Realtime insight into emissions performance of inland shipping vessels

PAPER

The full report is available on Project Measurements on ships - Topsector Logistiek

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Colophon

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This paper contains the most important insights from the report 'Reductiepotentieel van de milieu- en klimaatimpact van binnenvaart - Meten op Schepen' [Reduction potential of the environmental and climate impact of inland shipping - Measurement on Ships]. The report is commissioned by Topsector Logistiek about the Measurement on Ships project. In addition to TNO, Covadem, EICB, Nestra and Shipping Technology contributed to the project.

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January 2024

Summary

Superior insights through high-definition telemetry

High-definition telemetry provides superior insights into emissions performance. That is the conclusion of Topsector Logistiek's 'Meten op Schepen' [Measurement on Ships] project. This was achieved by monitoring 19 inland shipping vessels in real time for 12 months. A signal was received every 2 seconds from all available sensors: position, speed, under keel clearance, fuel consumption via calibrated flowmeter, engine power, rpm, rudder angle, load and weather.

The information gathered provides highly accurate insights into the emission performance of the ships. An important conclusion that can be drawn from this is that the standard emission factors currently available and widely used for inland shipping are too low by a factor of 2 to 3. This situation disadvantages frontrunning companies that make their reports on the basis of measured data. It also changes the position of inland shipping in modal shift calculations. A second conclusion is that route has a lot of influence on emissions per tonne.km and that the CO_2 emissions of a trip can be predicted accurately by route, ship type, load and water level. Valuable, concrete insights can also be obtained from the data that provide ship-specific perspectives for action to minimise fuel consumption. And this is just the beginning of what is possible with high-definition telemetry.

Introduction

Superior insights through high-definition telemetry

To create highly detailed insight into inland shipping emissions and the factors that determine these emissions. That was the goal of one year of measurement on 19 ships. For this project, Topsector Logistiek had data collected by CoVadem, Shipping Technology and Nestra on inland vessels for one year and had this data analysed by TNO and put into context by the EICB. This 'high-definition telemetry' project has now been completed and has indeed yielded superior insights and important results.

One outcome with major implications is that the default values that have been used for inland shipping emissions until now lead to an underestimation of emissions. The real-world measurements are a factor of 2 to 3 times higher than the commonly used key figures for fuel consumption and CO_2 that are currently given by Global Logistics Emissions Council (GLEC) and others. As a result, industry frontrunners reporting with primary, measured data - according to the CountEmissionEU protocol - fare much worse than companies that fall back on generic, secondary data, such as average key figures, for example from GLEC.

The study also shows that a very accurate, high-definition picture of total emissions and emissions per tonne and tonne.km can be created based on ship data such as fuel consumption, cargo weight, vessel speed and under keel clearance. With these KPIs, emissions from inland waterway transport can be assigned at shipment level and companies can be compared with each other. The study shows which variables the sector can modify to reduce emissions from inland shipping in the future. The detailed, quantitative results of this study have brought its impact into razor-sharp focus.

This paper elaborates on the approach used and outcomes of the study, the implications of the outcomes, and the follow-up required.

Most important results of the study

The 'Meten op Schepen' [Measurement on Ships] study is based on more than a year of monitoring data from 19 inland vessels of different types (container, bulk and tanker) and size (CEMT class IV to VI) in which detailed and instantaneous information on fuel consumption, load, speed and conditions was shared every two seconds. For many ships, this made more than 4,000 hours of data available. During this year, the 19 participating ships were deployed as normal on international routes. No specific situations were created to investigate hypotheses.

