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

D6.1 Evaluation guidance report with methodology and templates

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1. Purpose of this guidance document

The overall aim of the PROMINENT project is to promote innovation in the inland waterway sector. Innovations are thereby largely concentrated on those technologies and concepts, which could support inland waterway transport becoming more economically and environmentally competitive (energy consumption, carbon footprint, pollutant emissions).

The specific targets of the PROMINENT project are to

- Develop cost-effective solutions applicable to 70% of the fleet and reduce the implementation costs by 30%;
- Involve all relevant stakeholders;
- Actively address and remove implementation barriers.

In order to reach these targets, the PROMINENT consortium will carry out a series of different pilots. The technologies and concepts that qualified for pilot operations were selected in the course of the project (WP1). In Annex 1 the relevant background information for this deliverable is summarised. It particularly presents the findings of WP1 and the main indicators and targets that are relevant for the pilots in WP5.

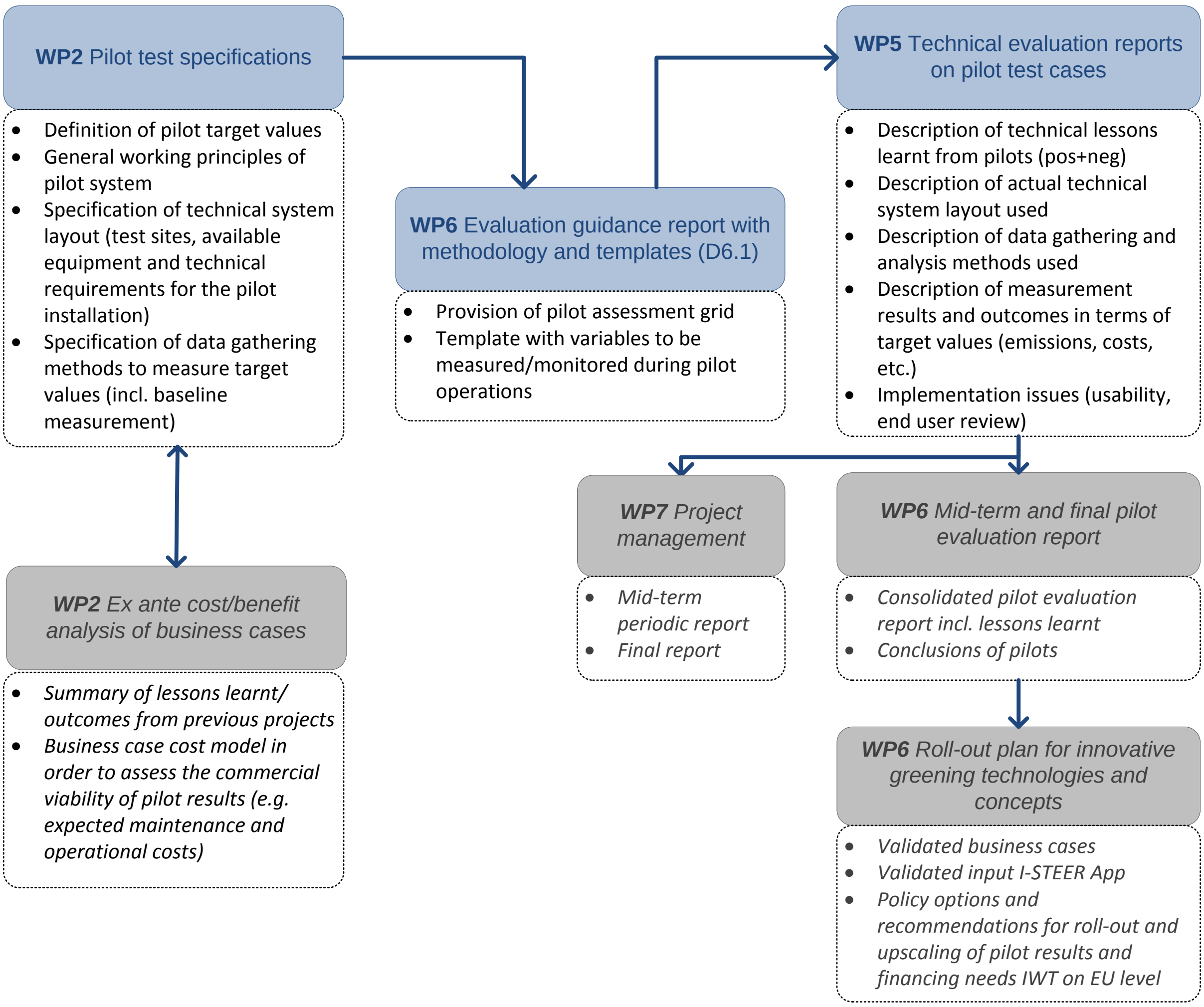
The pilot operations should ultimately demonstrate to what extent the ambitious overall targets can be reached. Furthermore, the pilots should not be seen as singular demonstrations, but more importantly, the pilot activities and analyses should allow the formulation of conclusions on the macro-level, that is, allow the definition of a realistic roll-out plan for the proven technologies and concepts. This roll-out plan is expected to present a mix of technologies and concepts, tailored to fleet families and typical operating areas. The outcomes and experiences of the pilot operations should therefore be collected and monitored in a coordinated and harmonised way.

This deliverable has two main purposes

- **Allow harmonised and coordinated data collection:** Make sure that the data collected during pilot operations can be used for overall evaluations and assessments. By defining the data requirements for the evaluation and assessment process – which takes place in WP6 – Deliverable 6.1 specifies which data the pilot operators of WP5 should record and monitor. The coordinated approach should subsequently also allow the formulation of well-founded and comparable conclusions with regard to the roll-out and upscaling of technologies and concepts that have been tested through the pilots.
- **Allow timely progress monitoring**: The data collected and consolidated through the respective assessment grids will be fed into the mid-term pilot evaluation report (D6.2). Should expected outcomes and targets of the pilots not be reached, the data collected through the assessment grid will allow the early identification of possible adaptations or remedial actions.

2. Positioning Deliverable 6.1 within the PROMINENT WP structure

Deliverable 6.1 (*Evaluation guidance report with methodology and templates*) provides the link between the preparation of the pilot activities (WP2-4) and the actual pilot operation (WP5) on the one hand, and the assessment of outcomes as well as the development of a roll-out strategy on the other hand[1].



The main deliverables in WP2 (pilot test specifications and ex ante cost-benefit analyses) shall *ex ante* define the main target values, the technical system layout of the pilots, the proposed data gathering methods, as well as the business case cost model. The technical pilot evaluation reports of WP5 shall *ex post* describe the technical lessons-learnt (both positive and negative), the actual technical system layout used, the actual data gathering and analysis methods used, as well as the measurement results and outcomes in terms of target values (emissions, costs, etc.) and implementation issues (usability, end user review, implementation barriers).

Based on the contents of the technical pilot evaluation reports and the filled-in D6.1 assessment grids, the mid-term and final pilot evaluation reports can be drafted. These deliverables in turn

[1] Please see also Annex 2 for a more detailed specification about the inputs and interlinkages of SWP 6.1 with other parts in PROMINENT

provide the main foundation for the overall roll-out plan. This roll-out plan contains policy options and recommendations for the roll-out and upscaling of the pilot results. As the roll-out plan shall probably also contain policy recommendations on European level, the impact assessment methodology shall be taken into account as well (see Annex 3).

3. Assessment grids and templates for pilot evaluation

Based on the requirements of the pilot evaluation process and the development of the roll-out strategy (WP6), different assessment grids/templates have been developed and coordinated with the respective SWP5 leaders (pilot coordinators).

