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

D 3.4 Design and Project Plan for the Demonstration of Real-Life Testing

Certification, monitoring and enforcement

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Summary

PROMINENT is a multiannual research- and implementation program for the inland navigation industry which is funded by INEA (Innovation & Networks Executive Agency of the European Commission). PROMINENT focusses on researching, testing and introducing alternative energy concepts and technologies for the European industry of inland navigation which are economically viable, safe and environmentally friendly.

The focus of WP 3 is to develop and test procedures for the certification, monitoring and enforcement of emissions of engines complying with stringent emissions limits. Engine operational and emission characteristics will be analysed for a range of different vessel types with different operating profiles. This includes certification, (real life) verification and evaluation of portable on-board measurements and continuous on-board monitoring.

The objective of the pilot test specification is to agree on and to present a plan for the real life pilots in WP5, in order to evaluate the WP3 proposals for certification and monitoring.

The project plan for real life testing focusses on the following subjects:
- The evaluation of on board measurement and monitoring options with laboratory type equipment (Standard Reference Material, SRM) and with sensor based equipment;
- The evaluation of engine emissions and load patterns for a range of different vessels on different routes;
- The evaluation of data-processing and –presentation methods.

The results will be used to evaluate the procedures for certification and monitoring defined in the D3.2 & D3.3 combined report. These are especially procedures for on board validation of the performance of (Retrofit & OEM) emission control devices and for the evaluation of Real Sailing Emissions (RSE).

List of Abbreviations

CCNR	Central Commission for the Navigation of the Rhine
CESNI	Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation
CO	Carbon Monoxide
DPF	Diesel Particulate Filter
EC	European Commission
ECE	UN Economic Commission for Europe
ECU	Electronic Control Unit
EPM	Environmental Performance Monitoring
GHG	Green House Gas
INEA	Innovation & Networks Executive Agency
IMO	International Maritime Organization
ISC	In Service Conformity
ISM	In Service Monitoring
ISO	International Standardisation Organization
IUC	In Use Compliance
IWT	Inland Waterway Transport
LNG	Liquefied Natural Gas
NRMM	Non-road Mobile Machinery
NTE	Not To Exceed value
OBD	On Board Diagnostics
OEM	Original Equipment Manufacturer
PEMS	Portable Emission Measurement System
PM	Particulate Matter
PN	Particulate Number
PT	Particulates
RDE	Real Driving Emissions
REC	Retrofit Emission Control device
RSE	Real Sailing Emissions
RPM	Rounds per minute
SCR	Selective Catalytic Reduction
SRM	Standard Reference Material
THC	Total Hydro Carbons
WP	Work package

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1 Introduction to PROMINENT

PROMINENT is a multiannual research- and implementation program for the inland navigation industry which is funded by INEA (Innovation & Networks Executive Agency of the European Commission). PROMINENT focusses on researching, testing and introducing alternative energy concepts and technologies for the European industry of inland navigation which are economically viable, safe and environmentally friendly.

Previous projects are, amongst others, PLATINA and PLATINA-II. These projects supporedt the European Commission with the implementation of NAIADES and NAIADES-II. The NAIADES II programme will facilitate long-term structural changes in the inland waterway transport sector. It also includes short term actions currently being undertaken by the European Commission to address the difficult economic situation of the sector. Regarding new directives the European Commission is aware of the complexity of the existing market and makes [NAIADES IIa] & [NAIADES IIb] a few statements regarding emissions.

“The approach to be adopted on emission limits should be strictly technology neutral from the perspective of engine technology and fuel choice. Due to this, it is assumed that the technology with the best cost/benefit characteristics would prevail”.

“When defining new emission limits for the IWT engines, it may be necessary to differentiate between small and large vessels and between existing and new engines because of the technological and economic limitations that existing engines and small vessels face. The Commission is also aware that sufficient time must be allowed for the sector to adapt to more ambitious emission limits.”

“Although IWT emits much less CO2 than road transport, the external costs of its emissions to air (air pollutants and CO2) are roughly equal to those of road transport. This is due to the higher cost of IWT air-pollutant emissions.”

1.1 Innovations improving the environmental performance of IWT

The European IWT fleet consists of approximately 18.000 vessels (and 40.000 crew members) and plays a crucial role in major transport chains. The sector has a large potential to become more environmentally friendly (i.e. reduction of Green House Gases and pollutants) and transport chains can also be improved by shifting more cargo to the IWT sector, which reduces congestion on the European roads. During the last years, the European Commission and the partners of the PROMINENT consortium have been investing in the promotion of (technological) innovations in the inland navigation industry.

