Comparative LCA of cable car, bus and streetcar using a synthetic model

Master‘s Thesis of Zonglin Cai

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Introduction: Minimizing the carbon footprints of human activities and pursuing sustainable development have emerged as paramount issues across various sectors. The transport sector is crucial in this context, particularly in Europe. Therefore, the environmental impacts of different transport modes, such as buses, streetcars, and cable cars, should be evaluated and compared to pursue better sustainability in transportation. To meet this purpose, Life Cycle Assessment (LCA) is introduced into this comparative analysis due to its comprehensiveness and reliability. A set of consistent life cycle and baseline transport models, encompassing both vehicles and infrastructure across all three passenger transport modes, has been developed for comparison.

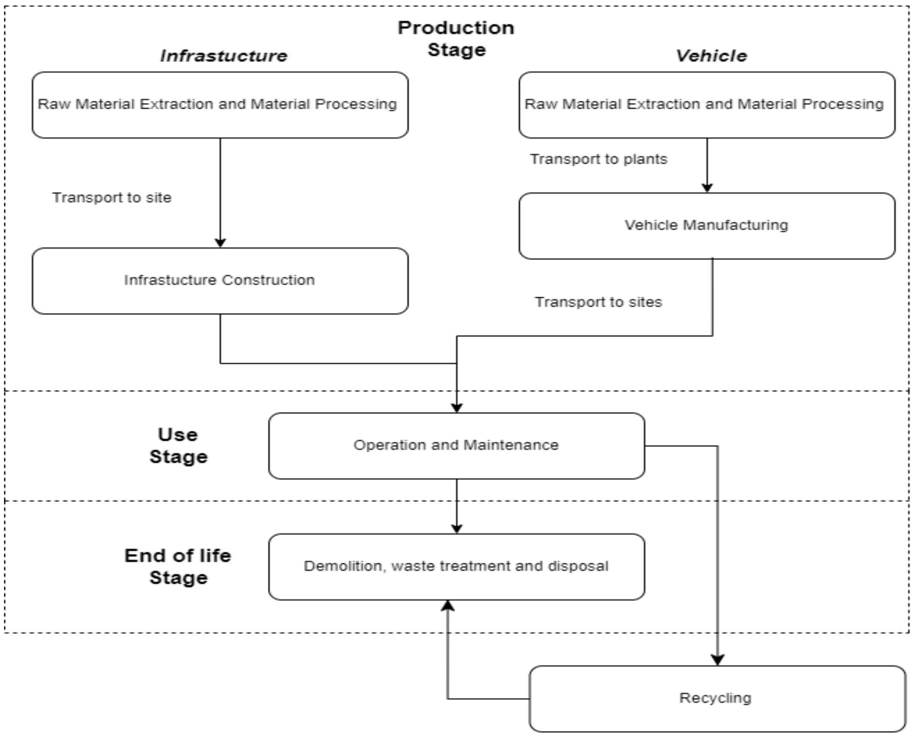

Fig 1. System boundary for transport modes

Goal and scope: The main goal of the present study is to compare the environmental performances of three different public passenger transport modes in city areas (cable cars, buses, and streetcars) using the LCA methodology for more sustainable urban mobility. The secondary goal is to implement the developed methodology for the Frankfurter Ring Urban Ropeway Project and evaluate the environmental impacts of the three transport mode options in the case study.

Functional unit: 1 passenger-kilometer (pkm)

System boundary: The system boundary of the LCA model is shown in Fig 1 and applies to all three transport modes. Recycling of the metals and other recyclable materials is excluded from the study.

Inventory and Impact Assessment: Data and models for both vehicles and infrastructures of the respective transport modes are distinguished and collected for comprehensive comparative analysis. Data sources aggregated for the study include the ropeway manufacturers, the Umweltbundesamt, relevant EPDs, existing databases (such as Ecovient and GaBi), and a comprehensive literature review. The IPCC 2021 GWP 100a method is chosen to quantify climate impacts, and the results are expressed in CO_2-equivalents (CO_2-eq).

