Renewable Energy, Environment, and Power Quality Journal (REE&PQJ)
ISSN:3020-531X
Volume 26, July 2026

Real-World Energy Consumption Comparison Between a Diesel Vehicle and a Battery-Electric Vehicle

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Abstract. This study presents a real-world comparison of energy consumption between a battery-electric vehicle (BEV), the Skoda Enyaq iV80, and a conventional internal combustion engine (ICE) vehicle, the Skoda Octavia 2.0 TDI. Both vehicles were driven over identical rural, suburban, and motorway routes to capture representative driving conditions, including uphill and downhill segments. Data acquisition was performed using OBD-II logging for the diesel vehicle and vehicle-integrated telemetry for the BEV. The diesel vehicle exhibited fuel consumption patterns strongly influenced by engine load, gear selection, and transient driving events, whereas the BEV showed energy usage highly dependent on speed, elevation change, and opportunities for regenerative braking. Across all environments, the BEV demonstrated significantly lower energy consumption on a tank-to-wheel basis compared to the ICE vehicle. The results confirm the inherent efficiency advantage of electric drivetrains in real-world operation, particularly in low-speed and variable-speed driving scenarios such as suburban routes. The study provides practical insight into the performance of both vehicle types under everyday driving conditions and contributes toward understanding the energy implications of transitioning from ICE to electric mobility.

Key words. Battery electric vehicle, Internal combustion vehicle, real-world driving, energy consumption.

1. Introduction

In recent decades, the efficiency of internal combustion engines (ICEs) has improved only gradually, despite continuous technological development and a wide range of engineering measures aimed at reducing energy losses. These measures include engine downsizing, turbocharging, optimized combustion strategies, and waste-heat recovery systems. Nevertheless, contemporary research and industrial development efforts are increasingly focused on reducing pollutant emissions—such as particulate matter and nitrogen oxides—rather than substantially improving overall engine efficiency. This trend is influenced by the tightening of emission regulations worldwide, which drive manufacturers toward exhaust after-treatment technologies and combustion optimization rather than transformative efficiency gains.
At the same time, global demographic and mobility trends highlight the limitations of relying solely on incremental improvements to ICE technology. Between the years 2000 and 2050, the world population is expected to grow by a factor of 1.7, while the number of automobiles is projected to increase by a factor of 3.6. This disparity indicates that even if ICE efficiency were to continue improving, the total emissions from road transport would still rise, driven by the sheer growth in the global vehicle fleet. Consequently, a transition toward alternative propulsion systems that do not rely exclusively on fossil-fuel combustion becomes imperative.
Battery-electric vehicles (BEVs) have emerged as the most mature and widely deployed alternative. Compared to ICE vehicles, BEVs exhibit significantly higher tank-to-wheel efficiency due to several intrinsic advantages: electric motors do not waste energy during idling, they provide highly efficient low-speed operation without inefficient clutch engagements, and they recover a portion of kinetic energy during braking through regenerative systems. Multiple real-world studies confirm these advantages. For example, Martins et al. show that electric powertrains are substantially more energy-efficient across a wide range of operating conditions, particularly at lower speeds and in urban environments. Similarly, a multi-year field test comparing a battery-electric vehicle with a diesel passenger car demonstrated that the electric vehicle consistently consumed less than half of the energy required by the ICE vehicle over comparable routes.
The transition toward electrified mobility is also reflected—though not uniformly—in national registration statistics. In Slovenia, there were nearly 1.3 million registered passenger vehicles at the end of 2024. Of the 53,000 newly registered vehicles that year, the average age of the overall fleet was 11.3 years, and the renewal rate was 4.2%. Hybrid vehicles accounted for 26% of newly registered cars in 2024, representing a 23% increase relative to the previous year. In contrast, new BEV registrations declined by 27% during the same period. Long-term data illustrate rapid early growth in the Slovenian BEV market: in 2015, only 288 electric passenger cars were registered; by 2020, the number rose to 3,677; and by the end of 2024, it reached 16,969. However, annual first registrations fell from 4,308 new BEVs in 2023 to 3,156 in 2024, suggesting that market

growth is becoming more sensitive to economic conditions, infrastructure development, and policy incentives.