1.2 PROMINENT objectives

PROMINENT is aimed at providing solutions to make inland navigation as competitive as road transport in terms of air pollutant emissions by 2020 and beyond. In parallel, PROMINENT aims to further decrease the energy consumption and carbon footprint of IWT. This is an area where IWT performs better than road transport.

For inland waterway vessels, the current engine emission standards are CCNR Stage II and EU NRMM Stage IIIA. More stringent (future) emission standards like EU NRMM Stage IIIB and the proposed Stage V for inland navigation vessels will require reductions of NOx and PM emissions between 60% and 90%. PROMINENT aims to support the widespread implementation of innovative and environmentally friendly solutions in IWT to improve the sector's economic competitiveness and environmental performance. In addition to the development of "hardware" solutions, PROMINENT will focus in particular on improving the "orgware". In other words, PROMINENT will also focus on improving the framework conditions, which are primarily responsible for the current stagnating innovation levels in the IWT sector. This will be done by setting clear and achievable targets.

1.3 Targets and work packages of PROMINENT

The goals of PROMINENT are:

1. Developing cost-effective solutions and standardised applications (reducing required investment costs):

1.1. 70%+ coverage – Developing solutions that are applicable to at least 70% of the European inland fleet and their operating areas.

1.2. 30% costs reductions – Reducing implementation costs of innovative greening solutions by 30%.

2. Involving all relevant actors concerned in the research and innovation process

2.1. 100% inclusive - All stakeholders who are required for the full coverage of the innovation cycle from initial concept to real-life deployment are to be taken on board.

3. Actively addressing and removing current implementation barriers by 2020

3.1. Visible and physical results by 2017 – Producing results on the ground during the project lifetime

PROMINENT has 2020 as ultimate time horizon. With respect to this time frame, another goal is:

4. Setting up a roll-out strategy which is geared towards producing the required full impacts by no later than 2020.

1.4 PROMINENT WP3 Objectives and Deliverables

Work package 3 explores the feasible technical options for certification, monitoring and enforcement procedures regarding emissions and operational profiles, and prepares their pilot testing.

New stringent emission limits require the drastic reduction of harmful emissions of NOx and PM. The differences between inland vessels and trucks are so large that the same emission control systems cannot be used. Inland vessels require some specific solutions for certification and monitoring compared to engines for land based Non Road Mobile Machinery (NRMM) and HD Vehicles. This is due to the required long life time of engines and the realistic option of installing Retrofit Emission Control devices (REC).

The focus of WP 3 is to develop and test well-designed procedures for the certification, monitoring and enforcement of emissions of engines complying with stringent emissions limits. Engine operational and emission characteristics will be analysed for a range of different vessel types with different operating profiles. This includes certification, (real life) verification and evaluation of portable on-board measurements and continuous on-board monitoring. The options for collection of on-board monitoring results in a central database will be investigated. This is done for the enforcement of air pollutant emissions (NOx, PM) as well as for the creation of incentives for the vessel owner to benchmark and demonstrate its vessel's environmental performance. For this latter purpose, on-board monitoring data will be combined with open-source data such as AIS data and data on the waterway characteristics.

Already during this phase of technical research and development, the views and opinions of stakeholders will be taken into account, including those of:

- European Commission
- CCNR, CESNI
- National authorities
- Manufacturers of engines and emission control systems
- providers of technical services
- vessel owners/operators and their associations

The following table shows the deliverables of WP3

Name / sub WP	Main Deliverables
3.1 Improved certification, monitoring & enforcement	D3.1, State-of-the-art report
	D3.2, Assessment of certification procedures
	D3.3, Assessment of options for monitoring and enforcement
3.2 Prepare and Evaluate real life testing	D3.4, Design and project plan for the real-life testing
	D3.5, Ex-ante cost/benefit analysis of systems for certification, monitoring and enforcement

Table 1: Deliverables of Work package 3

1.5 Objectives and Scope of WP3.4 Pilot Test Specification

The objectives of the pilot test specification is to agree on and present a plan for the real life pilots in WP5, in order to evaluate the WP3 proposals for certification and monitoring. This will be done with the majority of the vessels used for measurements in WP5.

Consequently the objectives of the measurements in WP5 are focussed on the following aspects:

- Measurements of engine load patterns for different vessels on different routes;
- On board emissions measurements with different engine and emission control technologies;
- Evaluation of different on-board measurement systems, especially with the accuracies and practicalities of this equipment.

