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Regulatory adjustments needed for plug-in hybrid vehicles in Europe

The energy consumption of plug-in hybrid vehicles (PHEVs) is significantly higher in real-world driving than in type approval procedures. An evaluation of one million vehicles highlights this major difference and points to the need for action in EU emissions regulation.

Motivation and objectives

Plug-in hybrid vehicles (PHEVs) contribute significantly to passenger car manufacturers' compliance with CO_2 fleet reduction targets in Europe. However, their real-world CO_2 emissions are three times higher than the type approval values (Plötz & Gnann 2025, EEA 2025).

At the same time, European regulation of PHEVs within the framework of CO_2 fleet targets requires an empirical review of real PHEV emissions and, if necessary, an adjustment of the regulation based on empirical data. This empirical review of the regulation is still pending. In this context, some have also proposed to suspend the upcoming adjustments of the regulation.

This policy brief analyzes the potential need for regulatory adjustments for PHEVs based on empirical data. Realistic values are derived for the so-called utility factor (UF), which describes the predominantly electric driving share as a function of the electric range. The aim of this policy brief is to create an evidence-based, low-bureaucracy basis for possible adjustments to PHEV regulation that also considers the increasing range of modern vehicles.

Analysis of real driving data from one million PHEVs

We use real-world data from the On-Board Fuel Consumption Monitoring (OBFCM) of the European Environment Agency (EEA) for approximately one million PHEVs registered in Europe between 2021 and 2023. The data includes real-world fuel consumption data in various operating modes over the lifetime of the vehicles to date. Regression analyses are used to determine realistic correlations between actual electric driving share and electric range and compare them with the current and regulatory UF curves. Finally, measures currently under discussion to reduce consumption are analyzed and the CO_2 impacts of various regulatory options for Germany were quantified.

In the type approval process, the **utility factor (UF)** weighs the two driving modes of PHEV (charge depleting (CD) = battery discharging and charge sustaining (CS) = combustion engine driving) in relation to each other depending on the electric range. A high value means that a lot of electric driving is done, and a high electric range also favors high UF. The weighting of the modes depends largely on a **scaling factor** d_n. The higher this value, the lower the assumed electric driving share for given range.

Fuel consumption and emissions 300% too high

The average real-world fuel consumption of PHEVs in Europe is 5.9 l/100 km (see Fig. 1), which is approximately 300% higher than the type approval consumption. PHEVs thus show fuel consumption on the road close to the 7.0 l/100 km of new combustion engine vehicles. The reason for this can be seen in the OBFCM data on the proportion of electric driving: this is only around a quarter of distance driven (proportion of distance with the combustion engine switched off in CD mode and energy-based electric driving share: 27–31%).