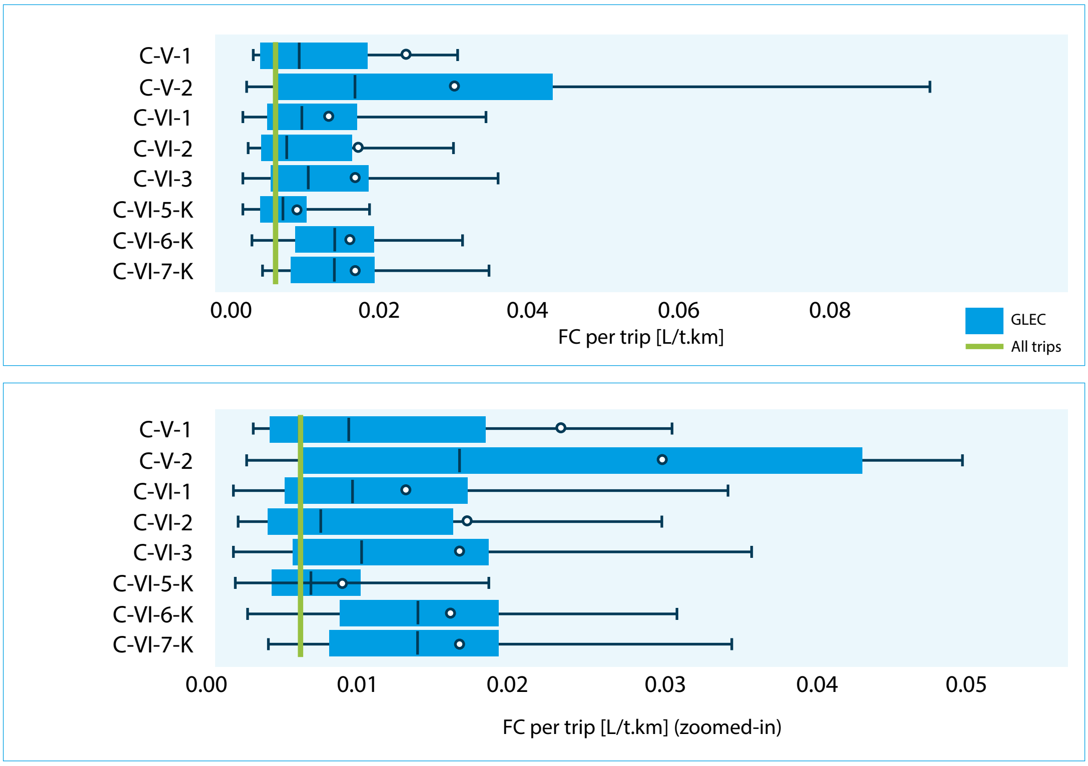
Underestimate of CO_2 default values by a factor of 2 to 3

It was determined how the measured emission figures compare with the default values used for the Dutch Emissions Registry and the default values from GLEC in order to assign emissions to logistics activities. The GLEC default values are widely used in the logistics sector, including to prepare CO_2 footprint analyses and also to calculate the impact of modal shift measures.

The GLEC default values were compiled several years ago at a time when highly detailed data, such as that gathered by high-definition telemetry in the 'Meten op Schepen' project, was lacking. The GLEC default values are therefore not detailed by deployment, load and route. This study shows that these factors actually do have a major impact on fuel consumption and emissions per tonne.km.

A comparison between measured emissions and calculated emissions based on GLEC shows that measured emissions are higher by a factor of 2 to 3 (see figure below). The consequence is that results based on primary, measured data give much less favourable emission figures than results based on default values.

Figure 1
Distribution of measured emissions compared to default values



The implications of this are huge. First of all, the current default values do not give an incentive to invest in proper measurement of emissions (primary data). A large proportion of inland waterway vessels can paint a more positive picture of their performance than reality by reporting using default values.

Secondly, GLEC default values are also widely used in formulating government policies and monitoring their progress. Such default values are for example used to calculate the impact of modal shift. Based on real-world data, the effect of a modal shift on CO_2 emissions may turn out to be much less significant than previously thought. This could for example mean that a much larger cargo volume would have to be shifted from road to inland shipping to achieve the same CO_2 savings, or that, because of the lower savings, companies would continue to use road transport after all.

Given the major impact of using, as it now appears, overly positive default values, it is necessary to take action on this in the short term.

Factors determining variation in emissions per tonne.km

Moreover, this study shows that there is large variation in emissions per tonne.km. The factors that determine fuel consumption and emissions per tonne.km were investigated. The analyses done have shown that various factors affect emissions such as current speed and direction, under keel clearance, vessel speed, etc. In this, a difference can in particular be seen in downstream and still-water shipping routes on the one hand, and upstream shipping routes on the other.

