A comparative analysis of the effect of electrification in reducing greenhouse gas emissions

NUS-RightShip Hackathon

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0 Abstract

This comparative analysis investigates the impact of electrification on reducing greenhouse gas (GHG) emissions within the maritime industry, and aims to assess and compare the effectiveness of electrification strategies within Pasir Panjang Terminal, considering various vessel types, operational profiles and load factors.

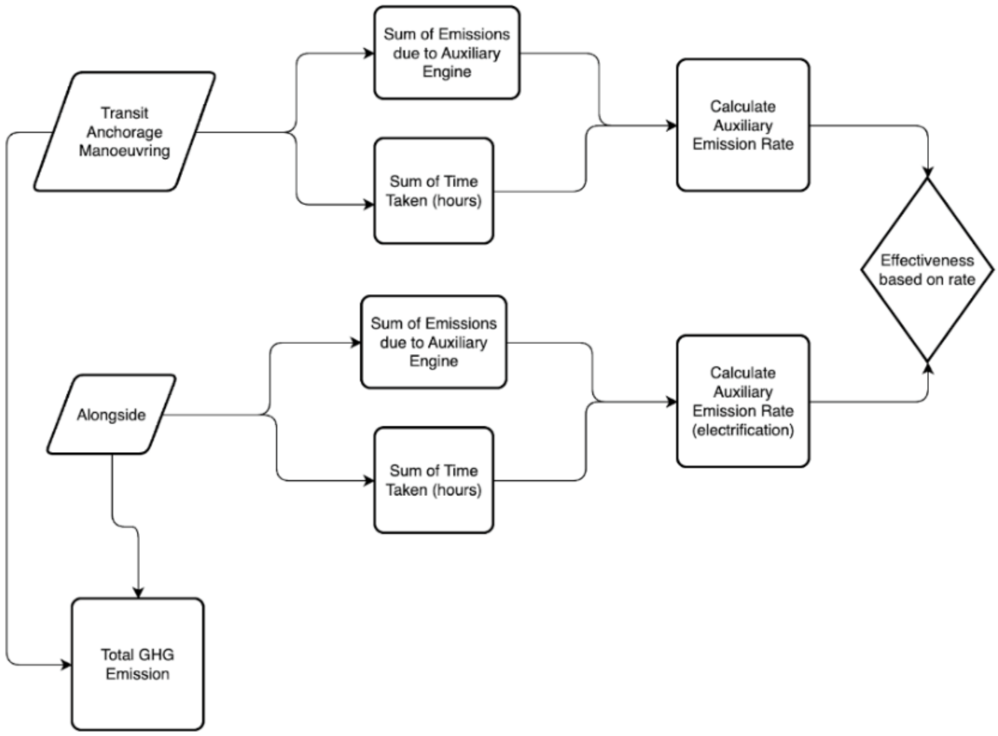

Fig. 1: Process for deriving effectiveness of electrification in reducing GHG emissions from vessel activity

1 Methodology

The total amount of emissions of each pollutant is calculated from the respective amounts contributed by the propulsion engine, auxiliary engine, and auxiliary boiler of all activity hours tracked in the vessel_movements_PPT.csv dataset. This is dependent on the vessel's activity duration, emission factor (EF) and load factor as derived below:

1.1 Activity duration

Activity duration (in hours) is derived from iteratively calculating the timedelta (in seconds) between timestamps of chronologically successive movement logs in vessel_movements.csv dataset. This is restricted to a maximum timedelta of 10000 seconds.

1.2 Emission factor

The EF of a certain pollutant is specific to the engine source in the vessel, as determined by the supplementary datasets provided, and may be dependent on Engine Type, Emissions Tier and Auxiliary engine load as denoted in vessel_movements_PPT.csv. By iteratively looking up matching key-value pairs, EFs for each pollutant was recorded and organized into separate datasets according to the engine source (propulsion engine, auxiliary engine and auxiliary boiler).

1.3 **Load factor**

Load factor is dependent on actual and derived maximum speed of a vessel, calculated from values taken from vessel_movements_PPT.csv. This value may be affected by the vessel's operating mode.

1.4 Operating mode

Operating mode (transit, manoeuvring, anchorage or alongside/hotel) of each movement log was determined by conditional logs, dependent on the vessel's speed, navigational status and position. The positional boundaries of tracked vehicles is the port boundary, where provided shapely polygon data was used as a predicate to check for vessel points within the polygon.

2 Effectiveness of Electrification

To compare the efficiency of electrification, the rate of emissions from the auxiliary engine (AE) during all vessel's 'Alongside/Hotel' operation is measured against the rate of emissions from the auxiliary engine during their 'Transit/Anchorage/Maneuvering' phase, as described in Figure 1. The calculation is given as below:

$$Rate\ of\ Emissions\ from\ AE\ =\ \frac{Total\ Emissions\ from\ AE}{Total\ Activity\ time\ by\ AE}$$

2.1 **Electrical load variation**

The amount of electrical load demand during daytime and nighttime does not vary significantly (Day load = 17955.1016, Night load = 17732.3197).

2.2 **Amount of GHG emissions reduced by electrification**

The Rate of Emissions from AE for the 'Alongside/Hotel' phase was 186.4852g/h while the Rate of Emissions from AE for the "Transit/Anchorage/Maneuvering' phase was 65.5617g/h.

3 Results

The Rate of Emissions from AE for the 'Alongside/Hotel' phase was significantly greater than the Rate of Emissions from AE for the "Transit/Anchorage/Maneuvering' phase. This difference may be attributed to the increased movements and processes required for precise berth activities[1], which far outweighs the mitigative effect of electrification in the berth. This suggests that electrification may not actually be an effective method in reducing GHG, and Singapore should opt for alternative methods such as developing a more efficient vessel berthing system.

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[1] Retrieved from: https://www.researchgate.net/publication/348674603_The_CO2_reduction_potential_of_shore-side_electricity_in_Europe