Accelerating Light-Duty Fleet Decarbonisation through Energy Efficiency Audits: Results and Methodology Assessment

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Abstract. The transport sector is responsible for 37% of the energy consumption in Portugal (70% of it due to road transportation), supplied almost completely by fossil fuels. Portugal must reduce these sector's emissions by 98% to achieve carbon neutrality by 2050, thus making transportation a crucial sector for a successful decarbonisation of the economy. This scenario sparked action at ADENE – the Portuguese Energy Agency to create MOVE+, an auditing methodology that incentivises and guides a broad group of stakeholders to act on the decarbonisation of mobility, starting with light duty and freight fleets. It comprises a framework to rate fleets on energy efficiency which enables regular implementation and monitoring of decarbonisation measures in areas such as vehicle technology, telematics, driver training, tyre selection, and maintenance. This paper shows that the application of the MOVE+ methodology helped identify an electrification potential of 24% on average per fleet, according to the Best-in-Class (whereas the analysed sample shows 20% of electrification). A multiple linear regression model validates the correlation between MOVE+ obtained scores, in the evaluated dimensions, and the fleet's specific CO_2 emissions. The methodology also allows us to assess that Portugal is lagging to meet the carbon neutrality target for the transport sector by 2050. Such assessment allows us to estimate that, regarding light-duty fleets, at the current pace zero emissions will only be reached by 2080, thus highlighting the need for public policy adjustments that push towards faster decarbonisation.

1 Introduction

In response to the European Union (EU) and Portugal's commitment to achieving carbon neutrality by 2050, several packages and plans have been put in place. In Portugal, a Roadmap to achieve Carbon Neutrality by 2050 – Roadmap for Carbon Neutrality (RCN50) – was established, as was a National Energy and Climate Plan (NECP 2030) to set some intermediate goals for the 2030 horizon.

Since the transport sector is responsible for about 28% of greenhouse gas emissions (accounting only scope 1) in Portugal, and road transport accounts for 76% of those

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emissions [1], Portugal needs to reduce transport emissions by at least 98% through, amongst others, electrification and renewable energy integration in transport, to meet RCN50 objectives and thus achieve carbon neutrality [2]. To keep Portugal on track to achieve these goals, the NECP 2030 includes an objective to promote sustainable mobility and sets targets of 20% renewable energy integration in the transport sector and 40% of CO_2 emissions reduction by 2030 (in comparison to 2005 levels) [3].

These ambitious goals can be achieved by combining fleets' energy efficiency and transport electrification [4]. Energy efficiency is influenced by a variety of factors, including average speed, idling condition, rolling without engine load, use of on-board telematics systems, road grade, road type, driving aggressiveness and congestion level, among others [5,6,7].

To evaluate and integrate all these factors simply and comparably, ADENE – Portuguese Energy Agency developed MOVE+® Fleets, a voluntary monitoring and evaluation (M&E) methodology that rates fleets based on their energy efficiency on a scale from F – least efficient – to A+ – most efficient. Additionally, it fosters sustainable mobility solutions through the identification of measures to minimize the fleet's environmental impact and enables regular implementation monitoring of decarbonization measures. MOVE+ framework evaluates four areas relevant to energy efficiency in light-duty vehicle (LDV) fleets: vehicles, drivers, maintenance, and consumption management. Operations management is also evaluated for heavy-duty freight vehicles and will be considered for heavy-duty passenger vehicles.

This work aims to determine the correlation between MOVE+ scores obtained in each of its evaluation areas, and the LDV fleet's specific CO_2 emissions, based on the results achieved so far. It also intends to estimate when the monitored fleets will be able to meet carbon neutrality.

2 Methodology

The results of MOVE+ audits performed to date were used to calculate the fleet electrification status and its CO_2-specific emissions. As the fleet characterization is known from the audits, the electrification level was calculated by dividing the number of electric vehicles (battery and plugin hybrid) by the total number of vehicles in the fleet, which allowed, controlling for the share of light-duty freight vehicles in the fleet, to estimate electrification potentials according to best-in-class (computed with Equation 1). To compute the CO_2-specific emissions of each fleet, Equation 2 was used.

$$EP_{BIC} = -0{,}1075 \times P_{Lfreight} + 0{,}2715 \quad (1)$$

Where EP_{BIC} is the electrification potential and $P_{Lfreight}$ is the percentage of light-duty freight vehicles in the fleet.

$$CO_{2\ specific\ emissions} = \Sigma_i (E_i \times CF_i / d_i) \quad (2)$$

Where Ei represents energy consumption (usually in litres or kWh), CFi shows the corresponding conversion factors and di the travelled distance in kilometres. The conversion factors depend on the final energy sources used, which can be diesel, gasoline or electricity, and are presented in Table 1[†].