The different variables and target values have been divided into five main categories:

- Vessel types used
- Journey characteristics
- Benefits of pilot
- Cost impacts of pilot
- Implementation and roll-out issues

Moreover, three measurements are foreseen for each variable:

- Baseline value (comparable data before pilot execution)
- Expected pilot outcome (*ex ante* - before pilot execution)
- Actual pilot value (*ex post* – after pilot execution)

Whereas the overall structure is the same for all pilot types (to allow comparison), the assessment grids have been customised for the specific pilot types as much as possible. A summarising overview of the technologies tested in the pilots is presented in the Annex 4.

a. Assessment grid for pilot on Monitoring exhaust gas emissions and operational profiles on existing innovative vessels (SWP 5.1)

Dimensions	Explanation	Unit	Baseline value (comparable data before pilot execution)	Expected pilot value (before pilot execution)	Actual pilot value (after pilot execution - to be reported during mid-term evaluation)
Vessel type used					
Main engine power	What is the total power of the main engines?	kW			
Number of engines on board		number			
Number of auxiliary engines		number			
Power of auxiliary engines		kW			
Type of main engine 1	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 1	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	profile/function	gram fuel consumption per kWh, per load rate			
Type of main engine 2	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 2	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	profile/function	gram fuel consumption per kWh, per load rate			
Type of main engine 3	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 3	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	profile/function	gram fuel consumption per kWh, per load rate			
Type of auxiliary engine(s)	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Other relevant vessel characteristics with impact on test result	e.g. number of propellers, propeller configuration, diameter propellers, etc.	[verbal description]			
Loading capacity	What is the maximum effective loading capacity of the vessel?	tonnes/TEU/M3			
Length	What is the length of the entire convoy?	metres			
Width	What is the width of the entire convoy?	metres			
Empty draught	What is the draught of the stationary and empty vessel?	metres			
Loaded draught	What is the draught of the stationary and fully loaded vessel?	metres			
Vessel configuration	Convoy shape, number of barges	[verbal description]			
Referenced fleet family	Which vessel type was used in the pilot test procedure? Choose the fleet family with the closest match.				
Journey characteristics					
Date and time of pilot operations		date pilot started			
Typical journey or operating area	Port names, river names	[verbal description]			
Sailed kilometres (full and empty)	distance	km			
Sailed kilometres empty	distance	km			
Hours engine 1 (if relevant share running on LNG)					
Hours engine 2 (if relevant share running on LNG)					
Hours engine 3 (if relevant share running on LNG)					
Cargo transported	total volume transported during pilot	tonnes/TEU/M3			
Average payload	With how many cargo was the vessel loaded on average per km (incl. empty trips)?	tonnes/TEU/M3			
Total kWh consumed	Total energy usage	kWh			
Total kWh consumed by engines equiped with LNG	Energy usage	kWh			
Distribution engine load / operational profile (1)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Distribution engine load / operational profile (2)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Distribution engine load / operational profile (3)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Average revolutions per minute (1)	Average number of revolutions during pilot test (or distribution?)	rpm			
Average revolutions per minute (2)	Average number of revolutions during pilot test (or distribution?)	rpm			
Average revolutions per minute (3)	Average number of revolutions during pilot test (or distribution?)	rpm			
Referenced typical journey	Which journey was undertaken in the pilot test procedure? Choose the fleet family with the closest match.				
Pilot data					
Fuel consumption diesel	Indicate the fuel consumption	kg			
Fuel consumption LNG	Indicate the fuel consumption	kg			
Energy value LNG	energy value	MJ per kg			
Urea consumption	indicate the urea consumption	kg			
Emissions	CO_2 emissions	kg in total and in grams per kWh			
	NO_x emissions	kg in total and in grams per kWh			
	PM emissions	kg in total and in grams per kWh			
	PN	number per kWh			
	CH_4 emission (methane slip)	kg in total and in grams per kWh			
	NH_3 emissions	kg in total and in grams per kWh			
	Other relevant emissions (e.g. SO_2, CH_4)	kg			

Dimensions	Explanation	Unit	**Baseline value** (comparable data before pilot execution)	**Expected pilot value** (before pilot execution)	**Actual pilot value** (after pilot execution - to be reported during mid-term evaluation)
Costs impacts of pilot					
Initial investments	Cost of on board monitoring system (hardware)	EUR			
	Installation costs of monitoring equipment on board	EUR			
	Verification and calibration costs (using PEMS)	EUR			
	Measurement cost with PEMS	EUR			
	Number of days installation time	days			
	Certification costs	EUR			
	Costs for out-of-service time (needed for installation of pilot equipment)	EUR			
Operational costs	Impact on maintenance costs (marginal costs due to equipment)	EUR			
	Data communication costs	EUR			
	Other impact on operational costs (e.g. communication/roaming costs, Lizenzgebühren for system operation, etc.)	EUR			
Other relevant benefits	Carbon footprint and emission performance labels for clients	[verbal description]			
Other relevant benefits	Which other relevant benefits did you observe during the pilot operation, compared to conventional operation? E.g. changed behaviour of staff resulting in lower fuel consumption? Others?	[verbal description]			
Implementation and roll out issues					
Technology readiness level					
Assessment of implementation barriers					
	Technical: reliability, level of proper full continous monitoring without errors?	[verbal description, and indication ...% of time of pilot data was recorded properly]			
	Technical: accuracy, difference between mobile device (PEMS) and fixed On Board Measurement	[verbal description, and % difference]			
	Technical: durability; lifetime of sensors and equipment, experienced failures of equipment?	[verbal description]			
	legal / enforcement: what is the level of acceptance at inspection and certification, enforcement bodies?	[verbal description]			
	other technical: space, engine requirements				
	cultural: issues with staff on board, willingness to innovate, awareness clients as regards environment, ...?	[verbal description]			
	knowlegde: problems acceptance, abilities of human resources, awareness at clients, skills and education suppliers, ...?	[verbal description]			
	legal: certification efforts, anti-tempering measures, reliability, fraud proof, ...?	[verbal description]			
	market: willingness to pay from shippers, incentives, marketing/sales advantages?	[verbal description]			
	financial: investment barriers, operational costs?	[verbal description]			
Test environment	Which external circumstances could have influenced the test result (positively and/or negatively)?	[verbal description]			
Replicability of test results	Describe how reliable, accurate and reproducible the used measurement methods were. Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Transferability of test results	To what extent can the test results be transferred and scaled up to other fleet families and typical journeys. Can large deviations in the outcomes be expected if the pilot were applied in another context? Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Other points of attention	...				

b. Assessment grid for pilot on Pilot LNG (SWP 5.2)