2 Evaluation of On-Board Measurement Options

2.1 On-Board Measurement Options

The following measurement options will be investigated in WP5.:

- SRM and PEMS (on board measurement procedures):

SRM stands for Standard Reference Materials, e.g. the equipment used for official measurements. PEMS stands for Portable Emissions Measurement System. The PEMS systems are developed for measurement of Real Driving Emissions (RDE) of road vehicles. In figure 2 below, it is mounted in a city bus. PEMS uses high quality analysis according to the same measurement principles used within an engine laboratory. It is currently limited to the NOx measurement, Measurement of Particulates mass and Particulates Number (PN). The system includes a pipe to be connected to the exhaust pipe for measurement of the exhaust mass flow. On many vesselss, it will be quite difficult and expensive to connect such a pipe, taking into account the large pipe diameters and rigid installation in the vessel. Alternative options for this exhaust flow are a) accurate measurement of the fuel flow in combination with the 'carbon balance' calculation method or b) measurement of the inlet air flow. This latter is also very though due to physical dimensions.

- SEMS and EPM.

The abbreviation SEMS has been introduced by TNO around 2012. It stands for Smart Emissions Measurement System. Refer to [Vermeulen 2012] and figure 3 below. It is a much simpler sensor based measurement than PEMS, but developed for the same purpose. It does not have the exhaust mass flow measurement, but uses a carbon balance method instead. It has been validated in a vehicle laboratory with the official laboratory measurement system and with PEMS.
EPM stands for Environmental Performance Monitoring, also referred to as OBM (On Board Monitoring). The principles and sensors of EPM are similar to the SEMS system, but this system is meant for permanent on board monitoring of both pollutant and CO_2 emissions. Several suppliers offer these type of systems, although this is still in a start-up phase.

Figure 2. Portable Emissions Measurement System (PEMS) mounted in a bus

Figure 3. Smart Emissions Measurement System (SEMS). Small box on top of the engine control cabinet

The on-board measurements will be done by the following WP3/WP5.1 partners:

- SGS: PEMS/IMO measurements. SGS has extensive experience with these on-board measurements including particulate mass emissions measurement;
- Multronic and TNO: SEMS / OBM measurements. Multronic and TNO both have extensive experience with these measurements;
- If possible also the data of the vessels of NAVROM sailing on the Danube will be included in the data analysis for WP3.

It is planned to evaluate in total about 20 vessels.

2.2 Parameter List

The parameters list for the on-board measurements was established between the partners of PROMINENT involved in these measurements (especially DST, Multronic, NAVROM and TNO).
The parameter list is included in Appendix A. It includes fixed vessel parameters and dynamic parameters. The parameters are generally recorded per second and consequently averaged to one value per minute.

3 Evaluation of Certification

3.1 Real Sailing Emissions

Real Sailing Emissions is the equivalent of Real Driving Emissions for road vehicles. Formal implementation of RDE took place during the last 10 years for road vehicles. It was first implemented for trucks with Euro VI in 2013. For passenger cars, it will be formally implemented with Euro 6c in 2017.
RDE are measured with so called PEMS equipment. PEMS stands for Portable Emissions Measuring System (as aforementioned).

Real Sailing Emissions should be controlled by:
1. Test cycles and test points during the laboratory Type Approval of a new engine or an engine with Retrofit Emissions Control system, and
2. By an on-board measurement procedure, to measure the emissions of a vessel in regular service.

The measurement of Real Sailing Emissions, will be an important item for the measurements in WP5.1 and WP5.3.

3.2 Engine Load Pattern

The measurement of the engine load pattern of different type of vessels on different routes will be one of the main items of real life pilots as input for WP3. The engine load pattern measurements will be done on the vessels of WP5.1 (about 20 vesselss), but also on the after-treatment pilot WP5.3 and with the vessels participating in the efficient navigation pilots (WP5.4).

One of the main questions is whether the load pattern of the official test cycles for propulsion of vessels; E3 or E2 cycle, corresponds to reality. The average power of these cycles is 69% of the installed engine power.
The standard procedure for these type of measurements is testing according to the standard ISO test cycles, presented in the figure below:
- E3: test points for direct propulsion (the majority)
- E2: test points for constant speed propulsion.

