The environmental impact of capacity utilisation in RoRo shipping

A life cycle assessment

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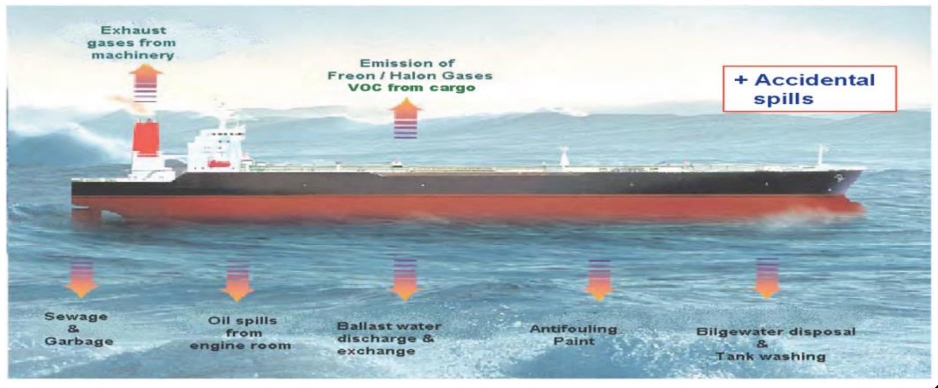
Introduction

Sea transport covers about 90% of the world's trade, and is considered the most cost-efficient way to transport raw materials and goods (IMO, 2016). In the period from 2007 to 2012, the total shipping industry emitted 3.1% of the annual global CO_2 emissions and 2.8% of the annual greenhouse gas (GHG) emissions, given in CO_2-equivalents (IMO, 2014). One solution to the problem of pollution has been to build larger vessels. A larger vessel is more cost-effective and more energy effective per unit of cargo than a small vessel (economies of scale), and is therefore preferable in many situations.
The scope of this thesis was to do a LCA of the entire life cycle of five RoRo vessels with varying capacity, and use the results to analyse the impact of capacity utilisation on environmental performance for the different vessel sizes.

In the assessment, the building phase, operational phase and scrapping phase were included, in addition to dry-docking. The main emissions related to the operational phase is shown in the figure below.



LCA methodology and modelling

A LCA consists of four phases:

- Goal and scope definition
- Life cycle inventory
- Life cycle impact assessment
- Interpretation

The table below shows the data for the five vessels included in the assessment. The capacity varied from 2000 RT to 10,000 RT. One RT is equal to 7.38975 m^2.

		Case 1	Case 2	Case 3	Case 4	Case 5
Car capacity	RT	2 000	4 000	6 000	8 000	10 000
LOA	m	156	189	211	228	243
B	m	21.9	26.4	29.6	32.0	34.1
T	m	7.0	8.4	9.4	10.2	10.8
Lightship weight	t	7 735	12 737	17 052	20 974	24 628
Service speed	kn	17.0	18.0	19.0	20.0	20.0
Main engine MCR	kW	5 614	8 651	12 651	17 935	18 445
Propulsion power	kW	3 103	4 782	6 992	9 913	10 195
M/E FOC	t/d	13.4	20.7	30.2	42.8	44.0
Sailing distance per year	nm/y	93 636	99 144	104 652	110 160	110 160

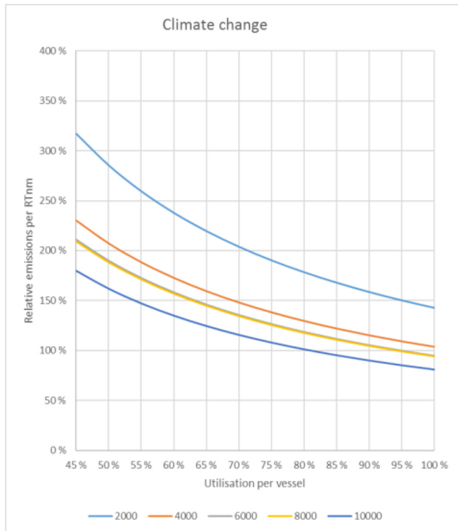
For the assessment, several processes were calculated:

- Material consumption
- Fuel consumption
- Exhaust gas emissions
- Lubrication oil consumption
- Sludge
- Garbage
- Paint consumption
- Waste and recycling at end of life

It was assumed that the vessels had identical operational patterns through their lifecycles, sailing 75% of the time with 100% utilisation and spending 25% of the time in port.

