REPORT - OCTOBER 2025

Smoke screen: the growing PHEV emissions scandal

Long-range PHEVs and EREVs are a diversion on the road to zero emissions

T&E

Published: October 2025

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To cite this report
Transport & Environment (2025). *Smoke screen: the growing PHEV emissions scandal*

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Acknowledgements

The findings and views put forward in this publication are the sole responsibility of the authors listed above. The authors kindly acknowledge the external peer review by Jan Dornoff from the International Council on Clean Transportation (ICCT).

Glossary

BCG	Boston Consulting Group
BEV	Battery electric vehicle
CD	Charge-depleting – PHEV mode that uses mainly the electric motor for propulsion, thus depleting the battery
CS	Charge-sustaining – PHEV mode where the engine keeps the battery at a steady charge level and propulsion is provided by the internal combustion engine (ICE)
DC	Direct current – direct current charging allows electric vehicles to charge much faster than alternating current (AC) charging
EEA	European Environment Agency
EAER	Equivalent all-electric range – concept defined by the WLTP to represent the portion of the charge-depleting mode distance powered by electricity during the lab test
EC	European Commission
EREV	Extended-range electric vehicle
HEV	Hybrid electric vehicle – group of vehicles that includes both full and mild hybrids
ICE	Internal combustion engine
NEV	New energy vehicle – group of vehicles that includes BEVs, PHEVs and EREVs in China
OBFCM	On-board fuel consumption monitoring devices
OEM	Original equipment manufacturer (carmaker)
PHEV	Plug-in hybrid electric vehicle
TCO	Total cost of ownership
UF	Utility factor
VDA	German Association of the Automotive Industry
WLTP	Worldwide Harmonized Light Vehicles Test Procedure – global standard for testing vehicles

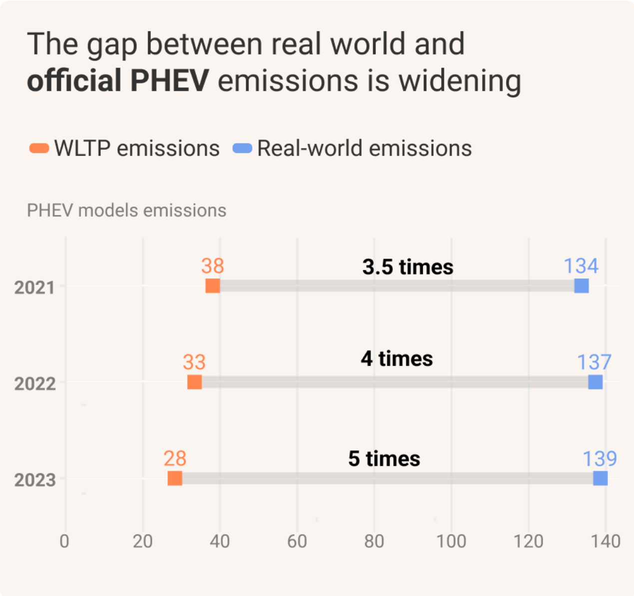
Executive summary

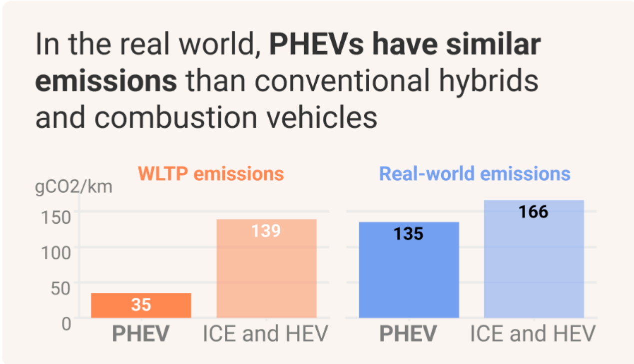
In 2026, the European Commission (EC) will review the car CO_2 emission standards - EU's flagship automotive climate and industrial policy. While the EC prepares for the review, the automotive industry is calling to weaken the regulation, notably by calling to prolong the sales of plug-in hybrid electric vehicles (PHEVs) beyond 2035 and to reverse the correction of the official PHEV emissions (based on utility factors). A specific variant of PHEV, extended-range electric vehicles (EREVs), which are becoming increasingly popular in China, have also entered the debate.

This report sheds light on the risks posed by PHEVs, highlighting the crucial importance of upholding the planned utility factor corrections and shows that PHEVs are not future-proof options for European drivers and the European automotive industry.

- **The real-world CO_2 emissions of PHEV models registered in 2023 are nearly five times as high as the official emissions. This real-world gap has been widening over the years from 3.5 in 2021 to 4.9 in 2023 based on official data transmitted from on-board fuel consumption meters (OBFCM).**
- **The gap is mostly caused by flawed assumptions on the share of electric driving mode (the 'utility factor', UF) which leads to a drastic underestimate of official PHEV emissions. The UF overestimated the electric driving share, assuming 84% over 2021-2023, whereas real-world data shows this to be just 27%.**
- **Even when driven in electric mode, PHEVs emit 68gCO_2/km as their electric motors have insufficient power and the combustion engine needs to kick in. The engine supplies power for almost one-third of the distance travelled in electric mode. This would mean an extra €250 in petrol costs every year, as drivers don't expect to pay for fuel when driving in electric mode.**
- **As a result, PHEVs emitted roughly the same as conventional hybrids and combustion vehicles in the real world. Despite official emissions being 75% lower.**
- **It is welcome that the UF values are being corrected. But even with the planned 2027/28 UF correction, PHEV real-world emissions would be 18% higher than the official figures.**
- **The gap between official and real-world emissions also burdens the wallets of PHEV owners. Over a year, drivers have to pay over €500 more than official values imply.**
- **Cancelling the utility factor correction would slow the transition to zero-emission mobility as carmakers would need to sell 45% BEV, rather than 58% under current regulations. PHEV-focused carmakers could limit BEV sales to just 32%.**