Dimensions	Explanation	Unit	Baseline value (comparable data before pilot execution)	Expected pilot value (before pilot execution)	Actual pilot value (after pilot execution - to be reported during mid-term evaluation)
Vessel type used					
Main engine power	What is the total power of the main engines?	kW			
Number of engines on board		number			
Number of auxiliary engines		number			
Power of auxiliary engines		kW			
Type of main engine 1	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 1	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	profile/function	gram fuel consumption per kWh, per load rate			
Type of main engine 2	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 2	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	profile/function	gram fuel consumption per kWh, per load rate			
Type of main engine 3	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 3	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	profile/function	gram fuel consumption per kWh, per load rate			
Type of auxiliary engine(s)	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Other relevant vessel characteristics with impact on test result	e.g. number of propellers, propeller configuration, diameter propellers, etc.	[verbal description]			
Loading capacity	What is the maximum effective loading capacity of the vessel?	tonnes/TEU/M3			
Length	What is the length of the entire convoy?	metres			
Width	What is the width of the entire convoy?	metres			
Empty draught	What is the draught of the stationary and empty vessel?	metres			
Loaded draught	What is the draught of the stationary and fully loaded vessel?	metres			
Vessel configuration	Convoy shape, number of barges	[verbal description]			
Referenced fleet family	Which vessel type was used in the pilot test procedure? Choose the fleet family with the closest match.				
Journey characteristics					
Date and time of pilot operations		date pilot started			
Typical journey or operating area	Port names, river names	[verbal description]			
Sailed kilometres (full and empty)	distance	km			
Sailed kilometres empty	distance	km			
Hours engine 1 (running on LNG)					
Hours engine 2 (running on LNG)					
Hours engine 3 (running on LNG)					
Cargo transported	total volume transported during pilot	tonnes/TEU/M3			
Average payload	With how many cargo was the vessel loaded on average per km (incl. empty trips)?	tonnes/TEU/M3			
Total kWh consumed	Total energy usage	kWh			
Total kWh consumed by engines equiped with LNG	Energy usage	kWh			
Distribution engine load / operational profile (1)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Distribution engine load / operational profile (2)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Distribution engine load / operational profile (3)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Average revolutions per minute (1)	Average number of revolutions during pilot test (or distribution?)	rpm			
Average revolutions per minute (2)	Average number of revolutions during pilot test (or distribution?)	rpm			
Average revolutions per minute (3)	Average number of revolutions during pilot test (or distribution?)	rpm			
Exhaust gas temperature	Temperature distribution, relevant for the technical effectiveness of SCR	% interval celcius (0-150, 150-200, 200-250, >250)			
Referenced typical journey	Which journey was undertaken in the pilot test procedure? Choose the fleet family with the closest match.				
Benefits of pilot					
Fuel consumption diesel	Indicate the fuel consumption	kg			
Fuel consumption LNG	Indicate the fuel consumption	kg			
Energy value LNG	energy value	MJ per kg			
Urea consumption	indicate the urea consumption	kg			
Emissions	CO2 emissions	kg in total and in grams per kWh			
	NOx emissions	kg in total and in grams per kWh			
	PM emissions	kg in total and in grams per kWh			
	PN	number per kWh			
	CH4 emission (methane slip)	kg in total and in grams per kWh			
	NH3 emissions	kg in total and in grams per kWh			
	Other relevant emissions (e.g. SO2, CH4)	kg			

Dimensions	Explanation	Unit	**Baseline value** (comparable data before pilot execution)	**Expected pilot value** (before pilot execution)	**Actual pilot value** (after pilot execution - to be reported during mid-term evaluation)
Costs impacts of pilot					
Initial investments	Total costs of standard modules pilot equipment (hardware)	EUR			
	a) Cost LNG Tank	EUR			
	b) Cost tank connection space	EUR			
	c) Cost water/glycol pack	EUR			
	d) Cost bunker station	EUR			
	e) Cost control and monitoring system	EUR			
	Installation costs of equipment on board	EUR			
	Installation costs of control devices	EUR			
	Verification costs	EUR			
	Measurement costs (SGS)	EUR			
	Number of days installation time	days			
	Certification costs	EUR			
	Costs for out-of-service time (needed for installation of pilot equipment)	EUR			
Operational costs	Fuel costs diesel	EUR			
	Fuel cost LNG	EUR			
	Lubricant costs	EUR			
	Urea costs	EUR			
	Impact on maintenance costs (e.g. filter exchange, etc.) (marginal costs due to equipment)	EUR			
	Loss of payload due to LNG fuel tank	tonnes/TEU/M3			
	Loss of turnover due to weight/space LNG fuel tank	EUR			
	Reduction of cost for port dues	EUR			
	Other impact on operational costs (e.g. communication/roaming costs, Lizenzgebühren for system operation, etc.)	EUR			
Other relevant benefits	Which other relevant benefits did you observe during the pilot operation, compared to conventional operation e.g. improved manoevrability, more roundtrips per year, more cargo or interest from clients, higher freight rates, reduction of vibrations, etc.	[verbal description]			
Implementation and roll out issues					
Technology readiness level					
Assessment of implementation barriers					
	technical: space, engine requirements, durability/reliability issues?	[verbal description]			
	cultural: issues with staff on board, willingness to innovate, awareness clients as regards environment, ...?	[verbal description]			
	knowlegde: problems acceptance, abilities of human resources, awareness at clients, skills and education suppliers, ...?	[verbal description]			
	legal: certification efforts, anti-tempering measures, reliability, fraud proof, ...?	[verbal description]			
	market: willingness to pay from shippers, incentives, marketing/sales advantages?	[verbal description]			
	financial: investment barriers, operational costs?	[verbal description]			
Test environment	Which external circumstances could have influenced the test result (positively and/or negatively)?	[verbal description]			
Replicability of test results	Describe how reliable, accurate and reproducible the used measurement methods were. Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Transferability of test results	To what extent can the test results be transferred and scaled up to other fleet families and typical journeys. Can large deviations in the outcomes be expected if the pilot were applied in another context? Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Other points of attention	...	[verbal description]			

c. Assessment grid for pilot on Pilots diesel after treatment (SWP 5.3)

Dimensions	Explanation	Unit	**Baseline value** (comparable data before pilot execution)	**Expected pilot value** (before pilot execution)	**Actual pilot value** (after pilot execution - to be reported during mid-term evaluation)
Vessel type used					
Main engine power	What is the total power of the main engines?	kW			
Number of engines on board		number			
Number of auxiliary engines		number			
Power of auxiliary engines		kW			
Type of main engine 1	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 1	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	average figure or profile/function	gram fuel consumption per kWh			
Type of main engine 2	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 2	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	average figure or profile/function	gram fuel consumption per kWh			
Type of main engine 3	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Age of main engine 3	Year of construction	year			
Maximum continuous rating	rpm - revolution per minute	rpm			
Specific fuel consumption	average figure or profile/function	gram fuel consumption per kWh			
Type of auxiliary engine(s)	engine brand and model, back pressure, certification (pre-CCNR, CCNR Stage 1, CCNR, Stage 2)	verbal description			
Other relevant vessel characteristics with impact on test result	e.g. number of propellers, propeller configuration, diameter propellers, etc.	[verbal description]			
Loading capacity	What is the maximum loading capacity of the vessel?	tonnes/TEU/M3			
Length	What is the length of the entire convoy?	metres			
Width	What is the width of the entire convoy?	metres			
Empty draught	What is the draught of the stationary and empty vessel?	metres			
Loaded draught	What is the draught of the stationary and fully loaded vessel?	metres			
Vessel configuration	Convoy shape, number of barges	[verbal description]			
Referenced fleet family	Which vessel type was used in the pilot test procedure? Choose the fleet family with the closest match.				
Journey characteristics					
Date and time of pilot operations		date pilot started			
Typical journey or operating area	Port names, river names	[verbal description]			
Sailed kilometres (full and empty)	distance	km			
Sailed kilometres empty	distance	km			
Hours engine 1 (equiped with SCR, DPF)					
Hours engine 2 (equiped with SCR, DPF)					
Hours engine 3 (equiped with SCR, DPF)					
Cargo transported	total volume transported during pilot	tonnes/TEU/M3			
Average payload	With how many cargo was the vessel loaded <u>on average</u> per km (incl. empty trips)?	tonnes/TEU/M3			
Total kWh consumed	Total energy usage	kWh			
Total kWh consumed by engines equiped with SCR,DPF	Energy usage	kWh			
Distribution engine load / operational profile (1)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Distribution engine load / operational profile (2)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Distribution engine load / operational profile (3)	Distribution of engine load during pilot test.	kW, intervals: 0%-10%, 10%-20%,...90-100%.			
Average revolutions per minute (1)	Average number of revolutions during pilot test (or distribution?)	rpm			
Average revolutions per minute (2)	Average number of revolutions during pilot test (or distribution?)	rpm			
Average revolutions per minute (3)	Average number of revolutions during pilot test (or distribution?)	rpm			
Exhaust gas temperature	Temperature distribution, relevant for the technical effectiveness of SCR	% interval celcius (0-150, 150-200, 200-250, >250)			
Referenced typical journey	Which journey was undertaken in the pilot test procedure? Choose the fleet family with the closest match.				
Benefits of pilot					
Fuel consumption	Indicate the fuel consumption	kg			
Urea consumption	indicate the urea consumption	kg			
Emissions	CO2 emissions	kg in total and in grams per kWh			
	NOx emissions	kg in total and in grams per kWh			
	PM emissions	kg in total and in grams per kWh			
	PN	number per kWh			
	NH3 emissions	kg in total and in grams per kWh			
	Other relevant emissions (e.g. SO2, CH4)	kg			

