LNG BINNENVAART
Deployment in Inland Waterway Transport

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Breakthrough LNG deployment in Inland Waterway Transport

Activity 1.5 Specification of pilot test settings

Pilot test settings for vessels

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1 Introduction

This document contains the pilot test settings for the pilot vessels which will be deployed in the Action and also dives into the comparison analysis between the pilot vessels. The test settings include the factors which will be measured and analysed during the pilot test of the vessel, being in line with the enumerated settings under activity 2 of the Grant Agreement. Each pilot test will have a duration of approximately six months.

Analyses will be made on three factors:

- Reduction in **emissions** thanks to LNG technology
- Reduction in **fuel consumption** thanks to LNG technology
- Reduction in **operational costs** thanks to LNG technology

The reduction concerns the comparison between the LNG driven (either dual-fuel or mono-fuel) and conventional 100% Diesel driven vessels. Furthermore, there will also be a comparison on the emissions between data obtained during test bed trials and data obtained during the pilot test in practice. During the end evaluation a comparison will be made between the performance of the pilot vessels based on the three factors mentioned above.

The analyses will be based on data obtained from:

- Monitoring of the following **seven parameters**:
    1. Running hours of LNG, Diesel and DF engines (time);
    2. Engine speed;
    3. Load (torque / power) of LNG, Diesel and DF engines;
    4. LNG and Diesel consumption of LNG, Diesel and DF engines;
    5. Water depth, position, speed (GPS data);
    6. Overall LNG and Diesel bunkering figures (volume weight and quality of the fuel);
    7. Gas Ventilation Events, System Failures, Leakages, Abnormalities, Pressure Data
- **E2/E3 cycle data of test bed trials**
- **Monitoring of emissions on board** by an accredited institution[1]

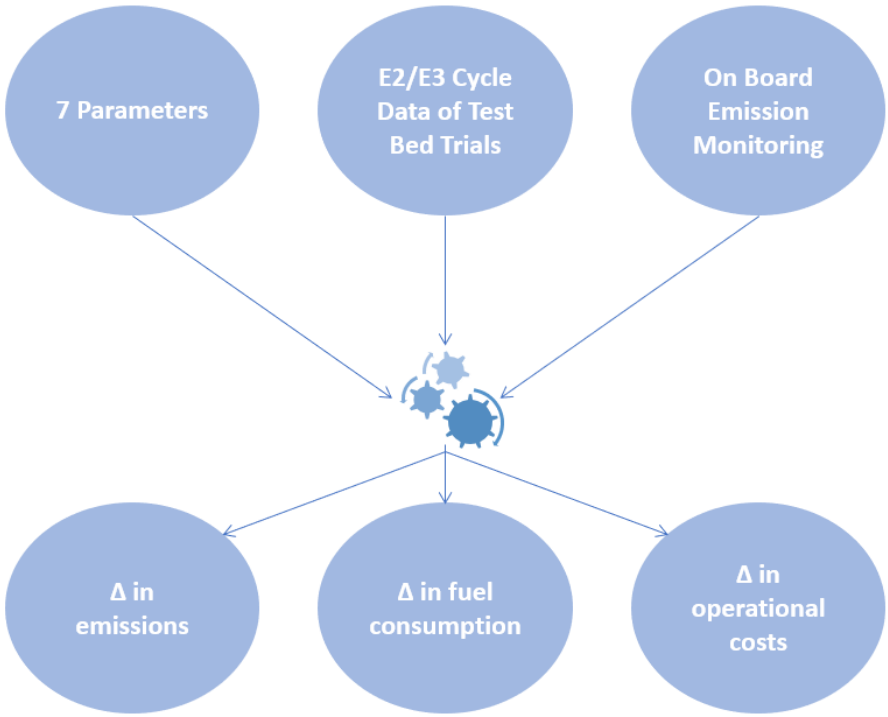
Thus, there will be three 'groups' of data contributing to the analyses on the abovementioned three outcome factors; reduction in emissions, fuel consumption and operational costs.

[1] For example SGS, Eurofins or KW3

2 The data

Figure 1 below summarizes the process described in chapter 1 introduction, the data obtained in three ways and the outcome concerning change in emissions, fuel consumption and operational costs.

Figure 1: used data & outcome



Source: own elaboration

The chapters 2-6 will discuss how and by whom the data will be obtained, stored and analysed.

In short, the reduction in emissions; being the emission reduction of the pilot LNG vessel as compared to conventional Diesel vessels and the comparison in emissions of the engine during test bed trials and in practice will be measured by 'E2/E3 Cycle Data of Test Bed Trials' and 'On Board Emission Monitoring'.
The reduction in fuel consumption and the overall analysis on fuel will be measured by parameters 1,2,3,4 and 5.
The reduction in operational costs will be analysed by, under which, data from parameter 7 and 6 and assumptions based on manufacturer specifications of the LNG installation.

2.1 Seven parameters

There are seven parameters, included in the Grant Agreement, which will be measured during the pilot test by each pilot test task holder. Table 1 on the next page provides a format which indicates among others the period and frequency on saving data for the seven parameters. Each task holder will generate an Excel file containing data of the seven parameters, of which the format will be in line with table 1.

The way to measure and save data is the responsibility of the task holder of the pilot test. This can be done through, for example, engine-specific software systems for some of the parameters. However, while there is no single suited method for measuring all seven parameters, and every pilot vessel has different software systems on board, the pilot test settings will not prescribe a specific method. The data format is leading.

The seven parameters will be measured during a period of six months. Though, the measurements will take place according to a certain frequency or based on the trips, six trips will be performed for the pilot test. Except for the pilot vessel 'Werkendam', there are no specific requirements for the trips concerning the duration or length, while every pilot vessel will have a different operational area and serve different market segments resulting in specific trajectories with unique lengths and durations.

