigation (CCNR)
European Shippers Council (ESC)
European Federation for Inland Ports (EFIP)
PLANCO
European Skippers' Organisation (ESO-OEB)
EUROMOT
Stichting Projecten Binnenvaart (SPB)
ESO/CNBA
Expertise- en Innovatie Centrum Binnenvaart (EICB)
The Netherlands Ministry of Infrastructure and the Environment, Maritime Directorate
ESPO/Port of Rotterdam

Agenda

Registration: 9:30-10:00

Schedule: 10:00-17:00

Chairman: Mr Dimitrios Theologitis, Head of Unit Ports and Inland Navigation.

1. **Welcome (Dimitrios Theologitis, DG MOVE)**

2. **Summary and adoption of the minutes of the first meeting of the Common Expert Group (18 September) and of the second meeting (23 October)**

3. **Results of Marco Polo accompanying measure**

   Performance gap IWT in relation to road transport & options for measures

   Business economic impact / External cost savings of policy options

   Cost/effectiveness approach, comparison of options

4. **Presentation of the UNECE initiative on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery (NRMM) equipped with Compression Ignition engines.**

5. **Next steps**

6. **Any other business and closing of meeting**

2

MINUTES

1. **Welcome by the Chairman**: The Chairman welcomes the participants.

2. **Summary and adoption of the minutes of the first meeting of the Common Expert Group (18 September) and of the second meeting (23 October)**: The Minutes of the first and the second meeting will now officially be adopted. The summarized Minutes are public.

3. **Results of Marco Polo accompanying measure** *(see presentation slides)*

Part A: Feedback and further research regarding issues formulated at the previous, Common Expert Group meeting

The transition period of new emission limits will depend on the standards chosen (i.e. more ambitious limits need more time). Usually this timeline is five years. From a perspective of technology and experience, a short transition time should not be a problem. For the transition period, the economic and political dimension is also important.

Regarding the implications for shipowners concerning inspections, it was stated that based on legislative requirements, the engines need to maintain their environmental performance for at least 10,000 engine hours. Besides the availability of the technology, also the conditions when sailing, the costs of mobile measuring equipments and the time needed for the measurement procedures should be considered. It was indicated that a measuring method has been developed[1]. Also a measuring method is being developed for the non-road heavy duty mobile machinery. This method is inexpensive, can be easily installed and can be easily modified for other transport modes. This topic requires a follow-up with respect to costs involved.

"Right-sizing" should not be considered as a voluntary measure. Additional power is needed for several reasons and there is no consensus when an engine should be considered "oversized".

It was stated that the unit prices and the R&D costs are expected to decrease over a longer production volume. For the Stage IV proposal no additional R&D is needed as it follows the US Tier 4 emission standard.

Some of the technical limits mentioned to installation of engines and other equipment on existing vessels are: the available space (e.g. limiting LNG use on small vessels), the possibility of having oil in the exhaust gasses of old engines (causing problems for the use of after treatment systems) and the low amount of maximum allowable back pressure.

The application of water emulsified fuels should further investigated as one of the possible technologies, but only for existing vessels.

In setting the implementation period, the technological, commercial and economical feasibility should be considered. The technological aspect should not be a problem, certainly not for new engines. However, other important aspect to consider are: how the emissions will be measured; financial implications (e.g. financing from banks); the availabilty of work force to re-equip and measure/inspect engines. The Chairman thanks the Group for their contribution and the Consultants for their structured and hard work carried out in a short period of time.

Part B: Quantitative impacts on transport operators, emissions and external costs

The administrative and inspection costs were not yet taken into account in the Cost Benefit Analysis. Regarding the Smart Steaming project in The Netherlands (VoortVarend Besparen), it has to be stated that the 6.7% fuel consumption reduction was also the result of other developments (e.g. water levels, new vessels, lower sailing speeds due to econonomic crisis). The evaluation report on the Smart Steaming project estimated that 3-4% overall fuel

[1] See http://iet.jrc.ec.europa.eu/pems/pems-non-road-mobile-machinery-nrmm-engines

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reduction in The Netherlands can be attributed to the program, however one cannot assume that this figure can simply be extrapolated to the whole EU. Regarding the econometer, it was mentioned that much will depend on the attitude of the skipper (e.g. whether the skipper is motivated to minimize fuel comsumption or not), the financial aspects (especially considering the impacts of the economic crisis) and the clients demand for quick delivery of goods. The consultants will investigate the 'Voortsparend Besparend' study further.

In combination with a modern engine, the after treatment systems DPF and SCR do not always have to be combined in order to reach Stage IV levels. This needs to be further analysed.

The answers to the questions following from the Part B presentation can be summarized as follows: (1) The focus of the analysis shall be performance based rather than technology based. However, it is important to look at the most cost effective technology to reach Stage IV or EURO VI values in order to make an estimate of the compliance costs for vessel owners. (2) EURO VI are just values (a terminology) that can be seen as reference. (3) A possible loss of payload of vessels was not taken into account in case of extra space needed for equipment. However, the installation costs accounted for also cover the adaptation of the vessel. (4) The differentiation between push boats will be made more clear by using installed kWh as main reference. (5) Regarding R&D costs it is concluded that for smaller vessels, with low RPM engines, the adaptation of truck engines will encounter problems due to high costs. In any case the available space for the after treatment systems is an issue for small vessels. Using other type of engines for IWT vessels is complicated and some engines are not designed to reach the emission standards for IWT. (6) The expression "new vessels" versus "existing engines" as shown in the presentation slides is clarified as: retrofit on existing vessels in case of existing engines and new engines in new vessels (new building). (7) New 38 meter vessels should not be taken into account. The impacts of bankruptcies is also an important issues in this study. (8) Logistical solutions have not been considered. However, this has been covered already in the PLATINA project which was used as input for the 'Marco Polo accompanying measure' project. (9) A sensitivity analysis of the results will be presented in the next meeting. (10) In particular, the influence of the price of LNG will be included in the analysis. There are indications that the price of LNG could come down as soon as the fuel infrastructure is fully implemented. (11) Care needs to be taken when extrapolating the experiences of the econometers in Netherlands to an EU level. The 'ideal' circumstances of the project (i.e. people motivated to participate), might be different on an EU level.

4. **Presentation of the UNECE initiative on uniform provisions concerning the approval of Retrofit Emission Control Devices (REC) for heavy duty vehicles, agricultural and forestry tractors and non-road mobile machinery (NRMM) equipped with Compression Ignition engines** *(see attached presentation slides and the GRPE WP29 website).*

The relevance of the work of UNECE lies in the development of a harmonized system to be set-up in different Member States. Retrofitting to Stage IV or EURO VI values for inland vessels will require extra work for REC. The certification will be done for a system and that the worst cases will be looked at. The number of certifications will be limited, in order not to put too much burden on the companies that supply the technology. The idea is that if Stage IIIa is reached, retrofit is not needed. Until now, a more strict interpretation was used in the 'Marco Polo accompanying measure' project. In the current approach if Stage IIIa is reached, an additional PM and NOx reduction is calculated. This will be adjusted in the next version of the report.

5. **Next steps:** the fourth meeting with the Common Expert Group is planned for the 17th of December 2012 in Brussels. A NAIADES Implementation Group Meeting will take place on 18 December 2012. *See also the presentation slide 143 of the 'Marco Polo support measure' project for remaining next steps.*

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6. Any other business and closing of meeting: regarding the legal roadmap the Chairman indicates that in the subsequent meeting the legal roadmap will probably be discussed (2013). A suggestion was made to make a short summary of the slides for non English speaking skippers.

MINUTES

Fourth meeting of the
Common Expert Group on emission reduction of the inland waterway transport fleet

Monday 17 December 2012
Meeting room AB-0B, Albert Borschette Center
Rue Froissart 36
Brussels

List of Participants

European Commission DG MOVE
European Commission DG ENVIRONMENT
European Commission DG ENTERPRISE
European Commission JRC-ISPRA
AECC (Association for Emissions Control by Catalyst)
Austrian Federal Ministry of Transport
Central Commission for Rhine Navigation (CCNR)
Community of European Shipyards Associations (CESA)
Ecorys
ESO/CNBA
ESPO/Port of Rotterdam
EUROMOT
European Barge Union (EBU)
European Marine Equipment Counsil (EMEC)
European Shippers Council (ESC)
European Skippers' Organisation (ESO-OEB)
Expertise- en Innovatie Centrum Binnenvaart (EICB)
France Ministère de l'Ecologie, du Développement durable et de l'Energie
PANTEIA/NEA
Promotie Binnenvaart Vlaanderen (PBV)

Inland Navigation Europe (INE)
Ministry of Infrastructure and the Environment (the Netherlands)
Ministry of Infrastructure and the Environment, Policy Programme Inland Waterway Transport (the Netherlands)
Ministry of the Sea, Transport and Infrastructure Inland Navigation Authority (Croatia)
PLANCO
Stichting Projecten Binnenvaart (SPB)
Via Donau

2

Agenda

Registration: 9:30-10:00

Schedule: 10:00-17:00

Chairman: Mr Dimitrios Theologitis, Head of Unit Ports and Inland Navigation.

1. **Welcome (Dimitrios Theologitis, DG MOVE)**

2. **Summary and adoption of the minutes of the third meeting of the Common Expert Group (22/11/2012)**

3. **Results of Marco Polo accompanying measure**

4. **Presentation on the particulate matter (PM versus PN) in order to examine the way to take them into account in future standards for IWT**

5. **Next steps**

6. **Any other business and closing of meeting**

3

Minutes

1. **Welcome by the Chairman:** The Chairman welcomes participants.

2. **Summary and adoption of the minutes of the third meeting of the Common Expert Group (22/11/2012):** The Operational Minutes have been adapted based on the comments received by some members of the Group. No additional comments were given on the Minutes during the meeting.

3. **Results of Marco Polo accompanying measure** *(see presentation slides)*

   Part 1A: Test cycles and truck engines. Stakeholders say it is technically possible to use truck engines on the IWT vessels. Some adaptations would be needed; however this is not innovative since this has already been done in the past. It is remarked that when converting a truck engine into a marine engine ('marinised truck engines'), the emission characteristics will change and will not be equal to the emission characteristics obtained by road transport. The changes needed for the type approval still needs to be sorted out. Besides the changes needed, space will still be an issue.

   Part 1B: Water emulsified fuels. There is some discussion on the economic feasibility of this technology. Tests done with this technology in the Netherlands indicated that the operating costs were not low, especially for cleaner engines. Perhaps this solution could be an interesting option for older engines.

   Part 1C: Passenger vessels. It is mentioned that a proposal has been drafted to also include passenger transport and auxiliary engines. The use of electric propulsion for the transport of cargo (as is sometimes the case for passenger transport), could be a solution for small vessels. Gas-electric, diesel-electric or even full electric technologies could be a solution for vessels of the future. The Chairman also points out that the limits chosen now should not stop or hinder the developments of the future.

   Part 2A: Updated technology scenarios. The analyses shall be looking at mature technologies that are realistic options for the coming years. The fuel efficiency presented is based on price and not on energy content. The savings are on CO_2 emissions.

   Part 2B: Updated cost figures for technical options. The costs of urea could be high for some skippers. Regarding the reduced NO_x proposal, stakeholders point out that the investment costs (R&D) of developing a new type of engine are very high. If one moves away from an option already developed (Stage IIIAa) into a new Stage (e.g. IIIb), additional development work would be needed. The presentation made by the consultants has been updated with costs based on spin-off effects of EURO VI engines obtained from interviews with different stakeholders (instead of current market prices). It was indicated that it is better to use these assumptions for future situations compared to using information based on tailor made solutions for the current situation.

   Part 2C: Methanol as alternative for LNG? It is pointed out that this technology has so many insecurities and safety issues that it is proposed

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during the meeting to skip this solution, certainly given that objectives of the European Commission for the coming 5 to 10 years. It is stressed that there is a need to be technology neutral as much as possible.

Part 2D: Number of engines and vessels to be installed, adapted and replaced. A question is raised regarding the decision of a skipper between the choices Stage IIIA (repowering) and Stage IV. It is indicated that skippers would decide for the cheaper option (i.e. from unregulated to Stage IIIA) instead of Stage IV. It is pointed out that at a certain moment, reconditioning should not be allowed if at least Stage IIIa is not reached.

It is questioned whether or not new small vessels (<110m) will be constructed in the near future. This should be adapted. This could for example be based on the orders of new ships that are going to be built.

Part 2E and 2F: Socio economic cost benefit calculations & Sensitivity analyses. Besides some fine tuning needed on some of the scenarios, the fact finding process of the project is completed. Some stakeholders indicate that the special value of this research work is the different possible technical measures per vessel size.

Part 2G: Further evaluation approach, comparing options. One member of the Group states that an 'LNG only' solution (i.e. 100% LNG) should be possible for both new as for retrofitted vessels and that it should be included as a possible option in the analysis. A sensitivity analysis should be carried out on the difference in the hardware costs between option 2a1 and option 2a2, since it is a different package (i.e. engine and SCR) and therefore requires additional research. Tuning or calibrating an engine would require investments in R&D. The analysis should be technology neutral.

4. **Presentation on the particulate matter (PM versus PN) in order to examine the way to take them into account in future standards for IWT** *(see presentation slides)*. EURO VI is a complete system and not just a paper with emission standards. The new EURO VI tests (WHTC) are closer to the real road driving cycles than previous test cycles. However, this cycle has not been tested on the road. For IWT it is advisable to perform real testing in actual sailing conditions. A possible measuring system could be PEMS. A question is raised on the danger replacing diesel by LNG. It is mentioned that LNG engines produce higher methane concentrations. However, LNG applications have many positive environmental impacts. The application of LNG requires separate methane limits.

5. **Next steps:** The chairman indicates that the information will be used as input for the definition of new standards by DG Entr and DG Move. The next meeting of the project will focus on a discussion on the emission levels and not on the possible technologies that can be used. The fifth meeting with the Common Expert Group is planned for the 28th of January 2013 in Brussels.

6. **Any other business and closing of meeting:** The Chairman points out that all the different aspects of IWT will be considered (e.g. logistics, network, environmental, etc) in different projects. It is also mentioned the importance translating the savings to the industry. The objective is to give the IWT sector a push. A member of the Group indicates that this could require financial support.

5

MINUTES

Fifth meeting of the
Common Expert Group on emission reduction of the inland waterway transport fleet

Tuesday 12 March 2013
Meeting room "JDE 51", Committees of the Regions
in: Rue Belliard 101, 1040 Brussels

List of Participants

Organisation
European Commission DG MOVE
European Commission DG ENV
European Commission DG ENTR
Association for Emissions Control by Catalyst (AECC)
Central Commission for Rhine Navigation (CCNR)
European Barge Union (EBU)
ECORYS
European Shippers Council (ESC)
European Skippers' Organisation (ESO-OEB)
European Federation of Inland Ports (EFIP)
European Association of Internal Combustion Engine Manufacturers (EUROMOT)
Federal Ministry of Transport (Austria)
Inland Navigation Europe (INE)
PANTEIA/NEA
Ministry of Infrastructure and the Environment (the Netherlands)
Ministry of the Sea, Transport and Infrastructure Inland Navigation Authority (Croatia)
PLANCO
Ministry of Transport of the Czech Republic
Via Donau

Revised Agenda

Registration: 9:30 – 10:00
Schedule: 10:00-17:00

Chairman: Mr Marc Vanderhaegen, DG MOVE, Ports and Inland Navigation

1. Welcome (Marc Vanderhaegen, DG MOVE)
2. Summary and adoption of the minutes of the fourth meeting of the Common Expert Group (17/12/2012)
3. Presentation of "Clean Power strategy" by Mr. José Fernandez, Clean transport and sustainable urban mobility (DG MOVE).
4. Presentation parts 1 and 2 of the final report "Contribution to impact assessment of measures for reducing emissions of inland navigation" - Marco Polo accompanying measure.
    - Policy objectives, emission standards and options
    - Cost Benefit Analysis
5. Presentation of the EU Financial instruments by Matthieu Bertrand, Unit connecting Europe-infrastructure investment strategies (DG Move).
6. Presentation parts 3 and 4 of the final report "Contribution to impact assessment of measures for reducing emissions of inland navigation" - Marco Polo accompanying measure.
    - Multi Criteria Tables
    - Next steps
7. Next Steps
8. Any other business and closing of meeting

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Minutes

1. **Welcome by the Chairman:** The Chairman welcomes participants to the fifth and final Common Expert Group meeting on emission reduction of the inland waterway transport (IWT) fleet. During the meeting the draft final report will be presented and discussed.

2. **Summary and adoption of the minutes of the fourth meeting of the Common Expert Group (17/12/2012):** The Minutes of the fourth meeting are adopted. No further comments were made.

3. **Presentation of "Clean Power strategy"** (*See presentation slides)*: DG MOVE emphasizes the ambition to deploy alternative fuels for all transport modes, including IWT. If shore side power supply is already used and regulated in IWT, new legislation for waterborne transports related to the clean fuel strategy should take it into account with respect to new standards.

   A participant shows concern about the absence of a strict common European standard on gas quality as it is difficult to design engines with low emissions for a wide range of gas qualities. Participants suggest to further study the possible locations for bunkering points for LNG by means of a pragmatic approach. A concentration of LNG bunkering points in neighbouring ports and close to densely populated areas should also be avoided. Furthermore it was considered that market players are reluctant about investments in LNG infrastructure due to lack of legislation for LNG.

   In the communication document[1] LPG is suggested as an alternative fuel for IWT. A participant remarked that LPG should be abandoned for reasons of safety. CNG and electric propulsion are used in practice for short range traffic and should seen as a potential alternative that could be added to the list of alternatives.

   DG MOVE explained that the Commission is about to ask CEN to do a mapping exercise. This exercise will identify for the purposes of the proposed Directive existing standards and future standardization needs

4. **Results of Marco Polo accompanying measure, parts 1 and 2** *(See presentation slides)*

   Part 1: Policy objectives, emission standards and options:

   After a presentation by the consultant, a discussion takes place on the policy objective that was refined by extending the time horizon from 2020 to 2030 and by focussing emissions to air pollutants with air quality impacts (i.e. having harmful effects on the population (mainly NOx and PM). The performance of inland waterway vessels on these parameters was benchmarked with road and this was used to calibrate the policy options.

   Some participants questioned the rationale for this approach, as CO_2 emission reduction is a major objective in the White Paper on Transport and should in their view be taken into account. It was then explained that the focus on NOx

[1] COM(2013) COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, Clean Power for Transport: A European alternative fuels strategy, 24.1.2013

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and PM is only for calibration of the policy options and that the impacts on CO_2 emissions are fully included in all the cost benefit analyses and also in the multi-criteria tables in the report. The Chairman requests the consultants to better explain this in the final report. Moreover, inland navigation should not be more harmful to human health than road if it wants to be perceived as an environmentally-friendly transport mode.

A discussion ensued about the methodology for external costs calculation for IWT which are based on the official figures from the Marco Polo External cost calculator. Results from other studies (e.g. IFEU, TNO) have been used by the consultant to determine the emission profiles of existing vessels which were used to calibrate the relative evolution of the emissions of the IWT fleet in the future years.

Some participants expressed concerns about the difference in values for the external cost levels compared to those of the aforementioned studies which are very recent. Also other parameters, such as the load factors would be significantly different. The Chairman explained that the values presented in the Marco Polo external cost calculator are updated every year and that the consultants have been asked to take into account the latest improvements to the Marco Polo calculator. The Marco Polo calculator is based on official data supplied by all EU member states and the load rates for IWT are derived from these official data. The Marco Polo external cost calculator is designed according to a consistent methodology for all modes of transport and with a EU wide coverage. Differentiated methodologies per modes of transport would not provide a basis for comparing them. The Chairman also informs the group of experts that the work done by the consultants has been fed back into the Marco Polo methodology with a number of improvements as a result. The adapted Marco Polo external cost calculator is expected to be published by April 2013. It was also remarked that a sensitivity analysis has been done to test the impact of variations in the input data.

The consultants presented the baseline emissions, an alternative baseline (Stage IIIb) which does not allow for inland navigation to catch up with road pollutant emissions and three options (various combinations of stages Iva, IVb and V) for emission levels which allow IWT to catch up with road by 2030. A participant mentioned that it is uncertain if new stage 5 engines will have EURO VI level emissions. According to engine manufacturers a timeframe of at least five years is needed for R&D and certification, especially for limited market segments. The consultant explained that additional time for the development of these stage 5 engines has been integrated in the various options, with new stage 5 emissions limits taking effect from the year 2022 or 2020 depending upon the policy option. Moreover, it was remarked that also integrators could achieve stage 5 by combining non-certified base engines with other technologies, requiring less R&D and less development time.

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Part 2: Cost Benefit Analysis:

The consultant presented the results of the cost/benefit analysis for the alternative baseline and the various options. It is remarked that CO_2 effects are included in all calculations and graphs of the cost-benefit analysis. Passenger vessels and auxiliary engines are excluded from the cost benefit analysis.

There are questions whether the expected cost level to reach Stage 4B emission limits is realistic in view of the current market prices. The consultant explained that due to economies of scale derived from the coverage of both new and existing vessels, the larger market volumes will reduce the price per vessel to adapt the engines. Participants retorted that no engine room is the same and that a tailor made approach will always be needed. However, the Consultant states that the figures have been determined on the basis of extensive discussions with experts on the possibility of developing standardised emission control modules which can be applied and installed in different settings for certain engine types and power ranges. The experts consulted have confirmed that costs for emission control systems are realistic and feasible taking into account the expected synergies with developments in other continents and NRMM segments.

The question is raised whether small vessels should be excluded from future emission standards due to relatively low benefit-cost results for small engines/vessels. The consultant explained that although lower, the benefit/cost ratio is still positive for small vessels. The exclusion of small vessels has been taken into account as one of the main parameter in formulation of the policy options, but also based on other ground such as the technical and financing feasibility. It is noted that for the small vessels, there are positive benefit/cost ratios in option 1 (Stage 4B new engines / 4A existing engines) as savings on external costs are higher than the compliance costs for the industry. However, the benefit/cost ratio for small vessels is higher in case of option 2 and 3 where stage 3B is selected. The Chairman points out that as for the other aspects, also the question on the level of requirements to apply to smaller engines compared to those of larger engines is still open for debate. In this context; it should be noted that also considerations concerning level playing field between small and large vessels should be taken into account. It was remarked in this respect that in particular the smaller vessels compete with road haulage. Therefore also the environmental performance of smaller vessels compared with road haulage may be an element to take into account in the considerations on level playing field in addition to the differences between small and medium/large vessels.

5. Presentation of the EU Financial instruments:

A representative of DG MOVE explains that in the framework of the multiannual financing framework the requested 50 billion euro for the Connecting Europe Facility (CEF) was reduced to 32 billion euro of which 23 billion euro available for transport. An agreement about the budget still has to pass the EU Parliament. If the multi-annual budget is not adopted, an agreement on CEF is not expected before next year. IWT is a priority within CEF. The IWT budget will be allocated: 30% for normal projects, 40% for solving bottlenecks and 30% for multimodal transport. The RSFF instrument, a financing tool for the 7th Framework programme, will continue through

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Horizon 2014 – 2020. The RSFF can be applied also to vessels and vehicles and can be combined with grants from the Connecting Europe Facility (CEF). In conclusion, there will be new or continuing possibilities to improve e.g. IWT infrastructure works and RIS, but most likely under co-funding conditions with a co-funding rate of 20%.

In this context, the possibilities should be further examined for setting up a loan guarantee for banks to reduce risks of investments in LNG,

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6. **Results of Marco Polo accompanying measure, parts 3 and 4** *(See presentation slides)*

Part 3: Multi Criteria Tables:

The consultant presents the results of the multi-criteria analysis. A participant remarks that it is possible to certify new engines under Directive 97/68/EC by service suppliers that adapted the engine with a retrofit package in order to comply with emission standards.

A question about the amount of vessels suitable for LNG retrofit is answered by indicating that according to the model calculations the 110 meter and larger freight motor vessels are suitable for a conversion to LNG. Existing push barges cannot be converted to LNG due to lack of space for the LNG tank. However, there are business cases where it is more attractive to build new push boats on LNG in order to replace existing push boats.

Some participants indicate to support only legal action targeted at new engines and not existing ones. It was remarked, however, that the policy options should be seen within a long-term framework and economic development. Only addressing new engines would provide ship owners an incentive to repeatedly overhaul existing engines in order to avoid an investment in more expensive new engines. Another participant points towards the very high benefits for society and the positive benefit/cost ratios of the policy options and also the positive impacts for society to include the existing engines. Public action is needed due to the on-going discussion on air quality, to prevent a loss of the green image of IWT and to support IWT during growing market demand. There are clear win-win situations for both society and industry for the large vessels. Another participant suggests that there is an imbalance between benefits for society and costs for ship-owners. Stricter emissions standards for new engines are supported and a long transition period for existing engines.

Part 4: Legal and monitoring issues

Stakeholders are invited to participate in a DG ENTR public consultation until the 8th of April on the revision of the NRMM Directive 97/68/EC. Subsequently an Impact Assessment will be carried out, in which the results of this study will be integrated. The tentative schedule is to present a new proposal by the end of this year.

The revision of the Directive on Air Quality is also planned for the end of this year.