Dimensions	Explanation	Unit	**Baseline value** (comparable data before pilot execution)	**Expected pilot value** (before pilot execution)	**Actual pilot value** (after pilot execution - to be reported during mid-term evaluation)
Costs impacts of pilot					
Initial investments	Costs of purchasing pilot equipment (hardware)	EUR			
	Installation costs of pilot equipment	EUR			
	Number of days installation time	days			
	Certification costs	EUR			
	Costs for out-of-service time (needed for installation of pilot equipment)	EUR			
Operational costs	Fuel costs	EUR			
	Lubricant costs	EUR			
	Urea costs	EUR			
	Impact on maintenance costs (e.g. filter exchange, etc.) (marginal costs due to equipment)	EUR			
	Reduction of cost for port dues	EUR			
	Other impact on operational costs (e.g. communication/roaming costs, Lizenzgebühren for system operation, etc.)	EUR			
Other relevant benefits	Which other relevant benefits did you observe during the pilot operation, compared to conventional operation e.g. improved manoevrability, more roundtrips per year, more cargo or interest from clients, higher freight rates, reduction of vibrations, etc.	[verbal description]			
Implementation and roll out issues					
Technology readiness level					
Assessment of implementation barriers		[verbal description]			
	technical: space, engine requirements, durability/reliability issues?	[verbal description]			
	cultural: issues with staff on board, willingness to innovate, awareness clients as regards environment, ...?	[verbal description]			
	knowlegde: problems acceptance, abilities of human resources, awareness at clients, skills and education suppliers, ...?	[verbal description]			
	legal: certification efforts, anti-tempering measures, reliability, fraud proof, ...?	[verbal description]			
	market: willingness to pay from shippers, incentives, marketing/sales advantages?	[verbal description]			
	financial: investment barriers, operational costs?	[verbal description]			
Test environment	Which external circumstances could have influenced the test result (positively and/or negatively)?	[verbal description]			
Replicability of test results	Describe how reliable, accurate and reproducible the used measurement methods were. Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Transferability of test results	To what extent can the test results be transferred and scaled up to other fleet families and typical journeys. Can large deviations in the outcomes be expected if the pilot were applied in another context? Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Other points of attention	...	[verbal description]			

d. Assessment grid for pilot on energy efficient navigation (SWP5.4)

Dimensions	Explanation	Unit	Baseline value (comparable data before pilot execution)	Expected pilot value (before pilot execution)	Actual pilot value (after pilot execution - to be reported during mid-term evaluation)
Vessel type used					
Main engine power	What is the power of the main engine?	kW			
Number of engines on board		number			
Number of auxiliary engines		number			
Power of auxiliary engines		kW			
Age of main engine	Year of construction	year			
Other relevant vessel characteristics with impact on test result	e.g. number of propellers, propeller configuration, diameter propellers, steering installation, etc.	[verbal description]			
Maximum continuous rating	rpm - revolution per minute	rpm			
Loading capacity	What is the maximum loading capacity of the vessel?	tonnes			
Payload	With how many tons of cargo was the vessel loaded	tonnes			
Length	What is the length of the entire convoy?	metres			
Width	What is the width of the entire convoy?	metres			
Empty draught	What is the draught of the stationary and empty vessel?	metres			
Loaded draught	What is the draught of the stationary and loaded vessel?	metres			
Vessel configuration	Convoy shape, number of barges	[verbal description]			
Referenced fleet family	Which vessel type was used in the pilot test procedure? Choose the fleet family with the closest match.				
Journey characteristics					
Date and time of pilot operations		date and time			
Origin of journey	Place of embarkement	city name			
Destination of journey	Place	city name			
Waterway sections navigated	On which waterway sections was the pilot carried out? Indicate the river/canal kilometres indicators.	km indicators			
Average engine load	Average engine load during pilot test.	kW			
Average revolutions per minute	Average number of revolutions during pilot test.	rpm			
Referenced typical journey	Which journey was undertaken in the pilot test procedure? Choose the fleet family with the closest match.				
Benefits of pilot					
Fuel consumption	Indicate the fuel consumption	kg			
Emissions	CO2 emissions	kg			
	NOx emissions	kg			
	PM emissions	kg			
	Other relevant emissions (e.g. SO2, CH4)	kg			

Costs impacts of pilot					
Initial investments	Costs of purchasing pilot equipment (hardware)	EUR			
	Installation costs of pilot equipment	EUR			
	Costs for out-of-service time (needed for installation of pilot equipment)	EUR			
Operational costs	Fuel costs	EUR			
	Lubricant and urea costs	EUR			
	Maintenance costs (e.g. filter exchange, etc.)	EUR			
	Other operational costs (e.g. communication/roaming costs, Lizenzgebühren for system operation, etc.)	EUR			
Other relevant benefits	Which other relevant benefits did you observe during the pilot operation, compared to conventional operation e.g. improved manoevrability, more roundtrips per year, reduction of vibrations, etc.	[verbal description]			
Implementation and roll out issues					
Technology readiness level					
Assessment of implementation barriers	technical: space, engine requirements, durability/reliability issues?	[verbal description]			
	cultural: issues with staff on board, willingness to innovate, awareness clients as regards environment, ...?	[verbal description]			
	knowlegde: problems acceptance, abilities of human resources, awareness at clients, skills and education suppliers, ...?	[verbal description]			
	legal: certification efforts, anti-tempering measures, reliability, fraud proof, ...?	[verbal description]			
	market: willingness to pay from shippers, incentives, marketing/sales advantages?	[verbal description]			
	financial: investment barriers, operational costs?	[verbal description]			
Test environment	Which external circumstances could have influenced the test result (positively and/or negatively)?	[verbal description]			
Replicability of test results	Describe how reliable, accurate and reproducible the used measurement methods were. Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Transferability of test results	To what extent can the test results be transferred and scaled up to other fleet families and typical journeys. Can large deviations in the outcomes be expected if the pilot were applied in another context? Please rate on a scale from 1 to 3 and specify reservations or concerns - if any.	1. Good 2. Medium 3. Bad +[verbal description]			
Other points of attention	e.g. accuracy of echo sounder measurements, flow velocity measurements				

4. Next steps

The developed assessment grids for the PROMINENT pilots will be tested together with the responsible pilot coordinators.

First attention will be paid to the pilots that will already start within a few months' time, the Energy Efficient Navigation Pilot (SWP 5.4) and the pilot for diesel after-treatment systems (SWP 5.3). The coordinators of these pilots already checked the templates with the pilot test specifications developed in SWP 2.2. The also the *ex ante* CBA parameters were thereby taken into account.

Since the pilot test specifications for the other pilots (On Board Monitoring – SWP 5.1 and LNG - SWP 5.2) will follow later, a further check will be done on the templates as soon as the pilot coordinators prepared their pilot test specifications and *ex ante* CBAs. The checks will take place for the following questions:

- *Are the required data applicable to your pilot activity?*
- *Are the required data feasible for your pilot activity?*
- *Which data are impossible to collect?*
- *Is it possible to provide a baseline measurement (zero measurement) as well as an ex ante expected value before the start of the pilot activities?*

The developed grids which are presented in chapter 3 are not set in stone. If needed the assessment grids will be adapted and fine-tuned according to the specific needs of the different pilots. They will then be provided to the pilot coordinators before the actual start of pilot operations.

The SWP 6.1 team will closely follow the development of the pilots (e.g. by means of participation to WP5 meetings) and will be standby to give advice and answers on questions from the pilot coordinators as regards the pilot objectives and measurement of data. Having collected practical experience with the assessment grids, they can be flexibly adapted in coordination with the WP6.1 leader in the course of the project.