The present paper examines the energy consumption of two comparable vehicles—one equipped with an internal combustion engine and the other operating as a battery-electric vehicle. The objective of the study is to quantify the energy required for propulsion across different driving environments and scenarios, including uphill and downhill rural roads, suburban driving, and motorway travel. By analyzing real-world driving data across these diverse conditions, the research aims to provide a comprehensive comparison of the operational energy demands of ICE and electric vehicles, thereby contributing to a clearer understanding of their relative efficiencies in practical use.

2. Methods

The purpose of the methodology was to systematically compare the real world energy consumption of two technologically distinct passenger vehicles: a Skoda Octavia equipped with a 2.0 liter diesel engine, and a Skoda Enyaq, a battery electric vehicle (BEV). Both vehicles were tested under comparable driving conditions, following an identical set of predefined routes representing rural, suburban, and motorway environments. The methodology was designed to ensure repeatability, robustness of data acquisition, and relevance to everyday driving scenarios.

The study relied primarily on On Board Diagnostics (OBD) data for the diesel vehicle and vehicle integrated telemetry and charging measurements for the fully electric vehicle. All measurements were performed in real traffic, with environmental conditions such as traffic density, weather, and road infrastructure allowed to vary naturally.

A. Description of the Test Vehicles

1) Skoda Octavia III (Internal combustion Vehicle (ICE))

The diesel reference vehicle was a Skoda Octavia III equipped with the 2.0 liter Modular Diesel Engine (MDB). This engine family, first introduced in the third generation of the Octavia, is widely used across the Volkswagen Group. The specific test vehicle employed the 110 kW (150 hp) variant—the most common version in everyday traffic. The vehicle accelerates from 0 to 100 km/h in 8.6 seconds The engine supports standardized OBD II communication, enabling continuous monitoring of fuel consumption, engine speed, torque load, air intake parameters, coolant temperature, and other operational variables. These data channels formed the basis for the consumption analysis. The vehicle has a curb weight of 1,433 kg, while the maximum permissible gross vehicle weight is 1,943 kg. This provides a payload capacity of approximately 510 kg, including passengers, cargo, and any additional equipment.

2) Skoda Enyaq (Battery Electric Vehicle (BEV))

The electric test vehicle was a Skoda Enyaq iV80, representative of modern BEVs in the European market. The vehicle is powered by a high voltage lithium ion traction battery and a high efficiency permanent magnet synchronous electric motor. Depending on the model configuration, the Enyaq supports AC charging (up to 11 kW) and DC fast charging (up to 143 kW). The traction battery is a lithium-ion system with a nominal capacity of 82 kWh, built from 288 individual cells and operating within a 400-V electrical architecture. Of the total installed capacity, 77 kWh are available as usable energy, while the remainder is reserved for battery protection, thermal management, and long-term degradation control. This configuration represents a typical design approach in modern electric vehicles, balancing high energy density with durability and safety. The vehicle delivers a total peak power output of 150 kW (204 PS) and a maximum torque of 310 Nm, providing strong and responsive performance characteristic of modern electric drivetrains. The manufacturer-rated driving range is 440 km under standard test conditions, and the vehicle accelerates from 0 to 100 km/h in 8.6 seconds, which positions it within the mid-range performance class of contemporary battery-electric vehicles.

In addition to the peak figures, the vehicle is also equipped with a continuous (sustained) power rating of 95 PS, a specification that is typically not highlighted in consumer-facing materials but is relevant for understanding long-duration power delivery, thermal management capability, and compliance with regulatory definitions of electric motor power. The vehicle has an unladen (kerb) mass of 2,075 kg, while the gross vehicle weight (GVW) is rated at 2,540 kg. This substantial difference between kerb weight and GVW reflects the allowable payload capacity, which includes passengers, cargo, and any additional equipment. The mass characteristics are typical for modern battery-electric SUVs, where the high-voltage traction battery represents a significant portion of the total vehicle weight.