Comments to the presentation by the Consultant on legal and monitoring issues are started with the suggestion to set for auxiliary engines on board of vessels the same emissions standards as for marine propulsion engines, which require the same cooling systems. Currently auxiliary engines on board of vessels are covered in the same way as land based radiator cooled engines in Directive 97/68/EC.

Legal issues on the regulatory environment for implementation of LNG must be quickly resolved. A European approach and coordination is needed. In particular, safety aspects have to be addressed with respect to the implementation of LNG. It is not clear if and how regulations on emission of LNG will be developed from an air quality point of view. This issue will be reviewed in the on-going revision of the NRMM Directive 97/68/EC. It was remarked that current regulations on emission standards are not technology neutral, since regulations in IWT focus on diesel engines. There is a lack of legislation on other fuels such as LNG and dual fuel engines. This is confirmed by another participant by stating that Directive 97/68/EC refers to diesel engines for engines over 19 kW. Despite the lack of regulations on spark ignited, combustion ignited etc. engines, it is not expected that there will be separate regulations for all fuels and fuel combinations.

The consultant is of the opinion that monitoring and reporting on compliance with emission limits for existing engines can be organized without significant additional burden given that the current monitoring and reporting systems can be used and expanded with a few attributes.

7. **Next steps:** The result of this study including the feedback from this meeting will be taken into account in a Commission staff working document to be annexed to the NAIADES Communication. The staff working document which will elaborate on further steps for the greening of the IWT fleet and will feed into the impact assessment for the various follow-up initiatives of a legislative nature. The study will also feed into the NAIADES II Communication which will set the issue of IWT fleet emission reduction in a broader context.

8. **Any other business and closing of meeting:** The Chairman thanks the participants for the input provided. He especially thanks the consultants for the considerable effort put into a quality report. The minutes of the meeting will be distributed by e-mail. All representatives will have until 31st of March to send in comments and contribute to the discussion of the report by means of short statements. This procedure also gives the representatives unable to attend the meeting today the opportunity to send in their comments. According to the final comments and input from this meeting some adjustments will be integrated in the final version of the report. However, the overall findings, conclusions and calculations will remain unchanged.

   The Chairman closes the meeting and expresses his appreciation for the positive and open communication during the Common Expert Group meetings, which helped to develop a sound approach for the greening of the IWT fleet.

Comments of the Netherlands on the report "Contribution to Impact Assessment of Measures for Reducing Emissions of Inland Navigation"

General

The Netherlands are satisfied with the attention the EC has given to the environmental performance of inland navigation in the staff working document "Towards NAIADES II"[1], and in the ensuing Common Expert Group on emission reduction of the inland waterway transport fleet. After all, it were the Netherlands and Germany who jointly organised the international workshop "Emissions from the Legacy Fleet" in November 2011. In this workshop, attention was for the first time being paid to the emissions of the large number of in-service engines. Regarding new engines, the Netherlands feel new emission limits should be put into force quickly, as the current emission standards already date back to 2007.

Goal should include air quality parameters *and* CO_2

The Common Expert Group started out with the goal "*to achieve by 2020 an overall performance regarding emission levels for inland waterway transport that is better or at least comparable to that of road transport*". After four out of five meetings, the EC has decided to change that goal such that the time horizon is now set to the year 2030, and the emission reduction goal focuses only on the air quality parameters NOx and PM10. The Netherlands do not agree with this change of approach, which effectively excludes CO_2 emissions from the goal set. The main reason is that the Netherlands feel the emissions of inland navigation to air should be dealt with in an integrated manner. Thus, the external costs of both air quality parameters (NOx and PM10) *and* CO_2 should be taken together when setting the goal. Second, CO_2 emission reduction is a major objective in the White Paper on Transport. This justifies inclusion of CO_2 in the goal set by the Common Expert Group.

The Netherlands propose to revert to the original goal, but to allow for some extra time for the goal to be reached. This would also buy necessary time for the legislative process. The goal could then be "*to achieve by 2022 an overall performance regarding emission levels for inland waterway transport that is better or at least comparable to that of road transport*". These emissions would then include NOx and PM10 *and* CO_2.

Marco Polo Calculator

The Netherlands are concerned, because the report by Panteia relies heavily on the Marco Polo Calculator. Some of the assumptions in the Marco Polo Calculator deviate strongly from previous reports about external costs. One example is the average load factor of 25%, which is clearly too low and does not represent a realistic value.

[1] SWD(2012) 168 final

2013-03-26

Verdissement des bateaux de navigation intérieure - avis des autorités françaises

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I. Commentaires sur le rapport "CONTRIBUTION TO IMPACT ASSESSMENT of measures for reducing emissions of inland navigation ", version du 1/1/2013

Les autorités françaises souhaitent souligner la qualité du rapport transmis qui permet de résumer la démarche du groupe de travail commun, d'expliquer les conditions de modélisation, et apporte une approche critique des résultats.

Après relecture du rapport, vous trouverez ci-dessous les commentaires des autorités françaises :

4.5 : il serait nécessaire de compléter le rapport avec une représentation schématique des différents niveaux d'émissions (niveaux équivalents en particulier), ainsi que les solutions technologiques pour le retrofit. La présentation du 12 mars 2013 est plus explicite sur ce point, en particulier comment peut-on passer d'un niveau d'émissions à un autre.

4.6.2 : les autorités françaises se félicitent de l'attention apportée au cas de la flotte de petit gabarit. De plus, cette attention se retrouve dans la distinction des champs d'application ("level playing field") et les options de politiques publiques proposées.

5.3.4 ; Si le développement technologique pour la mise sur la marché de moteurs étape V est nécessaire, il convient de poursuivre les efforts pour maintenir des moteurs adaptés au marché de la navigation intérieure. Comme évoqué dans le paragraphe 6.1.2, les autorités françaises demandent à la Commission européenne d'agir pour favoriser le lien avec d'autres marchés de moteurs (ex. EMNR) et garantir des prix accessibles pour l'équipement de moteurs neufs.

6.1.1 : concernant la faisabilité économique du retrofitting avec le LNG, il convient de noter que nous n'avons que peu d'expérience sur le sujet. En effet, les projets mis en place au Pays-Bas concernent uniquement des bateaux neufs. Aussi, l'adaptation de bateaux existants à la propulsion LNG est un point critique pour l'exigence d'une étape V.

6.2.2 : le lien dynamique entre les autorités et professionnels réalisé pour le groupe de travail commun doit être maintenu, notamment pour rendre visible les futurs projets réglementaires et garantir une bonne information de la profession.

7.1 : il convient de recentrer cette partie sur les implications réglementaires de nouvelles normes d'émissions, et non uniquement sur une mise en œuvre de la technologie LNG.

7.2 : la réalisation de tests sur une base individuelle pour les moteurs existants n'est pas envisageable pour les autorités françaises. En effet, si le coût administratif est difficilement supportable pour les autorités, le recours à une expertise privée pour la réalisation des essais conduira à augmenter le coût pour l'industrie. C'est pourquoi, il est nécessaire de standardiser les solutions pour passer d'un niveau d'émissions à un autre, et de prévoir une procédure d'agrément par type pour les systèmes SCR/DPF.

9.1 : les autorités françaises souhaitent ajouter la propulsion Diesel-électrique comme solution alternative à étudier.

9.3 : il est proposé l'amendement suivant sur le paragraphe relatif aux petits bateaux :

> Small propulsion engines may derive from other ~~NRMM~~ applications. It **should** be further investigated if an alignment of the emission limits for IWT purposes and other applications would be useful. **This alignment could stimulate industry to put on the IWT market new engines.**
>
> ~~And inventory can be made of engine applications in IWT where engines may derive from emission levels (e.g. engines of life boats and windlasses).~~

9.4 : les autorités françaises soutiennent la proposition d'améliorer le suivi des moteurs par le biais de la base européenne des bateaux (EHDB).

II. Commentaires sur le compte-rendu de la réunion du 12 mars 2013

Du fait des conditions de trafic en Paris et Bruxelles, les autorités françaises n'ont malheureusement pas participé au groupe de travail du 12 mars 2013. Toutefois, comme proposé par la Commission européenne, vous trouverez les commentaires des autorités françaises :

3. La qualité du gaz à considérer pour le développement du LNG est un point critique. Il est rappelé qu'il n'existe aujourd'hui pas de normes d'émissions pour l'agrément par type des moteurs fonctionnant exclusivement au gaz. La mise en œuvre de tels agréments nécessitent au préalable de fixer les caractéristiques du carburant d'essai.
En outre, les autorités françaises soutiennent pleinement l'ajout de la propulsion électrique à la liste des solutions alternatives.

4. Il est important de tenir compte des coûts de certification et des synergies à mettre en œuvre pour garantir la mise sur le marché de moteurs adaptés au secteur fluvial.

Les autorités françaises ne sont pas favorables à l'approche "sur-mesure" pour les bateaux existants. En effet, comme expliqué dans le commentaire, il en résulte un coût administratif conséquent, et un coût pour l'industrie de la navigation intérieure (réalisation de tests in situ).

La situation "gagnant-gagnant" dans le rapport est valable uniquement pour les classes de bateaux les plus importantes (p60). Il conviendrait de préciser ce point lorsqu'on parle de situation "win-win" pour l'industrie-la société dans le compte-rendu.

III. Avis général des autorités françaises

Pour le secteur du transport fluvial, les moteurs des bateaux de navigation intérieure sont soumis depuis 2004 aux dispositions de la directive 97/68/CE modifiée, en tant qu'engins mobiles non routiers.p

Les autorités françaises ont participé activement au groupe d'expert commun, mis en place par le Commission européenne (DG Move), relatif à la réduction des émissions de la flotte de la navigation intérieure, et restent attentives aux conclusions dudit groupe.

Si de nouvelles normes d'émissions doivent être appliquées aux moteurs des bateaux fluviaux, y compris à la flotte existante, il faut garantir la mise sur le marché de moteurs adaptés au petit gabarit, et la possibilité d'investissement des bateliers. Ceci reste possible par le rapprochement à d'autres marchés de moteurs (ENMR et routiers), et la facilitation des procédures certification.

Il serait également utile de disposer de normes européennes pour les rétrofits, afin d'éviter une approche "sur-mesure" qui nécessiterait des tests in situ sur chaque bateau. Cette approche présente des coûts administratifs et coûts pour l'industrie non supportables.

Enfin, tout comme pour le transport maritime, il conviendrait de mettre en place des incitations pour le développement de technologies contribuant à la réduction de la consommation de carburant ou de substitution de carburant, en particulier la technologie Diesel-electrique.

european barge union ebu

EBU - UENF European Barge Union - Union Européenne de la Navigation Fluviale - Europäische Binnenschiffahrts Union - Europese Binnenvaart Unie

EBU INPUT TO THE CONTRIBUTION TO THE IMPACT ASSESSMENT (IA) OF MEASURES FOR REDUCING EMISSIONS OF IWT

Introduction

The COMMISSION STAFF WORKING DOCUMENT "Towards NAIADES II" which has been released by the EC in May 2012 states that contrary to road transporters, barge operators have no strong economic or regulatory incentives to reduce IWT emissions. The Commission services are therefore preparing new measures for IWT to catch up and for this purpose set up a Common Expert Group (CEG)on emission reduction of the inland waterway fleet. **The goal being to achieve by 2020 an overall performance regarding emission levels for IWT that is better or at least comparable to that of road transport**. At the document that was presented at the last meeting of the CEG on 12.3.2013 the initial goal **to achieve by 2020 an overall performance regarding emission levels for IWT that is better or at least comparable to that of road transport** has been changed, with a **focus on air pollutant emissions only** (without greenhouse gas emissions) and shifting the time horizon to **2030.**

In the contribution of the consultants research regarding the emission reduction potential towards the background of technical feasibility and cost effectiveness both in terms for IWT and society has been undertaken. The most important findings and conclusions are:

- IWT is lacking behind road transport as regards renewal of engines due to lack of regulatory and mandatory standards and lacking a system of internalization of external costs.
- Therefore so far only a limited number of vessels has installed new engines and the potential for new engines to be installed is very high, due to the long lifetime of IWT propulsion engines, the way of exploitation of vessels, the ratio between laying and sailing time, and the possibility to navigate on a more opportune and continuous enginespeed and -load.

EBU's greening strategy

To contribute to the actual discussion EBU released its **Greening Strategy** which fed into the negotiation process. Although IWT is the most environmentally friendly mode of transport today, the sector is contributing to the European Strategy 2020 by introducing new technologies to keep pace with the new technologies and sail towards even more environmental benefits for society. In this respect LNG is considered the most promising future development as regards new vessels.

EBU therefore strongly encourages

- promoting and stimulating the introduction of LNG as an alternative fuel.
- allowing vessels to sail on LNG
- realizing the necessary regulatory framework asap at European level.
- realizing the necessary supply facilities asap along the whole waterway network
- developing, promoting and stimulating standardized after treatment solutions adapted to the sector's needs.

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european barge union ebu

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european barge union ebu

EBU - UENF European Barge Union - Union Européenne de la Navigation Fluviale - Europäische Binnenschiffahrts Union - Europese Binnenvaart Unie

EBU furthermore encourages the greening of the fleet and replacing of the engines with the newest technologies, which are installed according to the newest emissions standards. Meanwhile a good balance between environmental protection and technical and economic feasibility should be kept in mind. Policy options must take into account the serious economic crisis of the sector and distinguish between measures regarding the new fleet and the legacy fleet. The economic situation of the sector does not allow to invest in new engines and/or after treatment solutions without substantial funding.

General remarks on the latest contribution of the consultants to the IA of measures for reducing emissions of IWT

1. **Methodology** on which the assumptions are based in the report: the current methodology is based on the Marco Polo calculator which has been critisised as unfavourable for IWT since the beginning. A recent study by the German institute IFEU proved that the energy consumption of IWT and its air pollutants emissions are much lower than assumed in earlier studies. This might lead to much better outcomes of the air pollutant calculations (NOx and PM) when comparing them in this contribution to road and influence the analyses as presented.

2. **Focus on air pollutant emissions:** Greenhouse gas emissions have been left out as parameter when comparing IWT to road in the latest contribution. Rationale being that if CO_2 is taken into consideration IWT would prove as positive as road regarding emissions and no drivers for engine renewal would remain. The policy objective therefore in this study only focuses on the human health point of view and the influence of air pollutants rather than on all emissions.
   Although we understand the rationale of this revised approach which should support public funding of greening measures and renewal of the engines this must not disturb the balance between environmental protection and technical and economic feasibility of renewal of the engines. Therefore all parties involved, public and private, are expected to contribute to the greening process to mitigate the negative impact on human health and society.

3. **Level playing field:** no parts of the fleet should be excluded from emission targets when it comes to the renewal of the engines and/or after treatment solutions in order to avoid distortion of competition within the sector.
   To avoid distortion of competition with other modes only new engines can be targeted for new emission standards.

Remarks on the Policy options

As regards the emission standards on which the various policy options are based EBU claims that

- Revised emission standards only must apply to new engines (in new and existing vessels);

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european barge union **ebu**

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- Renewal and/or retrofit of the engines of the legacy fleet is only acceptable on a voluntary basis; a mandatory renewal of this fleet would lead to a distortion of competition, as other modes of transport do not have such an obligation;
- For both paths funding must be made available under NAIADES II and national funding programs;

The introduction of new standards and their support will largely depend on the availability of engines and the willingness of the engine manufacturers to invest in R&D and a very limited market. The IWT sector is depending on the introduction of new engines and standardized after treatment solutions.

Conclusion

1. EBU welcomes the report as it provides very interesting and useful information on the situation of IWT and its future potential.

2. Referring to the methodology which has been questioned during the process, a sensitivity study in addition to the actual study should be commissioned by the Commission to verify the assumptions in the actual study (reference IFEU).

3. EBU is committed to keep pace with new technologies and encourages the greening of the fleet and replacing or retrofitting of the engines under the conditions as referred to.

4. Given the high benefit of greening measures of the fleet for society all parties are expected to contribute to this development. Therefore EBU counts on the European Commission and the Member States to guarantee funding of engine renewal and after treatments of the existing fleet.

28 March 2013

The European Barge Union (EBU) represents the majority of the inland navigation industry in Europe. Its members are the national associations of barge owners and barge operators of meanwhile 9 leading European inland navigation countries.
EBU's main objective is to represent the interests of the inland shipping industry at a European and international level and to contribute to the development of a sustainable and efficient European transport system.

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Eso's comments on the contributions to impact assessment (March 12th,2013) of emissions reducing measures

General

The COMMISSION STAFF WORKING DOCUMENT "Towards NAIADES II" which has been released by the EC in May 2012 states that contrary to road transport, barge operators have no strong economic or regulatory incentives to reduce IWT emissions. The Commission services are therefore preparing new measures for IWT to catch up and for this purpose set up a Common Expert Group (CEG) on emission reduction of the inland waterway fleet.

At the document presented at the last meeting of the CEG on 12.3.2013, the initial goal to achieve by 2020 an overall performance regarding emission levels for IWT that is better or at least comparable to that of road transport, has been changed, the focus is on air pollutant emissions only (without greenhouse gas emissions) and the time horizon is shifted from 2020 to 2030.

In the contribution of the consultants research regarding the emission reduction potential towards the background of technical feasibility and cost effectiveness, both in terms for IWT and society, has been undertaken.

Some of the most important findings and conclusions are:

- IWT is lagging behind road transport as regards renewal of engines
  - due to lack of regulatory and mandatory standards and lacking a system of internalization of external costs;
  - due to the long lasting lifetime of IWT propulsion engines, which is a result of the way of exploitation, on the one hand caused by the ratio between laying and sailing time, on the other hand by the possibility to navigate on a more opportune and continuous enginespeed and -load;
  - the limited market for a new generation of IWT propulsion engines which causes high R&D and introduction costs.

- Therefore so far only a limited number of vessels has installed new engines; the potential for new engines to be installed is very high.

Strategy

Although IWT is the most environmentally friendly mode of transport today, the sector is already contributing to the European Strategy 2020 by introducing new technologies on fuel, engines and after treatment to keep pace with new developments and requirements and sail towards even more environmental benefits for society.

In this respect LNG is considered most promising for future development as regards new vessels, to begin with in the larger vessels.

On the other hand, diesel will for a long time be the prevailing fuel for IWT engines, especially in the lower power ranges on smaller vessels and the legcy fleet.

ESO therefore strongly encourages

- promoting and stimulating the introduction of LNG as an alternative fuel.

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- allowing vessels to sail on LNG
- realizing the necessary regulatory framework at European level.
- realizing the necessary supply facilities along the whole waterway network
- but also developing, promoting and stimulating ***standardized after treatment solutions*** adapted to the sector

ESO furthermore encourages the greening of the fleet and replacing of the engines with the newest technologies, installed according to the newest emissions standards. Meanwhile a good balance between environmental protection and technical and economic feasibility is of utmost importance.

> ***Policy options must take into account the serious economic crisis of the sector and distinguish between measures regarding the new fleet and the legacy fleet.***
> ***The economic situation of the sector does not allow to invest in new engines and/or after treatment solutions without substantial funding.***

General remarks on the latest report to the IA of measures for reducing emissions of IWT

1. Methodology on which the assumptions are based in the report: the current methodology is based on the Marco Polo calculator which since the beginning has been criticised as unfavourable for IWT.
   A recent study by the German institute IFEU proved that the energy consumption of IWT and its air pollutants emissions are much lower than assumed in earlier studies. This might lead to much better outcomes of the air pollutant calculations (NOx and PM) when comparing them in this contribution to road and influence the analyses as presented.

2. Focus on air pollutant emissions: Greenhouse gas emissions have been left out as parameter when comparing IWT to road in the latest contribution. Rationale being that if CO2 is taken into consideration IWT would prove as positive as road regarding emissions and no drivers for engine renewal would remain. The policy objective therefore in this study only focuses on the human health point of view and the influence of air pollutants rather than on all emissions.

3. Although ESO understands the rationale of this revised approach which should support public funding of greening measures and renewal of the engines this must not disturb the balance between environmental protection and technical and economic feasibility of renewal of the engines. Therefore all parties involved, public and private, are expected to contribute to the greening process to mitigate the negative impact on human health and society.

4. Level playing field: no parts of the fleet should be excluded from emission targets when it comes to the renewal and/or retrofit of the engines in order to avoid distortion of competition within the sector.

5. To avoid distortion of competition with other modes only new engines can be targeted for new emission standards.

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Remarks on the policy options

As regards the emission standards on which the various policy options are based ESO claims that

- revised emission standards only must apply to new engines (in new vessels; in existing vessels provided the installation will be technically and economically feasible);
- renewal and / or retrofit of the engines of the legacy fleet is only acceptable on a voluntary basis; a mandatory renewal of this fleet would lead to a distortion of competition, as other modes of transport do not have such an obligation;
- for both paths funding must be made available under NAIADES II and national funding programs.

The introduction of new standards and their support will largely depend on the availability of engines and the willingness of the engine manufacturers to invest in R&D in a very limited market. The IWT sector is depending on the introduction and sufficient and availability of new and reliable engines and standardized after treatment solutions.

Conclusions

1. ESO welcomes the report which provides very interesting and useful information on the situation of IWT and its future potential.

2. Referring to the methodology which has been questioned during the process, a sensitivity study in addition to the actual study should be commissioned by the Commission to verify the assumptions in the actual study (reference IFEU).

3. ESO is committed to keep pace with new technologies and encourages the greening of the fleet and replacing or retrofitting of the engines under the conditions as referred to.

4. Given the high benefit of greening measures of the fleet for society all parties are expected to contribute to this development. Therefore ESO counts on the European Commission and the Member States to guarantee funding of engine renewal and after treatment equipment of the existing fleet.

Brussels/Rotterdam/Brugge, 29 March 2013

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European Federation of Inland Ports
Fédération Européenne des Ports Intérieurs
Europäischer Verband der Binnenhäfen

Point of view of the European Federation of Inland Ports on the draft contribution of the consultants to the impact assessment of measures for reducing emissions of IWT

March 2013

The European Federation of Inland Ports (EFIP) fully subscribes the Commission's aim to achieve an environmental performance in the inland waterway transport sector that is better or at least comparable to the environmental performance of the road sector. It is time to wake up the inland waterway transport industry that its leading position as sustainable transport mode could be jeopardized if they do not invest in innovation and in further greening the sector.

EFIP therefore welcomes the efforts made by the Commission to develop a strategy in close cooperation with the common expert group that has been set up last year. European inland ports also appreciate the in-depth analysis being made by the consultants as a contribution to the impact assessment.

The European Federation of Inland Ports welcomes the opportunity to comment on the draft report of the consultants and would in that respect like to share the following remarks and views:

- EFIP believes that the environmental performance of the different transport modes can only be compared if all emissions are taken into account. EFIP therefore believes that the environmental performance of the IWT sector has to be measured taking account of both air pollutant emissions, greenhouse gas emissions and other emissions such as noise. Isolating the one or the other in the overall comparison of modes, is a wrong starting point. Besides, even if it is in the interest of the IWT sector to put greening high on its agenda, it is not in its interest to promote itself less sustainable than it actually is.

- But, the comparison of the overall environmental performance (measuring both air and GHG emissions) should not be used to exempt the IWT sector from any further greening policy. Therefore, next to the overall environmental performance, it is important to focus on each of the pollutants and to see where efforts have to be made. Concretely, it is clear that IWT can present good results when it comes to greenhouse gas emissions, but it will have to seriously step up its efforts to achieve better results as regards air pollutant emissions. Only by tackling air pollutant emissions, IWT will be able to strengthen again its green image and to catch up with the quickly evolving road transport sector. Moreover, if inland waterway transport wants to become an attractive transport mode for urban freight supply and distribution it is clear that it will have to lower its impact on health and thus lower its air pollutant emissions.

- EFIP supports an ambitious plan for developing and encouraging new technologies. New engines and new vessels must meet the highest environmental standards.
- At the same time, EFIP is fully aware of the slow current annual engine replacement within the existing IWT fleet. An IWT greening policy focusing only on the new fleet is thus not enough and will not lead to achieving the goals put forward. EFIP therefore believes that some solid financial and non financial incentives have to be given to the IWT sector in view of promoting and allowing a quicker engine replacement. EFIP prefers in that respect an encouragement policy above a mandatory replacement of existing engines based on new emissions standards for existing engines.
- The European inland ports also believe that the whole IWT fleet should in principle be treated the same way and be subject to the same standards. No difference between barge size should be made. Special attention should be paid though to small barges (e.g. Freycinet type), if not there is a serious risk that these types of barges disappear completely.
- For EFIP, LNG can become an important alternative fuel for inland navigation. But in order to allow its proper introduction and use on the market, the remaining regulatory barriers as regards the use of LNG as fuel and as cargo has to be lifted. Moreover, also other alternative fuels must be considered in the near future: hydrogen, biofuels (3rd and 4th generation) and electricity (especially for small barges). EFIP refers in that respect to its position on the recently adopted Clean Fuel Strategy:

  http://www.inlandports.eu/images/stories/downloads/positions/clean_fuel_strategy_efipposition.pdf

- Finally, in order to succeed this IWT greening policy, EFIP believes sufficient financial support will be needed both in terms of support for innovation and for a sector that has to be convinced to participate.

