Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 12 (2016) 288 – 300

Transportation Research Procedia

www.elsevier.com/locate/procedia

The 9th International Conference on City Logistics, Tenerife, Canary Islands (Spain), 17-19 June 2015

# Methodology to evaluate the operational suitability of electromobility systems for urban logistics operations

Tharsis Teoh[a]*, Oliver Kunze[b], Chee-Chong Teo[c]

[a]*TUM CREATE, #10-02, 1 Create Way, 138602 Singapore, Singapore*
[b]*University of Applied Sciences Neu-Ulm, Wileystraße 1, 89231 Neu-Ulm, Germany*
[c]*Nanyang Technological University, 50 Nanyang Ave, Singapore 639798, Singapore*

**Abstract**

A methodology was developed to evaluate the operational suitability of electromobility concepts for last-mile delivery operations. Electromobility systems consisting of electric vehicles of ten weight classes and four mid-operation charging strategies were synthesized and evaluated using a hypothetical grocery outlet replenishment scenario. A system of operational suitability indicators was developed based on the amount of and efficiency of resources needed. The results highlight a strong trade-off between single-charge driving range, payload capacity, and the minimum fleet size needed. If operational performance similar to that of diesel vehicles is to be reached, mid-operation charging could be a reasonable alternative to "simply" having a bigger vehicle battery.


Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics

*Keywords:* Electromobility; Urban logistics; Last-mile delivery; Operational performance; Electric vehicle

## 1. Introduction

When considering the adoption of electric vehicles for goods transport, one is made aware of several operation-specific disadvantages in comparison to combustion engine vehicles: primarily the significantly less driving range, due in part to the technical and financial limitation of onboard energy storage, and the inconvenience of charging. Additionally, the heavy and large battery pack installed may reduce the payload capacity of the vehicle. The limited

* Corresponding author. Tel.: +65-66014031; fax: +65-67777236.
*E-mail address:* tharsis.teoh@tum-create.edu.sg


Peer-review under responsibility of the organising committee of the 9th International Conference on City Logistics
doi:10.1016/j.trpro.2016.02.066

driving range and possibly reduced payload capacity are two technical constraints, which influence the operational capabilities of the vehicle. Nevertheless, technological advancement, such as fast charging and dynamic wireless charging, may reduce the disadvantages and remove barriers to adopting electric vehicles for logistics use.

Studies into the suitability of an electromobility[1]-based urban goods transport delve mostly into the economics of the vehicle purchase and the benefits to the environment (Davis, Figliozzi 2013; Feng, Figliozzi 2013; Lee et al. 2013). The exploration of how the vehicles would be used in the operation is secondary or assumed to be unchanged from how conventional vehicles would have been used. However, the aforesaid technical constraints may affect how the vehicles are being used; just as how range anxiety affects the distance a passenger vehicle would be driven (Moudrak 2013, p. 14). More research is required to understand how the technical specifications of the vehicles and chargers affect the operational capabilities of the goods transport system.

Real case studies of the electric vehicles could provide insight into the operational performance of the vehicles and the user acceptance (Jeeninga et al. 2002; Sustineo 2012). However, such an evaluation occurs at the product level, i.e. the purchased vehicles, and not at the conceptual level, which instead would allow the evaluation to be logically extended to other vehicles in the current (or future) market. The conceptual evaluation is especially appropriate for explorative studies in electromobility, where the technology still develops quickly. Accounting for the possible streams of development in the evaluation could aid the identification of the most suitable electromobility concepts for a given application; thus defining the emphasis future research should have. In particular, various charging strategies should be considered by the evaluation of concepts.

The research in this paper addresses the operational suitability of different electromobility concept variations for urban logistics operations. These concepts can vary in terms of the size of the vehicle, the desired single-charge driving range, and the type of charging infrastructure used. Wasson (2006, p. 50) defines operational suitability as the degree to which a system is “suited to a user’s specific application in a given operating environment” and “integrates and performs within the user’s existing system.” The question of how well it performs is interpreted in this study as the efficient use of resources available for the movement of goods. An excellent review of operational freight transport efficiency, which is inextricably tied to performance, is found in Arvidsson’s work, which develops a general definition of operational freight transport efficiency: “a set of utilisation measures of time, space, vehicle, fuel and driver in the movement of goods” (Arvidson 2011, p. 36). In this research paper, where the transport task is kept constant, an electromobility system’s operational suitability is gauged based on the amount and the efficiency of allocated resources - time, space, vehicle, fuel, and driver. Note that the consideration of cost, such as total cost of ownership[2], is not included in the study, but could easily be added for further research.

Two aspects need to be considered for the evaluation. On one hand, the application context is important: the different urban structures; road network; size and type of the operation; amount and type of products shipped; and many other product-, operational- and city-specific characteristics drastically affect the transport system requirements. On the other hand, the diverse and still maturing electromobility technology may allow potential adopters to cope with the range and payload requirements of the operation. To account for these aspects, part of the study used methods to synthesize an electric vehicle fleet, simulate the daily driving schedule of each vehicle in the fleet for the given operation, and estimate the influence of using different charging strategies and systems. The variations implemented allow an analysis of the different trade-offs the use of one electromobility system has in place of another, in terms of battery capacity, fleet size, and charging power.

The paper is organized as follows. The methodology section reports different methods used in this study, from the creation of the scenario up to the evaluation of operational suitability. Then, the results are presented: the partial validation; a comparison with a conventional vehicle; and the evaluation of the operational suitability of the fleets. Finally, the study concludes with the major findings of the paper and several further research recommendations.

[1] Electromobility is a concept that refers to the usage of electrified road transport. An electromobility system should at the very least include the electric vehicle and the charging system.

[2] The total cost of ownership considers “all costs arising with the ownership of an automobile including costs of purchasing, operating and maintaining, charges and taxes as well as costs of recycling and disposal over a specified timeframe under consideration of opportunity costs.” (Gass et al. 2014, p. 98)