Polluting and costly: growing gap between PHEV claims and reality





+500€

PHEVs operating cost are 500€ larger than what carmakers data suggest

Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environment Agency, EEA car registrations 2021-23, EAFO, Weekly Oil Bulletin

EREVs are not exempt from the PHEV shortfalls and offer limited potential for Europe:

- **EREVs, like PHEVs, rely on their combustion engine for extended range. With large fuel tanks, Chinese EREVs can drive 900 km in combustion mode, consuming 6.7 L/100 km — similar to some European petrol SUVs.**
- **Despite their limitations, EREVs have more powerful electric motors than PHEVs and can fast-charge. However, their real-world benefits in Europe are uncertain.**
- **EREVs offer limited strategic or industrial benefits to Europe, with little domestic industry interest and supply chains dominated by China.**

Weakening the EU car CO_2 rules would significantly increase emissions and undermine the EU's path to climate neutrality. The proposal from the German car industry lobby (VDA) to roll back the 2035 target and utility factor corrections could result in an additional 2.8 $GtCO_2e$ being emitted by 2050 — a 64% increase compared to cars emissions under the current EU regulations.

Promoting outdated PHEV transition technologies is a distraction that risks derailing Europe's growing EV value chain by deterring investment. Weakening the regulatory framework would widen the competitiveness gap with China, which is racing ahead with EV innovation. Prolonging the life of combustion technology would push the industry into a dead end. To build a future for Europe's car industry, the EU must stay the course, confirm the EU car CO_2 targets and confidently enter the EV age.

Recommendations

1	Maintain the 2030-2035 car CO_2 targets in the upcoming car CO_2 regulatory review, with no derogation for hybrids after 2035.
2	Safeguard both the 2025/26 and 2027/28 corrections of the utility factor curve to close the PHEV loophole.
3	Strengthen the utility factor curve with biannual corrections based on real-world data from 2030, and OEM-specific correction factors.
4	Design policies that accelerate the BEV uptake, while preventing the further uptake of poorly performing hybrids, and encouraging the ICE and plug-in market to shift towards best-in-class plug-in hybrid models.

Introduction

The EU's car CO_2 regulation is the EU's most effective climate and industrial policy to drive the transformation of the automotive sector. In 2026, the European Commission will review the regulation and assess whether its future targets remain fit for purpose.

But even before the review has started, pressure is mounting to weaken the rules. In 2025, the Commission introduced a new flexibility for carmakers – allowing them to average their emissions over three years to comply with the 2025 target. T&E warned that this must be the final concession to the car industry. Yet calls for further weakening continue to grow.

The automotive sector continues to call for further weakening of the targets and regulatory framework. For example, in May 2025, the German Association of the Automotive Industry (VDA) published a proposal calling for a broad set of changes to the regulation. The proposal seeks to weaken the 2035 target, promote the use of unsustainable fuels, and extend the role of plug-in hybrid electric vehicles (PHEVs) beyond 2035 (see T&E analysis of the VDA proposal for more). The VDA also proposed to weaken the so-called PHEV utility factor — the curve used in the Worldwide Harmonised Light Vehicles Test Procedure (WLTP) to calculate theoretical CO_2 emissions in relation to the electric range measured in laboratory conditions.

PHEVs are often discussed — sometimes relatively favourably — in the context of the review of the EU's car CO_2 regulation. But the potential, risks and regulatory challenges of this technology are not well understood by the public and policymakers. This lack of knowledge persists despite the European Environment Agency (EEA) releasing real-world emission data from vehicle fleets every year, showing that PHEVs are far from delivering on the promises of a transition technology.

To address these gaps and shed light on the real potential of PHEVs, T&E has carried out an in-depth analysis of market, and emission data for PHEVs — presented in this report. In the first section of this report, we analysed the latest data on real-world emissions of PHEVs, which was published in July 2025 and includes emissions from vehicles that were first registered in the EU between 2021 and 2023. We used these measurements to assess how much PHEV emissions are underestimated, based on the expected gap between real-world data and WLTP values under the upcoming Euro 6e-bis and 6e-bis-FCM standards.

The second section focuses on extended-range electric vehicles (EREVs). It investigates the market trends in China, and assesses the performance of these vehicles. While these new EREVs are marketed with impressive range figures — total driving ranges of up to 950 km and CO_2 emissions as low as 10 g/km — we assessed their actual characteristics. By comparing their performance and use cases, and examining expected models in Europe, we provide an evaluation of the advantages and disadvantages of the EREV technology in Europe.

In the third section, we forecast emissions from long-range plug-in hybrid vehicles (including EREVs) to estimate their real-world emissions if they are well designed. Finally, we calculated the additional emissions that combustion vehicles could produce after 2035 if the VDA proposals were implemented.

Section 1

1. Real-world PHEV emissions far higher than WLTP lab values

1.1 PHEVs and the utility factor: regulatory context and limitations

PHEVs are equipped with two distinct powertrains: an electric motor (e-motor) powered by a rechargeable battery and an internal combustion engine (ICE). These systems generally operate independently, enabling vehicles to switch between electric and combustion-based propulsion depending on driving conditions and battery charge status:

- In **charge-depleting (CD)** mode, the vehicle primarily runs on electricity from the battery. However, the ICE might still kick in when additional power is required such as during rapid acceleration or uphill driving.
- In **charge-sustaining (CS)** mode, the vehicle operates as a conventional hybrid vehicle with propulsion provided mainly by the ICE while the electric motor can still provide power thanks to recuperated energy. On average, the battery is maintained at a steady state of charge.
- In **charge-increasing (CI)** mode, the vehicle's combustion engine is used not only to power the wheels, but also to recharge the battery, resulting in higher fuel consumption and increased CO_2 emissions.