B. Measurement Equipment and Data Acquisition

To capture real time engine and vehicle parameters, an OBD data logger ELM 327 was connected to the diagnostic port of the vehicle. All vehicle parameters were recorded with the Car Scanner application. The recorded parameters from the diesel vehicle included the following:

- instantaneous fuel consumption (mg/stroke and calculated L/100 km),
- engine load and torque demand,
- engine speed (rpm),
- vehicle speed (km/h),
- intake air temperature and pressure,
- various temperatures,
- calculated engine power.

Data were sampled at 1 Hz, ensuring sufficiently high temporal resolution for transient driving conditions, such as acceleration, deceleration, and hill climbs.

The logged driving data from the electric vehicle included:

- vehicle speed,
- torque,
- DC Battery power,
- battery energy content,
- total accumulated charge,
- total accumulated discharge,
- motor rpm,
- acceleration,
- distance,
- trip duration

For the electric vehicle, a total of 313 parameters were monitored. Due to this extensive number of simultaneously recorded signals, the sampling frequency had to be reduced.

C. Driving Routes and Testing Conditions

Both vehicles were driven across the same set of predefined routes, designed to represent a broad spectrum of real world conditions:

1) Rural Driving

The route was executed in two directions: one comprising the uphill segment and the other constituting the downhill return segment.

Represents typical low to medium speed driving with variable engine load.

2) Suburban Driving

Involves moderate traffic density and frequent speed changes. Includes roundabouts, intersections, stop and go segments. Suitable for observing regenerative braking effectiveness in the BEV.

3) Motorway Driving

Constant cruising speeds at 100–130 km/h.

Allows evaluation of steady state consumption and differences between ICE and BEV aerodynamic efficiency.

All tests were conducted with:

- the same driver,
- similar ambient temperatures when possible,
- similar tire pressures and vehicle load,
- adherence to normal traffic regulations.

