

Article

Electrification of a Class 8 Heavy-Duty Truck Considering Battery Pack Sizing and Cargo Capacity

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Abstract: The design and performance optimization of fully electric trucks constitute an integral goal of the transport sector to meet climate emergency measures and local air quality requirements. Most studies in the literature have determined the optimum pack size based on economic factors, without accounting for the details of pack behavior when varying the size. In this paper, the effect of battery pack sizing and cargo capacity of a class 8, 41-ton truck on its overall energy performance and technical parameters of its powertrain is investigated. For this purpose, the proposed electric truck is designed and mathematically modelled using AVL CRUISE M software. The second-order equivalent circuit model is developed to predict the battery packs' parameters. The proposed battery pack model is extracted from experimental analysis on SONY VTC6 lithium-ion batteries performed in the lab. The weight changes due to adding the battery packs to the truck are also estimated and have been taken into account. The mathematical model of the powertrain is simulated in the long-haul driving cycle considering different cargo capacities and battery pack sizes. The results of this study revealed that the battery pack voltage reached its minimum value when the maximum cargo capacity was applied for the 399 kWh battery pack. In addition, increasing the occupied cargo capacity from 10% to 100% resulted in an increase in the regenerative brake energy of up to 9.87 kWh, while changing the battery size imposed minimal impacts on regenerative brake energy recovery as well as energy consumption.

Keywords: battery electric; battery pack; energy performance; simulation



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1. Introduction

As climate change becomes an increasingly pressing issue, the automotive industry is shifting towards electrification of vehicles to reduce carbon emissions. EV sales rose by 68% globally between 2017–2018 [1]. However, the heavy-duty vehicle industry has not seen the same volume of electric vehicle sales [2–4]. In 2020, global sales of electric heavy-duty trucks accounted for less than 1% of the total sales [5,6]. The trucking industry contributed 23% of transport GHG emissions in the US [7]. The low level of electrification of this space presents a large opportunity for a reduction in carbon emissions.

A primary reason for the dependence of the truck manufacturing industry on fossil fuels is the high energy demands compared to passenger cars [8]. Heavy-duty EVs require larger energy storage due to their greater range, weight, and aerodynamic load demands compared to passenger EVs [9–11]. Most heavy-duty trucks must travel long distances between each stop. This requires large batteries to be installed [12] or electric roads, which require large investments for infrastructure [13]. Since battery energy density is lower than fuel tanks used in Internal Combustion Engine (ICE) trucks, the energy storage system in heavy-duty vehicles becomes expensive and heavy due to electrification [9,14]. Accordingly, the extra mass of the battery packs reduces the cargo capacity since the total weight of the truck needs to remain constant during electrification [9,15].

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