For upstream shipping routes, bottlenecks in under keel clearance (the distance between the bottom of the vessel and the river bottom) in particular were found to determine fuel consumption. It was also found that CO_2 emissions per tonne.km upstream are on average a factor of 3 higher than downstream.

The effect of under keel clearance is mainly because ships are loaded according to the shallowest point. Although such shallows are only a small part of the route, they largely determine how much cargo can be carried and therefore also the emissions per tonne.km. That effect is more significant than the effect of greater resistance at the shallows on fuel consumption.

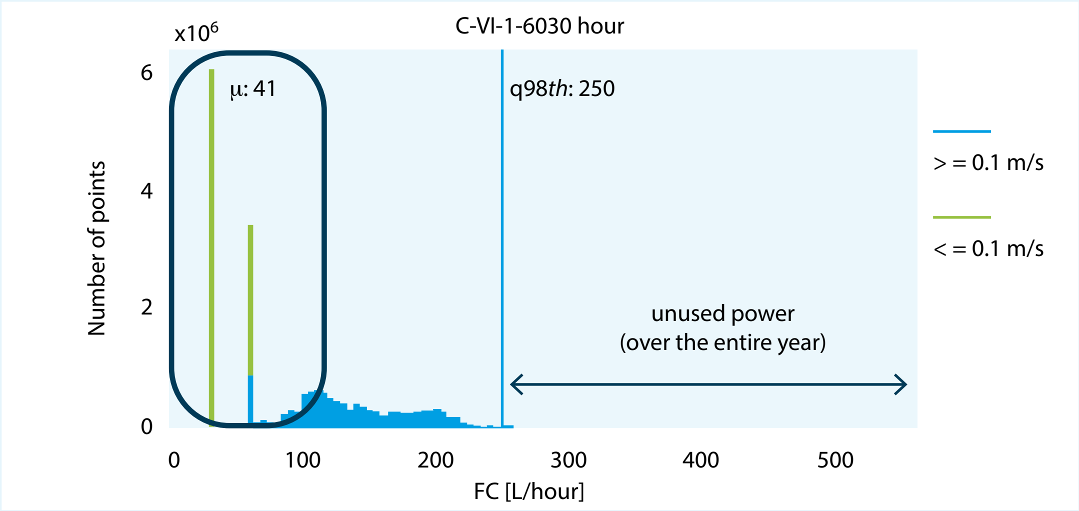
The effect of under keel clearance varies according to the type of load. Bulk carriers show greater variation in under keel clearance along the entire route than container ships. This is primarily because bulk carriers are more likely to carry an entire cargo from A to B: the total amount of cargo is then determined by the shallowest point on the entire route. Container ships often load and unload at multiple points and can adjust the maximum cargo for each part of the route according to the water depth on that section.
One conclusion is that default values become much more accurate if they are broken down by waterway segment, by direction, and also with attention to bottlenecks in under keel clearance and type of load.

For downstream shipping routes, vessel speed and engine power together determine about 80% of CO_2 emissions per tonne.km. Reducing vessel speed can yield significant fuel savings. Given that fuel consumption is not linear with speed, a 25% reduction in speed leads to 55% less fuel consumption, while the extra voyage time on a 30 km route is only 20 minutes.

The measurements show that ships often have engines with much more power than is actually used. Such an oversized engine may have been installed with a view to future possibilities, such as other uses, for example to carry both containers and bulk cargo. Or to make the vessel easier to sell.

However, a bigger engine also means higher internal losses and therefore higher emissions. The figure below shows that this vessel left a significant proportion (55%) of engine power unused throughout the measurement period. If this vessel had engine power of 1040 kW instead of the 2200 kW installed, it would have saved 51,000 litres of fuel per year. That saving equates to 177 tonnes of CO_2 emissions and € 55,000 in fuel costs. It is therefore very important to pay more attention to the actual power required when new ships are built or the engine is changed. The use of hybrid propulsion, with multiple generator sets, could also be a solution for this.

Figure 2
Unused engine power



These quantitative insights on the impact of downstream vessel speed and installed engine power provide inland shipping operators with perspectives for action to reduce ship emissions on their own in the future.

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