The European Association of Internal
Combustion Engine Manufacturers

EUROMOT

Summary of Euromot comments on the Panteia report "Contribution to impact assessment of measures for reducing emissions of inland navigation" of February 28th 2013

Euromot has strong concerns regarding the evaluations and recommendations contained in the Panteia report. In summary, the principle concerns and observations are as follows:

1. Studies of this nature are usually conducted in order to compare the benefit/cost ratio and impact to the various economic operators of different levels of ambition for emission reduction. Instead, for this study, the level of ambition was fixed in advance and the option with the highest benefit/investment ratio was consequently excluded from the final analysis.
2. There is a lack of clarity of the basic assumptions used in calculating the evolution of external costs presented in the report, in particular the assumed loading factor of the vessels versus the trucks. A side-by-side evaluation conducted by Euromot would suggest that a fully loaded vessel should compare favourably with a fully loaded truck, using the option with the highest benefit/investment ratio, namely the so-called 'stage 3B alternative baseline' option.
3. A key benefit of using inland waterway shipping in comparison to trucks has always been the quantity of goods that can be moved per unit of fuel consumed and unit of CO_2 produced. Euromot believe that this benefit (low climate change external cost) should be included in the analysis of the evolution of the external costs for the various options.
4. The above would imply that evaluation of measures to increase the loading factor of inland waterway vessels, and inclusion of the external costs of the CO_2 emissions would substantially mitigate the need for the expensive and highly ambitious engine emission reductions proposed in the Panteia report.
5. Whilst Euromot supports the evolution of 97/68/EC to enable the type approval of gaseous-fuelled (LNG) engines it does not support the proposed methane (CH_4) limit of 0.5 g/kWh. Euromot does not believe this is achievable with the technology currently envisaged for LNG-fuelled marine engines.
6. Euromot strongly advocates that the type approval of the complete engine (inclusive of after-treatment system) should remain under the auspices of 97/68/EC and that new engines that comply with this legal act should not require retrofit of additional emission reduction devices prior to placing into service in a vessel.

The rationale for above comments is detailed in the full version of this summary, available from Euromot.

President:
Georg Diderich

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Dr Peter Scherm

ENGINE IN SOCIETY

A European Interest Representative (EU Transparency Register Id. No. 6284937371-73)

A Non Governmental Organisation in observer status with the UN Economic Commission for Europe (UNECE) and the International Maritime Organisation (IMO)

INE
INLAND
NAVIGATION
EUROPE

STATEMENT
EC commissioned study on measures for reducing emissions of inland navigation
March 2013

1. Goal setting

INE supports an ambitious goal setting for greening the fleet

- By 2020 for new engines, by 2027 for existing engines
- Road equivalent air emission performance
- Applying to new and existing engines

INE believes this ambitious goal setting is both:

- **Necessary:** the IWT fleet starts to lag behind with regard to air pollutants in comparison to road and rail transport. Being more harmful to health than its land competitors will affect its competitiveness and relevance for modal shift in spite of its major capacity potential to absorb traffic growth contrary to the other land modes. The largest part of the IWT fleet operates in densely populated areas where air pollutant concentrations, to which the IWT fleet contributes , are still above the legal and recommended limits in EU legislation. This EU legislation will be strengthened.
- **Feasible:** the current annual average engine replacement pace within the IWT fleet is estimated at 10%. Today, it is estimated that 40% to 50% of the engines are written off. The technical solutions to achieve the ambitious goal are available and will further improve by 2020. A clear regulatory framework will provide fuel companies and equipment manufacturers with a reliable climate to produce and install commercially cost-effective and generic solutions and applications. The investment costs are an important factor for the shipowners in crisis times, but, depending on alternative fuel developments, these costs should also be considered in the perspective of increasing gasoil price. Finally, considering the enormous societal benefits of an ambitious goal setting, it makes perfect sense public authorities and customers play an active and supporting role to ensure a successful transition.

INE proposes to reach this goal in one single stage. It is highly unlikely because economically unrealistic and unfair to expect that barge owners will invest twice in a short period of time when an engine has a 20 years life cycle. 2020-2027 provides a longer transition period than 2016 and a common goal provides a level playing field for the entire fleet.
The IWT fleet will take a stable step forward with regard to its environmental performance and increase its competitiveness.

2. Technical feasibility

Today the most effective emission reduction solutions are:

- After treatment equipment (SCR + DPF)
- LNG

With regard to after treatment equipment, the commonly cited concerns about counter pressure, temperature and room do not prevent a large scale implementation given a transition period of 7 years:
These current solutions have been developed in absence of a market and regulation. Once a regulatory framework is in place, legal certainty enables market creation for optimizing existing solutions and elaboration of new products.

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The current annual average engine replacement pace within the IWT fleet is estimated at 10% based on market surveys (mix of engine subsidy programme results, end of transition period, increased navigation hours influencing lifetime of the engine)
At the current renewal pace, there are no practical limitations on the supply side of technical systems with regard to LNG and after treatment equipment. Engine manufacturers have shown in the past the capacity to produce adequate integrated sets themselves or in cooperation with relevant manufacturers once the regulation is in place.

The current annual installation rate of after treatment equipment and LNG installations is marginal, given the lack of regulation and competitive advantage. At present, the additional upfront investment costs cannot be offset in a higher transport user price, as the investment results in a competitive disadvantage vis-à-vis shipowners offering a lower market transport price without investment. Where shippers show an increasing interest in low-carbon solutions (energy cost reduction), air pollutants are today in the first place a public health concern. Combined solutions at the same time reducing pollutants and energy use or energy price could therefore provide a stronger incentive.

The 2013-2020 horizon provides a sufficient period for significant developments on the condition there is a regulatory framework in place which provides a reliable investment climate for market creation.:

- New fuels: maturing market for LNG and expected new solutions such as GTL (gas-to-liquids which can be sourced from renewable and non-renewable sources: FT and DME with close to diesel characteristics , low carbon emissions, no PM, no sulphur and 90% less NOx)
- New technology developments: maturing market for after treatment equipment

For small vessels new diesel stage V engines, CNG, batteries may become a solution.
Other new developments could pop up in this period.
There are no robust signals from the supply side that low pollutant emission solutions cannot be provided. There are only signals that framework conditions in terms of technical standards, subregulation, alternative refueling infrastructure, permission to carry and bunker alternative fuels should be timely in place to ensure correct and safe introduction in the market.

3. Economic feasibility

Prices are expected to significantly fall when the entire fleet will adapt to the new emission threshold due to economies of scale and due to market creation and innovation by regulation resulting in increased efficiency and standard emission control modules.
In addition, the investment should also be considered in the perspective of increasing gasoil prices (60% in 2008-2012).
LNG use for larger newbuilt vessels and even existing ones becomes attractive since LNG is substantially cheaper than conventional EN590 diesel.

For the ship categories ≥ 110m, the study ordered by DG MOVE shows that, even with the current state of the technology and without taking into account further innovative developments, Stage V (0.4 g/kWh NOx and 0.01 g/kWh PM) can be reached with a positive net present value. The upfront investment costs may still be significant but could be cushioned with easier access to capital. This segment causes 81% of the negative IWT externalities, while only representing nearly 20% of the number of vessels. The upfront investment costs may still be significant but could be cushioned with easier access to capital.

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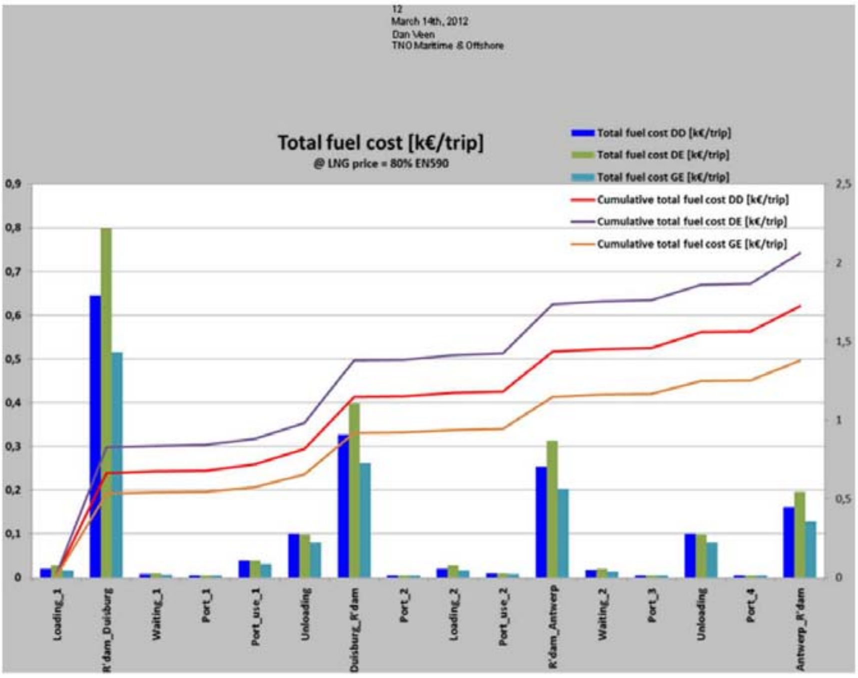
In the ship categories ≥ 110m, INE advocates:

- 2020 for introducing mandatory stage V emission thresholds for new engines
- 2027 as implementation limit for stage V emission thresholds for existing engines

combined with appropriate mechanisms for access to capital.



Source: TNO 2012
DD = Diesel direct, DE = Diesel electric, GE = Duel fuel LNG

For the ship categories < 110m, investment is expensive related to the size of the businesses at the current state of technology. Given the long lifetime of equipment, it would be however a strange signal to recommend investment by 2020 in suboptimal technology outdated in a couple of years. As green and clean increasingly becomes a license to drive, it would push the small and middle sized fleet off the cliff of competitiveness with Euro6 trucks coming on the market. The relative quick engine overhauls in the truck market compared to small and middle sized vessels operating less hours than larger vessels may very well result in reverse modal shift, if performance would be below IVB thresholds (1.2g/kWh NOx and 0.02 g/kWh PM).

The study ordered by DG MOVE shows that the benefit/cost ratio may be lower for small vessels, but is nevertheless positive.

In the ship categories < 110m, INE advocates:

- 2020 for introducing mandatory stage IVB emission thresholds for new engines

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- 2027 as implementation limit for stage IVB emission thresholds for existing engines combined with an appropriate funding package in line with the societal benefits.

4. Implementation feasibility

INE advances 2020 as a realistic transition period for new engines and 2027 for existing engines. 2013-2020-2027 is a long period. At present, there is no reason the economic crisis will take us beyond 2020. With an unambiguous goal setting and a clear regulatory framework in the pipeline this provides ample room:

- for series of existing and new solutions to enter the commercialisation phase and reach reasonable market prices
- for the adaptation of the entire fleet by 2027
- for the development of all relevant regulatory subsets and standards with regard to infrastructure, equipment, carriage and bunkering of alternative fuels etc. which the EC and Member States should prioritise on the agenda to ensure a positive reliable investment climate and a smooth implementation. It is positive to see work is underway for the infrastructure with the draft directive on clean fuel infrastructure. INE however proposes that 'Member States shall ensure that publicly accessible LNG refuelling points for inland waterway transport are provided in all inland ports of the TEN-T Core Network, by 31 December 2020 at the latest' to optimally support the implementation of the future NRMM legislation, while ensuring maximum flexibility for the provision of "refueling points for LNG" in inland ports as long distances can be covered with full tanks.

Two convincing elements underline the logic of a high ambition scenario:

- Industry will maintain its ecoperformance in land transport, strengthening its competitiveness to deliver low-carbon and congestion-free transport solutions to its clients with an improved health image.
- Society will see a strong reduction in PM and NOx concentrations benefiting the quality of life in Europe.

Given the very positive cost/benefit ratios, INE attaches priority to a quick elaboration of an adequate package to address easier access to capital and financial support at EU, national or regional level for infrastructure and vehicles ("early adapters") to support and accelerate the current adaptation process before the entry in force.

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Inland Navigation Europe (INE) is the European platform of national & regional waterway managers and promotion bureaux, established in 2000 with the support of the European Commission. INE sees major opportunities to contribute to long-term strategies for sustainable transportation by moving more goods by water in EU regions and cities with accessible and navigable rivers and canals. INE is a neutral platform without commercial interests.

[1] Concentratiekaarten voor grootschalige luchtverontreiniging in Nederland.
Rapportage 2010
© Planbureau voor de Leefomgeving (PBL)
Den Haag/Bilthoven, 2010

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AECC Comments on the Report "Contribution to Impact Assessment of Measures for reducing Emissions of Inland Navigation"

AECC* welcomes the conclusions of the report submitted in March 2013 by Panteia to the European Commission's DG Transport "Contribution to Impact Assessment of Measures for reducing Emissions of Inland Navigation", especially in the context of the revision of the Non-Road Mobile Machinery Directive 97/68/EC.

AECC supports the EU initiative on greening inland waterway transport in improving the sector's emissions towards the low emissions levels achieved by the on-road EU VI standard. AECC generally acknowledges the work done by Panteia and its consortium partners and supports the general thrust of their final report.

The on-going revision of the Thematic Strategy on Air Pollution by the European Commission's DG Environment has identified NRMM, which includes inland waterway vessels, as a key source of emissions to be tackled. In order to generate the improvement in ambient air quality required by EU legislation NOx emissions need further reduction to help resolve NO_2 limit breaches in most EU Member States, and PM emissions need to be further reduced as there is no safe threshold for short-term exposure to ultrafine particles according to the World Health Organization (WHO) REVIHAAP project.

In 2012, the WHO International Agency for Research on Cancer (IARC) classified Diesel engine exhaust emissions as carcinogenic to humans. This assessment was based on epidemiological studies in which the engines were not equipped with particulate and NOx aftertreatment systems. Studies show that a minimized number of ultrafine particles will benefit society in general and machinery operators in particular.

In addition, a reduction in Black Carbon emissions will produce a co-benefit for climate change as Black Carbon has a high global warming potential.

In general it is desirable that NRMM Stage IV requirements are extended to applications for which no Stage IV is currently defined (including inland waterway vessels). For the nearer term, the proposed emission Stage for new engines used in inland waterway vessels named "4B" in the Panteia report would come close to this, even though the NOx level of 1.2 g/kWh is still significantly higher than the existing NRMM Stage IV limit of 0.4 g/kWh.

For existing engines, the technical feasibility of retrofit has been demonstrated. In order to achieve emissions reduction as early as is needed, AECC supports the inclusion of emissions control requirements for the legacy fleet due to the long operating lifetime of inland waterway vessels and their engines. The emissions scenario for existing engines called "Stage 4A" in the Panteia report is in line with demonstrated, proven retrofit emissions control technology while economically viable as the consultant study outlines.

In addition, AECC further supports that the future NRMM standard Stage V as well as the standard for new engines used in inland waterway vessels is developed along the following lines (which would be equivalent to "Stage 5" in the Panteia report):

- Emissions control technologies are readily available to enable future NRMM requirements to align with on-road Euro VI emissions legislation. They are in use on Heavy-duty vehicles in the USA (since 2010), in Japan (since 2009) and in Europe.
- Emissions legislation compliance should be achieved in real-world operation.

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- A lower PM mass aligning with Heavy-duty Euro VI requirement should be defined.
- A single PM number limit should be defined for all NRMM engines above 19 kW. The Heavy-duty PMP (Particulate Measurement Program) protocols developed by UNECE can readily be used to measure PM mass and PM number emissions of non-road engines.
- The future Stage V legislation should cover all NRMM CI and SI engines including the smaller (<37 kW) and the larger ones (>560 kW) with the outlook of simplifying legislation by reducing the number of engine power bands and harmonizing their emissions requirements.
- Alternative fuel applications should promote climate-friendly technologies. In the case of LNG methane emissions with a much higher global warming potential than CO_2 should not be neglected. To ensure efficient solutions are deployed, a specific CH_4 limit could be defined for example.
- There should be fuel-neutrality (gaseous/liquid fuels) in terms of emissions limits.
- There should be identical emissions limits and introduction timing for constant speed and variable speed engines.
- The future Stage V should apply to all NRMM engines and machinery categories without exemption. Exemptions and derogations delay the benefit to the environment and prevent economies of scale. The increased flexibility allowance introduced for Stage IIIB engines have for example delayed the benefit of the tighter Stage IV emissions standard.
- Given the availability of technologies, introduction 3 years after publication in OJ should ensure sufficient lead time to the industry.

The latter comments on Stage V have also been shared with the DG Enterprise and Industry of the European Commission in the emissions control industry's answer to the NRMM public consultation which closed on 8 April 2013.

Should you need more information, you can contact AECC at info@aecc.eu or at +32 2 706 8160.

16/4/2013

**AECC is an international non-profit scientific association of European companies engaged in the development, production and testing of catalyst and filter based technologies for vehicle and engine emissions control. This includes the research, development, testing and manufacture of autocatalysts, ceramic and metallic substrates and speciality materials incorporated into the catalytic converter and filter and catalyst based technologies to control engine emissions. Members' technology is incorporated in the exhaust emission control systems on all new cars and an increasing number of commercial vehicles, buses, non-road mobile machinery and motorcycles in Europe.*
More information on AECC can be found at www.aecc.eu. Information on emissions control retrofit for existing heavy-duty vehicles and non-road machinery can also be found at www.dieselretrofit.eu.
AECC's members are: BASF Catalysts Germany GmbH, Germany; Corning GmbH, Germany; Emitec Gesellschaft für Emissionstechnologie mbH, Germany; Ibiden Europe B.V. Stuttgart Branch, Germany; Johnson Matthey PLC, United Kingdom; NGK Europe GmbH, Germany; Solvay, France; and Umicore AG & Co. KG, Germany.

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Annex 3 Shadow prices applied for external cost estimation

Air pollution

Shadow prices	*Air pollution*								
	PM2,5 (exhaust)			*PM10 (non-exhaust)*			*NOx*	*SO2*	*NMVOC*
€ 2000 value	*Metro politan*	*Urban*	*Outside built-up areas*	*Metro politan*	*Urban*	*Outside built-up areas*			
Austria	415,000	134,300	69,600	166,200	53,700	27,800	8,700	8,300	1,700
Belgium	422,200	136,200	91,100	169,900	54,500	36,500	5,200	11,000	2,500
Bulgaria	43,000	13,800	11,000	17,200	5,500	4,400	1,800	1,000	200
Czech Republic	252,600	81,400	62,700	101,000	32,600	25,100	7,300	8,000	1,000
France	392,200	126,300	78,400	156,900	50,500	31,400	7,700	8,000	1,400
Germany	384,500	124,000	75,000	153,800	49,600	30,000	9,600	11,000	1,700
Hungary	203,800	65,600	52,300	81,500	26,200	20,900	5,400	4,800	900
Netherlands	422,500	136,400	82,600	169,000	54,500	33,000	6,600	13,000	1,900
Poland	174,500	56,000	52,400	69,800	22,400	20,900	3,900	5,600	600
Romania	29,200	9,400	7,500	11,700	3,800	3,000	2,200	2,000	400
Slovakia	194,200	62,100	52,400	77,700	24,900	21,000	5,200	4,900	700

Source: Handbook on estimation of external costs in the transport sector. Internalisation Measures and Policies for All external Cost of Transport (IMPACT). Version 1.1. Delft, CE, 2008.

Climate change

The climate change costs have been estimated based on a study by Kuik et al. (2009)[1]. Through a meta-analysis of 62 studies, the study by Kuik et al. presents the avoidance costs of policies that aim at the long-term stabilisation of greenhouse gases in the atmosphere (in € 2005 value per tonne CO2).

There can be a large bandwidth in the external climate change (avoidance) costs. With regard to a long-term target of 450 ppm CO2 eq. (in order to keep global temperature rise below 2°C) the avoidance cost in 2025 is estimated to be €129 per tonne CO2 (bandwidth: €69-€241). For 2050 the central value is estimated to be €225 per tonne CO2 (bandwidth: €128-€396)[2].

Due to the uncertainties in forecasting long-term climate change cost (e.g. due to changes in oil prices and discount rates), the medium value has been selected for this study. It is generally assumed that climate cost increase over time.

Extrapolating the cost values of 2025 and 2050 from Kuik (2009) back to 2011 and adjusting it from price levels of 2005 to levels of 2011, results in a value of €86.60 per tonne of CO2 (price level 2011).

[1] Source: Marginal abatement costs of greenhouse gas emissions: A meta-analysis. O. Kuik, L. Brander, R.S.J. Tol, 2009. Energy Policy, vol. 37, Iss. 4 (2009); p. 1395-1403).

[2] Source: External Costs of Transport in Europe. Update Study for 2008. CE Delft (2011).

Annex 4 Engine power per vessel class

Engine power per vessel in kW

	Lower 20% percentile	Mean	Upper 80% percentile	average # of engines per vessel
<38.5*5.05m, 365t	74	128	177	1.04
38.5*5.05m, 365t	123	188	239	1.02
55*6.6m, 550t	201	273	331	1.06
70*7.2m, 860t	276	363	421	1.08
67*8.2m, 913t	353	445	536	1.08
85*8.2m, 1260t	430	547	637	1.04
85*9.5m, 1540t	588	736	880	1.11
105*9.5m, 2000t	735	902	1,047	1.16
110*11.4m, 2750t	915	1,180	1,325	1.15
135 * 11,4m 3500t	1,288	1,593	1,890	1.51
110*13.5m, 4050t	1,327	1,681	2,041	1.49
135*14.2m, 5600t	1,880	2,097	2,356	1.85
>135*14.2m, 5600t	1,346	2,192	2,650	1.85
PB 1000-2000 kW	1,074	1,337	1,567	1.88
PB >2000 kW	2,427	3,264	4,015	2.70

Engine power per vessel, per propulsion engine in kW

	Lower 20% percentile	Mean	Upper 80% percentile
<38.5*5.05m, 365t	74	123	173
38.5*5.05m, 365t	121	185	235
55*6.6m, 550t	178	259	326
70*7.2m, 860t	257	335	405
67*8.2m, 913t	309	413	500
85*8.2m, 1260t	401	525	634
85*9.5m, 1540t	485	663	848
105*9.5m, 2000t	576	777	956
110*11.4m, 2750t	809	1,029	1,254
135 * 11,4m 3500t	783	1,052	1,325
110*13.5m, 4050t	746	1,126	1,399
135*14.2m, 5600t	940	1,135	1,250
>135*14.2m, 5600t	968	1,185	1,325
PB 1000-2000 kW	544	710	798
PB >2000 kW	996	1,208	1,360

Annex 5 Description of measures aiming at behavioural change

Promote the deployment of econometers (under this option voluntary – will be compared with the obligatory deployment as per option 3) Category: Awareness of fuel efficiency	
Introduction:	Econometers can be used to monitor the use of fuel during sailing. Besides, based on some particular parameters, some of the econometers (e.g. the Advising Tempomaat) are able to suggest the skipper the most fuel efficient combination of track and speed of the vessel. More and more advanced types of econometers have been developed or are still under construction. There are for example econometers (like e.g. the Automatic Tempomaat, an extended version of the Advising Tempomaat), which are able to manage the speed of the vessel on its own. Some of the econometers are able to be combined with voyage planners. In the European (FP6) research project CREATING the use of an Advising Tempomaat was amongst the different applications, tested on a demonstration ship ('the Cleanest Ship'). Resulting from this demonstration, it was concluded that the use of such an application could give the ship owner a reduction of 10% on its fuel consumption (and thereby, 10% reduction of its GHG and air pollutant emissions)[1]. The actual reduction on fuel consumption depends highly on the present fuel efficient way of sailing of the skipper. Generally, the benefits of the use of econometers are expected to be higher for unexperienced skippers. Because of the benefits of the use of econometers and as a tool in 'smart steaming', the use of them was funded as part of the Dutch 'smart steaming' programme 'VoortVarend Besparen'.
Objective:	The objective is to create awareness among skippers, shipowners (but also barge operators and shippers) of the benefits of the use of econometers.
Stakeholders:	The primary stakeholders are: • Skippers (and other ship crew); • Shipowners. The secondary stakeholders are: • Barge operators; • Shippers.
Risks:	There are only limited risks on the promotion of the use of econometers. It is possible that a promotion campaign could fail and that the target groups do not become (sufficiently) aware of the benefits.
Acceptance:	It can be assumed that a promotion campaign will gain – at least, some – attention to the benefits of the use of econometers. In the final monitor of the 'Voortvarend Besparen' programme, it was concluded that among the interviewed skippers (mostly participants of the programme), they already used one or more tools for monitoring the fuel consumption of their ships.

[1] Test results are published on: http://www.informatie.binnenvaart.nl/milieu/293-onderzoeksresultaten-en-aanbevelingen-emissiereductie-binnenvaart.html

Promote the deployment of econometers (under this option voluntary – will be compared with the obligatory deployment as per option 3) Category: Awareness of fuel efficiency	
Introduction:	From this year on, the Port of Rotterdam have implemented a differentiation in the port dues for inland ships. The tariffs of the port dues are based on whether the ship engine(s) meet the standards of CCNR-2. Vessels which do not meet the standards of CCNR 2 have to pay 10% more port dues than vessels which meet the standard of CCNR 2. For ships meeting the standards of CCNR 2, vessels certified by the Green Award Foundation are granted a 15% discount on their port dues. If a vessel emits 60% less NOx and particulates than CCNR 2, it is even granted a 30% discount on its inland port dues. So, the shipowner of the 'cleanest' ship pays more than 36% less for his port dues than the owner of a ship with a CCNR 1 engine. The higher port dues for non CCNR 2 vessels are used to invest in an innovation fund for initiatives that contribute to the greening of the IWT.