[†] MOVE+ framework provides the conversion factors based on a bibliographic reference [8] and all other data is obtained during audits.

Table 1. Conversion factors used to convert energy consumption into CO_2 emissions. [8]

Final energy source	Conversion factor	Unit
Diesel	2211	gCO_2/litre
Gasoline	2270	gCO_2/litre
Electricity	291	gCO_2/kWh

To verify whether the MOVE+ rating system reflects a reduction in CO_2 emissions, a multiple linear regression (MLR) model was developed to determine the correlation between MOVE+ classification and CO_2-specific emissions. The MLR model was also utilised to better understand the effect of the vehicles, drivers and maintenance management areas, evaluated for LDVs, on CO_2-specific emissions. For this purpose, R Studio was used.

Although a fourth area is evaluated in the framework, consumption management, its purpose is to value a continuous reduction of the fleet's specific energy and emissions. Since its inclusion would prevent proper analysis of the other areas' influence on the fleet's specific emissions, it was decided not to include it in this work.

Lastly, because the framework fosters recurrent yearly audits, an analysis of the specific emissions in time was performed aiming to forecast when the carbon neutrality target will be reached. A linear regression model was used for this purpose, assuming a business-as-usual scenario for improvement measures implementation.

3 Results

The classified fleets have an average electrification level of 20% and a median of 22%, which exceeds the electrification goal of 12% by 2030 established in RCN50 [2] and the national average of 2,5% electrification (of total LDVs) [9]. This reflects the good practices already implemented by the classified fleets, which are at the forefront of the energy transition while highlighting the need for a broader, more representative application of the framework, however, the best-in-class analysis shows potential electrification up to 24%.

The MLR model built has a median residue of -2,12, a F-statistic of 1,036 and a p-value of 0,3872, indicating that the independent variables included in the model explanatory power need to improve. Statistical results for each area, particularly the predictor β and p-value, are presented in Table 2, which shows that only vehicle management has a significant correlation (p-value > 0.1).

Table 2. Statistical results for each area.

	β	p-value
(intercept)	209,3050	$3{,}98 \times 10^{-05}$
Vehicle management	-0,8137	0,0868
Drivers management	0,2660	0,2980

The correlation between the overall obtained classification and computed CO_2 specific emissions is presented in Figure 1, which shows that MOVE+ is producing the intended results and valuing decarbonization efforts that lead to lower energy consumption and, consequently, lower CO_2 emissions.

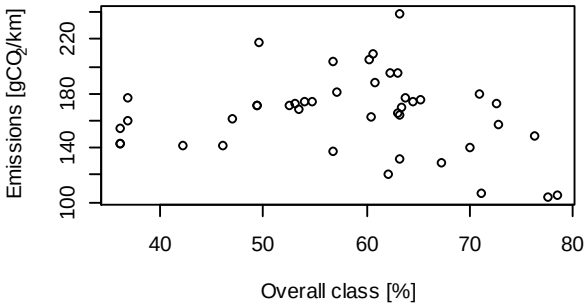

Fig. 1. Correlation between MOVE+ overall classification and CO_2 specific emissions.

Figure 2 depicts the impact evaluation of vehicles, drivers and maintenance management in CO_2 emissions. The vehicles management area has a negative influence (β=-0,8137) on CO_2-specific emissions, as shown in Table 2, which was expected due to the fleet electrification rate, tire energy efficiency label and other parameters addressed, that have a direct impact on emissions reduction. However, the same tendency is not mirrored in the drivers and maintenance management areas where a greater dispersion is shown (Figure 2) and the MLR model provided a limited explanation for these variables.

Vehicle management is related to direct decarbonization measures, whereas drivers and maintenance management are related to indirect measures, influenced by factors such as eco-driving training (drivers' behaviour) and frequent maintenance measures, which still impact the energy efficiency and good performance of fleets [5,6,7]. In addition, both areas show a lack of continuity on classification levels, with most fleets having classifications above 50% and 65%, in the drivers and maintenance areas respectively. Although the tendency can be explained by the more indirect impact on emissions that drivers and maintenance areas have when compared to vehicles' management, a more suited assessment approach needs to be developed. To address these shortcomings, a more extensive analysis in these two areas should be done to determine the necessary adjustments in scores or criteria.