Because of this multi-mode functionality, the actual fuel consumption and resulting CO_2 emissions of PHEVs can vary significantly in real-world use. This variability is related to multiple factors, including how frequently the vehicle is charged and driving behaviour, particularly the share of kilometres driven in CD mode compared to CS mode. As a result of these real-world variabilities, estimating PHEV emissions using standardised test cycles such as the WLTP is often inaccurate. To address this, Article 12 of Regulation (EU) 2019/631 requires the European Commission (EC) to evaluate how well WLTP values reflect real-world driving, based on data collected from OBFCM devices.

The WLTP relies on fixed assumptions about user behaviour, including how often the battery is charged and how much driving is done in electric mode. Central to the WLTP calculations is the so-called utility factor (UF), which aims to represent the proportion of vehicle operation that is powered by electricity. After research showed that the WLTP included overly optimistic assumptions resulting in large gaps between real-world and official emissions, the European Commission corrected the UF in a two-step approach. The first correction will take effect in 2025 for newly registered PHEVs and in 2026 for existing models. A second correction is scheduled for 2027/28. This is an important correction as it aims to better align official figures with the actual use of PHEVs on the road.

Utility Factor (UF)

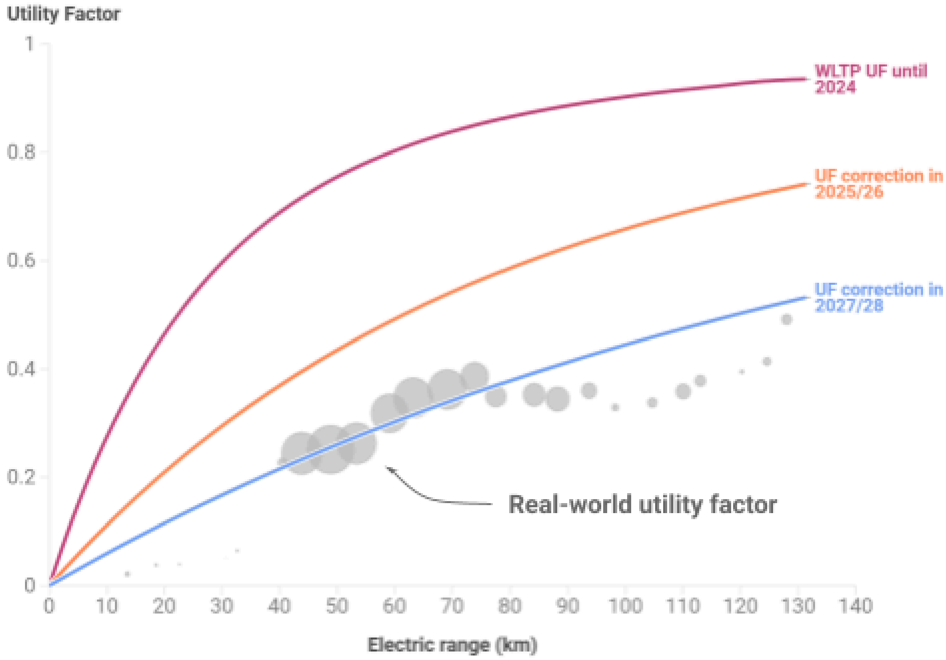
The utility factor (UF) is a central parameter in the WLTP used to estimate the official CO_2 emissions of PHEVs. It aims to reflect the share of total driving powered by electricity. Ideally, if the CD mode were driven entirely on electric power, the UF would simply be the distance driven in CD mode over the total distance. In practice, the CD mode often involves both the electric motor and combustion engine. To account for this, the WLTP defines the concept of equivalent all-electric range (EAER, which is referred to as 'electric range' in this report) to represent the portion of the CD mode distance powered by electricity during the lab test.

Using the current UF, a PHEV with a 70 km range is expected to drive in CD mode over 80% of the distance. With the UF correction coming into effect in 2025/26, the expected CD mode share for a 70 km range is 54% and 34% after the UF correction in 2027/28.

In real-world conditions, there is no widely agreed definition of the real-world utility factor. A European Commission staff working document suggests calculating the UF based on the total energy charged into the battery. Since the exact share of distance driven on electricity cannot be determined when both e-motor and combustion engine power the vehicle, this approach focuses instead on the vehicle's energy consumption. It defines the UF as the share of total energy consumed supplied by the electricity grid. According to the document, an initial comparison suggests that this energy-based UF better reflects real-world CO_2 emissions than a simpler method based solely on the distance driven in CD mode.