Smart steaming awareness programme –information needs	
Introduction:	The program Smart Steaming has been started in 2007 by the Dutch minister of Infrastructure and Mobility. The main goal of the program is to create a reduction of CO2 emissions in the inland water transport by changing the behavioural aspects of sailing. Reducing the emissions of CO2 also has a positive effect on the costs for the small and medium sized enterprises involved by reducing the fuel consumption. From 2011 onwards the Expertise and Innovation Centre for inland Barging (EICB) took over the program from the Dutch government. The following program components are used: • The creation of a platform: the efficient sailing measures are communicated by a platform consisting of inland shipping companies and other relevant stakeholders. The platform has to promote the Smart Steaming program through sufficient media attention and the organisation of events. • Introducing training and education: bargemen learn how to sail energy efficient. • Creating technical assistance tools: development and subsidisation of tools for fuel monitoring. • A fuel savings competition among shipping companies. • A CO2 Benchmark tool where IWT companies can compare their CO2 production and fuel consumption. • Communication and promotional activities.
Objective:	The aim of the program in the period 2007 – 2010 was to achieve an overall fuel reduction in The Netherlands and a reduction in CO2 emissions by at least 5% between these two years. As of 2011 the program was transferred to the sector and management given to EICB (Expertise and Innovation Centre for Inland shipping). In 2012 a new goal was adopted, a fuel reduction of 20% per tonne kilometer in the period 2007-2020.
Stakeholders:	The EICB is managing the program of smart steaming for the IWT sector. The program is financed by the Rotterdam Port Authority and some private companies. The following parties are involved in the program:

	• (Inland navigation) skippers • (Inland) shipping companies • Port Authorities • (Inland navigation) public organisations
Risks:	Changing behavioural aspect of skippers is a continuous process. The current economic climate however with fierce competition and lack of profits already makes ship operators and skippers quite aware of the costs. The current economic climate therefore already gives strong autonomous arguments for fuel cost reduction by means of change of behaviour.
Acceptance:	In 2011 a monitoring study was made on the first years of the program of Smart Steaming, the following conclusions came out: The CO2 reduction ambition was met: over the period 2007-2010 a reduction of 6.7% was measured among a small group of inland waterway transport operators that took part in the Smart Steaming Programme. It is however questionable if this group would be representative for a larger population of operators. Moreover it is noted that during this period there was a significant change in the economic activity and also the fuel price changed significantly. The economic downturn that started for IWT from September 2008 onwards could also explains the reduction of fuel consumption. Moreover the specific contribution of the Smart Steaming program could not be made clear with reliable figures.

Annex 6 Description of technological solutions

Application of truck engines

Introduction:
Modifying a truck engine for use in the marine environment is known as 'marinisation'. The differences include changes made for the operating in a marine environment, safety, performance, and for regulatory requirements.
There are many differences between marine and truck engines (marinisation):

- The exhaust system
- Cooling system
- Electrical and fuel systems
- Internal engine parts, such as heads and cams.

Requirements:
Refitting an inland waterway vessel with a truck engine (EURO VI) is feasible but some measures may be taken depending on the engine room and the engine to be replaced:

- Replacing the engine support (for low speed engines)
- Requirement for sufficient space in the engine room due to after-treatment equipment
- Adding wiring system (electronic vs. mechanical engine)
- Adapting the air intake and outlet system
- Adapting the wheelhouse

The advantages:
The advantages of using marinised truck engines for inland vessels are:

- Benefit from the research and development of the automotive industry.
- Compact engines
- Lower investment
- Faster renew of the engine due to shorter lifetime

The consequences:
Modifying the cooling system of a truck engine is required for safety. The air cooling is replaced by water cooling system. The consequence of this modification is the change of combustion conditions of the engine. This will lead to different emission levels (of NOx and PM).

LNG as Fuel for inland vessels

Source: various interviews and presentations at LNG seminar Rotterdam January 2013 and http://www.wartsila.com.

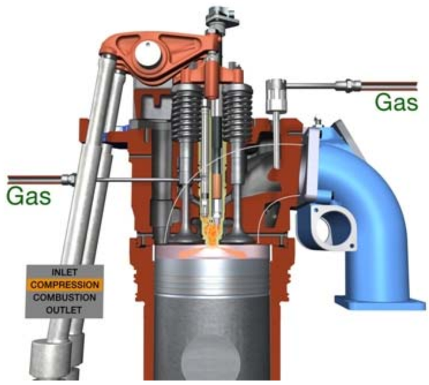
Using liquefied natural gas (LNG) as ship fuel has recently gained more attention not only in Europe, but also in Asia and the USA. The noticeable drivers which, taken together, which make LNG as ship fuel one of the most promising new technologies for shipping are:

- The lower carbon content of LNG compared to traditional ship fuels enables a 20% to 25% reduction of carbon dioxide (CO2) emissions and related reduction of impacts on global warming. Any slip of methane during bunkering or usage needs to be avoided to maintain this advantage.
- LNG is expected to be less costly than diesel.
- Using LNG as ship fuel will reduce emissions of NOx and PM.

LNG Engines:
Many manufactures are offering or developing LNG-fuelled engines. Gas engines which are currently available on the market can be divided into two main categories with varying characteristics and levels of efficiency:

- Pure Gas Concept:
  - Spark ignited Lean Burn Gas engine
- Dual Fuel Concepts:
  - Low pressure Dual Fuel (LPDF)
  - High Pressure Dual Fuel (HPDF)

Lean-burn gas engine (mono fuel).



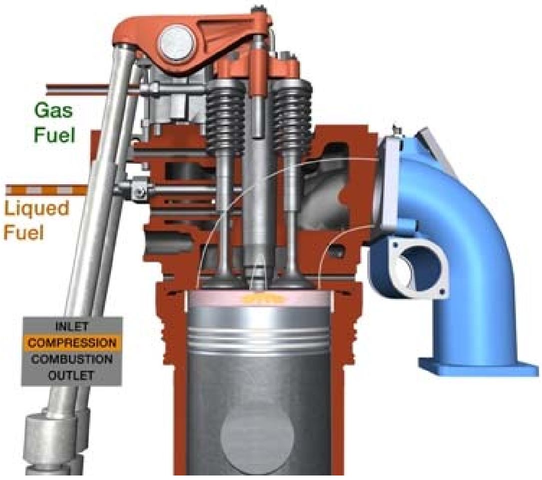
The lean burn mono fuel engine gives a simple installation onboard and is a more suitable solution for ships operating in regions with a developed grid of LNG bunkering stations. Lean Burn gas engine technology is based on the 'Otto Process': Spark ignited Lean Burn Gas engines. In this process, the gas is mixed with air before the inlet valves. During the intake period, gas is also fed into a small prechamber, where the gas mixture is rich compared to the gas in the cylinder. At the end of the compression phase the gas/air mixture in the prechamber is ignited by a spark plug. The flames from the nozzle of the prechamber ignite the gas/air mixture in the whole cylinder. After the working phase the cylinder is emptied of exhaust and the process starts again.

These engines have lower peak temperatures, which in turn results in less NOx formation from the combustion. There is a low pressure gas supply (4-5 bar). The energy efficiency at high load is higher compared to the diesel counterpart. However there is an increased risk on methane slip, however this can be minimised by design and combustion process control. LNG monofuel application is however not suitable for conversion of existing diesel engines.

Dual fuel engines:

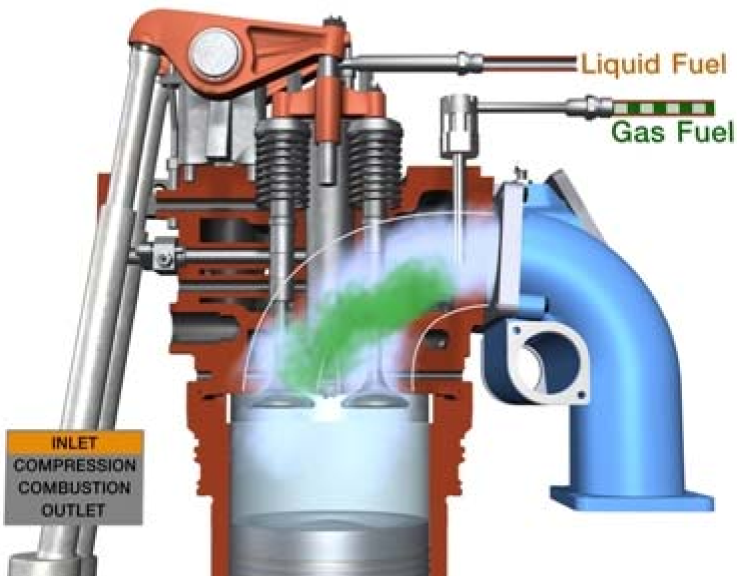
The dual fuel engine runs on both LNG and conventional fuel. It is a flexible solution when the availability of LNG fuel is uncertain (e.g. lack of LNG bunkering stations). Dual fuel engines offer all the benefits of a gas engine, whilst maintaining the ability to be operated as a conventional diesel engine when required. This provides maximum fuel flexibility and navigation safety without operational limitations. Furthermore, the capacity of the gas storage system can be designed to have the optimal balance between the space required for gas storage and the space deployment for vessel mission specific needs.

It is possible to convert existing diesel engines into dual fuel engines. There can be a difference between the applied gas pressure. A dual fuel high pressure (300-350 bar) gas injection engine maintains the diesel engine performance. The engine then utilises the diesel combustion process in all operational modes.



In gas mode, the gas is injected at high pressure after the pilot fuel and is ignited by the flame from the pilot fuel injection. The gas-diesel engine can be switched over instantly to liquid fuel mode operation. In this case, the process is the same as the conventional diesel process. The high pressure dual fuel engine gives much less issues with methane slip. However the NOx reduction is limited due to higher combustion temperatures. It would therefore require for example SCR technologies to bring down the NOx levels to the required emission standards (e.g. Stage 4B or Stage 5).

Also Dual Fuel engines are made on the basis of the Otto cycle with low gas pressure supply (4-5 bar). This type of dual-fuel engine utilies a 'lean-burn' otto combustion process when operating on gas. Here, the gas is mixed with air before the intake valves during the air intake period. After the compression phase, the gas/air mixture is ignited by a small amount of liquid pilot fuel (LFO). After the working phase the exhaust gas valves open and the cylinder is emptied of exhaust gases. The inlet air valves open when the exhaust gas valves close, and the process starts again.



A low gas pressure supply (4-5 bar) provides high energy efficiency at high load and low emissions but results in a challenge to control the methane slip, in particular at low load of the engine. The low pressure dual fuel engine is also more sensitive to the gas quality (methane number).

One of the main challenges is that a lot of room is required onboard for LNG tanks and this contributes to a loss of cargo space. For example, LNG requires about 1.8 times more volume than diesel with an equal energy content. For new-buildings it is quite simple to find space for the larger fuel tanks, while this may be much more difficult to find it on ships which are already in operation.

Hybrid Propulsion for Inland Vessels

Introduction:
A diesel-electric transmission system includes a diesel engine connected to an electrical generator, creating electricity that powers electric traction motors.
The propulsion installation on a conventional inland waterway vessel is dimensioned for the worst conditions, which are encountered only about 10% of the time: sailing fully loaded, against wind and/or current. The result would be two main engines of about 1,120 kW. Under average and light-loaded conditions, these engines are running significantly underloaded, which results in poorer efficiency and increased fouling. Typically, a genset would be running continuously as well for onboard electrical power. Thus three diesel engines (two large ones and a small one) will make a lot of running hours, often at low loads. Additional diesel engines are often installed for the cargo pumps and/or the bowthruster.

In a diesel-electric propulsion system, the diesel engines are normally medium to high-speed engines, with lower weight and costs than similar rated low speed engines that are used for direct mechanical propulsion. In a diesel electric system with several diesel engines it is hence an aim to keep the diesel engines loaded at their optimum operating conditions by starting and stopping generator sets dependent on the load, with an aim to keep the average loading of each running diesel engine closest possible to its optimum load point. The efficiency drops fast as the load becomes lower than 50% of MCR (Max Continuous Rating). At this working condition, the combustion is inefficient, with high NOx content, and with a high degree of soothing which increases the need for maintenance

The advantages:
- Lower fuel consumption and emissions due to the possibility to optimise the loading of diesel engines.
- High reliability, due to multiple engine redundancy.
- Reduced life cycle cost, resulting form lower operational and maintenance costs.
- Improved manoeuvrability and station-keeping ability, by deploying special propulsors such as azimuth thrusters or pods.
- Increased payload, as diesel-electric propulsion plants take less space.
- More flexibility in location of diesel engine and propulsors. The propulsors are supplied with electric power through cables.
- Low propulsion noise and reduced vibrations.
- Efficient performance and high motor torques, as the system can provide maximum torque also at slow speeds.

These advantages should be weighted up against:

- Increased investment costs. However, this is continuously subject for revisions, as the cost tends to decrease with increasing number of units manufactured.
- Additional components (electrical equipment – generators, transformers, drives and motors/machines) between prime mover and propeller increase the transmission losses at full load.
- For newcomers a higher number and new type of equipment requires different operation, manning, and maintenance strategy.

Hydrogen fuel enhancement for inland vessels

Introduction:
Hydrogen has been used extensively in the space program since it has the best energy-to-weight ratio of any fuel. Liquid hydrogen is the fuel of choice for rocket engines.
In recent years, the concern for cleaner air, along with stricter air pollution regulation and the desire to reduce the dependency on fossil fuels have rekindled the interest in hydrogen as fuel for other engines. One of the new developments is 'Hydrogen fuel enhancement' technique.

Hydrogen fuel enhancement is the process of using a mixture of hydrogen and conventional hydrocarbon fuel in a combustion engine to improve fuel economy, power output and emission reduction. The hydrogen is produced through an electrolysis system on board the vessel. This technique is different from hydrogen fuel cells (which use hydrogen with oxygen rather than hydrogen with air).

The advantages:
Hydrogen has a wide flammability range in comparison with all other fuels. As a result, hydrogen can be combusted in a combustion engine over a wide range of fuel-air mixtures. A significant advantage of this is that hydrogen can run on a lean mixture. (A lean mixture is one in which the amount of fuel is less than the theoretical, stoichiometric or chemically ideal amount needed for combustion with a given amount of air.)

Generally, fuel economy is greater and the combustion reaction is more complete when a vehicle is run on a lean mixture. Additionally, the final combustion temperature is generally lower, reducing the amount of pollutants, such as NOx en PM. There is a limit to how lean the engine can be run, as lean operation can significantly reduce the power output due to a reduction in the volumetric heating value of the air/fuel mixture.

Further development is needed:
Hydrogen has a small quenching distance, smaller than other fuels. Consequently, hydrogen flames travel closer to the cylinder wall than other fuels before they extinguish. Thus, it is more difficult to quench a hydrogen flame. The smaller quenching distance can also increase the tendency for backfire since the flame from a hydrogen-air mixture more readily passes a nearly closed intake valve, than a hydrocarbon-air flame.

Hydrogen has a relatively high auto ignition temperature. This has important implications when a hydrogen-air mixture is compressed. In fact, the auto ignition temperature is an important factor in determining what compression ratio an engine can use, since the temperature rise during compression is related to the compression ratio.

Methanol as fuel

Introduction:
Methanol is typically made from natural gas; though it is possible to produce it by fermenting biomass (this is why it is sometimes called 'wood alcohol'), this is not economically competitive yet. Because it is easier to transport natural gas to a distant market by converting it to methanol, which is a liquid at ordinary temperatures and pressures, than by chilling and liquefying it or by building a long pipeline, some countries are looking at exporting their natural gas by converting it to methanol.

The advantages:
Methanol is similar to ethanol as it is a potent fuel with an octane rating of 100 that allows for higher compression and greater efficiency than gasoline.

The disadvantages:
Methanol is extremely corrosive, and requires special materials for storage and delivery. The lower energy content and the higher cost ratio in building methanol refineries compared to ethanol distilleries have relegated methanol to the back seat. Moreover, producing methanol from natural gas results in a net increase of CO2, hastening global warming.

Better solution than LNG?
- Same emission profile as LNG and price level according to Stena Line
- Can be produced out of LNG
- Infrastructure and safety similar to Ethanol
- Liquid – no pressure tanks
- Suitable for Otto-motors or dual fuel
- Trade commodity (45 million tonne/year, China large producer)
- Stena line made real life experiments in marine environment

However:
- Toxic, poisoning - inhalation and contact with skin to be avoided
- Formaldehyde in exhaust gas
- Double volume vs. Diesel
- Fire and explosion – highly flammable (flash point 12.2 °C)
- Low flashpoint (not allowed in IWT)
- No Rules or Regulations specifically for use of methanol as a fuel onboard ships
- Tank on deck is required, resulting in possible problems to find a suitable location for the tank, in particular for dry bulk cargo vessels

Gas-to-liquid

Introduction:
Gas to liquids (GTL) is a refinery process to convert natural gas or other gaseous hydrocarbons into longer-chain hydrocarbons such as gasoline or diesel fuel. Methane-rich gases are converted into liquid synthetic fuels either via direct conversion or via syngas as an intermediate, for example using the Fischer Tropsch or Mobil processes.

The advantages:
A major environmental benefit of GTL fuel is that it is virtually sulfur-free, and has significantly lower emissions of carbon monoxide, hydrocarbons, nitrogen oxide and particulate matter then conventional petroleum products.
Besides this GTL can use the same infrastructure and engines as diesel.

The disadvantages:
GTL fuel lifecycle greenhouse gas emissions are approximately 25 percent higher than conventional oil, because 45 percent of the natural gas input is used in the conversion process from gas to liquid.

Outlook:
In general, converting natural gas to liquid petroleum products is becoming more competitive with conventional oil production as the conversion process improves and the benefits of clean synthetic diesel are priced into markets. But competition between liquefying natural gas for the power and industrial sectors, and converting it to a petroleum product for the transport sector will remain a key investment decision.

Fuel-water emulsion

The application of fuel-water-emulsion technology is an option to reduce emission levels, tackling both PM and NOx emission. It is one opportunity for the addition of water to the combustion process. The effect of water addition to diesel engines is known for a long time already. Among technologies with water addition, fuel-water-emulsion (FWE) can be regarded as the most promising for inland waterway transport. A FWE application for inland waterway transport is supplied by German manufacturer Exomission.1 It is an 'Ad-On-System' added to the engine for the emulsification, independent of the engine itself. Water and fuel are emulsified before injection into the engine. Without the emulsification water and fuel would not get mixed. As result, a homogeneous emulsion arises and is injected into the engine. The emulsion consists of oil droplets with a water nucleus. At beginning of the combustion process the water nucleus is transformed to steam explosively. This 'microexplosion' ruptures each fuel oil droplet and the droplet is reduced to numerous smaller fuel oil droplets. These smaller fuel oil droplets ignite and burn easier than the bigger droplets. PM and soot creation zones are reduced, the thermal effectiveness improves and fuel consumption decreases.

[1] This description of fuel-water-emulsion technology predominantly refers to the technology supplied by Exomission and is based only on information provided by the company Exomission (http://www.exomission.de/).

As another positive impact, FWE leads to a cooling down effect of the combustion chamber temperature. This will happen through the heating and evaporation of the water. The heat for heating and evaporation of the water is no longer available for heating up the combustion process and the temperature will be not so high. This will result in a reduction of NOx emission.

The dissociation of water at high temperatures further improves the combustion process.

The technology can be applied to all vessels, irrespective of engine type and injection system. It is adjusted to particular vessel conditions and no retrofit of the engine itself is required. Only a small room is needed on board for installation. The fresh water can usually be sourced from the conventional water tank onboard vessels. To avoid 'emery impacts' between rotor and cylinder, desalinated and demineralised water should be used. Therefore, equipment for water treatment has to be installed and requires some room. For instance, cartridge desalination equipment or reverse osmosis systems are used by supplier Exomission. Separate circuits for fuel and water avoid a mixture of fluids in tanks. Freezing of water tanks and other equipment does usually not occur. However, in extreme weather situation bio-ethanol can be added to avoid freezing.

The quality of the emulsion is important for the effectiveness of FWE. Highly efficient is an 'On-Board' / 'On-Demand' emulsion. An electronic control may adjust the water share of the emulsion automatically to the engine load. The use of emulsifiers for the stabilisation of the emulsion, which have some disadvantages, is not necessary. No addition of emulsifiers and a continuous adjustment of water share according to engine load have a positive impact on engine condition and effectiveness. The emulsification of water and fuel can be realised by shear forces as applied by Exomission, stator-rotor-principle and ultrasound. A completely mechanical procedure without moveable or rotating components reduces wear to a minimum. As smaller the resulting droplets are, the lower are PM and soot emission. Moreover, direct water contact with metallic equipment can be avoided. Flushing of engine before stop is required to remove the water from the engine and avoid corrosion. Before engine stop, the skipper switches off the emulsification manually and flushing is started automatically.

Different tests, e.g. at test bed of German inspection authority 'TÜV Nord', show the positive impact of FWE on emission. The application of FWE on a EURO III engine reduces PM emission by approximately 80% and NOx emission by approximately 25%. To achieve more ambitious emission standards, FWE can be combined with an SCR system to further reduce NOx emission. Compared to other SCR applications, the urea consumption is less due to the NOx mitigation resulting from the FWE. In general, the temperature of the combustion chamber is regarded as sufficient for the application of SCR systems. Only during operation of engines at very low loads SCR might not work properly. However, under these conditions the emissions are very low anyway. Moreover, lower exhaust gas temperature might improve effectiveness and durability of SCR systems. The installation of additional partial flow filters could further reduce PM emission. FWE reduces fuel consumption by approximately 2%. In combination with low water treatment and maintenance cost, overall operational cost in inland navigation can be reduced by FWE. Due to the low urea consumption, application of FWE in combination with SCR can be nearly cost-neutral in terms of operational cost.

Cost for FWE applications are estimated with 135 €/kW for smaller engines and 100 €/kW for larger engines (>1.000 kW). If instead of 'marinised' components standard components without extensive classification cost can be used, the estimated cost is expected to be up to 40% lower. Moreover, significant cost reductions of another up to 40% are expected, if series are produced and scale effects can be realised. The installation is expected to take 1 to 10 days. Part of installation work can be done during operation, but up to 3 lay days are required.

Among some stakeholders concerns exist regarding the application of FWE. They state that engine corrosion cannot be ruled out, extensive maintenance would be required and defects of fuel injection systems are possible. However, as there are no clear references to negative experiences with FWE applications, these concerns might result from experience with other water adding technologies. Moreover, according to a study by Lloyd's Register Technical Association (2005-2006) there is no evidence that existing concerns regarding FWE are justified. FWE is regarded as promising technology by German officials. Beginning in 2013, this technology is considered in the German support programme for the installation of engines and technologies to reduce emission of inland navigation vessels.

Annex 7 Comparison between the test cycles for Euro VI and Stage IV

Introduction

An emission test cycle is a protocol contained in an emission standard to allow repeatable and comparable measurement of exhaust emissions for different engines or vehicles. Test cycles specify the specific conditions under which the engine or vehicle is operated during the emission test. Specified parameters in a test cycle include a range of operating temperature, speed, and load. Ideally these are specified so as to accurately and realistically represent the range of conditions under which the vehicle or engine will be operated in actual use.

In order to compare Euro VI engines (heavy duty road) with NRMM Stage IV-engines (NRMM, inland vessels), it is necessary to distinguish the test cycles of both types of engines. In this annex, the characteristics of the test cycles of Euro VI engines and with NRMM Stage IV-engines will be elaborated and compared. The EURO VI-engines are used for heavy-duty road vehicles and are tested for this use, while the Stage IV-engines used for marine application will be tested for use of marine application. While road vehicles are used under more different circumstances (urban areas, highway etc.), the road engines are tested with more different modes than engines used for marine application. For EURO VI-engines there are two different test cycles used. Both test cycles – the World Harmonized Stationary Cycle (WHSC) and the World Harmonized Transient Cycle (WHTC) – are used for diesel engines. For positive ignition engines only the WHTC is used.

Euro IV engines: World Harmonized Stationary Cycle

As mentioned before, this test cycle is only used for diesel engines (next to the WHTC is in use). Using this test cycle, for EURO VI the maximum allowed emissions are:

Stage	Date	Test	CO	HC	NOx	PM	PN	Smoke
			g/kWh				1/kWh	1/m
Euro VI	2013.01	WHSC	1.5	0.13	0.4	0.01	8.0×10^{11}	
a - PM = 0.13 g/kWh for engines < 0.75 dm3 swept volume per cylinder and a rated power speed > 3000 min-1								

Source: Dieselnet.com

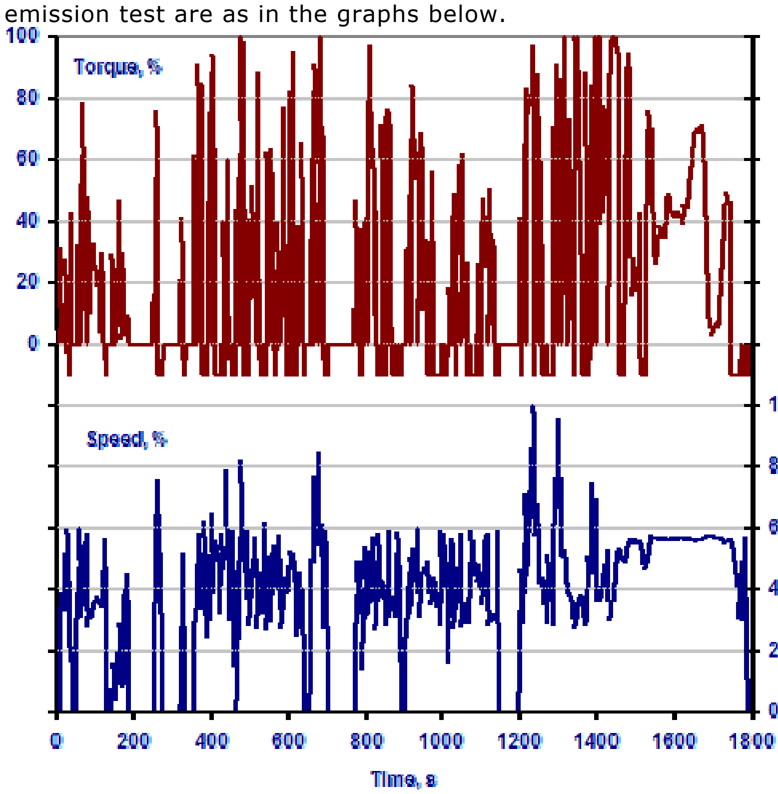
This test cycle is a steady-state cycle, the outcome of this test cycle is the sum of the different modes weighted by its specific factor, please see next table.