It is expected that the information on the baseline situation and the expectations will become available while the pilot is started. Next, two interim measurements and reporting moments are planned:

- Month 17 as input for the periodic report of the PROMINENT project, D7.3 – Month 18
- Month 23 as input for the Mid-Term pilot review report, D6.2 – Month 24

Subsequently the final pilot review data collection is expected in Month 30 as input for the Final pilot-review report D6.4, Month 31.

It shall be noted that a flexible and pragmatic approach will be followed, within the boundaries of the two main purposes of this deliverable (as defined in Chapter 1). In many cases the reality is that execution of pilots deviates from the original planning and may come with unexpected problems and challenges, delays, new insights. This might be a reason to adapt the approach for the sake of the quality of the results and recommendations as regards the roll-out.

Annex 1: WP6.1 Background information

Due to the Thematic focus of PROMINENT on **fuels, propulsion systems** (standardised solutions)**, auxiliary systems** and **ship-operational measures**, a selection of measures was made in WP1 (see D1.2) **to be further analysed within PROMINENT**. The most promising technologies are to be tested for situations that are most common and representative for the inland waterway transport market. Some of these measures identified focus primarily on reduction of energy consumption and CO2 while others are focussed specifically on the reduction of pollutant emissions:

Focussed on pollutant reduction:

- **LNG** as fuel in single or dual-fuel engines
- Installation of an **Selective Catalytic Reduction (SCR) diesel after-treatment system** and/or **diesel particulates filter (DPF)**
- **Gas-to-liquid** (GTL – synthetic diesel made from natural gas) as fuel
- **Installation of new engines** complying with CCNR II or the future Stage V

Focussed on CO2 reduction:

- **Support tool for energy efficient navigation** with speed and/or track advice
- **Diesel hybrid propulsion**
- **Right engine size** (install a smaller engine)

In general, the following conclusions can be made based on the research and analyses carried out in WP1:

- LNG as fuel is mainly an opportunity for large vessels that have a lot of fuel consumption per year. In that case the high investment costs of the LNG tank and fuel system can be earned back in savings in fuel costs. Although these vessels have a relatively big share in the emissions of IWT in Europe, the number of vessels suitable for LNG is relatively limited. Moreover, investing in a 100% LNG engine is risky because of the current uncertainty on the price gap between LNG and diesel. The dual fuel engine is more likely to be selected by ship-owners, but the costs are high as result of lack of standardisation. **The efforts to reduce costs by means of standardisation shall be combined with the dual fuel engine and this needs to be validated in the pilot (SWP 5.2) in order to make conclusions on feasibility and roll-out potential.**

- SCR/DPF is a cost-effective solution to reduce NOx and/or PM emissions for all vessels, and is attractive for environmentally conscious clients and/or in sensitive environments (e.g. urban areas). However, cost for periodic maintenance (once a year or more) are high, in particular for the DPF. Additional incentives are needed to increase the acceptance among ship-owners. **In the meantime, also efforts shall aim at cost reductions and increased technical feasibility by means of standardisations and development of modular systems and validation in pilots (SWP 5.3).**

- Energy efficient navigation is considered as a promising concept, in particular if the vessel makes a lot of sailing hours such as push boats and large motor vessels, and it is manoeuvring on free flowing sections with dynamic waterway conditions (strongly influencing fuel consumption). The payback time of investing in equipment will strongly depend on the fuel consumption savings and the required hardware and related investment costs. **The energy efficient navigation technology is tested and the different options shall be validated by means of pilots (SWP 5.4) in order to get a solid view on the roll-out potential.**

- The economic value of hybrid drivetrains and right sizing are very much depending on the specific journey and the related operating profile. These technologies are more seen as niche solutions rather than large scale applications**. Therefore they have not been selected for the pilots, except for the measurement hybrid systems and possibly also right sizing via the on board monitoring pilot (SWP 5.1).**

- Other technologies such as GTL and replacement with new CCNR II engines can have an additional benefit to reduce emissions, but are not stand-alone solutions to bring down the emission levels to one of the three target options defined in PROMINENT. However, they may still be a cost effective solution in terms of costs per kg of pollutant reduction. It can also be used in combination with other technologies. If part of a package they can contribute to achieving the target levels. **GTL and CCNR II engines could possibly be taken into account in the on board monitoring (SWP 5.1).**

The **LNG, SCR, DPF and energy efficiency navigation technologies** shall get the main attention in the further process and shall be validated in the pilots of WP5. Other technologies assessed as particularly promising in SWP 1.2 are – **installation of new engines**, **right sizing** and **hybrid concepts**. These will be assessed by measurements on existing conventional and hybrid ships (and consequent simulations). For **GTL**, monitoring results of vessels that are already sailing with this fuel, will be taken into account in order to validate the achievement of emission levels.

An efficient procedure for certification is a pre-requisite for the successful roll-out of the mainstream greening technologies LNG and diesel after treatment. Therefore, there are specific pilots foreseen to test and validate different options for certification, such as portable measurement devices (PEMS) and on board monitoring (OBM). These however do not have a direct contribution to reduction of emissions or fuel consumption which is the main objective of PROMINENT. The measurement pilots can however be used to validate the impact of other technologies, such as GTL, the emission performance of CCNR II engines.

Next to the pilots focussing on greening technologies following the findings and recommendations from WP 1, also other types of pilots are planned (SWP 5.5), linked to WP4 concerning:

- Prototypes for E-learning (follow-up of SWP 4.1):
    - E-learning module “energy and cost-efficient navigation (smart steaming)
    - E-learning module “handling of (alternative) fuel and cargo, especially dangerous goods”
    - E-learning module “vessel stability”
- Pilot e-SRB and e-Logbook (follow-up of SWP 4.2)
- Pilot Community of Practice (CoP) Logistics education (follow-up of SWP 4.3)

However, these pilots have a different character with different objectives. These pilots will be reviewed in detailed already in WP5 itself in the task 5.5.4. This task will already include the measurement of impacts, technical issues and implementation issues and will therefore provide the direct input for the SWP 6.4 (task 6.4.3). As a result, there is no need to develop a template and methodology for these specific pilots planned in SWP 5.5.

Consequently, based on the expertise of the PROMINENT consortium, **four approaches** have been pre-selected for in-depth analysis in the project, as they are particularly promising in light of achieving the PROMINENT objectives:

1) LNG (Liquefied Natural Gas) as alternative fuel;
2) Modular diesel after treatment systems (selective catalytic reduction (SCR) and Diesel particulate filters (DPF));
3) Energy efficient navigation support systems;
4) Technologies to monitor emissions and for certification.

The following steps have been taken in the process to develop this deliverable:

1) Kick-off meeting at 7 July with WP 6.1 partners
2) Review and summarising methodology guidelines from the Impact Assessment
3) Barriers from “Technology fact sheets” as presented in D1.2: Assessment of the short listed technologies and concepts along detailed criteria, taking the main European fleet families and their operational profiles into account (link to D1.1)
4) Assessment of additional barriers / success factors from D1.3
5) Assessment of specific objectives from pilot specifications
6) Development of an overall generic overview of indicators to be measured and reported
7) Development of pilot specific list of indicators and information fields to be collected from the pilots
8) Validation with pilot partners
9) Finalisation of report D6.1

Moreover, the work will be continued over the next months. Close contacts will be maintained with the pilot operators and the WP leaders in order to guide the pilot process and to serve as helpdesk with respect to the pilot objectives, the methodological issues and data collection requirements.

Key PROMINENT indicators and targets

Based on the overall PROMINENT objectives and more specifically the analyses in WP1, a set of indicators and targets has been developed. Obviously these indicators and targets are also addressed in the pilot review grids (see chapter 3). Indicators and targets have been developed as regards:

- Air pollutant emissions
- Tangible results and wide-spread impact by 2020

The identified assessment elements and its values are based on a summary of literature and previous work in the field. The outcome of this desk research is summarised below.