Necessary utility factor corrections are underway

Utility factor updates for 2025/26 and 2027/28 and real-world values



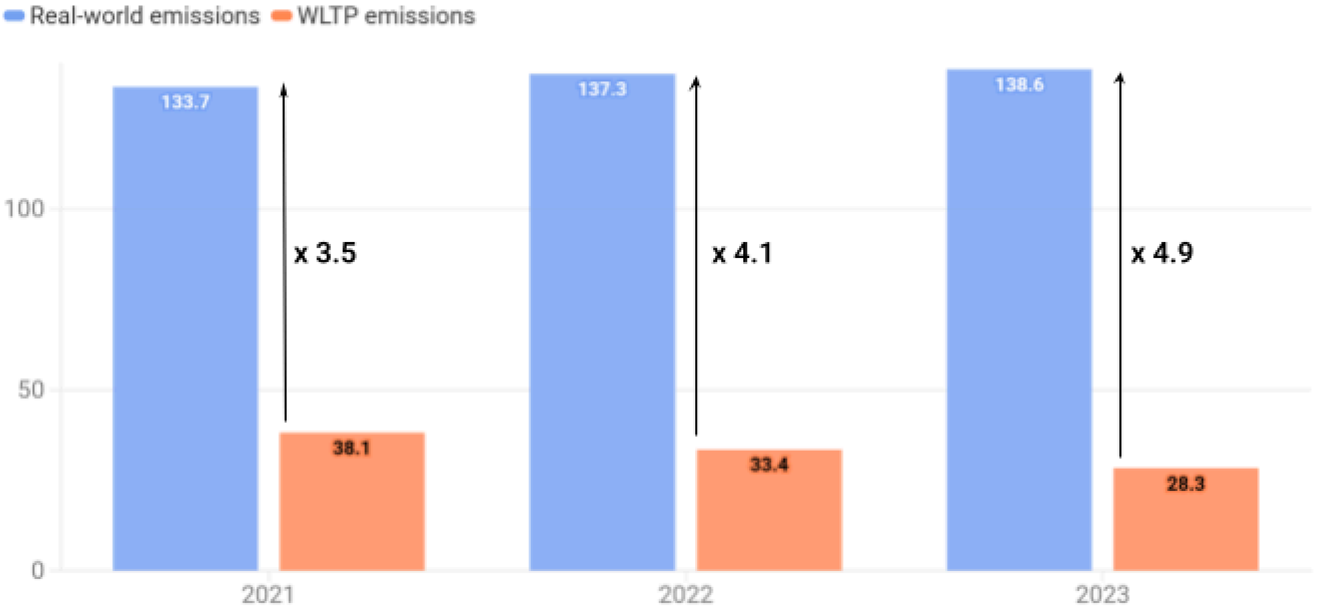
The real-world utility factor has been calculated using the energy-based approach as defined by the European Commission's staff working document. The bubble sizes represent the number of registrations per electric range group.

1.2 Real-world emissions are multiple times higher than WLTP emissions

Real-world emissions from PHEVs are rising, widening the gap between WLTP values and actual performance. The gap between official WLTP values and real-world performance has widened considerably: for vehicles registered in 2021, real-world emissions were about 3.5 times as high as WLTP figures, by 2023 already nearly five times as high based on data available in the OBFCM dataset. Real-world emissions of PHEVs registered in 2023 are on average 5% higher than for vehicles registered in 2021 despite a 25% increase in average electric range between 2021 and 2023. At the same time, the increased range has resulted in a 26% reduction in WLTP emissions. The persistent underestimation of PHEV emissions directly benefits manufacturers by helping them meet CO_2 targets more easily.

The gap between real-world and WLTP emissions is widening

Analysis of real-world vs. WLTP emissions by registration year



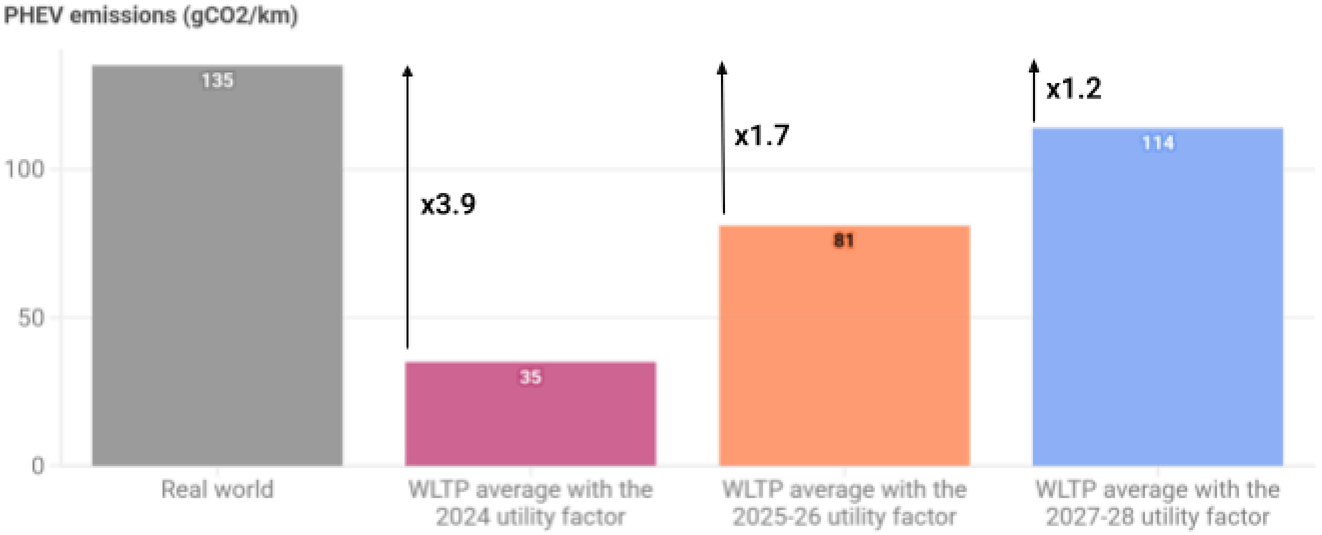
Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environmental Agency • Emissions are presented as arithmetic (non-weighted) averages derived from OBFCM data. WLTP emissions are based on the utility factor that was applicable before 2025.

This analysis uses [OBFCM data](#) reported in 2023 (referred to throughout as "real-world data") to calculate emissions based on actual fuel consumption in different driving modes. The dataset covers over 800,000 PHEVs registered between 2021 and 2023 (127,000 PHEVs registered in 2023 alone). Further details on the dataset and the data cleaning process are provided in the Annex, including the impact of possible weighting of the data. When considering the average real-world gap per model and recalculating the average based on official 2023 sales figures, we estimate that the average PHEV market would have emissions four times as high as those reported officially in 2023 on the official EEA dataset.