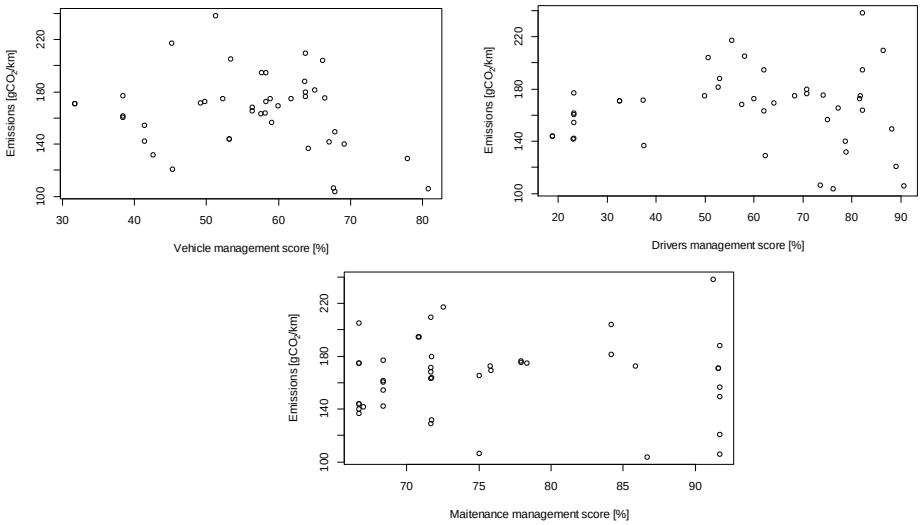

Fig. 2. Correlation between the vehicle management (on the top left), drivers management (on the top right) and maintenance management (on the bottom) and CO_2 specific emissions.

According to the forecast analysis, shown in Figure 3, where time is measured in months from January 2020, carbon neutrality will only be achieved by 2080 if this pace is kept constant. It is important to notice that this is an optimistic scenario as it is based on data from fleets that already have high electrification rates, which may lead to thinking that the decarbonization objective can even be achieved after the predicted time frame. As a result, to achieve RCN50 targets and consider the goals anticipation, public policies need to be adjusted, to promote the electrification of road transport, as well as green investment both for vehicles and charging infrastructure.

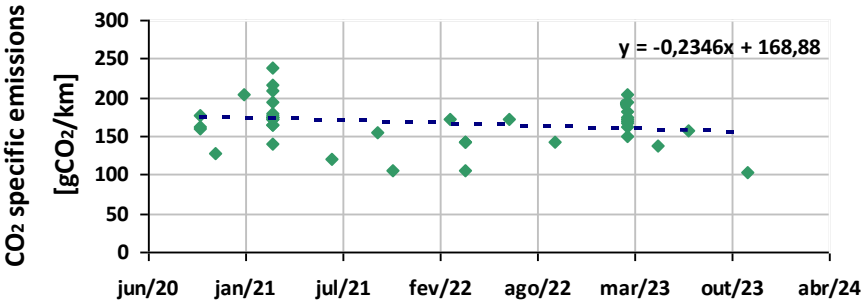

Fig. 3. Carbon neutrality forecast

4 Conclusions

To summarise, the MOVE+ framework reflects the good practices undertaken by entities and promotes fleets' decarbonization by giving higher scores when lower CO_2 specific emissions are achieved. This is heavily influenced by the vehicles' management area, which also reflects the reduction in CO_2 emissions when higher scores are attained in this area.

Although the drivers and maintenance management areas also contribute to the reduction of CO_2 specific emissions, this tendency is not broadly reflected in the results. This is partially a consequence of the absence of intermediate scores. Following these findings, additional in-depth analysis of these MOVE+ two areas, namely a revision of its criteria and scores, allowing for intermediate levels of evaluation, should be conducted, aiming to reflect the impact of energy efficiency, complementary to electrification, in CO_2 specific emissions.

Given that fleets already monitored and evaluated with MOVE+ are at the forefront of the energy transition due to their electrification pace, the prediction model used to estimate the achievement of carbon neutrality can be optimistic. Nonetheless, the findings of this work indicate that, at this rhythm, carbon neutrality for LDVs will only be achieved by 2080, falling short of the established targets. To meet the decarbonization targets for this sector, public policy adjustments are required alongside green investments in fleets electrification and charging infrastructure.

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