Configuration of Electric Vehicles for Specific Applications from a Sustainable Perspective

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Abstract

This study aims to design a powertrain configuration tailored for specific applications, allowing a reduction of net emissions, investment cost, and operational cost when comparing to its fossil fueled alternative. The methodology is divided into 3 phases: i) Select the specific niche to be electrified whose local conditions ease their social adaptation and monitor their current operation for a long time to determine their driving patterns and operational conditions, ii) Construct a real-world driving cycle based on the typical driving profile of the niche using the Energy Based Micro-Trips method, and iii) Define the vehicle performance metrics to optimize and then based on a multi-objective optimization and an iterative energy-based approach, determine the best electric vehicle's powertrain configuration (number of batteries, motor size, and gearbox transmission ratio) that optimizes the chosen performance metrics. In this work, a university shuttle service is considered as the case study. Based on a measurement campaign on the normal operation of these buses, a geometrical gearbox and an energy management system have been designed through a multi-objective optimization using an iterative energy-based approach. It was considered Deep-cycle Lead Acid and Lithium Polimer (LiPo) batteries within the design of choice. The best results were observed with LiPo batteries, which shows improvements of the vehicle's acceleration capacity by 26.5% while at the same time reducing energy consumption by 37%, CO_2 emissions by 31%, and the total cost of ownership by 10% when compared to its counterpart diesel buses. Furthermore, it was studied the evolution of the TCO as a function of autonomy under this configuration, and it was obtained that the TCO can be even better to its diesel counterpart under low autonomies (< 160km). In the case of study considered in this work (aka *CircuitoTec*), each route has approximate distances of 25 km and therefore a range of 50+ km is reasonable. Therefore, for this application, the operation of passenger transport with electric buses is not only feasible, but it is also a better choice.

Keywords
Powertrain, energy management, driving cycles, energy optimization, TCO.

Biographies

José Ignacio Huertas is a full-time professor of the Mechanical Engineering Department at Tecnológico de Monterrey. Researcher of the Energy and Climate Change Research Group. He belongs to the Mexican System of researchers (SNI) level 2, and to the Mexican Academy of Science. He has published 3 books, more than 50 indexed papers, has 2 patents conferred, has graduated 8 PhD and 89 MSc students, and has completed more than 90 research projects financed by private companies and governmental institutions in Colombia, Mexico, Spain, France, and USA. Areas of interest: Energy, Combustion, Vehicular emissions, Air pollution and Smart mobility

Antonio E. Mogro is an automotive engineer graduated with distinction from the University of the Armed Forces ESPE, in Ecuador. He has a master's degree graduated as an honor student in automotive engineering from the Tecnológico de Monterrey. Currently, he is a PhD candidate from the Tecnológico de Monterrey where he works as an academic researcher focusing on real world vehicle emissions. He has 6+ years of experience in research centers, 12+ years in academia, 10+ research projects and 9+ working/published articles.

Juan P. Jimenez is an engineer in automotive design from Tecnológico de Monterrey, he has experience in vehicle dynamics and electric powertrains. Currently, he works in the aftertreatment department in John Deere, México.