Real-world CO_2 emissions from PHEVs remain significantly higher than official WLTP values, even with the corrected 2027/28 utility factor (UF). Based on emissions data for all PHEVs reported in 2023, we estimate that average real-world emissions would still be 18% above the WLTP figures under the revised 2027/8 UF. This is a significant improvement, as the gap is even larger under the UF applicable before 2025: on average, real-world emissions are nearly four times as high as those assumed in the regulation. Even with the UF applicable in 2025/26, real-world emissions would still be almost twice the WLTP figures. This confirms that the planned correction in 2027/28 is essential to better reflect actual emissions and prevent underestimation.

Still a 18% gap with the 2027 utility factor update

Comparison of different utility factor scenarios with real-world emissions based on PHEVs sold in 2021/22/23

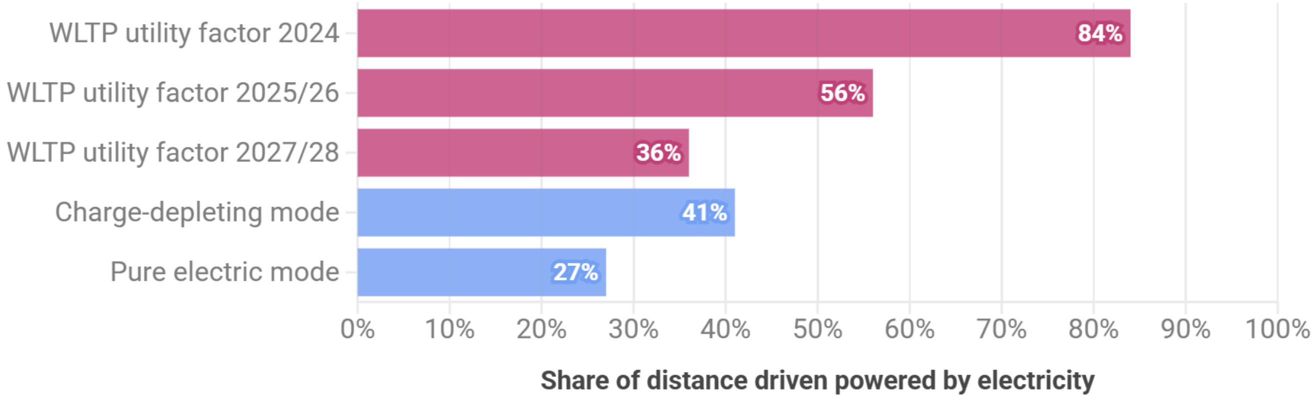


Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environment Agency • "2024 utility factor" refers to utility factor that was applicable before 2025. 2025-26 utility factor from the Euro 6e-bis and 2027-28 utility factor from Euro6e-bis-FCM.
Average emissions are weighted according to registrations of PHEV models.

For comparison, WLTP emissions were calculated based on estimated CD and CS mode values, applying the different UFs introduced in the previous section. This approach makes it possible to assess how well the current and upcoming UFs reflect real-world PHEV emissions (see Annex for full methodology). It should be noted that this is not a forecast: we simply recalculate emissions for the reported 2023 data using different UF curves and applying them to the existing data. For projections of emissions beyond 2025, see section 3.1.

The mismatch between official WLTP figures and real-world PHEV performance is mostly explained by an over-ambitious WLTP UF. Real-world driving data shows that only about 41% of distance is driven in CD mode, and this includes some use of the internal combustion engine in a combined mode. The share of pure electric driving is 27%. An energy-based UF, which the European Commission considers more accurate for reflecting real-world emissions (see info box in Section 1.1), puts the average UF at 31%. This is in stark contrast to the current WLTP UF of 84%. Even the planned correction of WLTP UF due in 2027/28 will still significantly overstate real-world electric use with a UF of 36%, which in turn leads to the actual PHEV emissions being underestimated.

Even the 2028 WLTP utility factor overstates how much a PHEV drives in electric mode



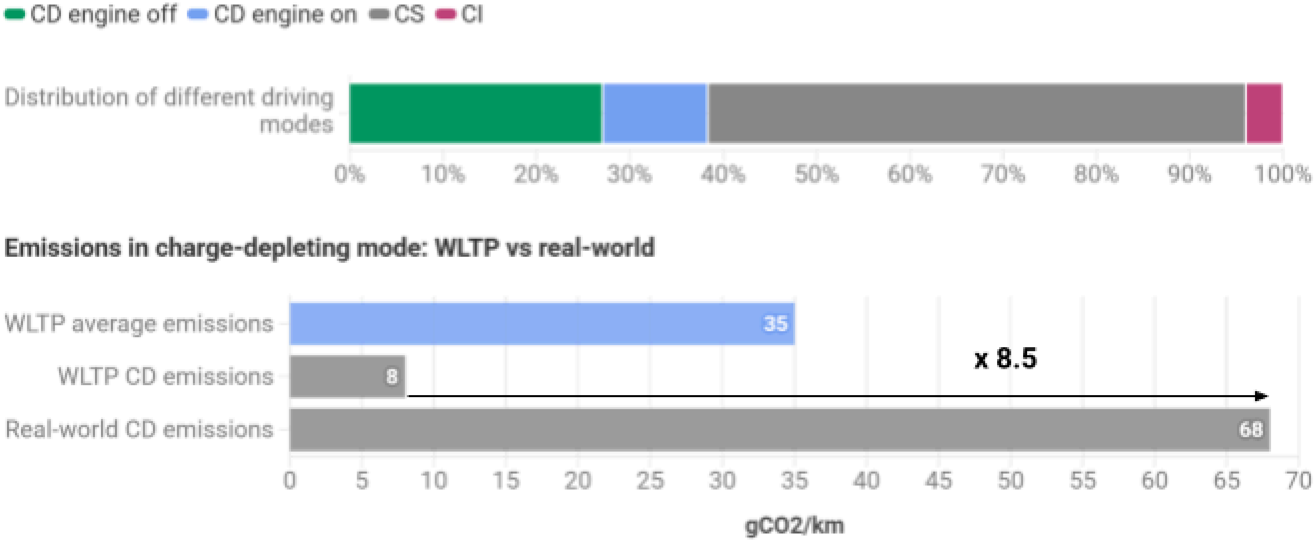
Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environmental Agency (EEA) • Charge-depleting mode is when the PHEV primarily runs on electricity but the engine kicks in when additional power is required. "Utility factor 2024" refers to the utility factor that was applicable before 2025.