A trip should simply have a starting point and endpoint. An endpoint in the scope of the pilot test could also be an intermediate stop in practice, at for example a terminal or quay. The parameters will make it possible to calculate average values controlling for the differences in trip lengths and duration between the pilot vessels.

In case of the pilot vessel 'Werkendam' a trip will be expressed in hours, one trip is equal to eight hours. This is due to the nature of the vessel and its activities which are usually conducted in a relatively limited radius. Therefore, the duration and not that much its length will play a decisive role in the pilot test of the 'Werkendam'.

Table 1: Data format for pilot tests

Parameter	Period	Frequency	Trip
1. Running Hours of LNG, Diesel and DF engines (time)	6 months	Sum value of total running hours over 6 months	
2. Engine Speed	6 months		Engine speed in intervals of 10% (10% of total engine speed, 20% of total engine speed, etc.) against the total time of one undertaken trip and six trips in total.
3. Load (Torque/Power) of LNG, Diesel and DF engine	6 months		Load expressed in kW in intervals of 10% of total load against the total time of one undertaken trip and six trips in total.
4. LNG and Diesel consumption of LNG, Diesel and DF engines	6 months	Sum value of LNG and Diesel consumption of LNG, Diesel and DF engines.	
5. Water depth, position, speed (GPS data)	6 months		Water depth: 1 minimal depth value per trip and six trips in total. Position: starting point, ending point and travelled kilometres in between, per trip and six trips in total. Speed: ground speed in intervals of 10% of max speed against the total time of one undertaken trip and six trips in total.
6. Overall LNG and Diesel bunkering figures	6 months	- Number of bunkerings; - Bunkered weight; - Bunkering time: • Time for circumnavigating • Time/costs for reserving the quay • Time for reserving a slot with the fuel supplier • Time for administrative requirements before bunkering • Time for bunkering itself	

		• Time for administrative procedures after bunkering • Engine rinsing, evaporate of pipes and reset of alarms	
7. Gas Ventilation Events, System Failures, Leakages, Abnormalities, Pressure Data	6 months	Number of 'incidents' during 6 months.	

2.2 E2/E3 cycle test bed trials data

E2 or E3 cycle test bed trials data will be obtained by each task holder of the pilot test. This data can be obtained from the engine manufacturer of the installed engines on board of the pilot vessel.

2.3 Measurement of emissions

During the pilot test emissions will be measured on board of the vessel by an accredited institution, which will be arranged by each pilot task holder. The emissions which will be measured are:

- CO
- HC
- NOx
- PM
- PN (if possible)

The emissions will be expressed in g/kWh, for Particulate Numbers (PN) applies an expression of numbers per kWh (#/kWh). However, while measuring PN is a complex process, values will only be included in the report if the measurements result in valid and reliable values.

3 Reduction in emissions thanks to LNG technology

3.1 Reduction in emissions compared to conventional Diesel vessels

The reduction of emissions will be analysed by each pilot task holder comparing the measured emission values of the pilot vessel with emission values of comparable conventional Diesel driven vessels. It will be assumed that the emissions of comparable conventional Diesel driven vessels will be equal to the current emission standards, being CCNR2. The emission values will be expressed in g/kWh.

3.2 Comparison of emissions between test bed trials and in practice

The comparison between test bed trials data and data in practice will be made by each pilot task holder by analysing the difference between the measured emission values of the pilot vessels with the corresponding obtained E2 or E3 cycle test bed trials data.

4 Reduction of fuel consumption thanks to LNG technology

The reduction of fuel consumption and corresponding fuel costs will be based on data related to parameter 4. 'LNG and Diesel consumption of LNG, Diesel and DF engines' and parameter 6 'Overall LNG and Diesel bunkering figures'. The measured fuel consumption will be compared with the amount of Diesel (=EN590) that would have been used in comparable Diesel only engines (values based on engine data as given by the engine manufacturer) or in 100% Diesel mode of dual-fuel engines, for the amount of power (kWh) generated during the specific period.

Each pilot task holder will report the actual LNG consumption and the predicted Diesel consumption that would have been used in case of Diesel only engines or in 100% Diesel mode of dual-fuel engines. The sum values of LNG and Diesel consumption will be multiplied by the average fuel price for respectively LNG and Diesel during the reporting period. The average fuel prices will be determined together by the pilot task holders, based on their market knowledge.

Values related to the Diesel consumption will be converted by each pilot task holder in order to have a reliable and valid comparison. Normally LNG is expressed in kilograms and Diesel in liters, for the price comparison in this study Diesel will be converted to kilograms based on the conversion rate of '1l Diesel = 0.84kg Diesel'. Furthermore, the difference in kilograms will also be corrected for variances in the energy density. It will be assumed that Diesel has an energy density of 42 MJ/kg. The energy density of LNG depends for an extent on its origin, but a density of 49 MJ/kg will be assumed.[2]

[2] https://www.pitpoint.nl/lng-brandstof-binnenvaart/

5 Reduction of operational costs thanks to LNG technology

Measuring a reduction in operational costs during the pilot test will not provide a highly representative view of the situation, since a representative view would need monitoring during a significant longer time or preferably the whole lifetime of the installation. However, an analysis will be done by each pilot task holder using under which data from parameter 7, in combination with information from planned maintenance intervals and assumptions based on manufacturer specifications of the LNG installation (e.g. concerning required maintenance and installation lifetime) in order to provide solid conclusions on the operational costs of the LNG installation.

6 Comparison between the performance of pilot vessels

The eventual comparison between the performance of the deployed pilot vessels will be made by SPB/EICB, based on the results provided by each pilot task holder. The comparison will be based on three factors: the reduction in emissions, fuel consumption (costs) and operational costs.