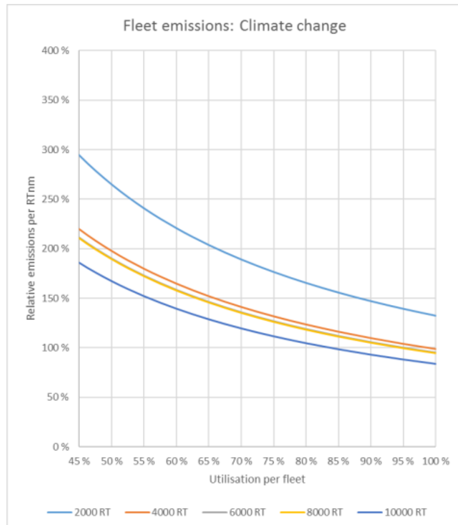
Results

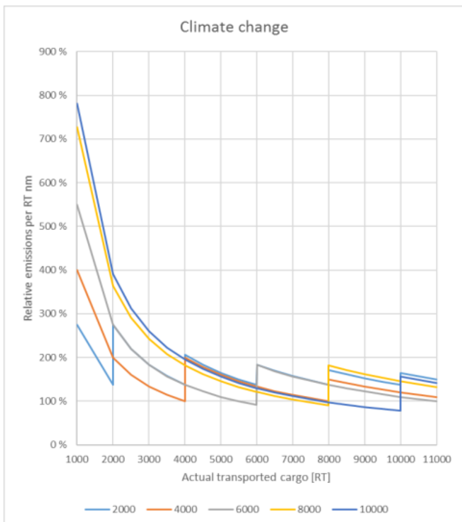
Results are presented for impact on climate change, and the graphs below show the emissions per RT nm for one vessel and for a specific amount of transported cargo and emissions per RT for a fleet. In addition to climate change, impact on human toxicity and terrestrial acidification were discussed in the thesis.



For all analysis, an emission level of 100% was assumed for the 6000 RT vessel at 95% utilisation. The figure on the left shows that the lowest environmental impact is obtained by the 10,000 RT vessel, and the highest impacts are related to the 2000 RT vessel.
At the same emission level, the 6000 RT vessel has a utilisation 0f 95%, the 8000 RT vessel has a utilisation of 93% and the 10,000 RT vessel has a utilisation of 81%. This means that the 10,000 RT vessel need to have 2400 cars more than the 6000 RT vessel to achieve the same environmental impact per transport work.

For the fleet perspective it was assumed that all fleets had a total capacity of 200,000 RT, and that the amount of vessels varied to obtain the correct capacity. The figure on the right shows that the lowest environmental impact is obtained by the 10,000 RT fleet, and the highest impacts are related to the 2000 RT fleet, as for the one vessel perspective. The reason for presenting emissions per RT is because the assumptions made on sailing distance influences the results too much for the fleet perspective. Emissions per RT give a more realistic perspective.





The graph on the left shows the emissions per RT nm when transporting a specific amount of cargo. Each vessel has the lowest emissions at 100% utilisation. The graph clearly shows the disadvantage of adding one car more than the capacity of the vessel, making the jagged curves. In reality, a ship owner "gives away" the additional cargo to another vessel because the lost profit is much lower than the additional costs of a new vessel. The same applies for emissions, and it is more sustainable to relocate the cargo and sail with a vessel at 100% utilisation.

Conclusion

The results shows that it is advantageous to use larger vessels for certain utilisations. If one vessel is considered, the largest vessel is more sustainable if it has a utilisation of 81% or more. If however, the cargo quantity is lower than this, it is better to use a smaller vessel.

From a fleet perspective, the same applies. However, the fleets used in this assessment is assumed homogenous. In reality, a fleet would consist of several vessel types which easily can adopt to different cargo quantities and fluctuations in the market.

It is concluded that utilisation has an impact on the environmental performance of a vessels. The larger vessels can sail with a lower utilisation than the smaller ones, but they are dependent on larger deliveries than the vessels with lower capacity.. What is learnt from the results is that each case and each cargo delivery has to be evaluated separately. There is no rule that apply for every scenario.

References

IMO. (2014). *Third IMO Greenhouse Gas Study 2014*. Retrieved from www.imo.org:

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