Proceedings of the 2022 Winter Simulation Conference
B. Feng, G. Pedrielli, Y. Peng, S. Shashaani, E. Song, C.G. Corlu, L.H. Lee, E.P. Chew, T. Roeder, and P. Lendermann, eds.

STUDYING LOGISTIC FLEET ELECTRIFICATION USING TRAFFIC MICROSIMULATION SOFTWARE

Frederick Pringle
Nagacharan Teja Tangirala
Muhammad Sajid Ali
Alois Knoll

Technical University Munich
Botzmannstrasse 3
85748 Garching, GERMANY

David Eckhoff

TUMCREATE Limited
1 Create Way
#10-02 CREATE Tower
Singapore, 138602 SINGAPORE

ABSTRACT

Electric vehicles (EVs) can make a significant contribution to addressing global climate change. However the adoption of EVs for road freight transport is low, owing to challenges such as limited range, cargo capacity constraints, and charging times. This paper briefly describes a simulation-based approach to studying the feasibility of EV adoption for road freight transport. With the help of the microscopic traffic simulator CityMoS, we assess the impact of electrification from an operational as well as climate perspective.

1 INTRODUCTION

The transport sector relies heavily on fossil fuels for its energy needs. In the EU, transport accounts for 63% of fuel consumption and 29% of all CO_2 emissions (Kleiner, Beermann, Çatay, Beers, Davies, and Lim 2017). Additionally, freight transport activity is predicted to grow by around 80% in 2050 compared to 2005. Therefore, electrification of freight vehicles is essential to mitigate the effects of freight transport on the climate. This is less trivial than the electrification of private vehicles. Owing to the cargo capacity requirements, trucks must be equipped with high-capacity batteries. This requires suitable infrastructure so that the charging times do not become a bottleneck. Furthermore, fleet operators have to modify their operational procedures to accommodate the electric trucks' limited range and charging requirements. Due to these additional constraints, a thorough understanding of fleet electrification is essential before large-scale adoption is possible. Extensive field tests are not feasible due to the high cost. Thus, we propose a simulation-based approach to assess and study electric fleets. In this paper, we describe our ongoing work using CityMoS (Zehe, Nair, Knoll, and Eckhoff 2017) to model and analyze the feasibility of an electric fleet, and present some of the results we have attained so far.

2 CITYMOS

CityMoS is a stochastic agent-based microscopic mobility simulation tool that can facilitate the study of city-scale transport systems. The modular nature of CityMoS allows for addition of new behavior depending on the study requirements. To simulate an electric fleet, we extended CityMoS to include models for fleet depots, electric trucks, cargo assignment, depot processes, and charging management. The accuracy and high-performance capabilities of the simulator make it easy to carry out extensive studies of electric fleets under various operational conditions.

With the help of CityMoS, a wide range of questions can be answered without going through the expensive and time-consuming process of field testing. The impact on service due to the substitution of Internal

Combustion Engine (ICE) vehicles with EVs can be analyzed by comparing the delivery completion rate. Different charging infrastructures and intelligent charging methods can be studied to find an efficient yet cost-effective solution. Furthermore, insights from simulations on mixed-fleet behavior are required to make informed decisions during the transition period from all-ICE to all-electric fleets. Moreover, the environmental benefits can be quantified by estimating the reduction of CO_2 emissions due to electrification. In this paper, we conduct a feasibility study to determine if an ICE fleet can be replaced with an EV fleet.

3 SIMULATION

A cargo delivery fleet operates with a central depot acting as a dispatch location. Each truck is provided with a set of deliveries to complete. The trucks pick up their cargo from the depot, complete the deliveries and return to the depot. Based on the input data of delivery assignment for a day, we simulated 67 trucks of a commercial fleet carrying out cargo deliveries in Frankfurt and its surrounding regions. We extracted road network data of the target region from OpenStreetMap and converted it into a format readable by CityMoS. We used the physical dimensions and battery specifications from the parameters of one of the commercially available electric trucks. To capture realistic travel times, we populated the target area with private car traffic. We calibrated the background traffic using the Mobilität in Deutschland (MiD) data. We assume that all the trucks are fully charged before the start of the day of deliveries. We ran the simulation for one day of simulation time to assess the fleet performance as well as the environmental benefits. The CiLoCharging project includes plans to run real-world field tests with electric trucks, during which time we will be able to validate and refine our models in an iterative procedure.

4 RESULTS

Simulation results show that the electric trucks can complete all of their assigned deliveries. After the trucks returned to the depot, the lowest battery charge of one of the trucks was found to be 61%. By using typical values for CO_2 emissions of freight trucks, we estimate that the total CO_2 emissions saved by using electric trucks are around 1.48 metric tons for the day, assuming that the trucks are charged using carbon-free electricity.

5 CONCLUSION

In this paper, we carried out a simple feasibility study of the electrification of the logistic fleet using CityMoS. The study highlights the capabilities of microscopic mobility simulation to provide valuable insights into fleet performance in a relatively short turnaround time. This study could be easily extended to support a larger timescale or fleet size. It is safe to conclude that given detailed models for background traffic, depot processes, fleet parameters, and delivery assignment data, a microscopic agent-based simulation tool such as CityMoS can provide valuable insights to support the transition to electric logistic fleets.

ACKNOWLEDGEMENT

This study is done as part of the CiLoCharging project which is funded by the Bundesministerium für Wirtschaft und Klimaschutz (BMWK) of Germany. The authors would like to thank the project partner DHL for providing the data required for the study.

REFERENCES

Kleiner, F., M. Beermann, B. Çatay, E. Beers, H. Davies, and O. T. Lim. 2017. "Current Status of the Electrification of Transport Logistic Vehicles-Early Niche Markets and Commercialization Opportunities". In *Proceedings of the European Battery, Hybrid and Fuel Cell Electric Vehicle Congress*. March 14^{th}-16^{th}, Genf, Switzerland, 1–7.

Zehe, D., S. Nair, A. Knoll, and D. Eckhoff. 2017. "Towards Citymos: a Coupled City-scale Mobility Simulation Framework". *5th GI/ITG KuVS Fachgespräch Inter-Vehicle Communication* 2017:03.