Mode	Speed (%)	Load (%)	Weighting Factor	Mode Length† (seconds)
0	Motoring	-	0.24	-
1	0	0	0.17/2	210
2	55	100	0.02	50
3	55	25	0.10	250
4	55	70	0.03	75
5	35	100	0.02	50
6	25	25	0.08	200
7	45	70	0.03	75
8	45	25	0.06	150
9	55	50	0.05	125
10	75	100	0.02	50
11	35	50	0.08	200
12	35	25	0.10	250
13	0	0	0.17/2	210
Sum			1	1895
† Including 20 s ramp				

Source: Dieselnet.com

Euro IV engines: World Harmonized Transient Cycle

WHTC is a test cycle used for all EURO VI-engines, combustion- as well as positive-ignition engines. The specific load conditions for the engine during the emission test are as in the graphs below.



Source: Dieselnet.com

Using this test cycle, for EURO VI the maximum allowed emissions (including a limit of CH4 (Methane)-emissions for gas engines) are:

Stage	Date	Test	CO	NMHC	CH4[a]	NOx	PMb	PNe
			g/kWh					1/kWh
Euro VI	2013.01	WHTC	4.0	0.16d	0.5	0.46	0.01	6.0×1011
a - for gas engines only (Euro III-V: NG only; Euro VI: NG + LPG)								
b - not applicable for gas fuelled engines at the Euro III-IV stages								
c - PM = 0.21 g/kWh for engines < 0.75 dm3 swept volume per cylinder and a rated power speed > 3000 min-1								
d - THC for diesel engines								
e - for diesel engines; PN limit for positive ignition engines TBD								

Source: Dieselnet.com

Non-road test-cycle

The ISO 8178 is an international standard designed for a number of non-road engine applications. It is used for emission certification and/or type approval in many countries worldwide, including the USA, European Union and Japan. Depending on the legislation, the cycle can be defined by reference to the ISO 8178 standard, or else by specifying a test cycle equivalent to ISO 8178 in the national legislation (as it is the case with the US EPA regulations).

The ISO 8178 is actually a collection of many steady-state test cycles (type C1, C2, D1, etc.) designed for different classes of engines and equipment. Each of these cycles represents a sequence of several steady-state modes with different weighting factors.

Weighting Factors of B-Type ISO 8178 Test Cycles					
Mode number	1	2	3	4	5
Torque, %	100	75	50	25	10
Speed	Rated speed				
Marine application					
Type E1	0.08	0.11	-	-	-
Type E2	0.20	0.50	0.15	0.15	-
Notes: Engine torque is expressed in percent of the maximum available torque at a given engine speed Rated speed is the speed at which the manufacturer specifies the rated engine power Intermediate speed is the speed corresponding to the peak engine torque.					

Source: Dieselnet.com

Annex 8 Emission standards for IMO Tier 3 and EPA Tier 4

Emission standards, US standards marine

US: EPA Tier 4 Standards for Marine Diesel Category 1/2 Engines

Power (P)	***NOx***	***HC***	***PM***	***Date***
kW	***g/kWh***	***g/kWh***	***g/kWh***	
P ≥ 3700	1.8	0.19	0.12a	2014c
	1.8	0.19	0.06	2016b,c
2000 ≤ P < 3700	1.8	0.19	0.04	2014c,d
1400 ≤ P < 2000	1.8	0.19	0.04	2016c
600 ≤ P < 1400	1.8	0.19	0.04	2017d

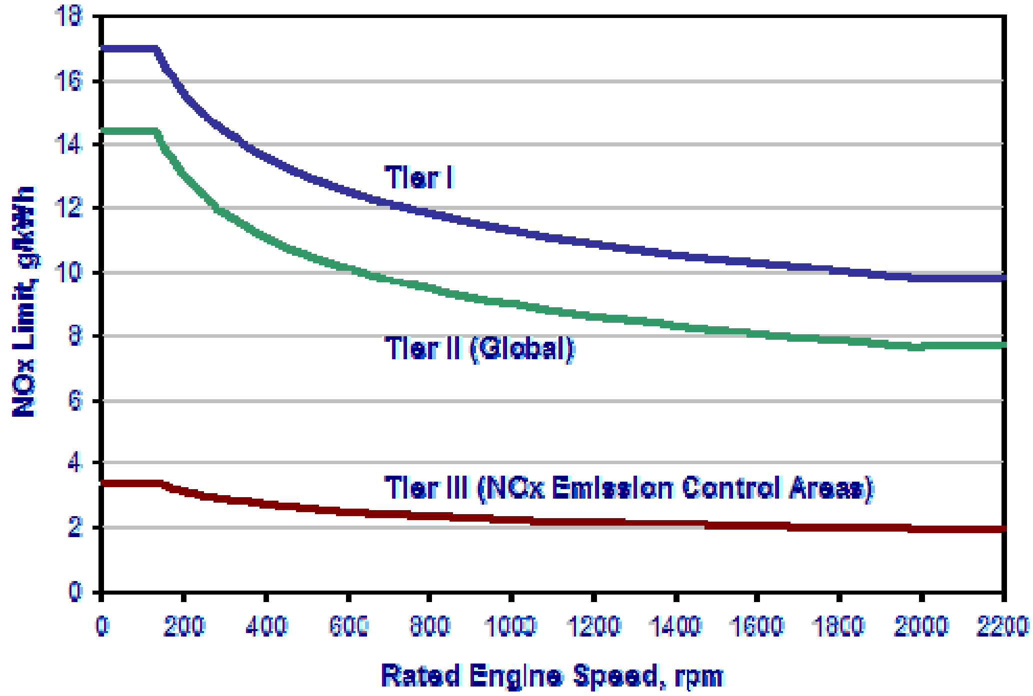
a - 0.25 g/kWh for engines with 15-30 dm3/cylinder displacement.
b - Optional compliance start dates can be used within these model years.
c - Option for Cat. 2: Tier 3 PM/NOx+HC at 0.14/7.8 g/kWh in 2012, and Tier 4 in 2015.
d - The Tier 3 PM standards continue to apply for these engines in model years 2014 and 2015 only.

Emission standards, IMO, MARPOL NOx limits

NOx emission limits are set for diesel engines depending on the engine maximum operating speed (n, rpm)

Tier	***Date***	***NOx Limit, g/kWh***		
		n < 130	***130 ≤ n < 2000***	***n ≥ 2000***
Tier I	2000	17.0	$45 \times n^{-0.2}$	9.8
Tier II	2011	14.4	$44 \times n^{-0.23}$	7.7
Tier III	2016*	3.4	$9 \times n^{-0.2}$	1.96

** In NOx Emission Control Areas (Tier II standards apply outside ECAs)*


18
16
14
12
10
8
6
4
2
0
NOx Limit, g/kWh
Tier I
Tier II (Global)
Tier III (NOx Emission Control Areas)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Rated Engine Speed, rpm

Annex 9 Environmental impacts of HC, CO, PN, CH4 emissions

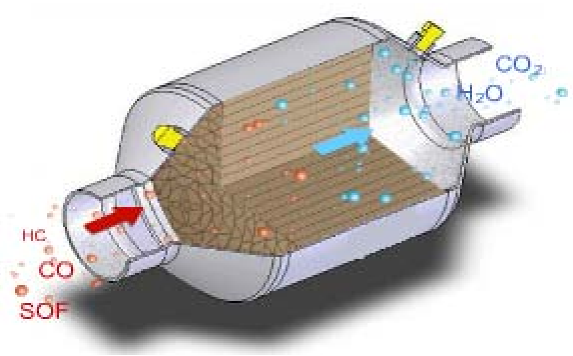
As mentioned in chapter 3, the environmental impacts of IWT concern in particular the climate change emission CO_2 and the air pollutants NO_x and PM. Nevertheless, the IWT sector also produces (to a lesser extent) other emissions:

- HC (hydrocarbons): HC are produced by (partially) incomplete combustion of hydrocarbon fuels (e.g. gasoline and diesel). HC include many toxic compounds that cause cancer and other adverse health effects. They also react with NOx in the lower atmosphere to form ground-level ozone, a major component of smog with nitrogen oxides in the presence of sunlight to form ozone.
- CO (carbon monoxide): colourless, odourless and poisonous gas produced by the incomplete burning of carbon fuels. CO reduces the flow of oxygen in the bloodstream and is particularly dangerous to persons with heart disease.
- PN (particle number): small diesel emission with the ability to diffuse deep within the lungs and be absorbed into the bloodstream.
- CH4 (methane): the main component of natural gas. This greenhouse gas emission emitted when using, for example LNG, has an impact on global warming.

The levels of these produced emissions depend on the type of fuel used (i.e. diesel or LNG) and the technologies chosen on a vessel. Some of the technologies presented in this study (e.g. DPF and SCR), especially in combination with other type of catalysts can strongly reduce the HC, CO, PN and CH4 emissions.

SCR in combination with Diesel Oxidation Catalysts (DOC)
Diesel Oxidation Catalysts (DOC) are effective for the control of carbon monoxide (CO), hydrocarbons (HC) and the soluble organic fraction (SOF) of particulate matter (PM10). DOC convert carbon monoxide (CO) and hydrocarbons (HC) to carbon dioxide (CO2) and water (see following figure). As a single technology, DOC can reduce CO between 70%-95%, HC between 70%-90% and PM10 emissions between 10%-40%[1]. DOC (as a stand-alone technology) has not been able to meet the European emission requirements, because this type of catalyst has little to no effect on nitrogen oxides (NOx)[2]. In this study, for the stages 4B and 5 the application of DOC is assumed in combination with SCR technology, including Ammonium Slip Catalyst (ASC).

[1] Less than 50 ppm sulphur in diesel fuel is required for PM 10 conversion (source: www.dcl-inc.com).
[2] Source: http://www.aecc.be/en/Technology/Catalysts.html



DPF
The DPF technology assumed in this study is based on (closed) wall flow filters and is therefore also effective in reducing Particle Number (PN) and includes a burner for active regeneration. These filters can reduce PN up to 99.7%[1].

LNG
As mentioned before, the use of LNG could increase the methane concentrations (CH4). The LNG technology assumed in this study for Dual Fuel includes an after-treatment methane slip catalyst in order to reduce CH4 emissions. These installations can decrease CH4 concentrations to zero.

Emission standards on HC, CO, PN and CH4

The following table presents the current emission standards for IWT (Stage IIIA) for the emissions CO, HC (in combination with NOx) and PM. The current legislation *does not have limitations for PN or CH4*.

Stage III A Standards for Inland Waterway Vessels

Category	***Displacement (dm3 per cylinder)***	***Date***	***CO***	***NOx + HC***	***PM***
			(g/kWh)		
V1:1	D ≤ 0.9, P > 37 kW	2007.01	5	7.5	0.4
V1:2	0.9 < D ≤ 1.2		5	7.2	0.3
V1:3	1.2 < D ≤ 2.5		5	7.2	0.2
V1:4	2.5 < D ≤ 5	2009.01	5	7.2	0.2
V2:1	5 < D ≤ 15		5	7.8	0.27
V2:2	15 < D ≤ 20, P ≤ 3300 kW		5	8.7	0.5
V2:3	15 < D ≤ 20, P > 3300 kW		5	9.8	0.5
V2:4	20 < D ≤ 25		5	9.8	0.5
V2:5	25 < D ≤ 30		5	11	0.5

Source: www.dieselnet.com

The following table present the EU emission standards for heavy-duty diesel engines using different testing methods. For the EURO VI regulation, a PN emission standard has been introduced.

[1] Source: JRC of Ispra - Joint Research Centre of the European Community

EU Emission Standards for Heavy-Duty Diesel Engines: Steady-State Testing

Stage	Date	Test	CO	HC	NOx	PM	PN	Smoke
			g/kWh				1/kWh	1/m
Euro I	1992, ≤ 85 kW	ECE R-49	4.5	1.1	8	0.612		
	1992, > 85 kW		4.5	1.1	8	0.36		
Euro II	1996.1		4	1.1	7	0.25		
	1998.1		4	1.1	7	0.15		
Euro III	1999.10 EEV only	ESC & ELR	1.5	0.25	2	0.02		0.15
	2000.1		2.1	0.66	5	0.10[a]		0.8
Euro IV	2005.1		1.5	0.46	3.5	0.02		0.5
Euro V	2008.1		1.5	0.46	2	0.02		0.5
Euro VI	2013.01	WHSC	1.5	0.13	0.4	0.01	8.0×10^{11}	
a - PM = 0.13 g/kWh for engines < 0.75 dm3 swept volume per cylinder and a rated power speed > 3000 min-1								

Source: www.dieselnet.com

EU Emission Standards for Heavy-Duty Diesel Engines: Transient Testing

Stage	Date	Test	CO	NMHC	CH4[a]	NOx	PM[b]	PN[e]
			g/kWh					1/kWh
Euro III	1999.10 EEV only	ETC	3	0.4	0.65	2	0.02	
	2000.1		5.45	0.78	1.6	5	0.16[c]	
Euro IV	2005.1		4	0.55	1.1	3.5	0.03	
Euro V	2008.1		4	0.55	1.1	2	0.03	
Euro VI	2013.01	WHTC	4	0.16[d]	0.5	0.46	0.01	6.0×10^{11}
a - for gas engines only (Euro III-V: NG only; Euro VI: NG + LPG) b - not applicable for gas fuelled engines at the Euro III-IV stages c - PM = 0.21 g/kWh for engines < 0.75 dm3 swept volume per cylinder and a rated power speed > 3.000 min-1 d - THC for diesel engines e - for diesel engines; PN limit for positive ignition engines TBD								

Source: www.dieselnet.com

The proposed NRMM Stage IIIB values[1] are presented in the following table. The proposed NRMM Stage IIIB/IV values *does not include PN or CH4 limitations*.

The proposal for engines >600 kW is a based on US Tier 4. These engines are expected to use SCR with an upstream DOC. These engines are currently in development and the full development cost will be borne by the much larger US market. These engines will only be suitable for ultra low sulphur diesel.
For engines <600 kW, the US Tier 4 does not apply and does not have after-treatment forcing standards. It is proposed to use IMO Tier 3 engines with SCR and without DOC. Therefore a NOx level that approximates the IMO requirement

[1] The proposed NRMM Stage IIIB limits for vessel with engines between 600 to 3700 kW assume the use of SCR technology (excluding DOC).

for this type of engine with the US Tier 3 HC level has been proposed.

Diesel engine 'Stage 3B' aligned with IMO Tier 3 and EPA Tier 4

Cat.	Displacement (L/cyl)	Net Power kW	CO (g/kWh)	NOx + HC	NOx	HC	PM
W1	disp. <0.9	19 ≤ P < 37	5.5	4.7			0.3*
W2	disp. <0.9	37 ≤ P < 75	5.0	4.7			0.3*
W3	disp. <0.9	75 ≤ P < 130	5.0	5.4			0.14
W4	0.9 ≤ disp. < 1.2	19 ≤ P < 130	3.5	5.4			0.12
W5	1.2 ≤ disp.	19 ≤ P < 130	3.5	5.6			0.11
W6		130 ≤ P < 600	3.5		2.1	1.0	0.11
W7		600 ≤ P < 1.400	3.5		1.8	0.19	0.045
W8		1.400 ≤ P < 3.700	3.5		1.8	0.19	0.045
W9		3.700 ≤ P			IMO T 3		

* Alternatively these categories may be certified to a NOx + HC level of 5.8 g/kWh and a PM level of 0.2 g/kWh.

Annex 10 Business economic impacts of policy options

Introduction

This Annex presents the business economic characteristics of different technologies and emission limit stages for the various vessel/engine categories. First attention is paid to the initial investment cost. Secondly the impact on the shipowner/operator is presented by means of the cumulative discounted cash flow development for a period of 20 years after the investments made for compliance with emission standards. Based on these graphs the technology with the lowest compliance cost becomes clear and this understanding of the overall impact for the shipowner/operator decisive for the assumption on the share of LNG based technologies in the future. Subsequently the share of LNG is determining the required investments to be done by the IWT sector and the overall compliance costs and these can be compared with the savings of external costs and the net present value for society.

In the estimations of the costs, characteristics and the performance of technologies to comply with emission standards it is expected that there will be a significant evolution as cost of equipment will reduce. By the time of equipment for inland waterway transport with emissions control technology for new engines and retrofit the market will benefit from more industrial companies and pre-configured emission control systems, utilising system components produced in larger volumes, e.g. for heavy duty trucks (Euro VI) and Non-road Mobile Machinery. This will be the case for engines up to 560 kW, and in many cases such components can be used for even larger systems, e.g. by dual-systems which would expand the power range to approximately 1000 - 1200 kW. Moreover it is expected that by 2017 such industrial-style emission control solutions will also be available for even larger engines (mining, locomotive, marine etc.) for example in the US and certain other areas, making such proven, cost-effective system components available for the larger engines applied in inland waterway transport as well. For application on new engines it is expected that installation of pre-configured, standardised system building blocks is feasible, and for a large number of retrofit of existing vessels as well.

Regarding LNG the IWT sector is expected to benefit from experience gained in the maritime sector and from favourable incentives and framework conditions established at EU level such as financial instruments to promote access to financing for the significant investments needed to upgrade the fleet, deployment of bunkering facilities as envisaged by the EU clean fuel strategy, and the development of the regulatory framework and standards regarding the application of LNG in IWT vessels. In view of these expected favourable conditions, a time-horizon of 20 years is used in order to determine the compliance cost for the industry consistent with the expected economic lifetime of the investments. The selection of the technology is based upon the technology with the lowest overall costs for the shipowner/operator over a time span of 20 years after the initial investment. In view of the expected increase in residual value of the LNG vessels over their entire lifetime given the long term operational savings perspective, this time-horizon is significantly expanded in comparison to other types of investments. Furthermore, the strong signal given by the European Commission through the recently adopted clean fuel strategy in favour for the deployment of LNG is expected to trigger in Member States at various levels policies that will have lasting favourable conditions for LNG uptake. This resulted in the conclusion that the majority of larger vessels will start using LNG as most attractive solution to comply with emission restriction. Only the existing push barges between 1000 and 2000 kilowatt installed power will not be able to be adapted to use LNG fuel because of lack of space due to limitations based on safety requirements and stability of the vessel.

Based on the assumption on the share of LNG it was possible to identify the demand for stage 5 diesel engines and to calculate the additional costs for research and development. In this respect a time horizon of 4 years was taken into account to determine the impact of the R&D on the price of the stage 5 diesel engines. These additional R&D costs have been allocated to the vessel category of the existing push barges between 1000 and 2000 kilowatt. The calculation is explained in this annex with a reference to the Arcadis study made in 2009 (please see pages 221 – 223).

Please note that passenger vessels and auxiliary engines are not included in this business economic evaluation. The business economic evaluation is focussing on the commercial operated freight vessels and the main propolusion engines.

Initial investment costs

The investment cost presented are undiscounted estimated costs for the year 2017 in $Euro_{2011}$, taking into account the expected development of the market in the coming years. Consultation with the producers and distributors and service suppliers in the industry took place on the detailed cost and performance setup of various technologies.

The following tables present the initial marginal investment cost for the hardware and installation for the three possible situations:

- New vessels with new engines
- Existing vessels with engine replacement
- Existing vessels with existing engine adapted / retrofit

Please note that the costs presented are the marginal investment costs compared to the business as usual scenario based on Stage IIIA engines.

Moreover, please note the business economic evaluation presented in this Annex shows that **stage 5 levels are generally reached by means of application of LNG+SCR+DPF technologies for the larger vessels**. Only for the category of existing push barges (1000-2000 kW) it was concluded that LNG would not be feasible from a technical and economical viewpoint. Therefore for these vessel Research and Development (R&D) would be needed to develop stage 5 solutions based on conventional (diesel) fuel systems. The additional R&D costs were therefore 100% allocated to the investment costs for the vessel type of existing push barges (1000-2000 kW). However, once the R&D is done, the stage 5 diesel engines can also be applied for other types of larger vessels. In order to allow comparison between the cost impacts of technologies, the situation for stage 5 diesel engines (excluding R&D) have been included for all larger vessel types. It was however concluded that in almost all cases the technologies based on LNG would have lower compliance costs for the vessel owner/operator.

Regarding the existing largest category of push boats (>2000 kW), it needs to be remarked that a retrofit to LNG is not seen as technically feasible. However, because of the high number of sailing hours and related fuel consumption it is expected from an economical viewpoint that the existing diesel fuelled push boats will be scrapped and replaced by new push boats using LNG. These additional costs for scrapping the existing vessels have been taken into account in the investment cost calculations for the existing large push boats (>2000 kW). It can be observed that the marginal investment cost for existing larger push to comply with stage 5 requirements are estimated between 4.2 and 4.5 million euro while the marginal investment costs for new large push boats are limited to 1.4 million euro. The large difference between these figures is explained by the additional scrapping costs for the existing large push barges.

New vessels with new engines

NEW ENGINES, NEW VESSELS (marginal investment costs)				
	Stage 3B Diesel SCR	***Stage 4B Diesel SCR DPF***	***Stage 5 LNG SCR DPF***	***Stage 5 DIESEL excluding R&D cost***
<38.5*5.05m, 365t, 189 kW	€ 17,758	€ 25,969		
55*6.6m, 550t, 274 kW	€ 20,213	€ 30,412		
70*7.2m, 860t, 363 kW	€ 21,714	€ 33,491		
67*8.2m, 913t, 447 kW	€ 21,979	€ 33,614		
85*8.2m, 1260t, 547 kW	€ 22,728	€ 34,908		
85*9.5m, 1540t, 737 kW	€ 25,835	€ 41,502		
110m, 2750t, 1178 kW	€ 35,001	€ 55,530	€ 591,148	€ 122,834
135m, 5600t, 2097 kW	€ 60,418	€ 96,494	€ 961,237	€ 216,325
Push Boat 1000-2000kW (1331 kW)	€ 45,366	€ 70,015	€ 947,515	€ 146,061
Push Boat >2000 kW (3264 kW)	€ 92,284	€ 147,991	€ 1,412,126	€ 334,484

Existing vessels with engine replacement (new engine)

NEW ENGINES, EXISTING VESSELS (marginal investment costs)					
	Stage 3B Diesel SCR	***Stage 4B Diesel SCR DPF***	***Stage 5 LNG SCR DPF***	***Stage 5 DIESEL including R&D cost***	***Stage 5 DIESEL excluding R&D cost***
<38.5*5.05m, 365t, 189 kW	€ 22,866	€ 34,908			
55*6.6m, 550t, 274 kW	€ 25,516	€ 39,693			
70*7.2m, 860t, 363 kW	€ 27,130	€ 42,969			
67*8.2m, 913t, 447 kW	€ 27,387	€ 43,078			
85*8.2m, 1260t, 547 kW	€ 27,935	€ 44,021			
85*9.5m, 1540t, 737 kW	€ 31,386	€ 51,216			
110m, 2750t, 1178 kW	€ 40,724	€ 65,544	€ 724,537		€ 132,849
135m, 5600t, 2097 kW	€ 69,657	€ 112,661	€ 1,176,592		€ 232,493
Push Boat 1000-2000kW (1331 kW)	€ 54,741	€ 86,422	€ 2,446,947	€ 806,820	€ 162,467
Push Boat >2000 kW (3264 kW)	€ 105,790	€ 171,626	€ 4,230,662		€ 358,119

Existing vessels with existing engine adapted to meet emission limit (retrofit)

EXISTING ENGINES, EXISTING VESSELS (marginal investment costs)		
	Stage 4A Diesel SCR DPF	***Stage 5 LNG SCR DPF***
<38.5*5.05m, 365t, 189 kW	€ 43,847	
55*6.6m, 550t, 274 kW	€ 48,975	
70*7.2m, 860t, 363 kW	€ 52,446	
67*8.2m, 913t, 447 kW	€ 52,542	
85*8.2m, 1260t, 547 kW	€ 53,134	
85*9.5m, 1540t, 737 kW	€ 60,931	
110m, 2750t, 1178 kW	€ 75,558	€ 739,359
135m, 5600t, 2097 kW	€ 128,829	€ 1,200,520
Push Boat 1000-2000kW (1331 kW)	€ 102,828	€ 2,613,550
Push Boat >2000 kW (3264 kW)	€ 195,261	€ 4,543,833

Total operational impact for the vessel owner

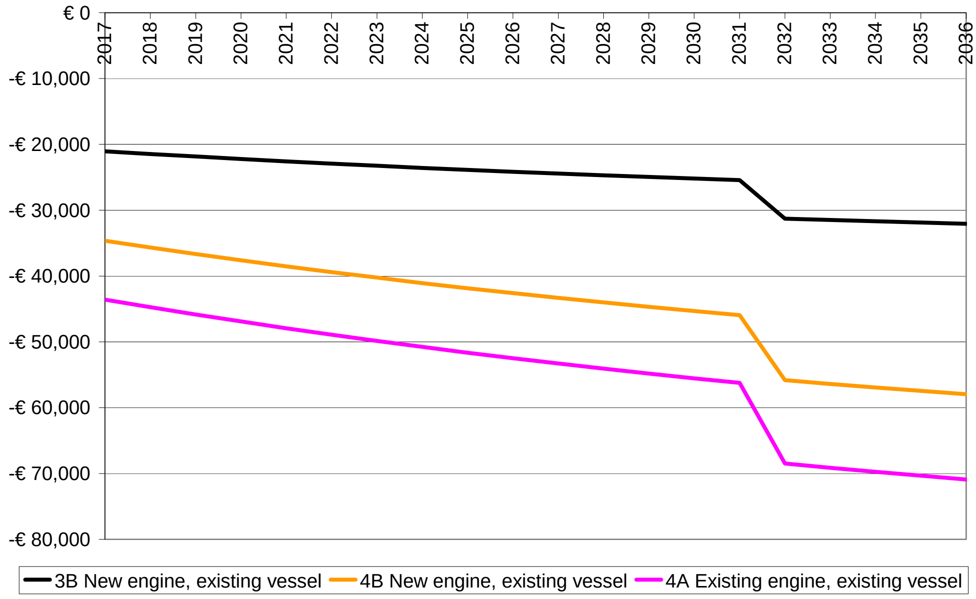
The initial marginal investment costs are only a part of the total economic impact for the vessel owner/operator. Other cost components such as impacts on fuel costs, urea consumption, repair and maintenance, reconditioning/replacement after lifetime also need to be taken into account in order to provide a view on the impact of the 'total cost of ownership'. The impact assessment on the total cost of ownership provides the situation regarding compliance costs.