The largest gap between WLTP and real-world PHEV emissions occurs in CD mode, often referred to as an "electric" mode where real-world CD emissions are even higher than the WLTP average. According to T&E analysis, real-world CO_2 emissions in CD mode average around 68 gCO_2/km, which is nearly nine times as high as the estimated 8 gCO_2/km in CD mode under the WLTP methodology, and almost twice the WLTP average overall emissions (including both electric and combustion modes). In practice, the combustion engine frequently assists the electric motor in CD mode, especially during acceleration, at higher speeds or uphill driving. On average, the ICE supplies power during almost one third of the distance driven in CD mode. This is largely due to insufficient e-motor power, as most PHEVs are not designed to operate fully electrically under typical real-world conditions.

This relationship is illustrated by the correlation between e-motor-to-combustion-engine power ratio and emissions in CD mode: vehicles with an average power ratio between electric motor and combustion engine of 0.9, emit approximately 45 gCO_2/km in CD mode. An average PHEV with a ratio of 0.7 has emissions of around 68 gCO_2/km. Vehicles in the lower decile in terms of their ratio of electric motor to combustion engine power, where it drops to around 0.5, have average CD mode emissions of 105 gCO_2/km.

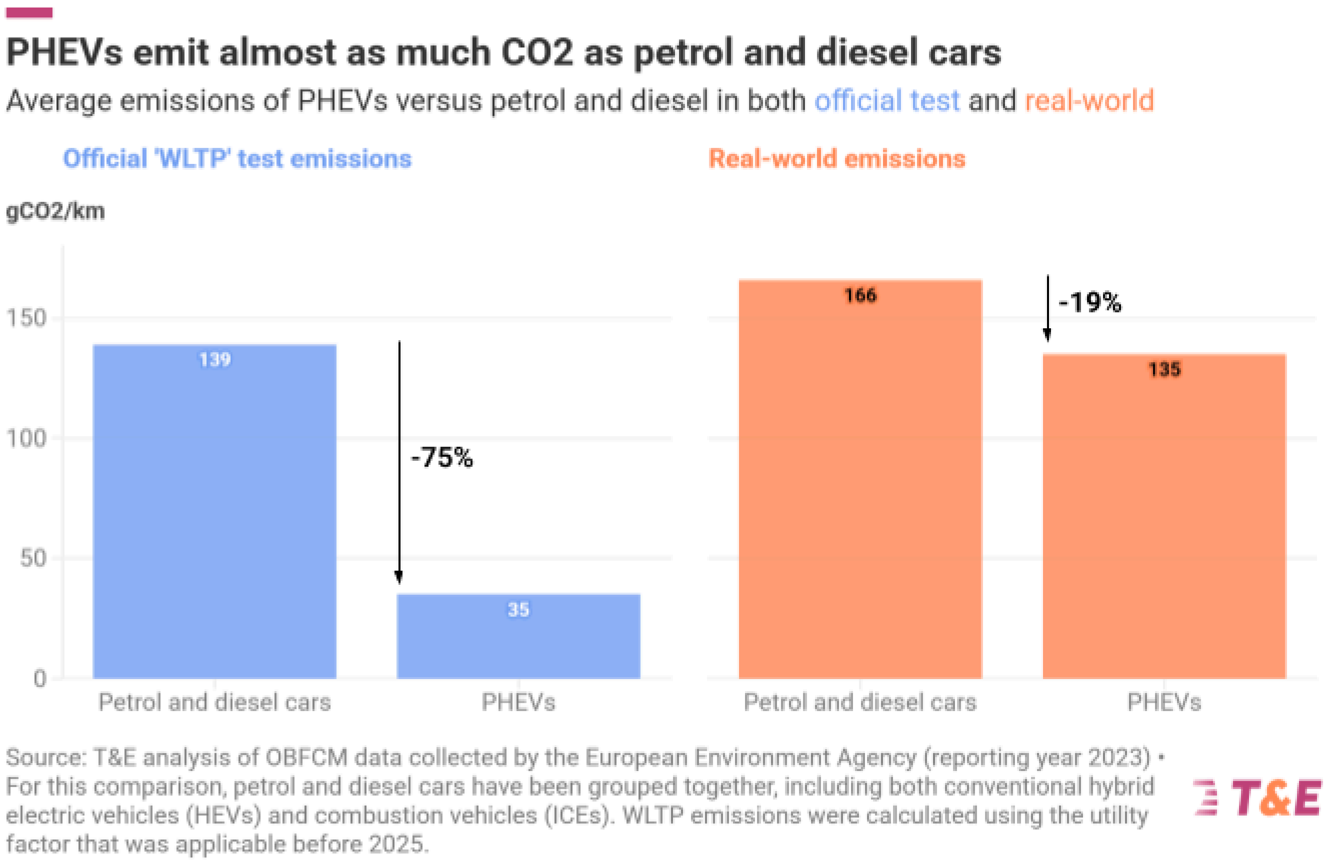
In real-world conditions, petrol PHEVs consume around 3 L/100km in electric mode. Considering an annual mileage of around 5,000 km in charge-depleting mode, the additional cost to refuel would be €250, whereas the driver would expect no fuel cost in electric mode.