Air pollutant emissions

In general PROMINENT shall result in improved environmental performance and more competitive IWT services. New technological solutions are to be developed and deployed to achieve emission levels in IWT that reflect the state of the art and are at least similar to those of road transport. Most attention in this respect is paid to the NOx and PM emission from the propulsion system.

In addition, since the number of installed engines per year is limited, also the existing fleet (legacy fleet) shall be targeted in order to ensure results on short term. Input from the side of PROMINENT is expected to provide information on the emission levels that can be expected as a result of promising retrofitting technologies. In terms of CO2 emissions, inland waterway transport already has a very favourable performance compared to road haulage, but further reductions are possible.

PROMINENT therefore aims to support the massive implementation of innovative greening solutions in inland waterway transport in order to improve environmental performance. Furthermore, the economic dimension of the technologies need to be considered as well: in order to further develop IWT as a cost attractive transport solution on the one hand and in order to identify solutions that are attractive business cases from the perspective of the ship owner on the other (e.g. cost savings through less fuel consumption or reduction of port dues). Only through this, the measures will be taken up by the market.

Since the outcome of the revision of the NRMM Directive is still uncertain, the PROMINENT consortium defines a number of possible (voluntary) emission standards in order to analyse the spectrum of favourable technologies and combinations of technologies. Moreover, the emission standards for PROMINENT shall mainly aim at the EXISTING vessels, and therefore focus on standards applicable by means of retrofitting technologies. The following table presents the three selected options to take into account for the targets regarding NOx and PM. These targets shall also be discussed with CESNI[2].

[2] Comité Européen pour l'Élaboration de Standards dans le Domaine de Navigation Intérieure - CESNI , http://www.ccr-zkr.org/10110000-en.html

Proposal limit values to be used for PROMINENT retrofit scenarios:

No	Emission limits In gram per kWh	Reference	Diesel / Emission control technologies assumed: (or PROMINENT target)
1	NO_x < 1.8 PM: no INCREASE	NO_x requirement of Latest proposal NRMM Stage V for IWP > 300 kW	Retrofit solution for SCR
2	NO_x < 1.8 PM < 0.045	EPA Tier 4 marine diesel (for engine > 600 kW)	Target for LNG engines (dual-fuel)
3	NO_x < 1.8 PM < 0.015 Particle Number limit: PN <$1x10^{12}$ per kWh	Latest proposal NRMM Stage V for IWP > 300 kW	Retrofit solution for SCR + DPF

Table 1: Proposed emission targets within PROMINENT

Option number 1 can be seen as a cost-efficient option to at least cut down NOx emissions significantly, as this is possible through the application of SCR only. Option 2 is especially suitable for LNG dual-fuel. Option 3 requires a more advanced technical solution: SCR and a diesel particulate filter to reduce dramatically the emission of PM and NOx. This target can most probably also be achieved by single fuel gas engines (with spark ignition). The further impacts and feasibility of the technologies and the emission standards will be further investigated in PROMINENT, also by means of application of technologies on the pilot vessels. Therefore, in the pilot reviews the emission levels of NOx, PM, PN and also CH4 and NH3 will need to be measures and reported. In addition the CO2 emission is very relevant and this can be derived from the fuel consumption of the vessel.
The following additional requirements apply:

- A Not To Exceed limit (NTE) for NOx: Above 25% power (for shipping also referred to as 'load'). The NOx emissions in individual points in the engine map shall not exceed 150% of the limit value.
- With application of SCR: average NH3 emission must be lower than 10 ppm.
- With application of natural gas (LNG): CH4 emission must be lower than approximately 6 g/kWh (A limit = 6, with reference to NRMM Stage V proposal from 30 June 2015).
- Option 1: No increase of PM emissions must be demonstrated on an engine test bed and durability must be guaranteed by the engine manufacturer (or system integrator) in the following cases:
  - If the base engine settings and/or configuration is adapted such as with EGR and with injection timing change
  - Any retrofit measure which may affect PM emissions or durability in a negative way (EGR, fuel-water emulsion, etc.)

Tangible results and wide-spread impact
Hand- in- hand with emission reduction, the following targets are to be met in order to produce physical results already during project lifetime as well as solutions that are taken up by the market on larger scale no later than 2020:

- ➔ Develop solutions that are applicable to at least 70% of the European inland navigation market, measured in fuel consumption
- ➔ Reduce implementation costs of innovative greening solutions by 30%
- ➔ Produce results on the ground during the project lifetime (2017) and provide a roll-out plan for implementation of project results by 2020 with a focus on retrofit solutions in order to ensure results on this short term.

Consequently, the following elements are relevant from the viewpoint of roll-out towards 2020.

1) **Effects on energy consumption and emissions**

Different technologies address different types of emissions. This is why two sub-criteria are set out:

<u>1a: Target for air pollutant emissions</u> (NOx, PM)
Greening solutions in PROMINENT aim at reducing air pollutant emissions in order to become competitive towards road transport in this field. The aim is to identify technologies that would lead to the emission levels presented in the table 1.

<u>1b: Target for energy consumption and climate change emissions</u> (CO_2, CH_4)
There is no specific PROMINENT target value for reduction of climate change emissions. In any case, the net impact for climate change / greenhouse gas emissions (including methane slip emissions) should not deteriorate. The inclusion of methane slip is relevant to set targets for the LNG technology. However, energy (fuel) savings (and proportional CO_2 reduction) also directly influence the benefit for the ship owner. This is expected to be a prerequisite for the uptake of technologies by the sector. The aim in this field is to at least reach a saving of 5% on the fuel consumption, also taking the possibility of combinations of technologies into account.

2) **Range of impact**

The PROMINENT target is to have as much uptake of the greening technologies by the market as possible. This is influenced by two sub fields:

a) The **technology needs to be applicable on large shares of the fleet** from a <u>technical</u> perspective, having a focus on retrofitting.
b) **The <u>business case</u> has to be attractive for the ship owner.**

<u>a) Technical feasibility</u>
This aim is to develop technologies which are applicability to large parts of the fleet and there is a focus on retrofit possibilities. The pilots shall report on relevant indicators such as the required space, the required state of the engine, type of engine (e.g. rpm, electronic/mechanical), the operational profile and further technical prerequisites for installation.

b) Business case / economic feasibility for the ship owner

The following indicators are relevant for the pilot reviews:

- Investment needed (e.g. ratio of investment related to the capital value of the vessel)
- Impact on revenues (e.g. higher payload, more trips)
- Share of savings on annual operational variable costs (%)
- Risk of investment (sensitivities, uncertainties)

3) Availability for mass implementation by 2020

Technology Readiness Level, TRL

The pilots shall demonstrate the successful application and technical maturity. Relevant for the pilot review is therefore into what extent the technology is ready for roll-out, whether the TRL 9 level has been accomplished by means of the pilot. It shall be noted in the pilot reviews into what extent the TRL 9 level is accomplished for the various fleet families. For certain vessel types and operational profiles the technology might be more challenging compared to others. Therefore, attention will be paid to the technology status for the particular fleet family and experiences already available with the technologies (e.g. pilot projects).

Non-technological maturity

The significance of barriers will also be different for the different fleet families and operational profiles as regards the need for financial and regulatory support to reach emission reductions. Therefore, the barriers will be identified and described and assessed separately for the various fleet families in a qualitative way. The pilot reviews shall address technical, legal, financial barriers as well as such related to knowledge, market or culture. This will be linked to the assessments made in SWP1.3 and presented in the Deliverable 1.3.

Annex 2: Position of SWP 6.1 in the PROMINENT project

Task 6.1.1 concerns the development of the pilot evaluation methodology, templates and guidance. The templates presented in Chapter 3 and being applied during the pilot preparation and execution take into account:

- various inputs on key barriers and success factors;
- specific information derived from the pilot preparation documents (WP2 and 3);
- the general information elements prescribed for Impact Assessment guidelines.