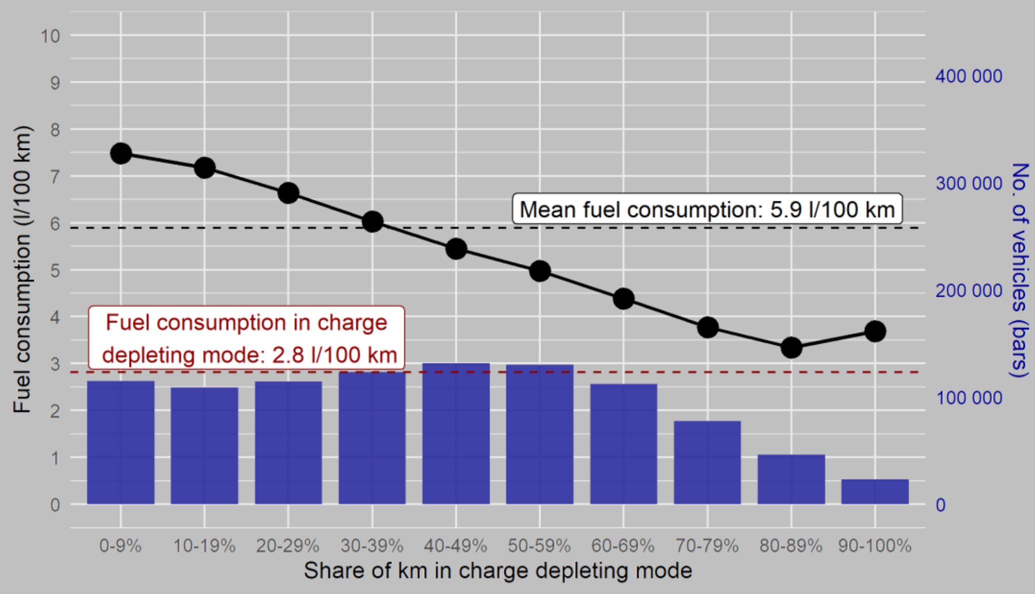

Fig. 1: Actual fuel consumption as a function of CD mode share.

Fuel consumption is shown in black on the left y-axis as a function of kilometers in unloading mode. The blue bars represent the sample size on the right y-axis. The dashed lines show the average total consumption (black) and consumption in charge depleting mode (red).

Type approval metrics do not indicate the proportion of electric driving

Regulatory distinctions are made between *charge depleting mode* (CD mode) and *charge sustaining mode* (CS mode).

CD mode is defined by regulations as requiring a certain minimum amount of driving energy to come from the battery over a WLTP cycle but not specifying what proportion of the distance must be covered purely electrically. This opens considerable scope for the use of the combustion engine even in CD mode. The OBFCM data shows that PHEVs travel about 40% of their distance in CD mode, with an average real-world fuel consumption of about 2.8 l/100 km (see Fig. 1), which is significantly higher than in type approval. This demonstrates that the combustion engine plays a significant role also in this mode in practice although it is expected to be mostly electric. In CS mode, however, fuel consumption is still significantly higher, averaging 7.4 l/100 km.

More frequent charging only reduces fuel consumption to a limited extent

Frequent charging has previously been considered an essential approach to increasing the climate benefits of PHEVs. The real-world data shows how consistent charging of vehicles (= high observed CD mode share) affects consumption: Although more frequent charging or a higher CD mode share reduces average fuel consumption, it never falls below the average real-world CD mode fuel consumption of 2.8 l/100 km (see Figure 1). Current PHEVs therefore consume no less than 2.8 l/100 km or 65 g CO_2/km on average in the fleet, regardless of how often they are charged, as the combustion engine is rarely switched off completely.

Planned tightening of PHEV regulation is necessary

Based on the real-world data, this policy brief calculates how much the actual consumption of current PHEVs would deviate from type approval values under different regulatory frameworks. Figure 2 shows the gap between actual and nominal fuel consumption of PHEVs under the current regulations and recent adjustments. In addition, calculations were made to determine how the regulations would need to be adjusted such that PHEVs consume on average only 20% more than their type approval values, as is currently the case for vehicles with combustion engines only. This gap between actual and nominal consumption would still be around 100% on average if the vehicles in the data had been approved according to the 2025 adjustment and 40% under the adjustment planned for 2027. For the gap to decrease to approximately 20%, the scaling parameter in the regulation would have to increase from $d_n = 2.200\ \mathrm{km}$ for 2025 and $d_n = 4.260\ \mathrm{km}$ for 2027 to $d_n > 5.000\ \mathrm{km}$. There is some uncertainty in calculating the consumption gap under an amended regulation, but all empirical approaches show the need to tighten the regulation beyond the change planned for 2027 to further reduce the real consumption gap (cf. Table 1).

Low emission reductions through display transparency and forced charging

Measures currently under discussion, such as "display transparency" (displaying the proportion of electric driving in the vehicle menu) or forced charging every 500 km ("inducement"), are likely to reduce the real emissions of PHEVs only marginally. The measures are far from sufficient to significantly reduce the gap between real and nominal emissions. This highlights the importance of the planned adjustments to the UF curve in the regulation.

