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Abstract

Amidst rising greenhouse gas (GHG) emissions due to increasing vessel traffic, our study at Pasir Panjang port outlines a baseline GHG emissions assessment and evaluates vessel electrification's impact. Data analysis reveals that stationary berthed vessels in particular are key culprits of GHG emissions. Implementing Shore Power (Cold Ironing) presents an opportunity to significantly reduce not only CO2 but also other pollutants. As Singapore progresses towards greener energy, the decarbonization potential of electrification strengthens, promising enhanced environmental outcomes for the maritime industry.

1. Introduction

Singapore, already one of the busiest ports in the world, is continuously growing in traffic and volume, reaching an all-time high of 3 billion gross tons in vessel arrivals in 2023[1]. Higher traffic consequently leads to more ships passing through Singapore in addition to the necessary support infrastructure, causing GHG emissions to increase.

With Singapore's ports being one of seven focus areas of the Maritime Singapore Decarbonisation Blueprint[2], a baseline assessment of GHG emissions in Singapore's ports is needed to accurately quantify emissions, as well as model how it can be reduced through electrification.

2. Baseline Assessment of GHG Emissions

With the provided dataset, ship data can be separated by operating type: transit, anchoring, manoeuvring and alongside (otherwise known as berthing). Our primary focus is the alongside period, where the vessel must be berthed and stationary.

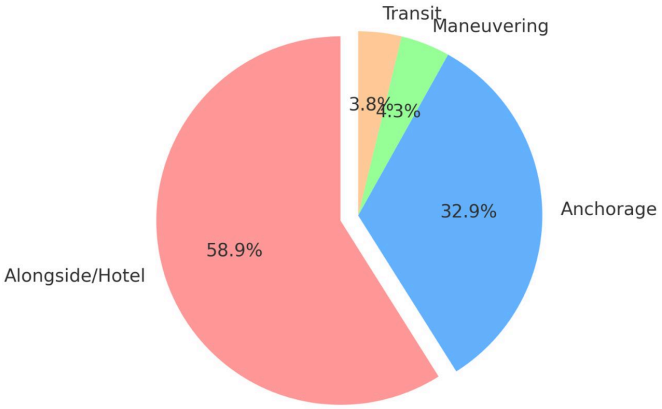


Figure 1: Breakdown of ship data by Operating Type

The alongside period, according to our obtained data, has the most CO_2 emissions, which is strongly correlated to this period also having the highest amount of activity hours. This means that the alongside period is the most significant period to focus on reducing emissions in.

[1]https://www.mpa.gov.sg/media-centre/details/singapore-crosses-record-three-billion-gross-tonnage-in-annual-vessel-arrival-tonnage
[2]https://www.mpa.gov.sg/regulations-advisory/maritime-singapore/sustainability/maritime-singapore-decarbonisation-blueprint

3. Electrification of Berthed Vessels

Shore Power, also known as Cold Ironing, has the ability to greatly reduce both air pollution and noise pollution at ports by connecting berthed vessels with on-shore electrical grids. This allows ships to operate without any of the on-board engines running.[3] Given that berthed or hotel vessels at Pasir Panjang Terminal are the primary source of GHG emissions, focusing on the electrification of these docked ships holds significant potential to markedly diminish environmental pollution.

Moreover, the analysis of the electric load in berthed vessels per hour shows that the electric load stays relatively constant across the entire day. This helps us ascertain that any emissions saved from switching to electrification is consistent across 24 hours.