This is based on the following specific inputs:

Input from WP1:

- Factsheets D1.2
- Report barriers D1.3 (SWP 1.3)

Pilot preparation documents:

- D2.1: Pilot test specification for standard after-treatment configurations (M6 - MUL)
- D2.3: Pilot test specification for energy efficient navigation (M6 - VIA)
- D2.5: Pilot test specification for standard LNG configurations (M12 - WAR)
- D3.4: Design and project plan for the demonstration of real-life testing (M12 – TNO)

Ex ante cost/benefit analysis:

- D2.2: Ex-ante cost/benefit analysis of business cases for standard after-treatment configurations (M6 - MUL)
- D2.4: Ex-ante cost/benefit analysis of business cases for energy-efficient navigation (M6 - VIA)
- D2.6: Ex-ante cost/benefit analysis of business cases for standard LNG configurations (M12 - WAR)
- D3.5: Ex-ante cost/benefit analysis of systems for certification, monitoring and enforcement (M12 – TNO)

Important to mention is also the alignment with the Impact Assessment guidelines, please see http://ec.europa.eu/smart-regulation/impact/index_en.htm. For more information, see Annex 3.

The pilot reviews D6.2 (Mid-term report – M24) and D6.4 (Final report – M31) will be used in all other parts of WP6:

- SWP 6.2:
  - T6.2.1: to validate the business cases for fleet families and conclude on financing options, D6.3 (M31)
  - T6.2.2: to allow the analyses of the financing requirements on European level for greening the European fleet of inland barges, D6.5 (M32)
- SWP6.3:
  - T6.3.1: to provide validated input for the I-STEER App which is the major instrument to disseminate the PROMINENT results as regards greening technologies and concepts to the sector, D6.6 (M34)
  - T6.3.2: to provide first results and recommendations to be communicated to various stakeholders for preparation of follow-up actions

- SWP 6.4:
    - to prepare the various analyses on the fields of on board monitoring and certification, engine room improvements, energy efficient navigation, D6.7 (M34)
    - and also to prepare the overall summarising roll-out plan, D6.8 (M36)

The pilot review templates may also be used to structure the collection of information needed for the periodic report D7.3 (M18) which shall describe the intermediate results of the project.

Annex 3: Impact Assessment guidelines

Important is to **align the methodology with the requirements of Impact Assessment studies**, since the recommendations as regards “Roll Out” will probably deal with adaptation or new legislation or other intervention actions by the EU such as financial support programmes for deployment and programmes to support further research and development.

Before the European Commission proposes a new initiative, it assesses the need for EU action and the potential economic, social and environmental impacts of alternative policy options in an impact assessment. Impact assessments are prepared for Commission initiatives expected to have significant economic, social or environmental impacts. These can be:

- legislative proposals,
- non-legislative initiatives (e.g. white papers, action plans, financial programmes, negotiating guidelines for international agreements) that define future policies,
- implementing and delegated acts.

Therefore, in order to prepare the grounds for such interventions and actions, PROMINENT is taking the Commission Staff Working Document “Better Regulation Guidelines” well into account in drafting the guidance, methodology and templates for the reviewing of pilots. In particular the pilots shall demonstrate and provide the proof for the assessment of impacts regarding the application of greening technologies in inland waterway transport.

The key questions to address in Impact Assessment studies are the following:

- What is the problem and why is it a problem?
- Why should the EU act?
- What should be achieved?
- What are the **various options to achieve the objectives**?
- What are their **economic, social and environmental impacts** and who will be affected?
- How do the different **options compare** in terms of their **effectiveness** and **efficiency** (benefits and costs)?
- How will monitoring and subsequent retrospective evaluation be organised?

Points of attention are:

- **Cost-benefit analysis, cost-effectiveness analysis, compliance cost analysis and multi-criteria analysis are the most commonly used methods for comparing options**.
- The choice of impacts for deeper assessment should be clearly justified, taking account of their:
    - Expected overall magnitude;
    - Relevance for specific stakeholders (enterprises and in particular SMEs, trading partners, economic sectors, consumers, learners, workers, public administrations, regions, developing countries etc.);
    - Importance for Commission horizontal objectives and policies (e.g. NAIADES II Communication, revised White Paper on Transport, TEN-T Regulations).
- Provide **quantitative information where possible and always qualitative**. Be clear and transparent about any limitations (e.g. data, methodological). Data sources should be provided and underlying assumptions illustrated in relation to any quantification.

- Provide **bandwidths rather than (unreliable) precise figures** and perform **sensitivity analysis** on uncertain assumptions (e.g. fuel price development)
- **Changes should be assessed relative to the baseline scenario**
- Different impacts are likely to occur at different times, this can be dealt with by means of discounting monetized estimates in economic calculations
- Impacts should be assessed from the **point of view of society as a whole** although distributional effects and cumulative burdens on individual parties should also be proportionately assessed and considered.
- **Geographical distribution of impacts**, should be kept at the forefront

What do these Impact Assessment requirements mean for PROMINENT?

A common basis is required for cost benefit analyses in PROMINENT and comparing options
Different options need to be compared and economic analyses are commonly used to present the benefits and costs. Therefore a common basis is established for the cost-benefit analyses in PROMINENT. This concerns the ex-ante cost benefit analyses that are made in WP2 and WP3 but also the updated cost benefit assessments based on validated parameters with more accuracy and reliability after the pilots have been carried out (SWP 6.2).

Moreover the impacts shall be assessed compared to a baseline scenario. Therefore, a common view is established in SWP6.1 on the current status (the baseline scenario) as regards the performance of inland waterway transport concerning air pollutant and greenhouse gas emissions and the operational costs of the inland waterway transport sector.

Therefore, a template was established for the costs / benefits assessments. This is based on the work carried out in the SWP 1.1 as regards the fleet families and representative journeys. For each fleet family and the representative vessel, the overall cost structure is provided and common values for parameters are provided (e.g. interest rates, time horizons). Subsequently parameters can be changed to calculate the differences in the costs and emission performance. This allows in the end to make a sound comparison of the economic performance of various greening options for the different fleet families and journeys and to make tailored recommendations as regards the effective and efficient roll-out of the technologies.

Main impacts need to be identified against the characteristics of the IWT industry and PROMINENT objectives
The assessment shall focus on the main impacts that are being expected as regards the economics of transport, the environment and social aspects taking into account the specific stakeholder setting in the IWT industry. Of key importance is to take into account the business economics for the ship-owner/operator against the background of a highly fragmented sector with limited investment capacity and lacking economic incentives to green the legacy fleet. As a result the **indicators concerning the investment levels and the impact on the running costs of a vessel are of key importance**. These elements therefore need to be on the foreground in the pilot review templates. Moreover**, as the roll-out is targeting 70% of the sector, this shall not only be limited to the pilot**

vessel itself, but rather aim at getting a clear view on the impacts for other relevant fleet families and operational profiles as well.

Another main impact area is obviously the reduction of emissions, as this is one of the main objectives of PROMINENT. Therefore, specific attention needs to be paid on the reduction of air pollutant emissions and greenhouse gas emissions. Notably the pilot projects shall demonstrate and validate the emission performance that is achievable with the selected technologies. The templates for the pilot review therefore shall therefore duly take this into account and report on all relevant emissions.

Identification of key uncertainties and sensitivity analyses

The uncertainties need to be identified and taken into account by means of sensitivity analyses. An example is the development of the fuel costs, which is impossible to predict but has an impact on the business economic performance of the technologies such as LNG and efficient navigation.

Geographic distribution

It is important to not only make assessments for the EU on an aggregated level, but also to illustrate on the various sailing areas and representative journeys what impacts are expected. Therefore, the representative journeys shall be taken into account, illustrating the impacts on the various types of waterways and fleet families across Europe.