The combustion engine supplies power during almost one third of the distance driven in charge-depleting mode



Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environmental Agency (EEA) • CD: charge-depleting; CS: charge-sustaining; CI: charge-increasing. Refer to section 1 of the report for more information.
Emissions were calculated with the utility factor that was applicable before 2025.

Frequent reliance on the combustion engine means many PHEVs emissions are no better than many conventional hybrids or petrol cars. Unlike conventional internal combustion engine vehicles (ICEs), which run entirely on fuel, or hybrid electric vehicles (HEVs), which use a small battery to support the engine under specific conditions, PHEVs are assumed to be cleaner because of their larger battery and ability to drive in electric mode. In practice, however, many PHEVs exhibit emissions similar to or even higher than some conventional ICE vehicles. A visual illustration of this is provided in Annex A.4.



Real-world PHEV emissions are far higher than regulatory assumptions, making them much closer to ICE vehicles than expected. While the WLTP estimates PHEVs emit 75% less CO_2 than ICEs, real-world data show PHEVs averaging at 135 gCO_2/km. This means the actual emissions gap is just 19%, not the large difference envisioned in current regulations.

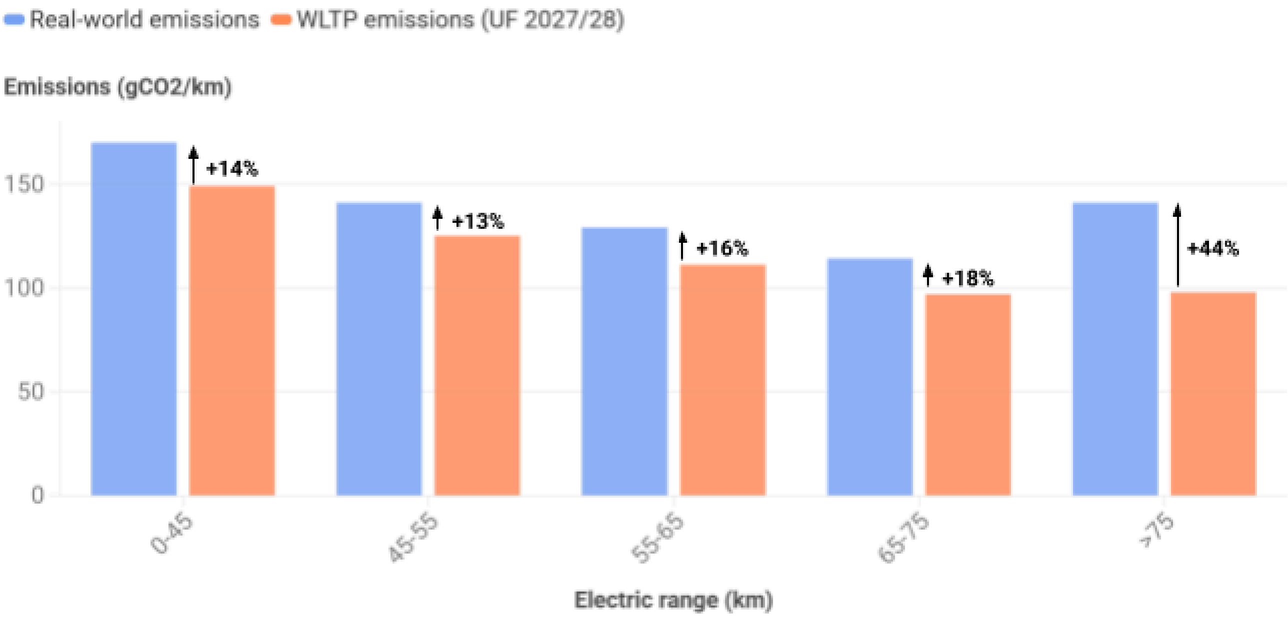
The 2027/28 UF correction marks an important step toward aligning WLTP values with real-world PHEV emissions and must be maintained. However, looking ahead, this gap may widen further as more long-range PHEVs enter the market: while longer electric ranges lead to higher UFs and therefore lower *official* emissions, they do not necessarily translate into lower *real-world* emissions, as the following section will demonstrate. To ensure the accuracy of WLTP values, a regular review of the UF based on real-world data is essential.

1.3 A higher electric range does not lead necessarily to lower PHEV emissions

A higher electric range does not lead necessarily to lower PHEV emissions, real-world data shows. Under the WLTP, a PHEV's electric range determines its utility factor (UF), which in turn defines the share of driving assumed to be in charge-depleting (CD) mode. The higher the electric range, the larger the assumed CD share and the lower the official CO_2 emissions. However, this link between range and emissions is in reality far weaker than the WLTP methodology assumes.

High electric range doesn't guarantee low emissions

Comparison of real-world PHEV emissions and WLTP estimates with 2027/28 utility factor shows higher emissions at longer ranges



Source: OBFCM data from 2021-22-23 registered by European Environmental Agency (EEA)

As the figure illustrates, actual emissions do decrease as electric range increases up to a point, but this trend breaks down for long-range PHEVs. Vehicles with an electric range above 75 km actually emit more CO_2 on average than those with a range between 45 and 75 km, despite their longer electric range. But long-range PHEVs not only display higher absolute real-world emissions, they also have the largest gap between real-world and official emission values. This observation is not caused by a small number of atypical vehicles: the >75 km segment contains a similar number of vehicles as the three categories below and shows no outliers. The main distinguishing feature is diversity, with around 15 brands present compared to about 20 in the shorter-range groups.