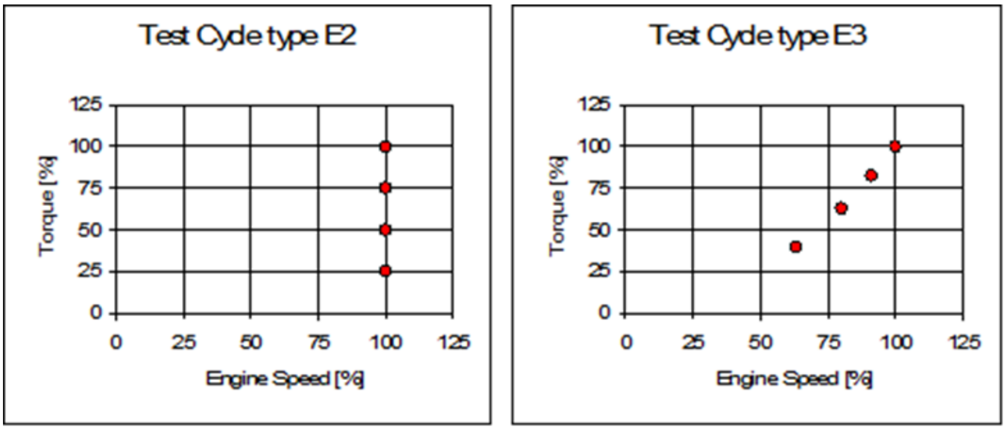

Figure 4. Standard ISO test cycles for vessels

Another point of investigation will be to establish the normal engine control area. This is the overall part of the engine map used in normal applications. In the figure below this is shown for direct propulsion. The majority of the different engine applications and different sailing characteristics should fall within the engine control area. It will be proposed that this area will also be indicated as the Not to Exceed (NTE) area. The NOx emission should be below a certain level in al points within this area.

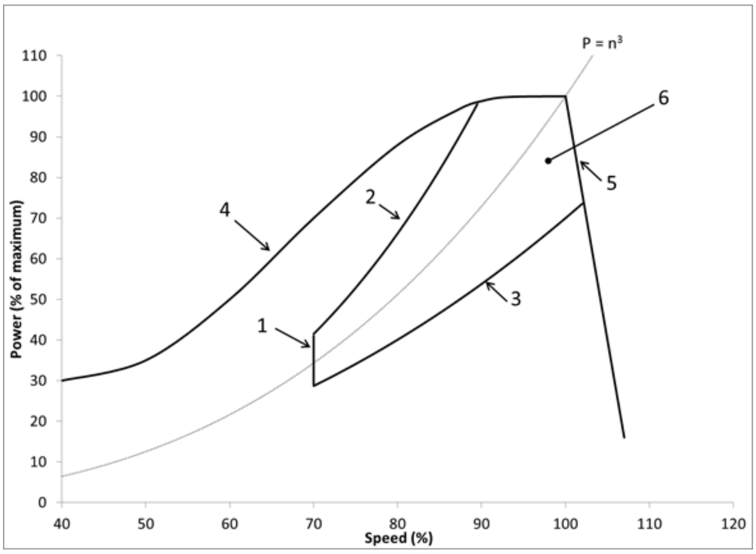

Figure 5. Engine control area of vessel with direct propulsion.
Source: Discussion paper draft concept delegated act NRMM V1.1, date 23 March 2016

Part of the evaluation will also be the accuracy in which the measuring points can be met. Due to the normal matching of engine, propeller and vessel, there is usually power margin at full speed. So at full speed only 80% to 90% of maximum power is used (see figure 6). This will also lead to a deviation in the formal ISO cycle point, although becoming more realistic for normal operation.

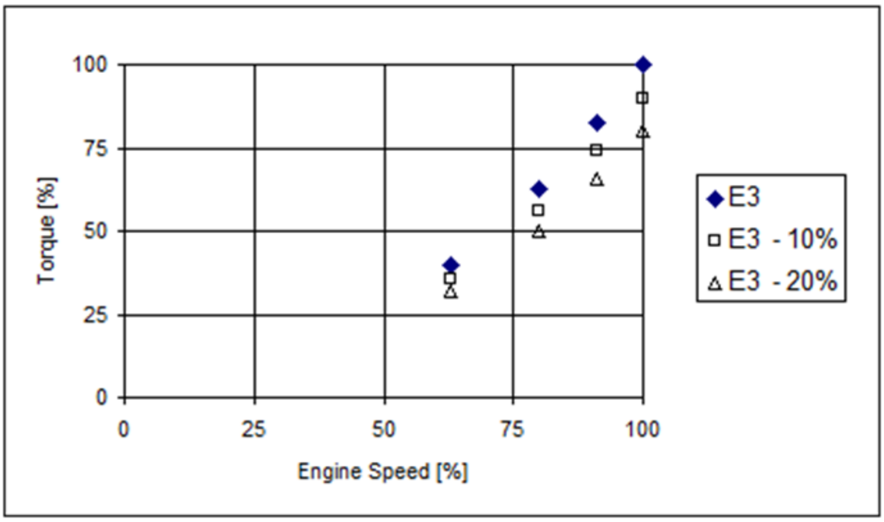

Figure 6. Possible matching deviation of E3 cycle points with an on board measurement

3.3 Certification of Retrofit Emission Control Systems

The current view on certification of retrofit solutions consists of a twostep approach:

1. Lab certification of the Retrofit Emission Control system (REC) for a wide engine family range;
2. On board approval or validation per engine type – REC combination.