D. Data processing and analysis

All tests

3. Results

A. Rural driving downhill

1) ICE Vehicle

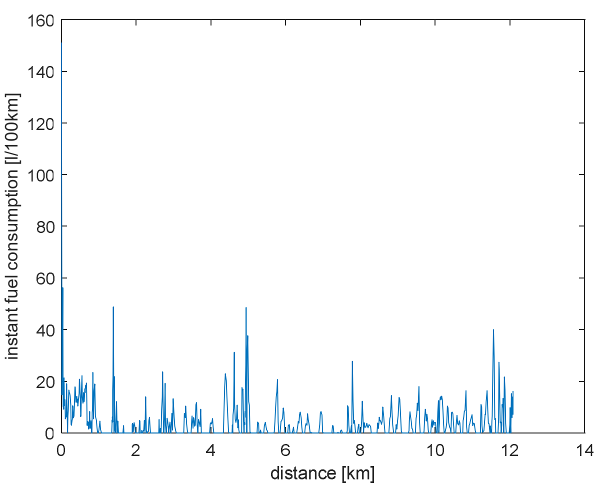

Fig. 1. Fuel consumption (l/100 km) for ICE vehicle on rural driving downhill

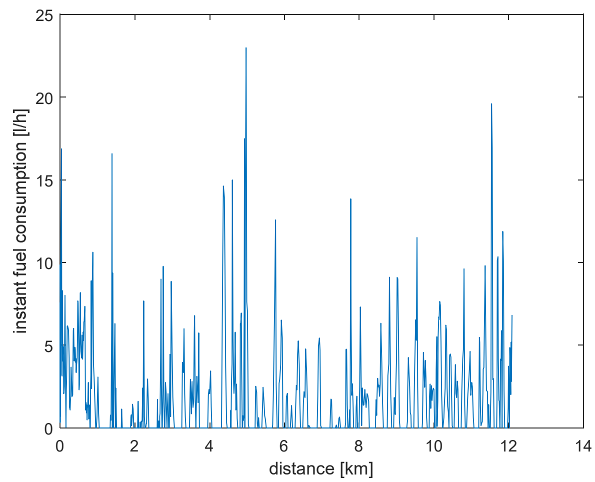

Fig. 2. Fuel consumption (l/h) for ICE vehicle on rural driving downhill

2) BEV Vehicle

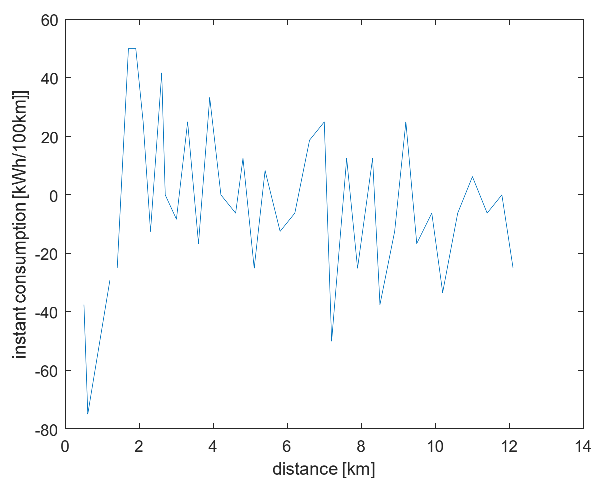

Fig. 3. Energy consumption (kWh/100 km) for BEV vehicle on rural driving downhill

