Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/NA10.20250264
Published: June 17, 2025

Comparison of the Use of Hybrid and Plugin Hybrid Electric Buses for Sustainable Urban Transportation Split Use Case

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Abstract

Urban livability faces significant challenges due to traffic congestion, noise pollution, and vehicle emissions. Electric buses offer a promising solution to reduce noise and tailpipe emissions in cities. However, their limited range, constrained by battery capacity, can hinder operational flexibility. As an alternative, plug-in hybrid electric buses and hybrid buses (referred as PHEB and HB, respectively) provide a more versatile option by combining zero-emission capabilities with conventional diesel engines. Their efficiency depends on battery capacity and the strategic allocation of electric drive sections along routes. Yet, existing electric drive assignment systems remain suboptimal, as they do not fully exploit the potential of hybrid propulsion. The significance of electromobility is highlighted in this work, by analyzing the broader environmental benefits and the impact on urban quality of life of these two main existing technologies, plug-in electric hybrid and electric hybrid. Unlike previous approaches that primarily emphasize energy efficiency, this work develops optimized strategies for maximizing electric driving distance while minimizing overall emission. The problem is formulated as a multi-objective optimization one, tackled using a state-of-the-art evolutionary algorithm along with the existing GreenK heuristic. These methods enable the exploration of different electric drive distribution scenarios while accounting for real-world traffic conditions and route topography. Results demonstrate that the electromobility technology used significantly impacts on sustainability, hybrid buses producing higher tailpipe emission levels (covering 17,9% less distance with the electric motor), but avoiding the need of any charging infrastructure. In either case, HB or PHB, the optimized electric drive strategy can significantly reduce emissions and enhance the efficiency of the public urban bus networks, contributing to more sustainable public transportation systems.

Keywords

Public urban transportation · Driving assignment strategies,· Multi-objective optimization · Sustainability · Genetic algorithm