The costs of the on-board validation should be low, because this needs to be done for almost each vessel that will be retrofitted. Whether this really needs to be done for each vessel or just per engine type – REC combination, is also a subject of the analysis in WP3 and WP5.1.
The on-board measurement options described in section 2.1 (PEMS/IMO, SEMS and OBM) will be investigated for their suitability for the on board validation. They are expected to fall in a price range of about 5000 EUR to 20.000 EUR per on-board measurement. These measurements will primarily be done on the vessels of WP5.1 (about 20 vessels), but also on the after-treatment pilot WP5.3 and partly with efficient navigation pilots (WP5.4).

The main results of this part will be a proposal, verified with key stakeholders, for the on-board validation of Retrofit Emission Control devices. This should include the recommended test procedure option(s) including parameter list and calculation method.

4 Monitoring and Enforcement

4.1 In-Service Conformity (ISC) Monitoring

The In-Service Conformity (ISC) monitoring is focused on NOx emissions and can be expanded with PM emissions. The on-board measurement options (PEMS, SEMS and OBM) will be evaluated for their suitability for In-Service Conformity (ISC) monitoring in line with the ideas on ISC monitoring with land based NRMM. One of the requirements is the suitability for independent testing.

4.2 On-Board Monitoring (OBM) for monitoring of environmental performance

This OBM is focused on environmental performance in a broader sense. It includes monitoring of NOx, CO2, engine power and fuel consumption. This system will stay permanently on the vessel and record these parameters. It will also record other parameters such as engine speed and vessel speed and cargo load if available. The emissions will be presented in both g/kWh as well as in g/km and g/ton.km emissions. In that way the overall performance of the vessel is presented, including the efficiency of the vessel (driveline and hull) and the sailing and (if desired) the logistics efficiency.

Part of the monitoring evaluation is also the data processing and presentations. Basically a number of presentations will be considered, ranging from most simple to very extensive:

a) a warning light indicating good or bad performance of the vessel to the skipper with/without a formal logging of the number of non-compliances;

b) display of the real time NOx emission to the skipper with/without a formal logging of these numbers (in combination with engine speed or other engine parameters;

c) a or b, in combination of the information in a central database assessable to a branch organization and/or certain authorities.

4.3 Enforcement

Actual Enforcement can be done in many ways but is not a part of the real life testing in WP5.
The work will be limited to the review of technical options to collect the data and present them in simple ways, linked to the type approval requirements of the engine(s).
The way of enforcement is at the end a political decision of the competent authorities.

5 Data Analysis of Real-Life Testing

5.1 Data Collection

Sailing emissions can be expressed in a number of ways. Emissions expressed as a function of delivered power, namely g/kWh, are most common in evaluating emissions of an engine. These values can directly be compared between different engines on different vehicles. In road transport and passenger cars emissions expressed as a function of covered distance, mainly g/km, are the common practice. Calculation of emissions therefor do not only consists of the calculation of emissions but also of the evaluation of the engine load or distance covered.
Precision of the data collected greatly depends on the way it is obtained. Although the sensors used in SEMS or OBM solutions are cheap compared to a PEMS system, they have sufficient accuracy and precision (around 2%). Inaccuracy is introduced when parameters which cannot directly be measured are calculated. PEMS, SEMS or OBM systems are measuring the concentrations of NOx and O2. With PEMS also CO2, HC and CO are measured. These concentrations need to be converted to mass flows and consequently they can be converted to g/h, g/kWh and g/km emissions.

For conversion to (NOx) emission mass flows three options are available:

- The standard option for laboratory testing: measurement of Mass Air Flow (MAF) and fuel flow. Adding these two will give the Mass Exhaust Flow, which is directly used to calculate the mass emissions;
- Measurement of the fuel flow in combination with the carbon balance method. The ratio of NOx concentration and CO2 concentration in combination with the fuel flow is sufficient to calculate the NOx mass flow [Verbeek 2001].
- Measurement of engine power in combination with the carbon balance method. The engine power is used to calculate the fuel flow based on the specific fuel consumption characteristic of the engine being tested. Consequently the calculation is according to the second one.