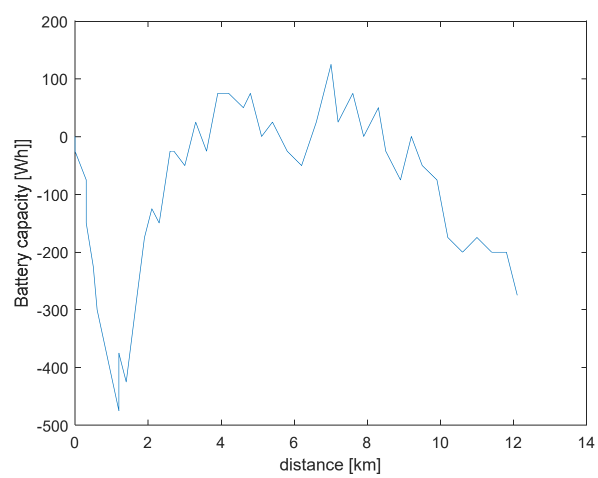

Fig. 4. State of battery capacity (Wh) for BEV vehicle on rural driving downhill

B. Rural driving uphill

1) ICE Vehicle

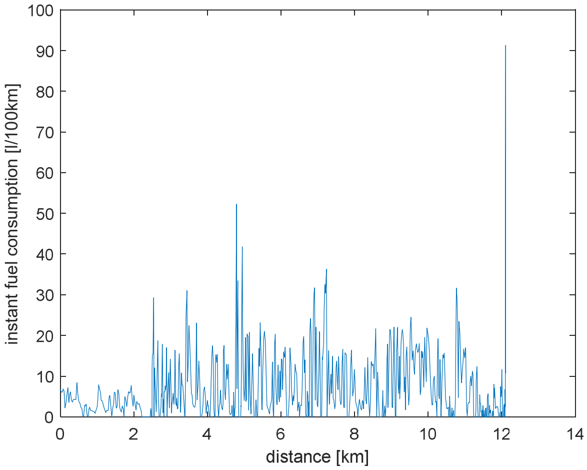

Fig. 5. Fuel consumption (l/100 km) for ICE vehicle on rural driving uphill

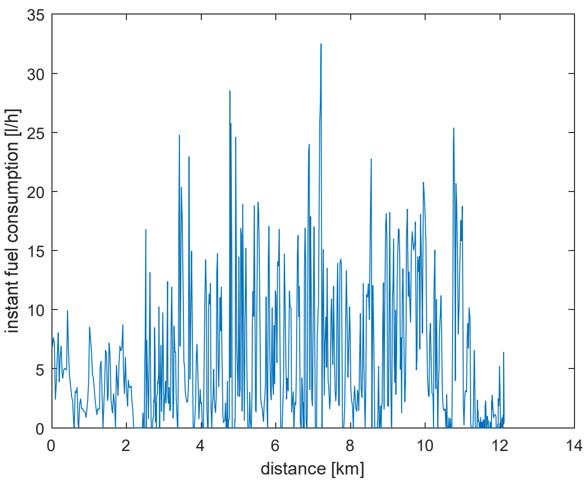

Fig. 6. Fuel consumption (l/h) for ICE vehicle on rural driving uphill

2) BEV Vehicle

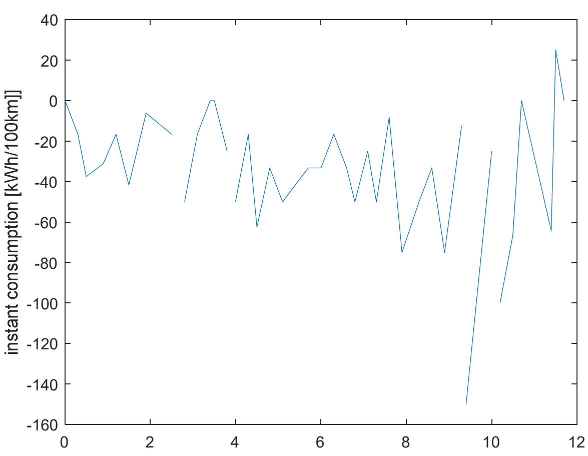

Fig. 7. Energy consumption (kWh/100 km) for BEV vehicle on rural driving uphill

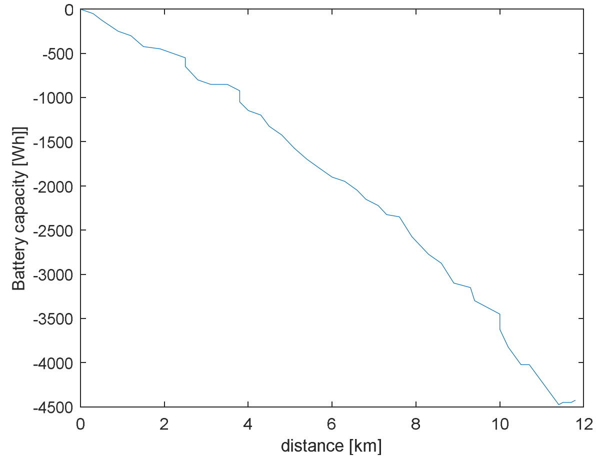

Fig. 8. State of battery capacity (Wh) for BEV vehicle on rural driving uphill

C. Suburban driving

1) ICE Vehicle

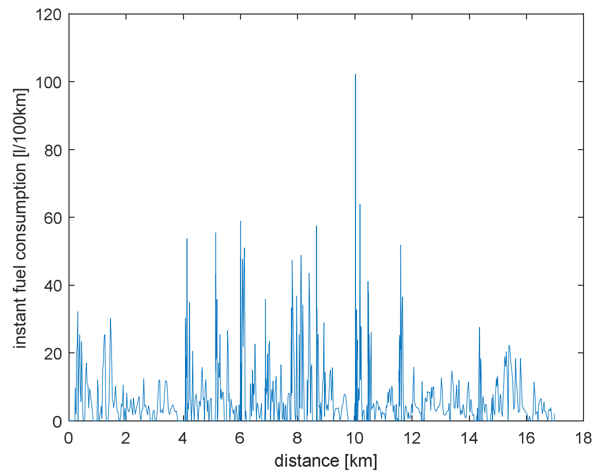

Fig. 9. Fuel consumption (l/100 km) for ICE vehicle on suburban driving

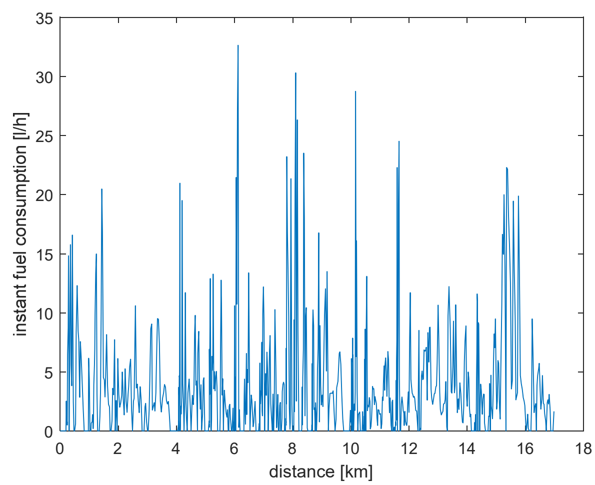

Fig. 10. Fuel consumption (l/h) for ICE vehicle on suburban driving

2) *BEV Vehicle*

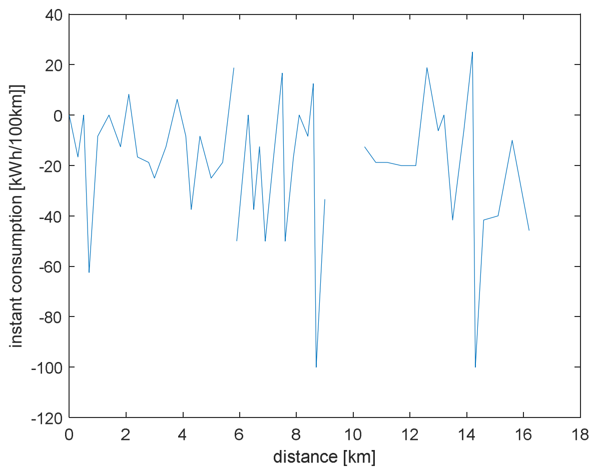

Fig. 11. Energy consumption (kWh/100 km) for BEV vehicle on suburban driving

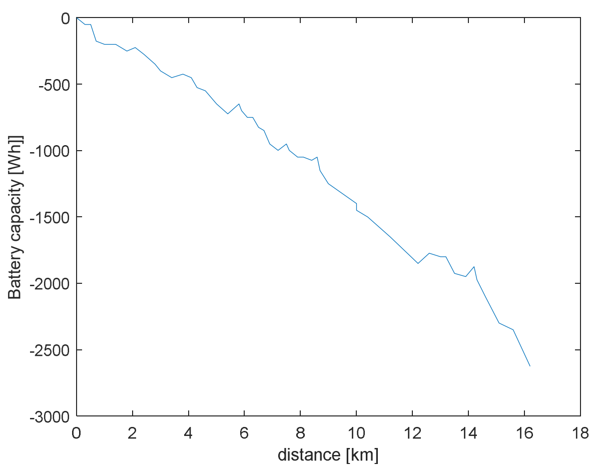