In cases where LNG can be selected the operational impact can be beneficial as the reduction of fuel costs can compensate for the additional investment costs. Therefore a 'compliance benefit' is expected for certain situations, which provide a win-win for both the society and the IWT industry. A relevant question was therefore into what extent the vessels with installed engine power over 981 kW would have a higher Net Present Value after 20 years with LNG+SCR+DPF compared to diesel to reach the stage.

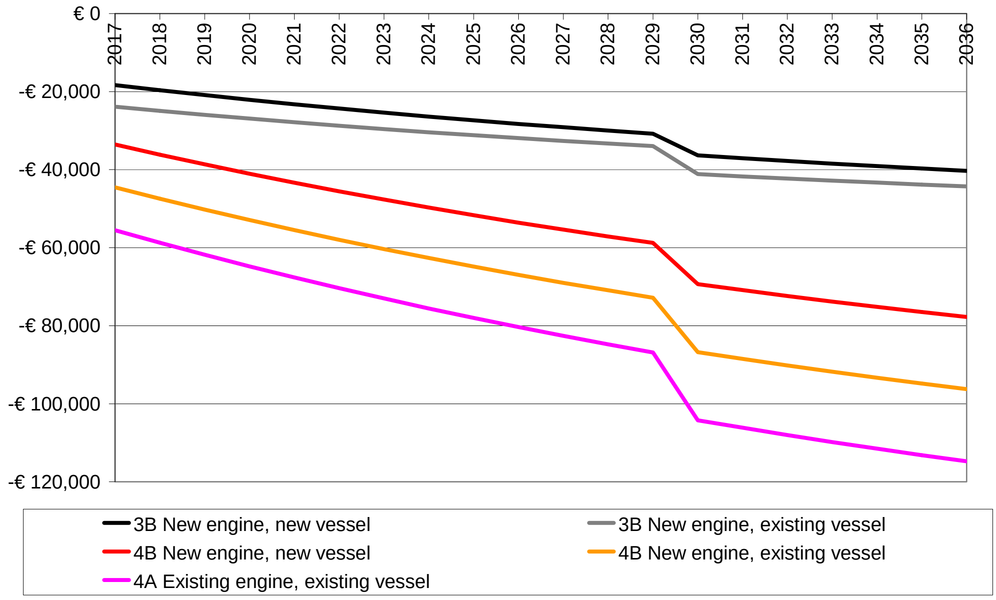
The following figures present the cumulative discounted cash flow for a 20 year period for selection of the vessels for the relevant emission standards/technology. To illustrate the development of the discounted cash flow it is assumed that the year of implementation is 2017. Please note that the figures present the marginal impact on the cash flow compared to the business as usual situation.

Please note that a discount rate is applied of 4% and note that these assessments are based on the baseline assumptions on a 20% price differences between diesel and LNG and an increase of fuel price based on the World Energy Outlook November 2012.

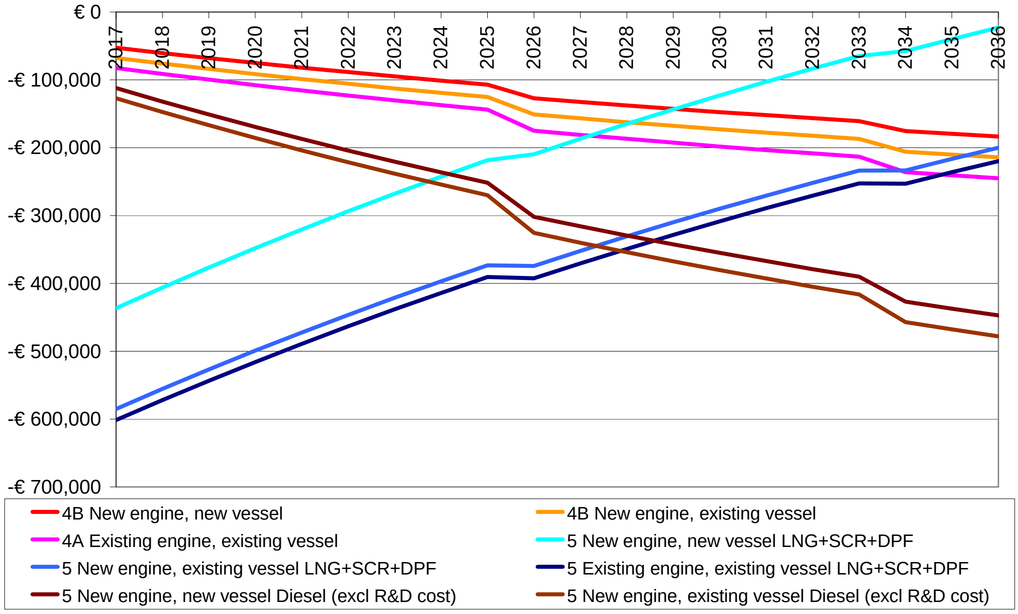
Vessel of 55 metre length, 550 tonnes load capacity, 274 kW net propulsion power (daytime operation)



Vessel of 85 metre length, 1260 tonnes load capacity, 547 kW net propulsion power (daytime operation)

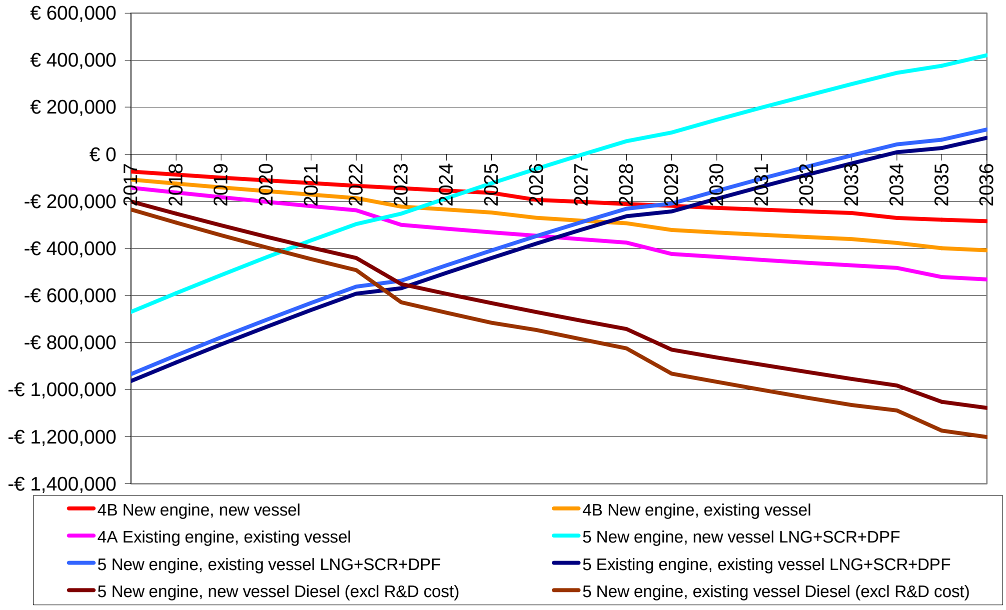


Vessel of 110 metre length, 2750 tonnes load capacity, 1178 kW net propulsion power, semi-continuous operation



In the graph for the 110 metre vessels the LNG option is illustrated in the blue lines while also the cash flow situation for a stage 5 diesel engine is made visible. It can be seen that the LNG option is very attractive for new vessels and that for the existing vessels there is a strong advantage if LNG is compared to stage 5 diesel. As a result the LNG technology is assumed to be selected for these vessels.

Vessel of 135 metre length, 5600 tonnes load capacity, 2097 kW net propulsion power (continuous operation)



It can be concluded from the graphs that new large motor vessels will have relatively short payback times in case of LNG. All new vessels can recover additional investment costs for LNG compared to Stage 5 Diesel (excluding the R&D costs) within 7 years and for the largest push boats this is even less than 3 years. With respect to the existing vessels with engine renewal the payback periods for additional investments are longer but still the existing motor vessels with propulsion power over 981 kW show payback periods below 20 years. Please note that some vessels use more than one engine, therefore in this case more engines need to be adapted. Annex 4 provides the information on the average number of propulsion engines installed per vessel type. In particular the 135 metre motorvessels and the push boats have 2 or 3 propulsion engines.

It is remarked that for new vessels the possibilities of application of LNG are much larger as the additional cost to apply LNG are smaller and the design of the vessel can take into account an optimised location of the tank (without loss of payload or space) as well as the safety regulations. This explains also the differences in the payback time between LNG and diesel based technologies for new versus existing vessels.

The analysis for existing 110 metre vessels shows that 11 years are needed as payback time compared with stage 5 diesel engines (not taking into account the R&D costs to develop the stage 5 diesel engine). For the period 2017 – 2020/2022 Stage 5 is not yet in force and then the comparison needs to be made with the Stage 4B requirement (1.2 gram NOx and 0.02 g PM per kWh). The stage 4B can be reached with a new stage IIIA diesel engine equipped with SCR and DPF. This solution has less investment costs for the operator compared to the LNG solution in case of the 110 metre vessel. The same applies for the comparison with Stage 4A addressing the existing engines. However it can be seen in the graph that the payback time is 19 years which still provides a small advantage for LNG compared to diesel over the full 20 year period.

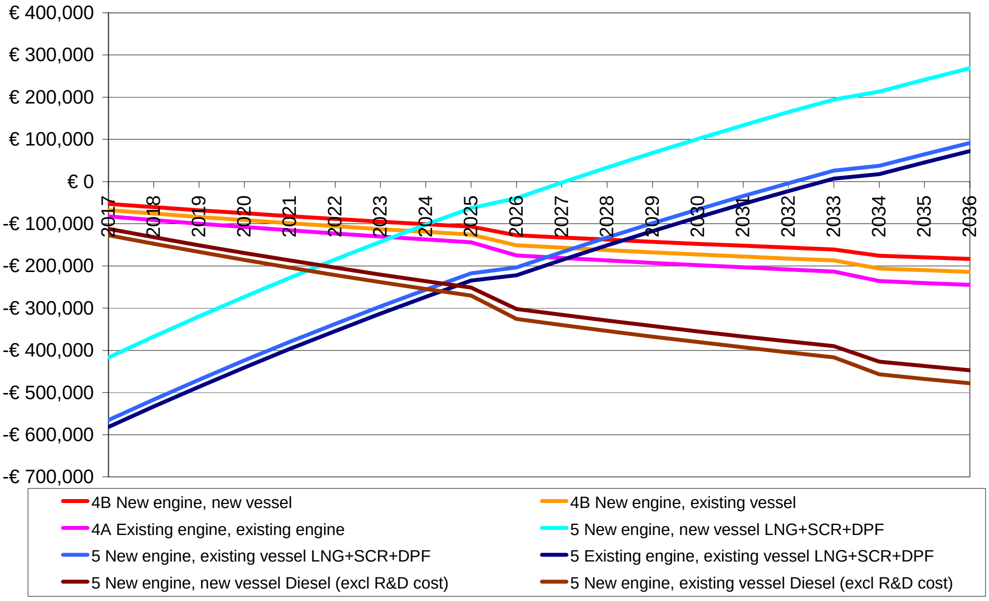
Moreover the assumption cost saving on fuel costs of 20% in case of LNG is considered as conservative but realistic as shipowners and banks are used to base their investments decisions on conservative (low risk) profit scenarios in their business plans. Supported by the favourable framework conditions for bunkering provided by the European Commission, it is expected that the LNG fuel could have a larger price difference as the size of the LNG market will increase (economies of scale). Secondly as volumes increase the price of LNG could be based more and more on the crude price of natural gas and the link with price of oil may be left which would bring the LNG price[1]. Also more advanced LNG engines (e.g. monofuel gas-electric configurations) would result in a larger difference in fuel costs between diesel engines and LNG engines.

Since the assumptions on the 110 metre class have a major impact on the overall results, a sensitivity analyses is provided on the impact a price difference of 30% while keeping the medium oil price scenario. In case of a 30% price difference the payback time of LNG+SCR+DPF compared to the diesel based

[1] Source: interview with an expert from BP on the scenarios for the LNG market and price development

stage 4A and 4B standards for this class are reduced to 10-11 years. When comparing Stage 5 LNG+SCR+DPF compared to the diesel based stage 5 the payback period is reduced to 5 years for new vessels and new engines and to 8 years for existing vessels and need their engine renewed. The following graph presents the situation on the discounted cash flow development at a price difference of 30%.

Vessel of 110 metre length, 2750 tonnes load capacity, 1178 kW net propulsion power, semi-continuous operation at 30% price difference between LNG and diesel fuel costs



It also shall be noted that the calculations are based on an average situation with semi-continuous operation and an average sailing profile. There will also be operators in the market with 110 metre vessels that apply 24/7 operation and make long international journeys and much more fuel consumption than the average. Examples of these could be coupled convoys and container and tanker vessels operating on the Rhine. Under these circumstances the existing 110 metre vessels would have shorter payback periods.

It is expected that the existing tanker vessels would have the lowest threshold to convert to LNG. These vessels can install the tank on deck (similar to MTS Argonon, see picture on the next page) and tanker vessels make in general relatively high operating and sailing hours on a yearly basis.

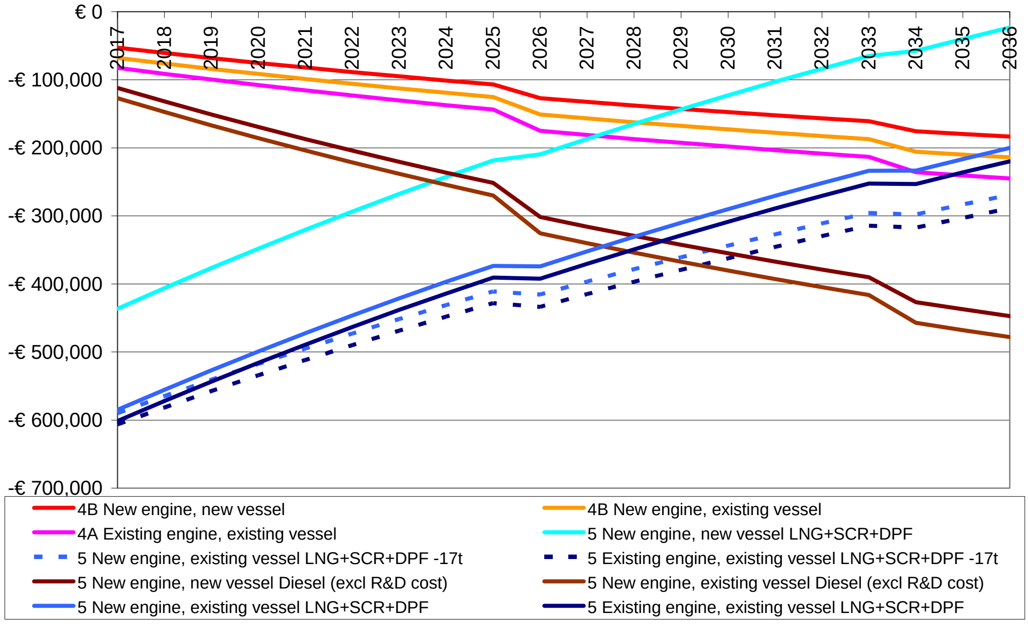
	110m, 2750t, 1178 kW	***135m, 5600t, 2097 kW***
Share of tankers in vessel class	38%	24%

Source: IVR database 2011

On the other hand it shall also be noted that there could be a loss of payload for bulk cargo motor vessels (e.g. transport of coal, ores sand/gravel). The additional weight of the LNG tank will decrease the net payload of the vessel. With several LNG bunker opportunities along waterways in Europe, there will be a limited need for a large LNG storage tank. Therefore it is assumed that a standard ISO-20 foot tank container can be sufficient. This tank container has a gross weight of 17 tonnes and a LNG payload of 8.4 tonnes. The additional weight of 17 tonnes would reduce the payload for motor vessels of 0.3 % in case of the 135 metre vessel and 0.6% in case of the 110 metre vessel. This would cause a loss of income of 6200 euro for the 110 metre vessel and 6700 euro per year for the 135 metre vessel. In terms of Net Present Value over a 20 year time period (2017-2036), this would be a discounted amount of -94,000 euro for the 110 metre vessel and -102,000 euro for the 135 metre vessel.

The following graph presents the cumulative cash flow development for the 110 metre vessel including the lines where for existing vessels with LNG+SCR+DPF a loss of payload of 17 tonnes is taken into account. The dotted blue lines present the case taking into account the loss of 17 tonnes.

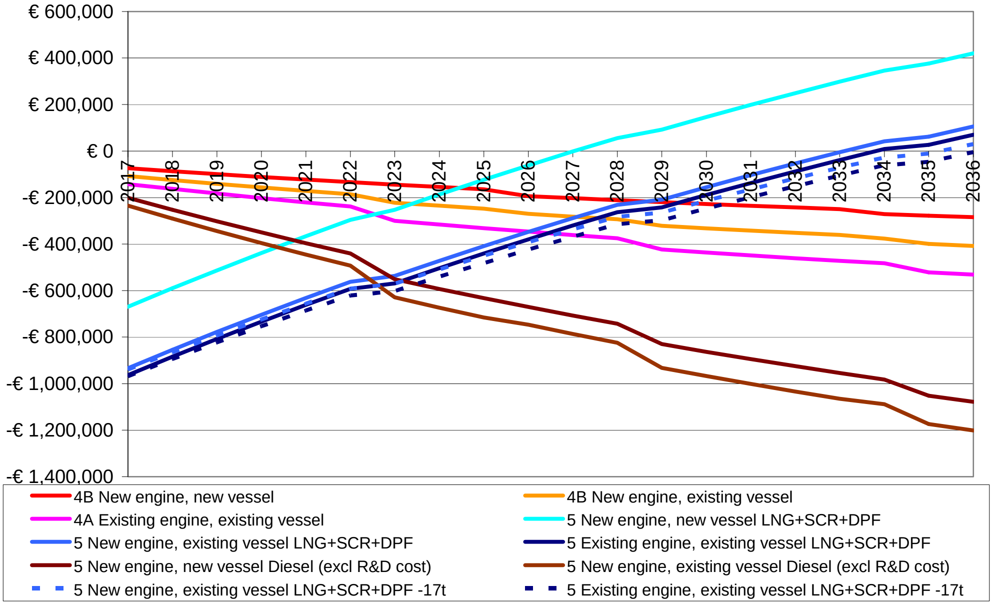
Vessel of 110 metre length, 2750 tonnes load capacity, 1178 kW net propulsion power, semi-continuous operation, loss of payload 17 tonnes due to LNG fuel tank



It can be seen that the impact is significant with respect to the payback period for LNG compared to the diesel based options for the 110 metre vessel. The payback period compared with Stage 5 diesel engines shifts from 11 to 12-13 years for the stage 5 diesel engine without the R&D cost taken into account.

The following graph presents the situation for the 135 metre vessel. For this vessel the difference in payback time is more limited as less than 1 year is added to the payback time of LNG compared to the Stage 5 diesel engines.

Vessel of 135 metre length, 5600 tonnes load capacity, 2097 kW net propulsion power (continuous operation), loss of payload 17 tonnes due to LNG fuel tank

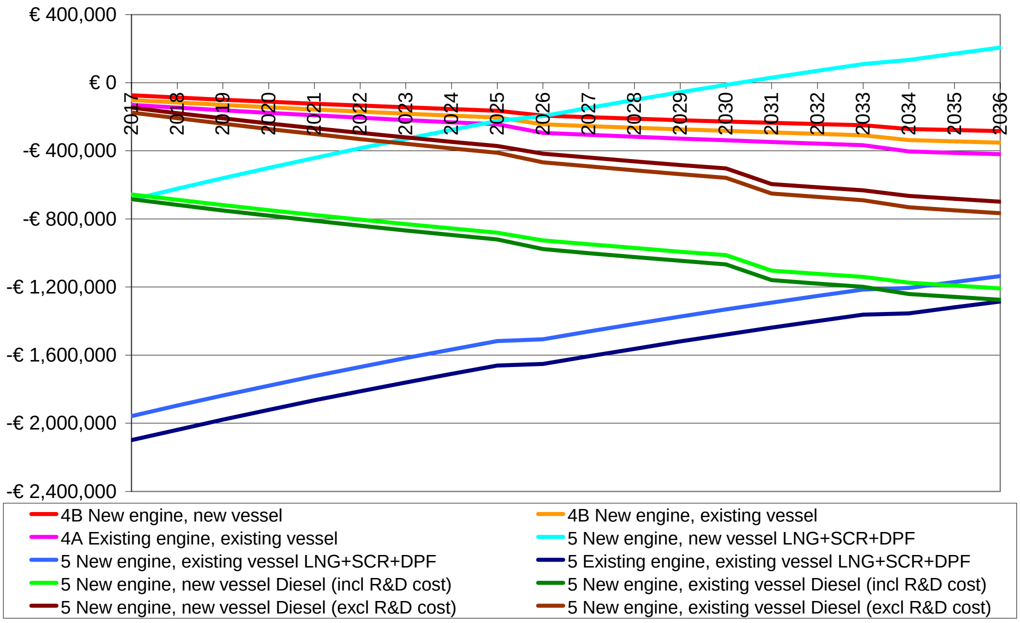


Container vessels however are generally not fully loaded and have spare capacity to hold a tank container for LNG fuel. Therefore for the container vessels it would be feasible to accommodate LNG tank without significant negative impact on the income for the operator/shipowner.

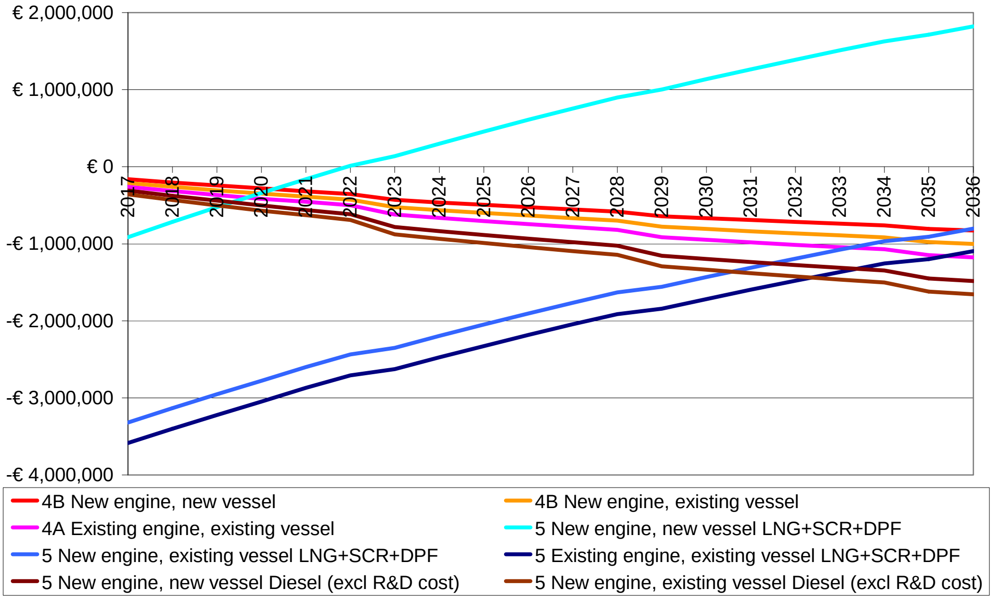
Severe technical barriers are however valid for the conversion of existing push boats. These push boats are usually small in size, have low weight and low draft. Since they use a lot of fuel these boats need a high storage capacity for fuel. Adding a heavy LNG fuel tank on an existing push boat is however technically a severe challenge due to problems with stability of the push boat and safety regulations while there are also limits because of the dimensions of locks and bridges in order to find a suitable place for the LNG tank on push boats. In particular this will be the case for the push boat with 1000-2000 kW power as these would be used for 2 barges and could operate in canals and rivers such as the Mosel. Based on an interview with a large push convoy shipping company it was made clear that it is possible to place the LNG tank vertically in the heart of the vessel (centre of gravity) in new push boats. In an existing push boat however there is no room for such a layout. Moreover it was remarked that selecting a smaller tank with more frequent bunkering would have negative impacts as stationary bunkering of LNG would cause some time loss since bunkering of diesel of push boats can be made during sailing. In particular the push boats that operate in 24/7 operation would be affected in case the tank is too small.