Of course every step may introduce some form of inaccuracy. The purpose of the program is to analyse this.
In the case of modern engines, the MAF is calculated by the engine ECU with good precision. In cars and trucks, this is standard practice. In marine applications MAF calculated by the engine ECU is not yet very common and MAF must be measured. Due to the high MAF in large engines an automotive type MAF-sensor cannot be used. The MAF is calculated indirectly based on engine revolutions (RPM), turbo pressure and temperature or by combining the results of fuel flow and with CO2 measurements. An aftermarket measurement of MAF is less precise due to the limited calibration options and limited knowledge of the engine. In conclusion, MAF is a very important factor when calculating different emission related parameters and the precision and accuracy on the MAF have large influence on the overall precision and accuracy. The method with MAF, will be compared with options 2 and 3 indicated above.
NOx emissions are measured as a mass concentration by a NOx sensor. Automotive sensors are used and obtain a precision in the order of 2%. In systems with NOx reduction, the accuracy can be strongly influenced by the position of the sensor. When an SCR is applied the NOx conversion within the SCR can show streams with high and lower NOx reduction. These discrepancies are the effect of uneven reagent (NH3) distribution across the catalyst surface. This can be solved by placing the NOx sensor far enough downstream of the catalyst.

CO_2 production can be based on fuel consumption or can be calculated based on the O_2 consumption. In both cases is assumed that fuel combustion is close to ideal and that the mass fraction of other emissions (CO, HC) is negligible.
PM emissions cannot be measured using regular OBD sensors. There are sensors available that can be used to check the performance of the DPF. These sensors can only be used in very low PM environments. They should be considered as qualitative sensors and not as quantitative sensors.
Fuel consumption can be calculated by the engine ECU, it can be directly measured by a flow sensor on the fuel lines, and it can be calculated from O_2 consumption. The precision of the different techniques varies strongly.
Propulsion power must be used in all calculations. Propulsion power can be broadcasted by the engine ECU or calculated from fuel consumption and RPM using efficiency corrections and deduction engine operation related power losses. The characteristic of the specific fuel consumption along the propeller curve in the engine map, can be used to calculate the power based on the actual fuel consumption.

5.2 Data Processing and Presentation

To make calculations of emissions expressed in g/kWh and in g/km compatible between different applications, vessels and test cycle reports, a number of details require specific attention.
All values are measured with a period of 10 seconds. Averages will be calculated over a time of one hour. The emissions [g], power [kW], distance covered [km] over one hour [h] will be calculated and these values will be used to calculate emissions in g/kWh, g/h or g/km or the totals (emissions [g], distance [km], time [h]). These emissions will be calculated on an hourly time base, on a yearly average and on trip basis.
The time scale on which the emissions are measured and the way they are averaged have a significant influence on the outcome. In PROMINENT SWP 5.1 it was decided to measure the data with a period of 10 s (0.1 Hz). Averages will be made over one hour. This ensures that small time dependent variations or spikes will be averaged out. The timescales of hours also correspond with the timescales of operations on board. It leaves room to average a number of shorter manoeuvres and gives insight on the emissions during longer stretches of continuous sailing.
Periods of long idling, complex harbour manoeuvres, long continuous sailing all have their specific characteristics and the calculation method can strongly influence the outcome of the calculated emission values in these different profiles. The PROMINENT partners will evaluate and synchronise the calculation method.
During idling and harbour manoeuvres the covered distance is close to zero, which makes emissions in g/km useless. For these load profiles total emissions or emissions expressed in g/h are most relevant. However, these values cannot be compared between different engines and vessels, but they can be included in the overall trip emissions.
The time distribution of different sailing characteristics will be presented using histograms. These will be made for: power, engine speed, vessel speed and probably also for exhaust gas temperature. The emissions will also be presented in these histograms. Again this can be done with NO_x expressed in g/kWh or in mass (g). Below an illustration of such a graph is given.