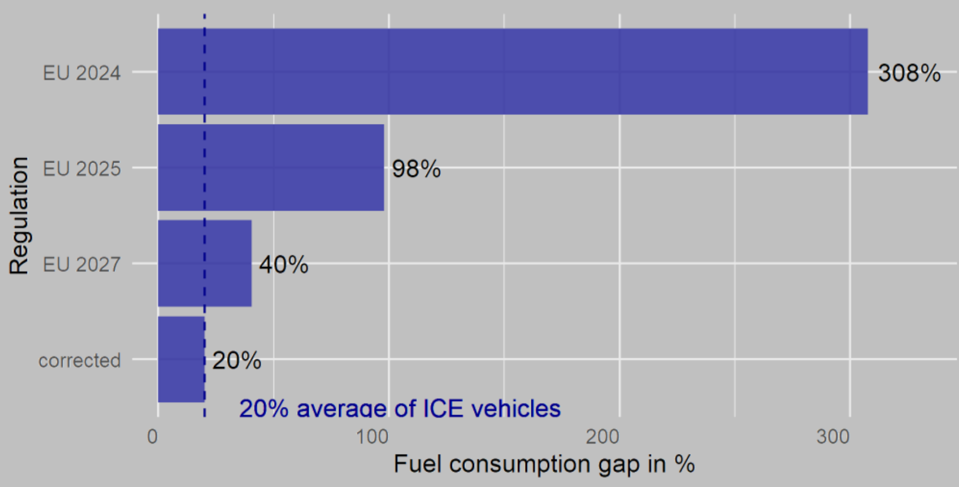

Fig. 2: Percentage gap between nominal and real-world fuel consumption of PHEVs in Europe according to different regulations

The bars show the average values of the deviation between type approval and real-world fuel consumption. Based on actual consumption, the various values for the 2024, 2025, and 2027 regulatory versions are shown, as well as a variant in which the regulation would be adjusted to achieve a 20% deviation between actual and type approval fuel consumption values.

Finally, the total CO_2 emission impacts of the measures discussed and of suspending the tightening of regulations were analyzed. A retroactive suspension of the tightening for 2025 would result in additional cumulated GHG emissions of approximately 23-25 Mt CO_2 eq. by 2045. If the adjustment of the scaling parameter were suspended in 2027, the cumulative additional emissions would rise to a total of 7 Mt CO_2 eq. These assessments were made on the assumption of a CO_2 reduction target of 100% for new cars from 2035 onwards. Given the 90% target currently under discussion at EU level, these figures would rise significantly.

Adjusting PHEV emissions calculations to reflect reality

Evidence-based regulation can be determined from real-world fuel consumption data. This allows the real-world fuel consumption deviation of PHEVs to be reduced to a level similar to that of pure combustion vehicles, thus enabling a fair comparison between the drivetrains. Such an adjustment should be made regularly in the future based on continuously collected OBFCM data. In any case, the adjustments to the regulation regarding the utility factor currently provided for by law should be implemented, as they significantly reduce the gap between nominal and actual fuel consumption and CO_2 emissions.

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Plötz, P., Gnann, T. Kasten, P., Steinbach, I., Jöhrens, J. (2025): Regulatory adjustments needed for plug-in hybrid vehicles in Europe. Report on the project Scientific Support for Climate Policy and Action Program (14-BE-2203); Karlsruhe, Berlin, Heidelberg 2026

Table 1: Scaling parameters and consumption gaps

Utility factor approach	d_n [km]	Mean consumption gap
EU regulation until 2024	800	>300 %
EU regulation 2025–2026	2,200	ca. 100 %
EU regulation from 2027	4,260	ca. 40 %
Empirically corrected UF	ca. 7,200	ca. 20 %
Other empirical UF approaches	4,700 – 5,900	ca. 25 – 35 %