Because of the large fuel consumption and the potential saving on fuel costs if LNG technology could be applied an additional analysis was carried out. This analysis focussed on the question if it would be economically feasible to write off the existing push boats and to replace them by new push boats running on LNG. The additional costs of depreciation of the existing push boats were therefore added to the initial investment cost and new overviews were made on the cumulative discounted cash flow. For the push boat 1000-2000 kW the additional cost are 1.6 million euro while for the large push boat (>2000 kW) the additional cost are 3.1 million euro. The following graphs present the results and the comparison with the diesel alternatives for stages 4A, 4B and 5.

Push boat 1000-2000 kW, capable of pushing 2 push barges, 1331 kW net propulsion power (semi-continuous operation)

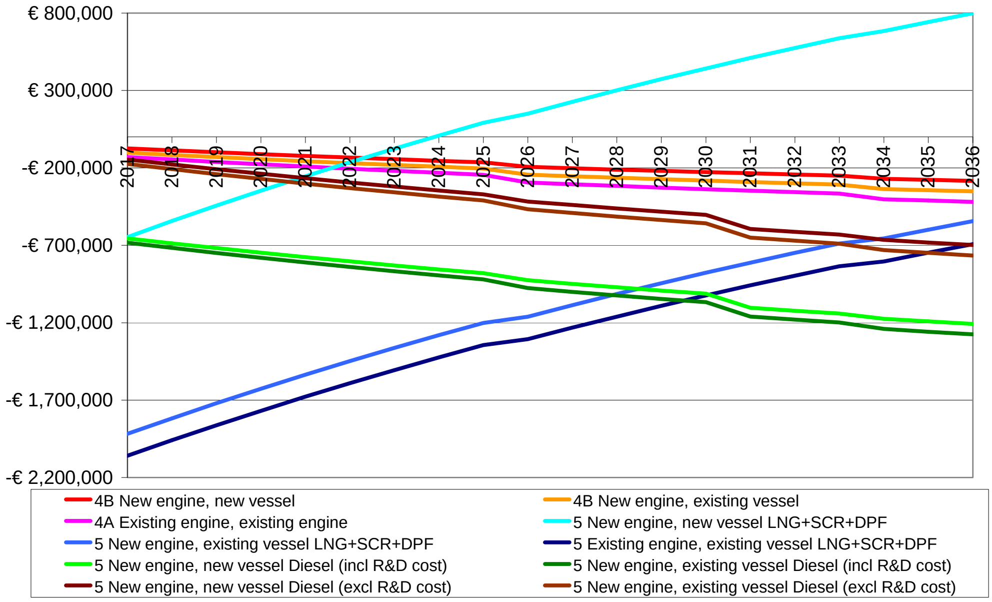


Push boat > 2000 kW, capable of pushing 4 or 6 push barges, 3264 kW net propulsion power (continuous operation)



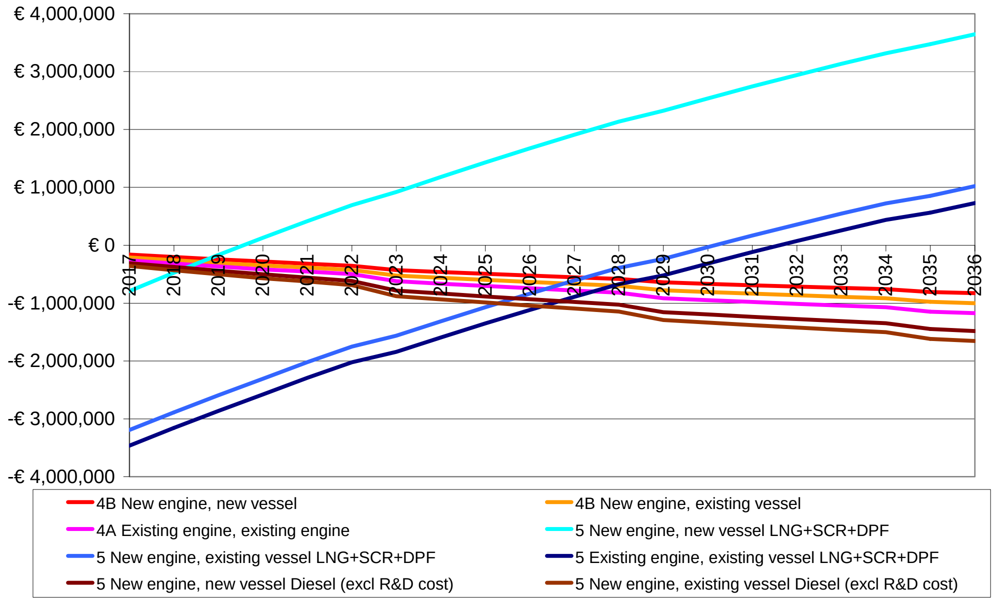
It is concluded that for the existing push boat 1000-2000 kW there is no convincing case to replace them on short term with new push boats designed for running on LNG. This is however different for the largest push boats over 2000 kW. The largest push boats have higher fuel consumption per year as they have larger engines and they are assumed to be operated in a 24/7 sailing scheme. Therefore, it is concluded that it would make sense to replace the existing large push boats (>2000 kW) on diesel with new push boats running on LNG. Since also here the differences are small with the diesel engines (similar to existing 110 metre vessels) a sensitivity analyses was made with a 30% difference in fuel costs between diesel and LNG. The following graphs present the results.

Push boat 1000-2000 kW, capable of pushing 2 push barges, 1331 kW net propulsion power (semi-continuous operation) at 30% price difference between LNG and diesel



Based on this sensitivity analysis it can be concluded that also in case of a 30% price difference the case for the push boats between 1000 and 2000 kW installed propulsion power is still not convincing to replace the existing push boats with new LNG fuelled boats.

Push boat > 2000 kW, capable of pushing 4 or 6 push barges, 3264 kW net propulsion power (continuous operation) at 30% price difference between LNG and diesel



The situation for the larger push boats in case of 30% fuel costs savings with LNG does however show much shorter payback times as within 10 years the additional investments are compensated by the savings on fuel costs.

All in all, it can be concluded that based on the economic assessments and considerations as well as the technological challenges, the following shares are expected for LNG for the large vessels with installed propulsion power over 981 kW:

Table **Share of LNG for new engines in new and existing (large) vessels based on economic indicators and technical barriers**

	110m, 2750t, 1178 kW	***135m, 5600t, 2097 kW***	***Push Boat 1000-2000kW (1331 kW)***	***Push Boat >2000 kW (3264 kW)***
New vessels, new engines	100%	100%	100%	100%
Existing vessels, with engine renewal 2017 until Stage 5 is in force (2020 or 2022)	100%	100%	0%	100%
Existing vessels, with engine renewal after Stage 5 is in force (2020 or 2022)	100%	100%	0%	100%
Existing vessels, with existing engine conversion (compared with stage 4A)	100%	100%	0%	100%

Explanation on the estimation cost for Stage 5 diesel engine

In order to increase the feasibility of stage 5 for IWT an alternative needs to be provided for LNG (+SCR+DPF). The required investments for LNG are relatively high and a large number of sailing hours are needed to offset the additional investments costs within 20 years of time. From the model calculations it became clear that the existing push boats between 1000-2000 kW would not shift to LNG.

Therefore, an alternative is desired that could be applied for these push boats. Moreover, such diesel based solutions reaching stage 5 could also be needed for other existing large vessels operating at less sailing hours and for vessels that can not be equipped with LNG for technical reasons.

At the moment however no R&D programme is foreseen to develop a diesel engine that would reach the emission limits of Stage 5. The following limits would apply:

	CO	HC	NOx	PM	PN
Emission standard	(g/kWh)			(in mg/kWh)	(in 1/kWh)
Stage 5	3.5	0.19	0.4	10	8.0×1.011

Members of Euromot pointed out that an engine manufacturer would require a budget of approximately 15 million euro to develop an engine range that could reach this limit. It was made clear also that the engine manufacturers do not have plans to develop such an engine and that the required budget is high compared to the size of the engine market for inland waterway vessels. Given the rather small number of stage 5 diesel engines expected, it is therefore assumed that only 1 engine manufacturer would develop such an engine.

An assessment of the compliance costs based on a diesel engine reaching stage 5 was also made with the ARCADIS study from 2009 'IMPACT ASSESSMENT STUDY – Reviewing Directive 97/68/EC-Emissions from non-road mobile machinery'. The reports indicates that according to Euromot, the total market for low emissions commercial propulsion engines <3300 kW is no more than 1500 units worldwide and Europe is just about 225 of this. This ARCADIS study made a comparison between the diesel engine in alignment with IMO 3/ EPA Tier 4 (Alternative Baseline in this study: Stage 3B) and the Stage 5 that was (at that time) proposed by the CCNR. It shall be remarked that because the Alternative Baseline is in full alignment with standards valid for IMO Tier 3 and US EPA Tier 4 therefore no additional R&D costs are required for the Stage 3B. The Stage 5 diesel engine will require, on top of SCR and DPF, considerable internal engine modifications. These internal engine modifications contain cooled EGR, EGR valves, controllable turbo pressure, 2 stage turbo charging, extra cooling capacity and high cylinder pressure capability, peak pressure, injection pressure. The industry situates these modifications on the borderline of what is possible (source ARCADIS, 2009).

Based on the expected number of vessels that would need new engines, an assessment was made on the additional costs per engine. Moreover, the engine itself will have a higher costs as result of the internal engine modifications (e.g. EGR, fuel injection, upgraded turbo). The example given in the Arcadis report was based on a 1400 kW engine which would have additional costs of 80,000 euro, so this would be an average additional cost of 57.14 euro per kW. On top of this the costs for the SCR and DPF need to be added.

The required R&D investments of 15 million euro are written off over a 4 year period. If only applied on the 23 new engines to be provided in the first four years to the push boats 1000-2000 kW the additional cost for R&D would be 644,400 euro per engine. In addition a cost increase is expected of 76,000 euro for the additional internal engine modifications and another 70,000 euro for the SCR and DPF after-treatment equipment. The total price of an engine including the SCR and DPF would therefore be around 790,400 euro. In the model calculations these values were applied for the first four years after stage 5 is in force (2022-2025 for option 1 and 2020-2023 for options 2 and 3).

After this period the R&D cost are excluded and the additional cost for the stage 5 diesel engine that were applied are 146,600 euro. It shall however be remarked that the actual R&D costs in practice could be spread over different vessel types while some existing push boats that are operated in 24/7 operation and are already depreciated could have a positive business case for a shift towards LNG.

The following overviews for the three situations therefore presents the net present value for the operational impact for the vessel owner for a single vessel for the time period 2017-2050 compared to business as usual. Please note that the cost figures have been discounted at a discount rate of 4%.

Operational impact for new vessels with new engines

NEW ENGINES, NEW VESSELS (NPV marginal operational costs)			
	3B Diesel SCR	4B Diesel SCR DPF	5 LNG SCR DPF
<38.5*5.05m, 365t, 189 kW	-€ 22,422	-€ 36,117	-€ 361,979
55*6.6m, 550t, 274 kW	-€ 31,684	-€ 53,436	-€ 358,610
70*7.2m, 860t, 363 kW	-€ 36,113	-€ 62,609	-€ 355,238
67*8.2m, 913t, 447 kW	-€ 41,257	-€ 75,725	-€ 316,561
85*8.2m, 1260t, 547 kW	-€ 47,461	-€ 96,424	-€ 201,013
85*9.5m, 1540t, 737 kW	-€ 58,051	-€ 125,978	-€ 192,857
110m, 2750t, 1178 kW	-€ 116,296	-€ 230,499	€ 88,019
135m, 5600t, 2097 kW	-€ 277,559	-€ 547,075	€ 731,566
Push Boat 1000-2000kW (1331 kW)	-€ 153,637	-€ 360,212	€ 477,905
Push Boat >2000 kW (3264 kW)	-€ 460,296	-€ 1,077,617	€ 2,758,999

The table shows that there is a strong advantage for the stage 5 LNG option for the vessels from 110 metre and more as in this case there is a 'win-win' situation: both industry (reduction internal costs) and society (reduction external do benefit.

Operational impact for existing vessels with engine replacement

NEW ENGINES, EXISTING VESSELS (NPV marginal operational costs)					
	3B Diesel SCR	4B Diesel SCR DPF	4B /5 LNG SCR DPF	5 DIESEL Including R&D costs	5 DIESEL Excluding R&D costs
<38.5*5.05m, 365t, 189 kW	-€ 27,209	-€ 47,722	-€ 494,102		
55*6.6m, 550t, 274 kW	-€ 36,914	-€ 68,255	-€ 509,079		
70*7.2m, 860t, 363 kW	-€ 41,152	-€ 79,255	-€ 518,537		
67*8.2m, 913t, 447 kW	-€ 46,184	-€ 93,938	-€ 491,608		
85*8.2m, 1260t, 547 kW	-€ 52,086	-€ 118,624	-€ 410,440		
85*9.5m, 1540t, 737 kW	-€ 62,132	-€ 145,642	-€ 415,368		
110m, 2750t, 1178 kW	-€ 118,227	-€ 266,827	-€ 152,548		-€ 617,138
135m, 5600t, 2097 kW	-€ 281,754	-€ 612,112	€ 348,076		-€ 1,503,339
Push Boat 1000-2000kW (1331 kW)	-€ 164,755	-€ 442,618	-€ 906,294	-€ 1,514,248	-€ 1,005,007
Push Boat >2000 kW (3264 kW)	-€ 468,440	-€ 1,302,433	€ 95,306		-€ 2,147,656

In the table for existing vessels with engine replacement it becomes clear that on longer term (2017-2050 period) the LNG scenario does provide win-win situations for the 135 metre vessel and the largest push boat.

Operational impact for existing vessels with existing engine adapted / retrofit

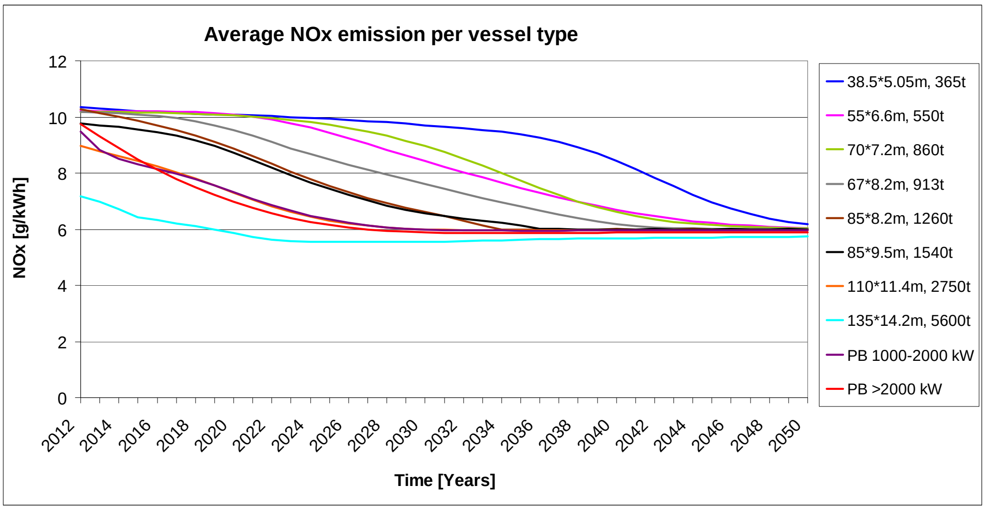
EXISTING ENGINES, EXISTING VESSELS (NPV marginal operational costs)		
	4A Diesel SCR DPF	4A/ 5 LNG SCR DPF
<38.5*5.05m, 365t, 189 kW	-€ 59,327	-€ 508,782
55*6.6m, 550t, 274 kW	-€ 83,075	-€ 525,798
70*7.2m, 860t, 363 kW	-€ 95,900	-€ 536,681
67*8.2m, 913t, 447 kW	-€ 112,151	-€ 511,058
85*8.2m, 1260t, 547 kW	-€ 140,824	-€ 433,710
85*9.5m, 1540t, 737 kW	-€ 165,305	-€ 440,091
110m, 2750t, 1178 kW	-€ 303,155	-€ 179,277
135m, 5600t, 2097 kW	-€ 677,150	€ 305,466
Push Boat 1000-2000kW (1331 kW)	-€ 525,023	-€ 1,060,094
Push Boat >2000 kW (3264 kW)	-€ 1,527,250	-€ 200,659

For retrofitting the existing vessels the net present value for vessels of 110 metre the LNG provides the lowest cost for compliance over the full time span (2017-2050). For 135 metre vessels there is still also an advantage compared to the business as usual to convert existing vessels to LNG. For the push boat of 1000-2000 kW however the Stage 4A diesel solution (SCR and DPF applications) is the option with the lowest compliance costs. However for the largest category push boats the LNG option is providing clearly the lowest compliance costs.

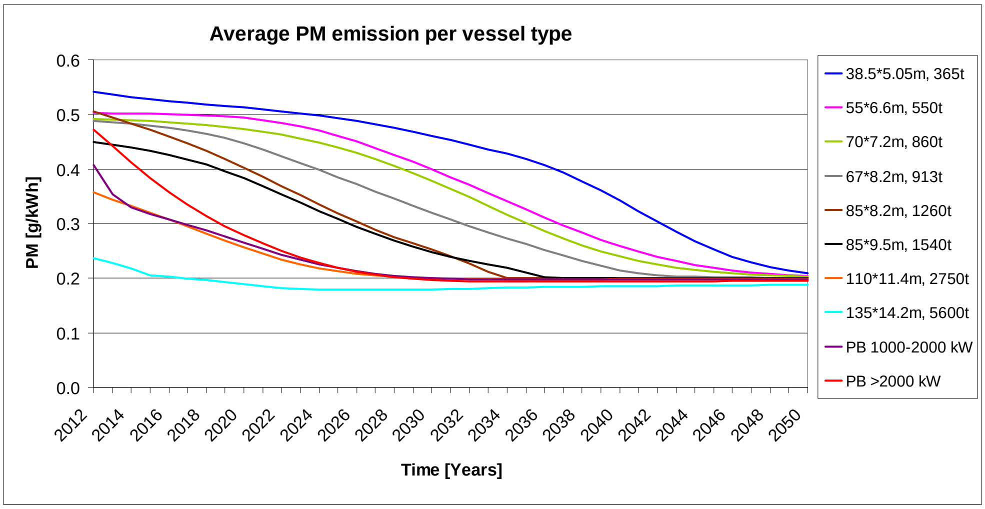
Annex 11 Emission performance graphs

Business as Usual (BAU)