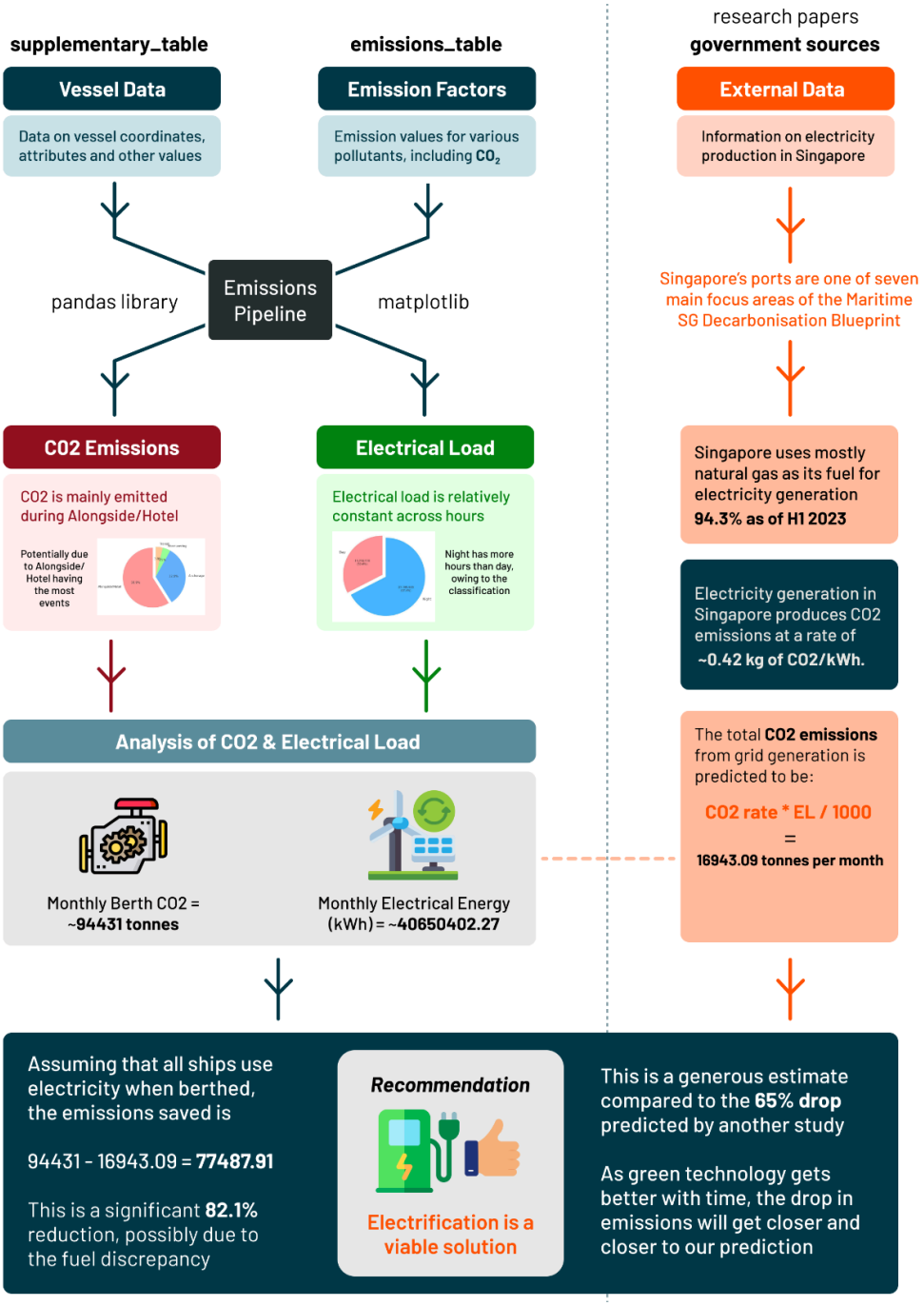
4. Generation of Electricity in Singapore

Electrification, while presented as an alternative to fossil-fuel based methods of power generation for vessels, is also subject to GHG emissions in the process. According to Singapore's Energy Market Authority (EMA), the average volume of CO_2 emitted per kilowatt hour can be modelled by the Operating Margin Grid Emission factor, amounting to about 0.4168 kg CO_2/kWh as of 2022[4]. The predominant method of electricity generation in Singapore is through natural gas.

This closely aligns with the statistic from the US Energy Information Administration (EIA), stating that natural gas in electricity production produces 0.97 pounds (0.44 kg) CO_2/kWh[5]. This gives us confidence to use the value of 0.4168 kg CO_2/kWh for further calculations.

[3]https://climate-change.ieee.org/news/maritime-transportation/
[4]https://www.ema.gov.sg/resources/singapore-energy-statistics/chapter2#:~:text=Singapore%27s%20electricity%20generation%20capacity%20increased,ESS)%20and%20electricity%20import%20capacities
[5]https://www.eia.gov/tools/faqs/faq.php?id=74&t=11

5. Flowchart



6. Conclusion

Thus, electrification at Pasir Panjang port could significantly reduce CO2 and other gas emissions and is a crucial step in advancing Singapore's maritime decarbonization efforts. As Singapore's energy grid becomes increasingly fueled by clean sources, the benefits of Cold Ironing will only correspondingly amplify. Hence, electrification offers a synergistic and resilient boost to the maritime industry's decarbonization journey.