Electromobility-based urban goods transport in Singapore

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Problem
Cities and countries are dealing with the externalities caused by transport activity, such as noise and air pollution and greenhouse gas emissions. Several governments around the world are turning to electrically propelled vehicles (or electric vehicles) to mitigate this problem.

In the context of urban goods transport, there is potential for substituting the conventional diesel vehicles for electric ones, if certain technical limitations are dealt with. Besides the high cost to purchase the vehicle, there are still severe constraints in the form of short driving range, the long charging duration and reduced payload capacity. These effects are particularly significant, when we consider that goods vehicles are typically heavily utilized, and any “unused” time is a cost to the company. Fortunately, charging technology for road electric vehicles has made decent strides in the past decade, with advances in fast and ultra-fast charging, and dynamic charging methods, both via embedded wireless chargers or overhead catenary systems.

The analysis provided in this study aims to evaluate the suitability of the urban logistics operations as it is in Singapore to adopt electric vehicles for their primary means of goods transport, while considering feasibility of the concept and the potential environmental benefits, which could be reaped by the society.
State of the art

Current studies in this field of electromobility for goods transport have focused on either specific transport projects, i.e. logistics use cases, or on vague descriptions of the mileage driven by goods vehicles of a certain class. The disadvantage of the evaluation strictly based on the mileage driven is that the logistics case is too superficial and simplistic. The type of logistics operation needs to be defined not only by distance but also by the weight carried by the vehicle. On the other hand, the disadvantage of the focus on logistics use cases is the difficulty to generalize to a wider use case, such as to describe a whole class of logistics operation types, e.g. retail replenishment or postal services. Failure to do so regulates the study to localized experiments or conclusions, which will not benefit the larger society.

Existing studies have also avoided the use of more advanced charging concepts currently available. This is probably not due to the lack of options, since the various charging technology have at least been in discussion in research and in the industry for several years. The failure to account for the various charging technology handicaps electric vehicles, which is admittedly more dependent on charging infrastructure, than the diesel vehicle is on the fuelling station.

Evaluations in this field have also mostly focused on the financial cost of ownership and the potential environmental benefits of the usage. Since these methods have existed for a long time, the studies that have applied them are generally satisfactory. Nevertheless, as mentioned previously, the weight of the vehicle is not taken into account precisely, and is often considered statically, which affects the calculation of energy consumption.

Methodology

The study employs several methods to evaluate the question on suitability at the Singapore level. Though the approach is by case studies, the study will extrapolate the results to a general applicability in Singapore. In this scenario-based analysis, a decision is made on its suitability based on the elimination-by-aspects approach. This approach quickly and transparently evaluates whether the transport demand scenario can be supported by the electromobility system in question. Before the evaluation is conducted, the parameters of the electromobility system are set, such that it is best suited, given the technological constraints. This includes the sizing of the battery capacity to meet the route energy demands.

The scenario is created using a simplified duty cycle obtained through interviews with logistics managers of the companies in question. Then, driving schedules are created for vehicles in the fleet using the vehicle routing problem as a problem model, and a simple scheduling algorithm. Next, these are evaluated using electric vehicles and different charging systems, according to energy consumption, total cost of ownership, and CO2 emissions. The end result is the set of scenarios, which can succeed using electromobility.

Outlook

Though the study seems minimalistic, the most significant indicators for evaluation was chosen, which allows for a transparent but relevant decision making tool. The framework can also easily be extended using more complex tools, especially for developing scenarios.