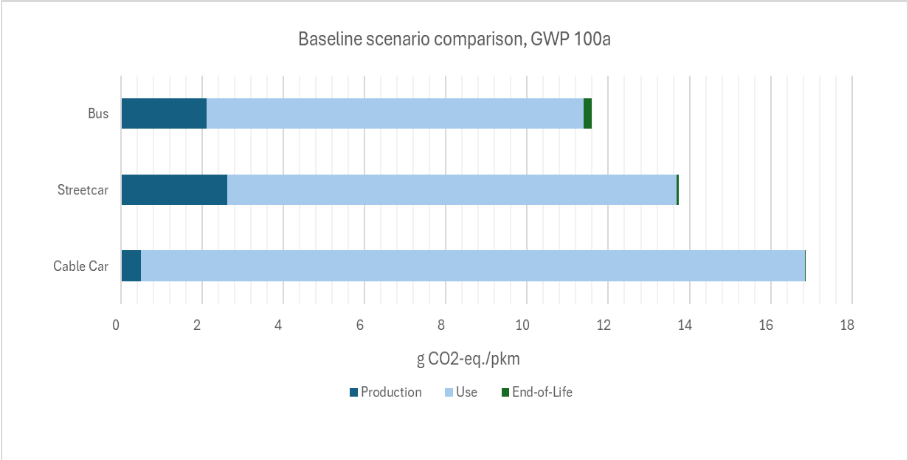

Fig 2. GHG emissions under the baseline scenario

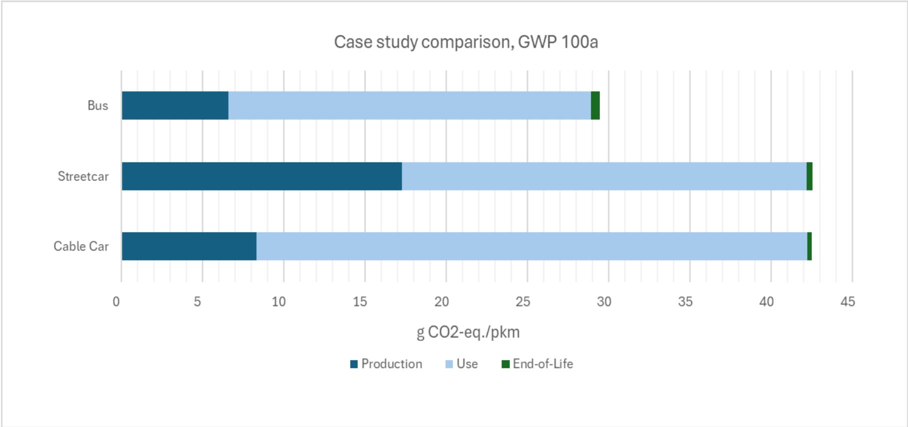

Fig 3. GHG emissions in the case study

The results reveal that electric bus systems produce the lowest GHG emissions among the three transport modes based on the baseline scenario and the case study. Cable car systems exhibit no advantage over streetcars and buses in terms of carbon emissions during the use stage. However, sensitivity analysis shows that higher-capacity cable car systems can slightly reduce total carbon emissions. Enhancing vehicle seat utilization and adopting a cleaner energy mix will also contribute to reducing GHG emissions. In the actual case study, the cable car system with 3S-Small Technology produces lower carbon emissions than streetcars based on shorter routes and higher service capacity requirements, which makes it considerable for future sustainable urban mobility. This research provides valuable insights for policymakers and stakeholders to understand the climate impacts of buses, streetcars and cable cars, thus making effective measures and transport choices to ensure better sustainability transportation.

Limitations: The data utilized in the studies are sourced from various sources, resulting in inconsistencies and potential uncertainties. Several processes and sub-processes in the production stage lack sufficient data. There are no definitive equations to calculate the energy consumption for buses and streetcars during the use stage. Additionally, the baseline transport model overlooks vehicle dwell time and charging time and makes several assumptions that may be overly idealized compared to real-world conditions. Incorporating more accurate foreground data and conducting uncertainty analysis may helps to improve the accuracy of the assessment.