NOx emission performance in gram per kWh, BAU

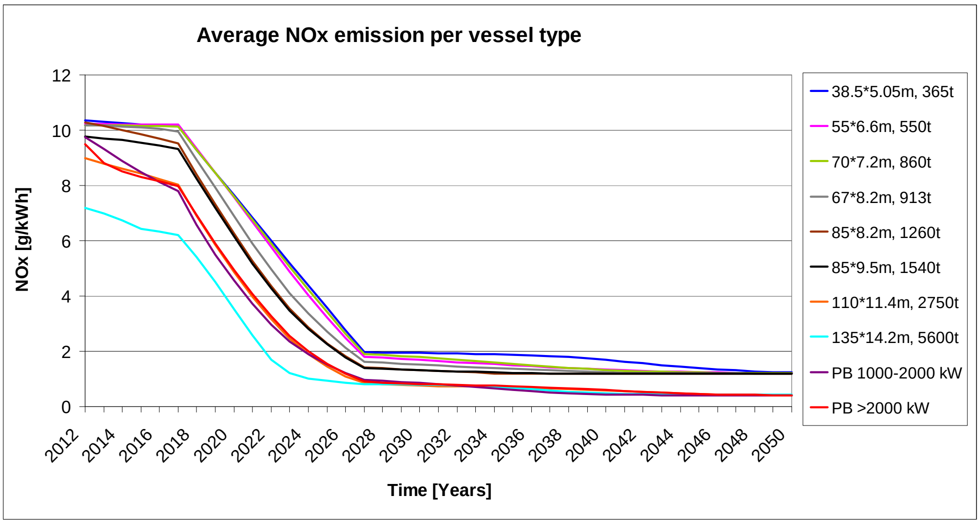


PM emission performance in gram per kWh, BAU

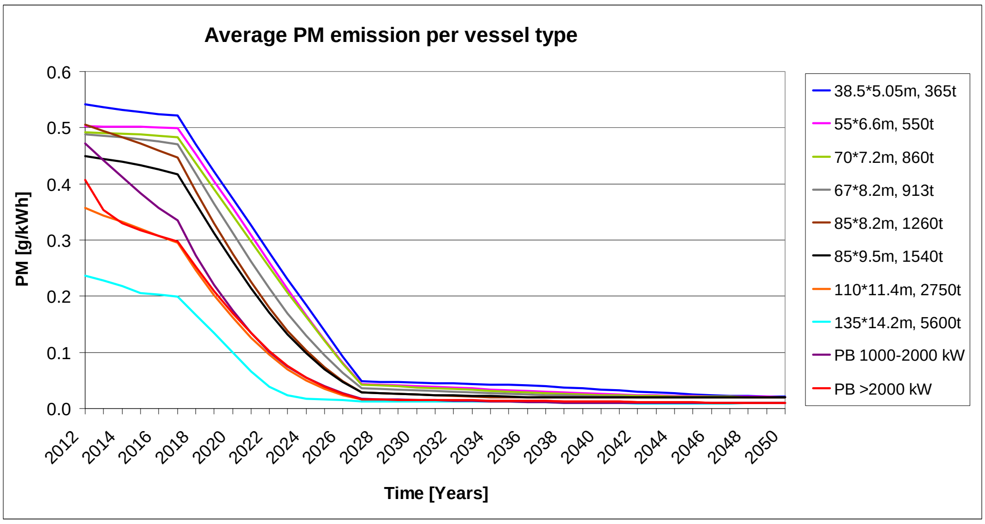


Option 1: maximised time for Stage 5 development

NOx emission performance in gram per kWh, Option 1

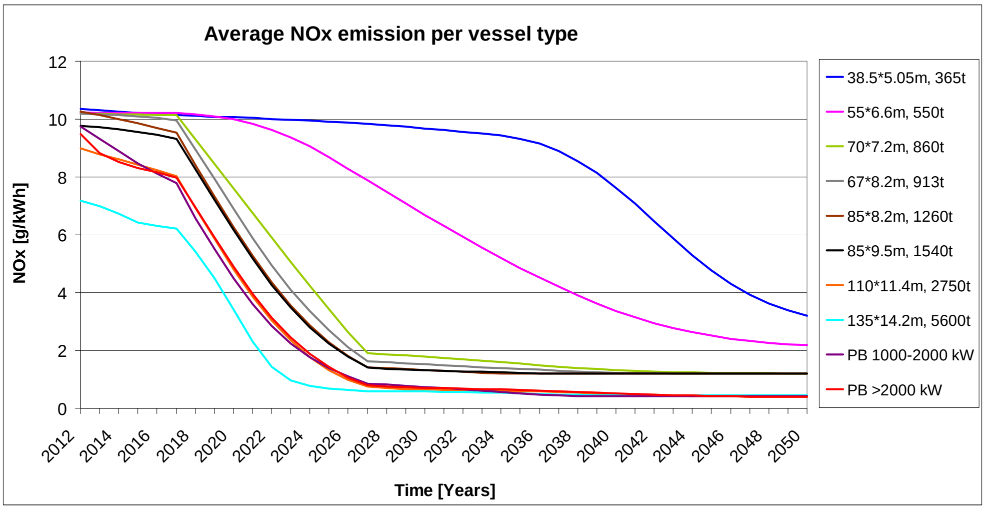


PM emission performance in gram per kWh, Option 1

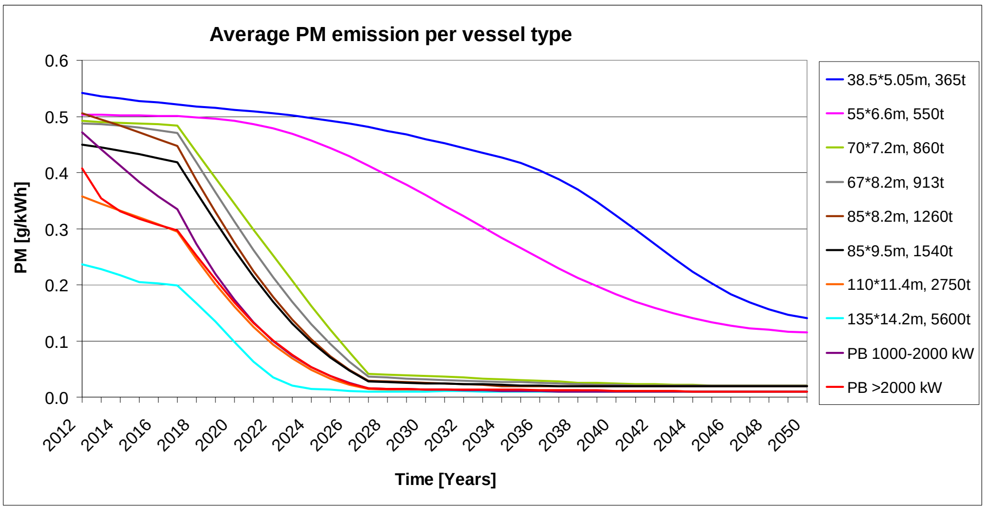


Option 2: Optimised cost-effectiveness

NOx emission performance in gram per kWh, Option 2

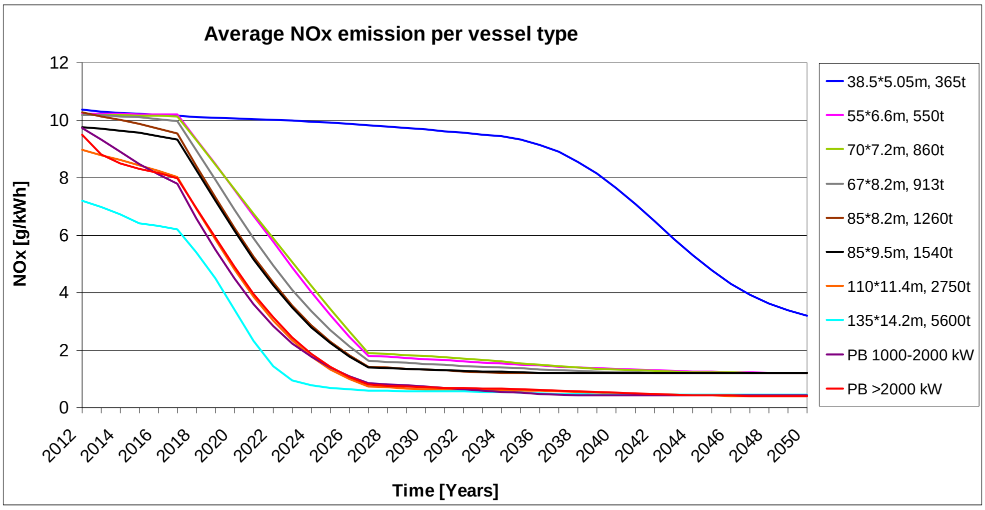


PM emission performance in gram per kWh, Option 2

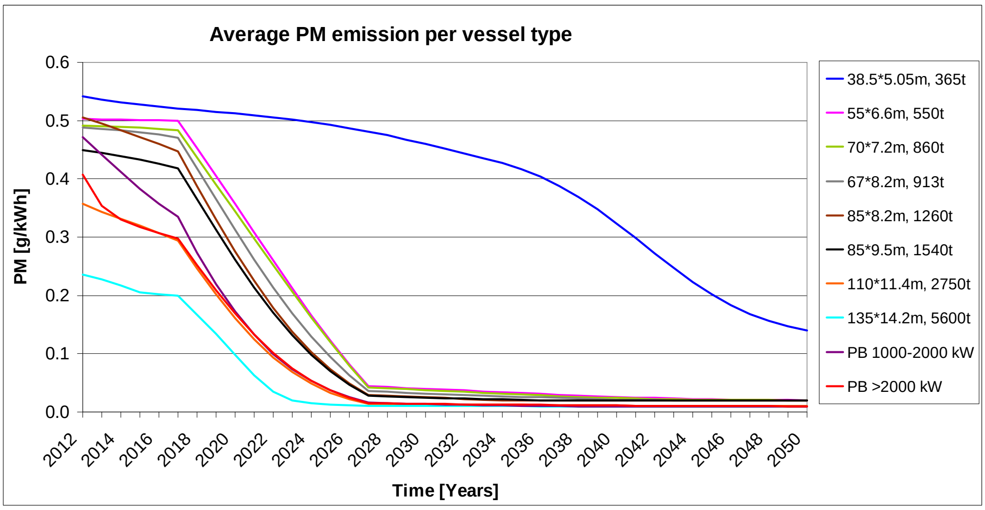


Option 3: Mix effectiveness and level playing field

NOx emission performance in gram per kWh, Option 3

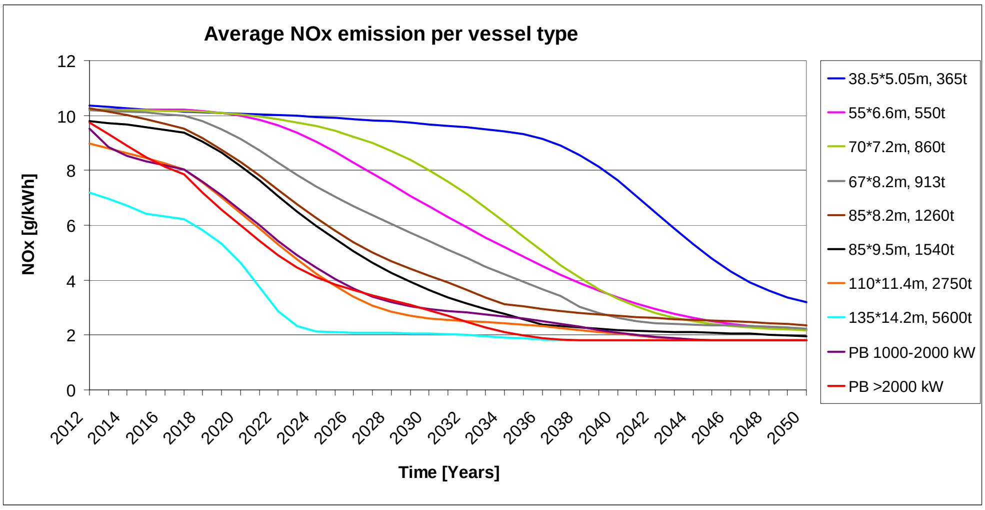


PM emission performance in gram per kWh, Option 3

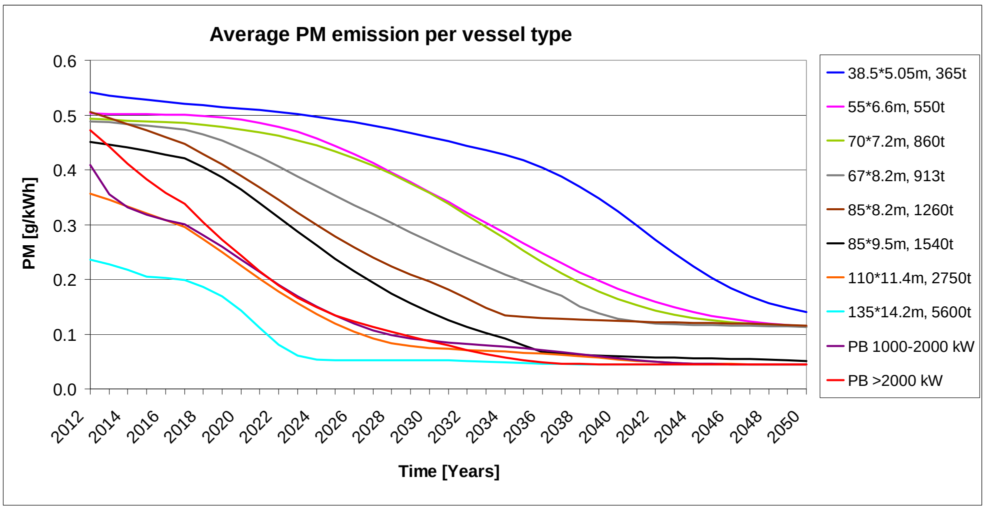


Alternative baseline: 3B only for new vessels

NOx emission performance in gram per kWh, Alternative Baseline



PM emission performance in gram per kWh, Alternative baseline



Annex 12 Cost-benefit data

This Annex presents the cost benefit data. Part A presents the detailed breakdown according to vessel types. Part B presents the specific costs and benefit results for the retrofitting of existing engines compared to the total impact. Please note that passenger vessels and auxiliary engines are not included in this cost benefit analysis. The cost benefit analyses is focussing on the commercial operated freight vessels and the main propolusion engines.

Part A: data per vessel type

NPV Investments by IWT industry in hardware and installation costs per vessel class

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	-€ 3,302,339	-€ 85,599,623	-€ 3,302,339	-€ 3,302,339
55*6.6m, 550t, 274 kW	-€ 9,731,323	-€ 47,571,696	-€ 9,731,323	-€ 47,571,696
70*7.2m, 860t, 363 kW	-€ 5,051,744	-€ 33,381,154	-€ 33,381,154	-€ 33,381,154
67*8.2m, 913t, 447 kW	-€ 6,626,436	-€ 37,728,359	-€ 37,728,359	-€ 37,728,359
85*8.2m, 1260t, 547 kW	-€ 8,794,614	-€ 43,484,797	-€ 43,484,797	-€ 43,484,797
85*9.5m, 1540t, 737 kW	-€ 14,528,713	-€ 68,397,464	-€ 68,397,464	-€ 68,397,464
110m, 2750t, 1178 kW	-€ 100,067,895	-€ 880,813,425	-€ 1,047,362,386	-€ 1,047,362,386
135m, 5600t, 2097 kW	-€ 51,174,772	-€ 518,642,214	-€ 517,969,134	-€ 517,969,134
Push Boat 1000-2000kW (1331 kW)	-€ 6,477,532	-€ 45,962,565	-€ 49,089,371	-€ 49,089,371
Push Boat >2000 kW (3264 kW)	-€ 5,174,296	-€ 124,560,271	-€ 124,560,271	-€ 124,560,271
TOTAL	-€ 210,929,665	-€ 1,886,141,567	-€ 1,935,006,598	-€ 1,972,846,971

NPV IWT Industry per vessel class

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	-€ 4,103,274	-€ 109,083,617	-€ 4,103,274	-€ 4,103,274
55*6.6m, 550t, 274 kW	-€ 12,096,413	-€ 65,297,681	-€ 12,096,413	-€ 65,297,681
70*7.2m, 860t, 363 kW	-€ 6,574,516	-€ 47,567,880	-€ 47,567,880	-€ 47,567,880
67*8.2m, 913t, 447 kW	-€ 9,739,960	-€ 59,406,868	-€ 59,406,868	-€ 59,406,868
85*8.2m, 1260t, 547 kW	-€ 13,684,849	-€ 79,340,733	-€ 79,340,733	-€ 79,340,733
85*9.5m, 1540t, 737 kW	-€ 27,496,360	-€ 129,816,358	-€ 129,816,358	-€ 129,816,358
110m, 2750t, 1178 kW	-€ 199,405,003	-€ 327,232,721	-€ 299,525,178	-€ 299,525,178
135m, 5600t, 2097 kW	-€ 106,527,879	€ 192,327,525	€ 192,159,088	€ 192,159,088
Push Boat 1000-2000kW (1331 kW)	-€ 12,439,615	-€ 60,295,066	-€ 68,096,948	-€ 68,096,948
Push Boat >2000 kW (3264 kW)	-€ 11,332,377	€ 15,318,304	€ 15,318,304	€ 15,318,304
TOTAL	-€ 403,400,245	-€ 670,395,095	-€ 492,476,261	-€ 545,677,529

NPV External cost savings per vessel class

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	€ 10,379,188	€ 292,520,692	€ 10,379,188	€ 10,379,188
55*6.6m, 550t, 274 kW	€ 56,387,870	€ 206,080,293	€ 56,387,870	€ 206,080,293
70*7.2m, 860t, 363 kW	€ 42,220,025	€ 198,220,216	€ 198,220,216	€ 198,220,216
67*8.2m, 913t, 447 kW	€ 118,845,927	€ 346,811,518	€ 346,811,518	€ 346,811,518
85*8.2m, 1260t, 547 kW	€ 274,552,350	€ 669,852,501	€ 669,852,501	€ 669,852,501
85*9.5m, 1540t, 737 kW	€ 608,554,517	€ 1,122,392,252	€ 1,122,392,252	€ 1,122,392,252
110m, 2750t, 1178 kW	€ 7,077,474,745	€ 11,388,509,014	€ 11,526,109,842	€ 11,526,109,842
135m, 5600t, 2097 kW	€ 5,180,003,091	€ 7,332,874,352	€ 7,469,969,747	€ 7,469,969,747
Push Boat 1000-2000kW (1331 kW)	€ 460,448,664	€ 758,179,370	€ 765,884,172	€ 765,884,172
Push Boat >2000 kW (3264 kW)	€ 650,731,540	€ 1,053,657,933	€ 1,067,193,177	€ 1,067,193,177
TOTAL	€ 14,479,597,918	€ 23,369,098,140	€ 23,233,200,483	€ 23,382,892,905

Share of reduction of the external cost savings: external cost saving compared to external costs in BAU

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	1%	28%	1%	1%
55*6.6m, 550t, 274 kW	9%	31%	9%	31%
70*7.2m, 860t, 363 kW	7%	31%	31%	31%
67*8.2m, 913t, 447 kW	10%	29%	29%	29%
85*8.2m, 1260t, 547 kW	11%	28%	28%	28%
85*9.5m, 1540t, 737 kW	17%	30%	30%	30%
110m, 2750t, 1178 kW	29%	46%	47%	47%
135m, 5600t, 2097 kW	39%	55%	56%	56%
Push Boat 1000-2000kW (1331 kW)	27%	44%	44%	44%
Push Boat >2000 kW (3264 kW)	27%	43%	44%	44%
TOTAL	28%	45%	45%	45%

NPV Society

The following table presents the overview on the Net Present Value for society. The NPV Society is the difference between the NPV Savings on external costs minus the NPV Industry.

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	€ 6,275,914	€ 183,437,076	€ 6,275,914	€ 6,275,914
55*6.6m, 550t, 274 kW	€ 44,291,458	€ 140,782,612	€ 44,291,458	€ 140,782,612
70*7.2m, 860t, 363 kW	€ 35,645,509	€ 150,652,336	€ 150,652,336	€ 150,652,336
67*8.2m, 913t, 447 kW	€ 109,105,966	€ 287,404,650	€ 287,404,650	€ 287,404,650
85*8.2m, 1260t, 547 kW	€ 260,867,502	€ 590,511,768	€ 590,511,768	€ 590,511,768
85*9.5m, 1540t, 737 kW	€ 581,058,157	€ 992,575,894	€ 992,575,894	€ 992,575,894
110m, 2750t, 1178 kW	€ 6,878,069,742	€ 11,061,276,293	€ 11,226,584,664	€ 11,226,584,664
135m, 5600t, 2097 kW	€ 5,073,475,212	€ 7,525,201,877	€ 7,662,128,835	€ 7,662,128,835
Push Boat 1000-2000kW (1331 kW)	€ 448,009,049	€ 697,884,304	€ 697,787,224	€ 697,787,224
Push Boat >2000 kW (3264 kW)	€ 639,399,163	€ 1,068,976,236	€ 1,082,511,480	€ 1,082,511,480
TOTAL	€ 14,076,197,673	€ 22,698,703,044	€ 22,740,724,222	€ 22,837,215,377

Benefit / Investment ratio per vessel class

The following table presents the Benefit/Investment ratio. This ratio is calculated by means of dividing the value for the NPV Society by the -NPV Investments.

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	1.9	2.1	1.9	1.9
55*6.6m, 550t, 274 kW	4.6	3.0	4.6	3.0
70*7.2m, 860t, 363 kW	7.1	4.5	4.5	4.5
67*8.2m, 913t, 447 kW	16.5	7.6	7.6	7.6
85*8.2m, 1260t, 547 kW	29.7	13.6	13.6	13.6
85*9.5m, 1540t, 737 kW	40.0	14.5	14.5	14.5
110m, 2750t, 1178 kW	68.7	12.6	10.7	10.7
135m, 5600t, 2097 kW	99.1	14.5	14.8	14.8
Push Boat 1000-2000kW (1331 kW)	69.2	15.2	14.2	14.2
Push Boat >2000 kW (3264 kW)	123.6	8.6	8.7	8.7
TOTAL	66.7	12.0	11.8	11.6

The options 1, 2 and 3 that reach the policy objective would generate a multiplier value of 12 for option 1, 11.8 for option 2 and 11.6 for option 3. This means that each euro invested in the technology to reach the emission limit would generate 12 euro of savings for society. Again it can be concluded that the highest ratios are reached at the largest vessels. The investments for the largest push boats however include also the writing off for the existing push boats in order to replace them with new push boats on LNG. The relatively high investments explain the lower ratio compared to other vessels in the engine class starting at 981 kW installed net propulsion power.

Benefit / Cost ratio per vessel class

The following table presents the Benefit/Cost ratio. This ratio is calculated by means of dividing the value for the NPV Society by the **-**NPV IWT industry.

	ALTERNATIVE BASELINE - Stage 3B new engines only	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
<38.5*5.05m, 365t, 189 kW	1.5	1.7	1.5	1.5
55*6.6m, 550t, 274 kW	3.7	2.2	3.7	2.2
70*7.2m, 860t, 363 kW	5.4	3.2	3.2	3.2
67*8.2m, 913t, 447 kW	11.2	4.8	4.8	4.8
85*8.2m, 1260t, 547 kW	19.1	7.4	7.4	7.4
85*9.5m, 1540t, 737 kW	21.1	7.6	7.6	7.6
110m, 2750t, 1178 kW	34.5	33.8	37.5	37.5
135m, 5600t, 2097 kW	47.6	-39.1 (win-win)	-39.9 (win-win)	-39.9 (win-win)
Push Boat 1000-2000kW (1331 kW)	36.0	11.6	10.2	10.2
Push Boat >2000 kW (3264 kW)	56.4	-69.8 (win-win)	-70.7 (win-win)	-70.7 (win-win)
TOTAL	34.9	33.9	46.2	41.9

The options 1, 2 and 3 that reach the policy objective would generate a multiplier value of:

- 33.9 for option 1
- 46.2 for option 2
- 41.9 for option 3

The compliance costs for the industry are therefore comparatively limited if the impact for the overall society is compared with the impact for the IWT industry. A large contribution for the relatively low additional compliance costs for the options 1,2 and 3 compared to the alternative baseline is explained by the fuel savings that are reached by means of the application of LNG for the larger vessel category. In this respect it has to be remarked that the negative ratio that can be seen for options 1, 2 and 3 in the table for the 135 metre motor vessels and the Push Boat > 2000 kW. This negative ratio actually indicates a 'win-win' situation. For these types of vessels that are assumed to operate in 24/7 operation there are compliance benefits instead of compliance costs.

Moreover it can be concluded that in general the highest efficiency is reached for the larger vessels.

Part B: costs and benefit overview for retrofitting existing engines in total

In order to analyse the additional value of including existing engines within the scope of the policy options, additional analyses were done.

	OPTION 1 - Maximised time for development Stage 5 large vessels	OPTION 2 - Optimised cost-effectiveness	OPTION 3 – Mix of cost-effectiveness and level playing field
Total savings external costs	€ 23,369,098,140	€ 23,233,200,483	€ 23,382,892,905
Share provided by improved performance retrofit existing engines	€ 4,425,886,015	€ 3,994,052,088	€ 4,143,744,511
	19%	17%	18%
Total NPV IWT Industry	-€ 670,395,095	-€ 492,476,261	-€ 545,677,529
Share NPV Industry for retrofit existing engines	-€ 376,957,984	-€ 214,069,364	-€ 250,998,981
	56%	43%	46%
Share Societal benefits related to existing engines	€ 4,048,928,031	€ 3,779,982,724	€ 3,892,745,530
ratio Benefits/Cost related to existing engines	10.7	17.7	15.5
Total NPV Investments	-€ 1,886,141,567	-€ 1,935,006,598	-€ 1,972,846,971
Share NPV Investments for retrofit existing engines	-€ 366,744,156	-€ 254,452,602	-€ 286,201,991
	19%	13%	15%
Ratio Benefits/Investment related to existing engines	12.1	15.7	14.5

It can be concluded that addressing the existing engines has clear benefits for society. The Benefit/Cost ratios varies between 10.7 for option 1 and is 17.7 for option 2. Also the Benefit/Investment ratios are positive with values between 12.1 for option 1 and 15.7 for option 2.

Annex 13 Overview of possible funding mechanisms

Overview of existing national funding programmes
Currently, only a limited number of European countries offer dedicated funding or support programmes for emission reducing measures. A comprehensive list of notified support programmes, which is based on the Inland Waterway Transport Funding Database (operated and maintained by the PLATINA project), is available on www.naiades.info/funding.

- **Austria:** 'National environmental aid scheme for company-related traffic measures' as well as the 'ERP Programme Transport'. The environmental aid scheme covers max. 30% of the environmentally relevant costs, whereas the ERP instrument offers favourable interest rates.

- **Belgium**: 'Walloon aid scheme for inland waterway transport 2008–2013', which supports the modernisation and adaptation of the Walloon IWT fleet (e.g. low-emission engines and aggregates, steel bottoms, radar, GPS, autopilot, RIS equipment, telescopic bridge, ADNR adaptations, adaptation of ship's cargo hold: coating, container compatible) at a maximum co-financing rate of 30% of the investment costs.

- **Czech Republic**: 'Aid scheme for commercial enterprises for the modernisation of inland waterway transport vessels', which supports the acquisition of low-emission diesel engines and aggregates as well as adaptation measures to enhance safety of navigation and avoid environmental damage (e.g. bow thrusters, modernisation of hull and bottom, radar, autopilot). The maximum rate of co-financing amounts to 49% of the eligible costs.

- **France**: 'Aid for the modernisation of French inland waterway transport' supports actions that result in Reduction of fuel consumption and emissions (e.g. hull, propulsion) and environmental evaluations, as well as general technical improvements of vessels, at a maximum co-financing rate of 30%, based on additional costs only, compared to standard equipment. Studies can be co-financed at 50%.

- **Germany**: 'Aid programme for low-emission diesel engines for inland navigation vessels', 'Innovative Ship Building', and 'Navigation and maritime engineering' programmes. The aid programme supports installation of lower-emission diesel engines (for new and existing vessels) and the installation of diesel particulate filter and nitrogen reduction systems. Funding rates vary between 30 to 40% of the eligible costs (for SMEs up to 50%). Eligible costs are calculated on a fixed amount per kW (max. 27 EUR per kW). Development costs for new and innovative types of vessels are also supported, at max. 50% for industrial research and max. 25% for pre-competitive research.

- **The Netherlands**: 'Random Depreciation of Environmental Investments (Vamil) & Environmental Investment Allowance (MIA)' and 'Temporary aid scheme for innovation in inland waterway transport (SIB)'. The first instrument is a fiscal instrument, whereby actions have to be listed on the so-called Milieulijst (Environment List), which is updated on an annual basis; examples for IWT technologies include fuel consumption meters, measures to reduce energy consumption, propeller shaft packing, etc. Effective funding can be derived from deduction of max. 41.5% of investment cost from the fiscal profit.

- **Poland**: 'Inland Waterway Fund' supports the introduction of new technical solutions, improvement of work conditions and safety, improvement of environmental protection by means of soft loans with interest rates of 0.4%.

- **Croatia**: 'Aid programme for inland waterway transport based on the 'de minimis' rule'. Supported actions vary per tendered call, but include innovative devices or equipment and their installation on IWT vessels such as RIS-based or environmentally friendly equipment. Co-financing can amount up to max. 30% of the costs for purchase and installation.

Most of these programmes available across Europe are broader support programmes, with no specific focus on inland waterway transport. Within those programmes, however, inland waterway operators can also apply for support for emission reducing measures.

Typical eligible funding items
Eligible items, which could lead to emission reductions in inland waterway transport and which are typically included in the programmes analysed, include:
- Low emission engines and aggregates
- Propulsion systems and automatic propulsion regulators
- Installation of diesel particulate filters and nitrogen reduction systems
- Fuel consumption meters
- Adaptations to the hull and the cargo hold
- New methods in shipbuilding
- RIS equipment
- Efficient transhipment facilities

Eligibility is generally restricted to companies and organisations with a seat in the respective countries.

Typical funding rates
Typical funding rates vary between 20% and 30% of the required investment costs. Mostly, SMEs can qualify for a higher preferential funding rate. The highest funding rate of 50% for SMEs was found in the German fleet modernisation programme. The maximum contribution per company thereby is € 200.000 over a period of 3 years (de minimis rule).

Other preferential funding rates are sometimes encountered if clear or additional environmental benefits can be proven by the applicant: e.g. 30% instead of 20% funding rate if particular environmental benefits can be demonstrated.

Typical support instruments

The support instruments generally take the form of direct grants, but in some occasions also soft loans (e.g. with an interest rate of 0.4%) or tax rebates (e.g. 41.5% deduction of the company’s fiscal profit) have been identified.