Annex 4: Information about the technologies and concepts addressed in the pilots

Energy efficient navigation

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

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

The greatest impact on **reduction of fuel consumption** can be achieved by combining all measures listed above. However, the measures can be considered also as stand-alone ones, resulting also in reduced fuel consumption or increased utilization of the vessel. E.g. provision of comprehensive information on the fairway conditions may allow the master of a vessel either to choose the track with greatest water depths or to maximize the amount of cargo to be taken on-board. Therefore, the three measures listed above are described separately.

Speed adaptation

Apart from engine and hydrodynamics characteristics, the fuel efficiency of an inland waterway vessel is also largely dependent on - continuously changing - fairway characteristics. The most important parameters are the fairway depth influencing the shallow water resistance, the width resulting possibly in the so-called "canal effect" and the stream velocity of the river. The energy consumption of a vessel rises disproportionately in shallow and narrow waters (confined conditions) and in areas with higher counter current flow if a constant speed over ground is to be maintained. Accordingly, a remarkable potential to save fuel exists on free flowing rivers with continuously changing underwater topography and corresponding varying waterway depths and flow velocities. The fuel savings can be achieved by adaptation of the vessel speed to the changing navigation conditions e.g. by reducing the speed in unfavourable stretches, leading to significant reduction of power at relatively small increase of sailing time. Depending on the present navigation conditions, it can be even possible to achieve noticeable fuel savings without increasing the sailing time too much or at all, e.g. by going faster in deep river stretches and slowing down in shallow-water stretches. The potential gains in fuel savings depend on the respective waterway conditions.

Optimised track choice

As already mentioned, the resistance and power requirement of a vessel for sailing on a certain stretch of a waterway at a given speed over ground are affected by the river cross section and the lateral distribution of its flow velocities. The fuel consumption of the vessel is directly related to its power requirement. In areas with reduced water depths, shallow-water effects may occur, increasing the power requirement and the fuel consumption disproportionately.
These effects can be reduced by finding those parts in the cross section where the water depths are greatest, leading to minimum fuel consumption. Provided the flow velocities across the river are

constant or very small, the track for minimum fuel consumption can be defined as the one where the water depths are greatest. However, the flow velocities can change across the river depending on the water level changes as well as the shape of the cross section. As the flow velocities have an impact on the fuel consumption of a vessel - e.g. when sailing upstream greater flow velocities will lead to an increase in fuel consumption - the correct determination of the track associated with the minimum fuel consumption has to be done considering the lateral distributions of both parameters: the water depth and the flow velocity. Then, the optimum track would comprise in the ideal case greatest water depths and lowest flow velocities, which, however, is not necessarily to be found in a river cross section, leading to the demand of proper estimation and balancing the effects due to changing water depths as well as flow velocities.

Waterway information

The provision of full information on the navigation conditions of a waterway (water depth and flow velocities across the river both spatially (longitudinal and lateral direction) as well as temporal) enables the application of energy-efficient sailing via adaptation of the vessel speed to the changing navigation conditions and choice of the optimum track for minimum fuel consumption. Besides, the lowest section of the whole transport route determines the possible draught and thus the maximum payload and the load-factor of the vessel (so-called load-limiting water depth). Hence, the knowledge of this depth is a precondition for the optimization of the payload (by reduced necessary safety margins).

The information requested can be derived by comprehensive surveying of the entire waterway using dedicated surveying vessels and application of proper water-level and hydro-morphologic models accounting for water-level and riverbed changes in real time, whereby the impacts on water depths and flow velocities are to be determined. Further, the respective information can be derived in real time, using measurements performed on cargo and passenger vessels in operation e.g. via echo-sounder measurements and flow velocity measurements. However, the measurements performed by vessels in operation pose still many open questions regarding spatial density, frequency, accuracy and reliability of the measurements derived and the information on the navigation conditions provided.

On Board Monitoring and certification

An efficient procedure for certification is a pre-requisite for the successful roll-out of the mainstream greening technologies LNG and diesel after treatment. Therefore, there are specific pilots foreseen to test and validate different options for certification, such as portable measurement devices (PEMS) and on board monitoring (OBM). Main aims are to get a better view on the involved costs and the reliability and accuracy of on board measurement technologies (for example the durability and accuracy of sensors).

In addition the measurement pilots can be used to validate the impact of other technologies, such as GTL and the 'real world' the emission performance of CCNR II engines and possibly others.

Diesel after treatment

Selective Catalytic Reduction (SCR)
Selective Catalytic Reduction of NOx (SCR deNOx) is a technology applied on diesel engines to reduce the NOx emissions, by adding a reductant (urea-water solution) to the exhaust gas, which is absorbed onto the catalyst, converting NOx in diatomic nitrogen (N2) and water (H2O).

Wall flow diesel particulate filter (DPF)
A Diesel Particulate Filter reduces the PM emissions. The most efficient DPF is the wall flow DPF, commonly made from ceramic materials with a honeycomb structure with alternate channels plugged at opposite ends. According to the Manufacturers of Emission Controls Association (MECA), particulate matter is captured by interception and impaction of the solid particles across the porous wall. Important is a sufficiently high average temperature such that the stored particle matter is regenerated (converted to CO2) and the filter is kept clean. Alternatively a special active regeneration system can be installed, which increases the filter temperature periodically to high temperature for fast regeneration.

Combined SCR and DPF
SCR and DPF are often combined because then all gaseous and particulate emissions are reduced (by 70% or more) and usually the most stringent (future) emission legislation can be met. SCR and DPF often work together nicely leading to an increased SCR efficiency. One of the technical options is the "SCR on DPF technology", where the DPF part acts as an SCR catalyst as well. This can lead to a more compact configuration.

Liquid Natural Gas

Liquefied natural gas or LNG is natural gas that has been converted to a liquid form for the ease of storage or transport by cooling natural gas to approximately −162 °C. Afterwards, it is stored at essentially atmospheric pressure. Liquefied natural gas takes up about one six hundredth the volume of natural gas in the gaseous state at atmospheric pressure or about 2.5 times less volume than CNG at 250 bar pressure.

Inland waterway vessels have a variety of engine configurations on board, this being partly determined by the size of the ship, the route and the distribution of the engine's part load and full load periods. LNG power offers a number of engine configurations for inland waterway vessels. The following engine suppliers have LNG-powered engines: Wärtsilä, PON Power/Caterpillar, Rolls Royce and Scania. These four engine manufacturers each have their own engine configurations. More engines may become available in the future.

There are dual fuel engines but also ‘mono-fuel’ engines for LNG, the so called ‘spark ignition natural gas engine‘. This engine is also referred to as ‘pure gas engine’. It uses only natural gas and cannot run on diesel fuel. In ships it is usually used in a gas-electric drive. The latest development in inland shipping engine configuration is the gas-electric drive. The gas-electric drive is a system whereby an inland waterway vessel uses one or a number of gas engines that drive generators (gensets) that generate electricity. This electricity goes to electric motors that drive the ship. However, this implicates that the business case technology is depending completely on the price advantage of LNG versus diesel, while a dual fuel engine would still be able to use diesel as main fuel in case the diesel price is lower compared to LNG. The uncertainty about the LNG price development versus the diesel price development is a reason for ship-owners to prefer the dual fuel ekjngine in order to take less economic risks.

The PROMINENT partner Wärtsilä optimized a dual fuel engine for natural gas combustion. This LNG Dual-Fuel system has already been in use for more than 10 years in coastal and ocean shipping. The engines are now also supplied for inland shipping. The LNG Dual-Fuel engines are specifically designed as Dual-Fuel systems so only a limited quantity of pilot fuel is required. The Dual-Fuel engine can nevertheless run fully on diesel. This involves proportions of 1% diesel and 99% LNG.

The focus of PROMINENT will be on the achievement of cost reduction and standardisation of LNG kits based on the dual fuel / pilot diesel engine (99% LNG and 1% diesel) which is developed by Wärtsilä.