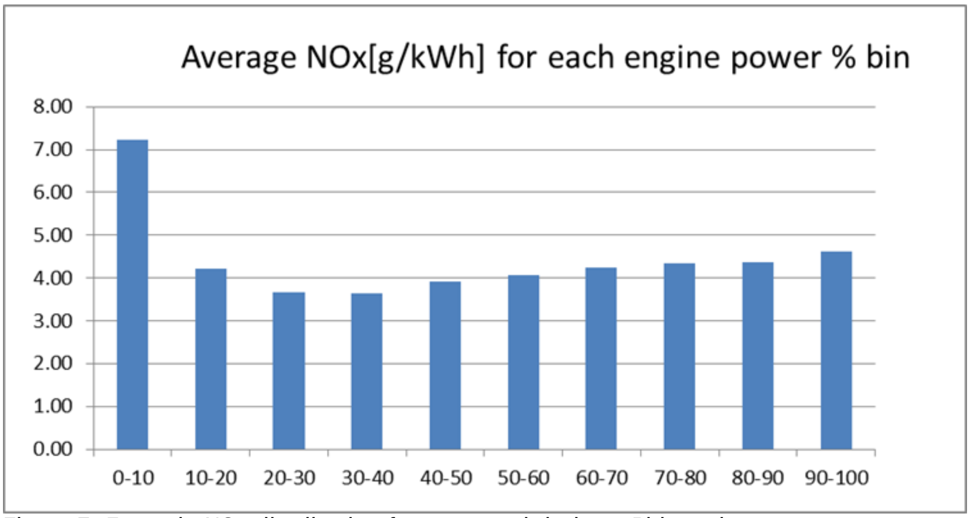

Figure 7. Example NOx distribution from a vessel during a Rhine trip

It will be attempted to make a geographical map of the total emissions of every vessel.

To compare the testbed results of the ISO 8178 E3 cycle with the real sailing results an emission score will be calculated using the same weighting factors. The emissions will be binned based on engine load in accordance with the E3 cycle. Then the weighting factors will be used to calculate the real sailing E3 cycle emissions. These two values, lab-E3 cycle and real sailing-E3 cycle can then be compared to Real Sailing Emissions (RSE), calculated from the total emissions and total power. Below a figure is given where the lab-E3 cycle and real sailing-E3 cycle are compared with effective emissions.

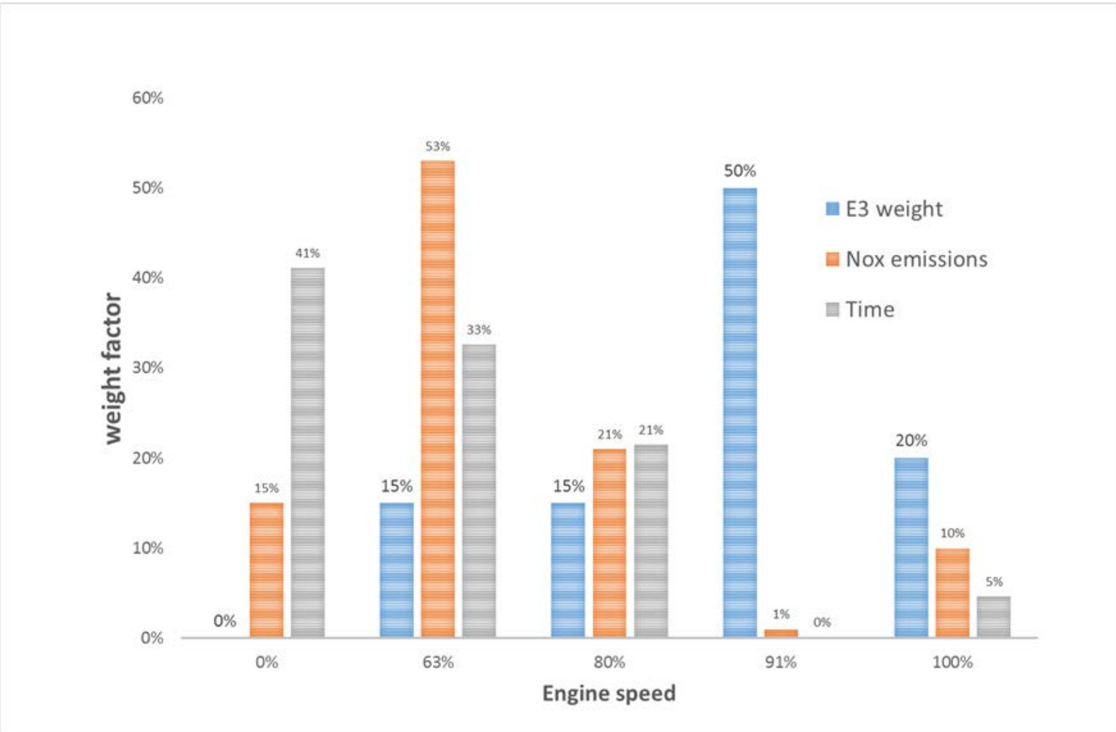

Figure 8: Example of E3 weight factors, compared to sailing time and NOx emissions for the different load points of the E3 cycle

In PROMINENT D1.1 - ANNEX A3 a list of representative journeys was defined. A number of trips from this list will be selected. For these selected journeys the total emissions for every single journey will be calculated. The emission profile of these trips can be studied as well.

