

Impact of Temperature, HVAC Usage, and Driving Patterns on the Energy Consumption of ICEVs and BEVs

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Abstract

Vehicle energy consumption is affected by multiple factors, such as environmental conditions and operational characteristics. This study provides a comprehensive analysis of the energy consumption of internal combustion engine vehicles (ICEVs) and battery electric vehicles (BEVs) through both chassis dynamometer and real-world driving tests. It examines varying temperature settings (low, high, and normal), the impact of air-conditioning and heating systems, as well as traffic conditions. The results show that BEVs experienced greater energy efficiency losses compared to ICEVs in cold temperatures and with the use of heating systems. While the chassis dynamometer and real-world tests exhibited similar trends, real-world tests showed more variability due to external factors. Additionally, while ICEVs showed significant reductions in energy efficiency under urban traffic conditions, BEVs exhibited relatively smaller changes. The results highlight the distinct efficiency characteristics of vehicles across different operational environments.

Keywords Battery electric vehicle · Internal combustion engine vehicle · Fuel consumption · Energy efficiency · Chassis dynamometer test · Real-world driving test

1 Introduction

The global focus on carbon reduction and improving energy efficiency has heightened the importance of sustainable transportation solutions. In the automotive sector, one of the primary methods for achieving carbon reduction and improving energy efficiency is through enhancing the performance of vehicles. In addition to this, introducing environmentally friendly powertrains, such as Battery Electric Vehicles (BEVs) and Fuel Cell Electric Vehicles (FCEVs), is also a key approach (Mahmoudzadeh Andwari et al., 2017; Offer et al., 2010; Pramuanjaroenkij & Kaka, 2023).

These strategies represent significant steps toward reducing carbon emissions and promoting sustainable transportation solutions.

The energy consumption characteristics of vehicles are influenced by numerous factors, ranging from driving patterns such as speed and acceleration to external conditions such as ambient temperature and traffic congestion (Fontaras et al., 2017; Kropiwnicki et al., 2013; Li et al., 2016; Sweeting et al., 2011). Several studies have examined the influence of ambient temperature on vehicle performance. Luján et al. (2019) investigated fuel consumption of Internal Combustion Engine Vehicle (ICEV) in relation to ambient temperature, finding that fuel consumption increased by nearly 10% in the NEDC at -7°C compared to 20°C , reflecting reduced thermal efficiency in colder conditions. However, no significant fuel consumption penalty was observed in the Worldwide Harmonized Light Vehicles Test Cycle (WLTC) at low temperatures, indicating that the effect of ambient temperature on fuel consumption may vary depending on the driving cycle.

Taggart (2017) analyzed the impact of ambient temperature on BEV efficiency and driving range using real-world data from Tesla Model S vehicles. The study found that low

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