University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Applied Science

of

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"Energy Consumption and GHG Emissions Evaluation of Conventional and Battery Electric Refuse Collection Trucks"

Department of Mechanical Engineering

Wednesday, October 16, 2019
10:00 A.M.
Engineering Office Wing
Room 230

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Abstract

The notorious fuel consumption and environmental impact of conventional diesel refuse collection trucks (D-RCTs) encourage collection fleets to adopt alternative technologies with higher efficiency and lower emissions/noise impacts into their fleets. Due to the nature of refuse trucks' duty cycles with low driving speeds, frequent braking and high idling time, a battery-electric refuse collection truck (BE-RCT) seems a promising alternative, taking advantage of energy-saving potentials along with zero tailpipe emissions. However, whether or not this newly-introduced technology can be commercially feasible for a collection fleet and/or additionally mitigate GHG emissions should be examined over its lifetime explicitly for the specific fleet. This study evaluates the performance of a D-RCT and BE-RCT in a collection fleet to assess the potential of BE-RCT in reducing diesel fuel consumption and the total GHG emissions.

A refuse truck duty cycle (RTDC) was generated representing the driving nature and vocational operation of the refuse truck, including the speed, mass, and hydraulic cycles along with the extracted route grade profile. As a case study, the in-use data of a collection fleet, operating in the municipality of Saanich, BC, Canada, are applied to develop the representative duty cycle. Using the ADVISOR simulator, the D-RCT and BE-RCT are modeled and energy consumption of the trucks are estimated over the representative duty cycle. Fuel-based Well-to-Wheel (WTW) GHG emissions of the trucks are estimated considering the fuel (diesel/electricity) upstream and downstream GHG emissions over the 100-year horizon impact factor for greenhouse gases. The results showed that the BE-RCT reduces energy use by 77.7% and WTW GHG emissions by 98% compared to the D-RCT, taking advantage of the clean grid power in British Columbia. Also, it was indicated that minimum battery capacity of 220 kWh is required for the BE-RCT to meet the duty cycle requirements for the examined fleet. A sensitivity analysis has been done to investigate the impact of key parameters on energy use and corresponding GHG emissions of the trucks. Further, the lifetime total cost of ownership (TCO) for both trucks was estimated to assess the financial competitiveness of the BE-RCT over the D-RCT.

The TCO indicated that the BE-RCT deployment is not financially viable for the examined fleet unless there are considerable incentives towards the purchase cost of the BE-RCT and/or sufficient increase in carbon tax/diesel fuel price. From the energy use evaluation, this study estimates the required battery capacity of the BE-RCT for the studied fleet, and the TCO outputs can assist them in future planning for the adoption of battery electric refuse trucks into their collection fleet where the cost parameters evolve.

Keywords: Refuse collection truck, Representative duty cycle, WTW GHG emissions, Total cost of ownership (TCO)