6 References

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On-road NOx and CO2 investigations of Euro 5 Light Commercial Vehicles, Kadijk et. al., 2015 TNO report TNO 2015 R10192

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Appendix A: Parameter List

General fixed ship parameters				
Parameter_name	short name	format	unit	source (to be filled out once)
ship identification	**Ship ID**	123456789		manual or ships documentname
length_over_all	**length**	xxx.x	m	manual or ships documentname
beam	**beam**	xx.x	m	manual or ships documentname
maximum_draught	**max. draught**	x.x	m	manual or ships documentname
ship type	**ship type**	text		manual or ships documentname
operational configuration	**config**	text		ship operator
propulsion_configuration	**propconfig**	text		manual or ships documentname
propellor 1_diameter	**propdiam1**	x.x	m	manual or ships documentname
propellor 2_diameter	**propdiam2**	x.x	m	manual or ships documentname
propellor 3_diameter	**propdiam3**	x.x	m	manual or ships documentname
gearbox 1_ratio	**gearrat1**	x.xxx	1:x.xxx	manual or ships documentname
gearbox 2_ratio	**gearrat2**	x.xxx	1:x.xxx	manual or ships documentname
gearbox 3_ratio	**gearrat3**	x.xxx	1:x.xxx	manual or ships documentname
prop1_engine_power_mcr	**PWR1**	xxxx	kW	manual or ships documentname
prop2_engine_power_mcr	**PWR2**	xxxx	kW	manual or ships documentname
prop3_engine_power_mcr	**PWR3**	xxxx	kW	manual or ships documentname
engine 1_RPM_max	**RPM1**	xxxx	rev./min	manual or ships documentname
engine 2_RPM_max	**RPM2**	xxxx	rev./min	manual or ships documentname
engine 3_RPM_max	**RPM3**	xxxx	rev./min	manual or ships documentname
cargo_capacity	**cargo_cap**	xxxxx	ton	manual or ships documentname
Cargo table	**Cargo_table**	x.xx / xxxx	m / ton	manual or ships documentname

Dynamic measurement parameters on-board				
Parameter_name	short name	format	unit	source (usually)
ship identification	**Ship ID**	123456789		manual or ships documentname
actual operational configuration	**config**	text		ship operator
engine_nr	**engnr**	x	#	manual
date	**date**	151110	yymmdd	AIS or CAN-bus
time	**time**	134900	Hhiiss	AIS or CAN-bus
liquid_fuel_consumption (LFC)	**LFC**	x.x	L/h	CAN-bus (J1939)
mass_air_flow (MAF)	**MAF**	x.x	kg/h	CAN-bus (J1939)
engine_coolant_temperature (ECT)	**ECT**	xx	degC	CAN-bus (J1939)
actual_engine_torque (AET)	**AET**	xx	%	CAN-bus (J1939)
reference_torque (RET)	**RET**	xxxx	Nm	manufacturer/CAN-bus (J1939)
engine_speed (RPM)	**RPM**	xxxx	rev./min	CAN-bus (J1939)
actual_draught_fwd	**TF**	x.xx	m	usually manual, once per trip
actual_draught_aft	**TA**	x.xx	m	usually manual, once per trip
additional draught pusher?	**ADP**	x.xx		
actual_cargoweight	**DWT**	xxxxx	ton	usually manual, once per trip
echo sounder	**ES**	x.xx	m	
Position of echo sounder with respect to satelite positioning system?	**Pos_ES**			
STW (speed to water)	**STW**	xx.x	m/s	Ultrasonic transducers NMEA 0183
SOG (speed over ground)	**SOG**	xx.x	m/s	AIS or instrument
River flow velocity	**RFV**	xx.x	m/s	Can be calculated from SOG and STW
Longitude	**lon**	xxx.xxx	deg.dec	AIS or instrumentname
Latitude	**lat**	xxx.xxx	deg.dec	AIS or instrumentname
Direction (track angle)	**dir**	xxx	deg	Can be collected from AIS
Rudder position	**RP**	xxx	deg	
NOx	**Nox**	xxxx	ppm	NOx sensor
O2	**O2**	xx	%	O2 sensor
PM?	**PM**			
Exhaust gas temperature	**ExhT**	xxxx	°C	Temperature sensor
Gensets: up to 4				
Generator_power	**GenPWR**			
Alternative for power: Generator_vo	**GenVolt**	xxxx	Volt	instrument or manual
Alternative for power: Generator_cu	**GenAmp**	xxxx	Ampere	instrument
Amount of signals depends on hybrid configuration				
Battery Voltage	**BattVolt**	xx	Volt	CAN-buc (J1939)
Motor_voltage	**MotVolt**	xxxx	Volt	instrument or manual
Motor_current	**MotAmp**	xxxx	Ampere	instrument