Fig. 12. State of battery capacity (Wh) for BEV vehicle on suburban driving

D. Motorway driving

1) *ICE Vehicle*

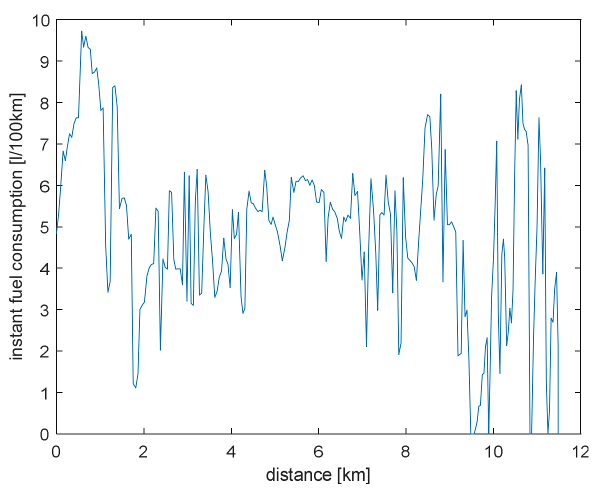

Fig. 13. Fuel consumption (l/100 km) for ICE vehicle on motorway driving

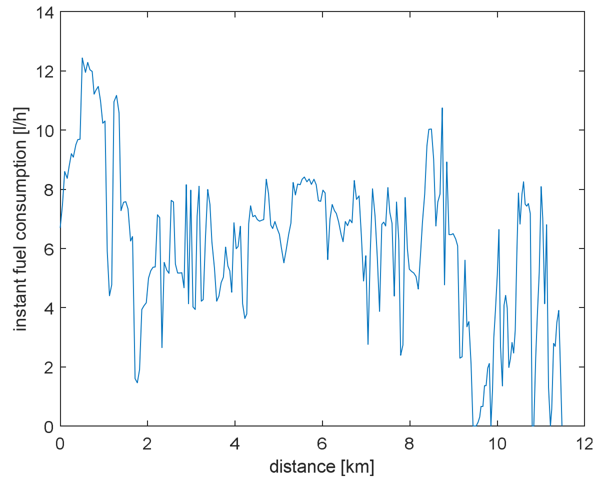

Fig. 14. Fuel consumption (l/h) for ICE vehicle on motorway driving

2) *BEV Vehicle*

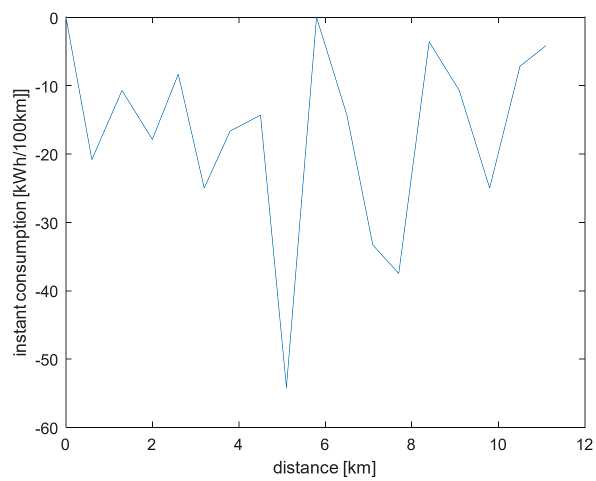

Fig. 15. Energy consumption (kWh/100 km) for BEV vehicle on motorway driving

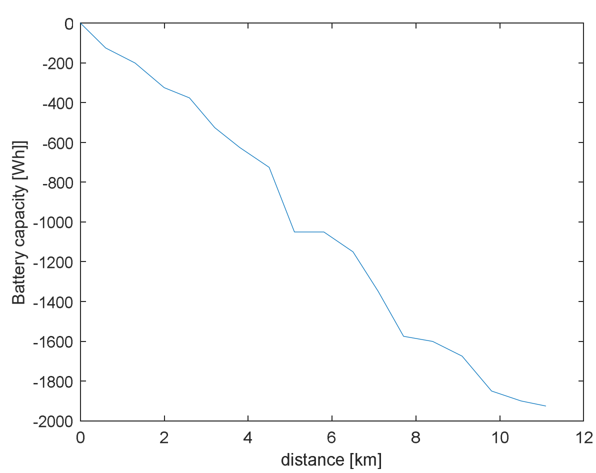

Fig. 16. State of battery capacity (Wh) for BEV vehicle on motorway driving

4. Conclusion

This work presented a detailed real-world comparison of the energy consumption of a Skoda Octavia III diesel vehicle and a Skoda Enyaq battery-electric vehicle across rural, suburban, and motorway driving environments. The results consistently showed that the BEV required substantially less energy for propulsion, particularly in conditions involving frequent speed changes and opportunities for regenerative braking. Rural segments highlighted the sensitivity of both vehicles to elevation changes, where the diesel vehicle exhibited higher variability in consumption, while the BEV benefitted from efficient downhill recuperation. In suburban driving, the BEV achieved the most pronounced efficiency advantage due to its ability to avoid idling losses and recover braking energy. Motorway testing revealed smaller differences between the two powertrains, though the BEV still outperformed the ICE vehicle on a tank-to-wheel basis.

Overall, the findings confirm that electric drivetrains provide clear energy efficiency benefits under typical real-world driving conditions. These results support the broader transition toward electric mobility, particularly in environments where driving patterns favor the operational strengths of BEVs. The methodology and results presented in this study contribute to a more accurate understanding of real-world vehicle efficiency and offer valuable information for consumers, policymakers, and researchers evaluating the impacts of electrification in the transport sector.

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