The high real-world emissions in absolute terms are attributable to significantly higher emissions in charge-sustaining (CS) mode. For vehicles above 75 km range, real-word CS emissions average 202 gCO_2/km, nearly 25% higher than in the 65-75 km range group. The main parameters impacting emissions of this group are higher vehicle mass and combustion engine power: long-range PHEVs are the heaviest in the dataset, averaging 28% more mass and 33% more engine power than the group just below.

At the same time the most pronounced gap between real-world and WLTP emissions is found in the long-range category. This discrepancy is the result of three factors coming together:

(1) **Utility factor overestimation**: For long-range PHEVs, the share of driving assumed to be electric is overstated roughly twice as much as in the other range groups (see first chart in Section 1.1)
(2) **Underestimation of CS emissions**: WLTP CS values are about 10% below real-world levels for long-range PHEVs, compared to a 5% gap in other groups. While WLTP CS values also increase in this long-range group, the increase is insufficient to reflect the higher real-world CS emissions, resulting in the larger discrepancy.
(3) **Underestimation of CD emissions**: Real-world charge-depleting (CD) emissions exceed WLTP values by a factor of more than 16, versus a factor of about 7 in the other groups.

Together, these factors lead to a pronounced mismatch between official and real-world emissions of long-range PHEVs.

A correlation analysis confirms that electric range is the weakest predictor of real-world PHEV emissions, while vehicle mass and engine power are the strongest (see Annex A.5 for details). This means that simply increasing electric range does not guarantee lower emissions. Indeed, longer ranges come with larger and heavier batteries and often more powerful combustion engines needed to power heavier vehicles when the battery is depleted, which push-up real-world emissions when operating in CS mode. CD emissions are also expected to be higher with heavier vehicles when the electric motor alone is not powerful enough to sustain accelerations. We also suspect that the charging behaviour does not necessarily improve with longer range, especially for corporate vehicles owners who can use fuel cards to refuel.

Most PHEVs do not have fast-charging capability, which reduces drivers' incentive to plug in regularly. This limitation means charging often takes several hours, making it less convenient than simply refuelling with petrol or diesel. Also when considering fuel tank size the issue becomes apparent: the average PHEV has a fuel tank of around 51 litres, providing a driving range of about 730 km in CS mode, according to WLTP figures. This long range using the combustion engine alone allows drivers to rely almost entirely on fossil fuels. To encourage regular charging, the fuel tank size could be limited and PHEVs be equipped with fast-charging capabilities.

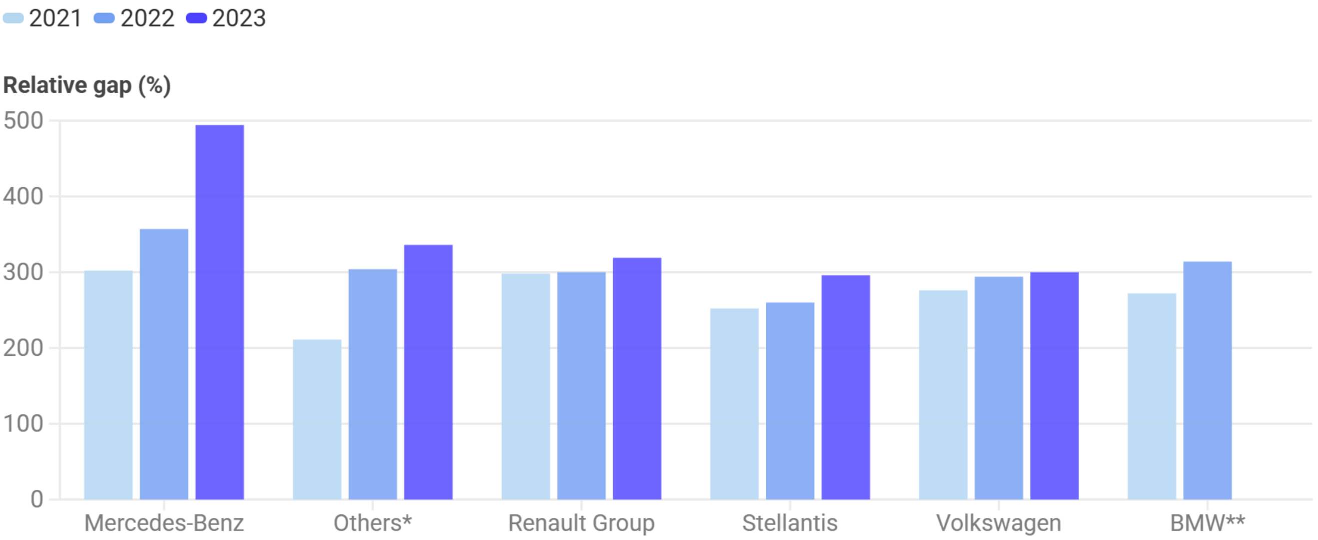
1.4 Some carmakers benefit more from the WLTP flaws

Some carmakers benefit more from underestimation of emissions from the WLTP, creating unfair competitive advantages. Brands like Mercedes-Benz and Land Rover show gaps well above the average difference between real-world emissions and WLTP figures. While the average gap is at 300%, these brands exceed it by more than 70 percentage points. This means their true emissions are understated far more than those of other manufacturers, making it easier for them to be compliant with EU targets.

The gap between WLTP figures and real-world emissions for PHEVs is widening year by year across OEM pools. For vehicles registered in 2021, 2022 and 2023 the divergence has grown steadily for all major European carmakers, with Mercedes-Benz group showing the most pronounced increase: its 2023 PHEVs exhibit a gap of 494%, significantly more than from other carmakers, underlining again how some manufacturers benefit increasingly from WLTP's shortcomings.

Growing gap between real-world and official emissions for all major European carmakers

Relative gap between real-world and WLTP emissions for different carmaker pools



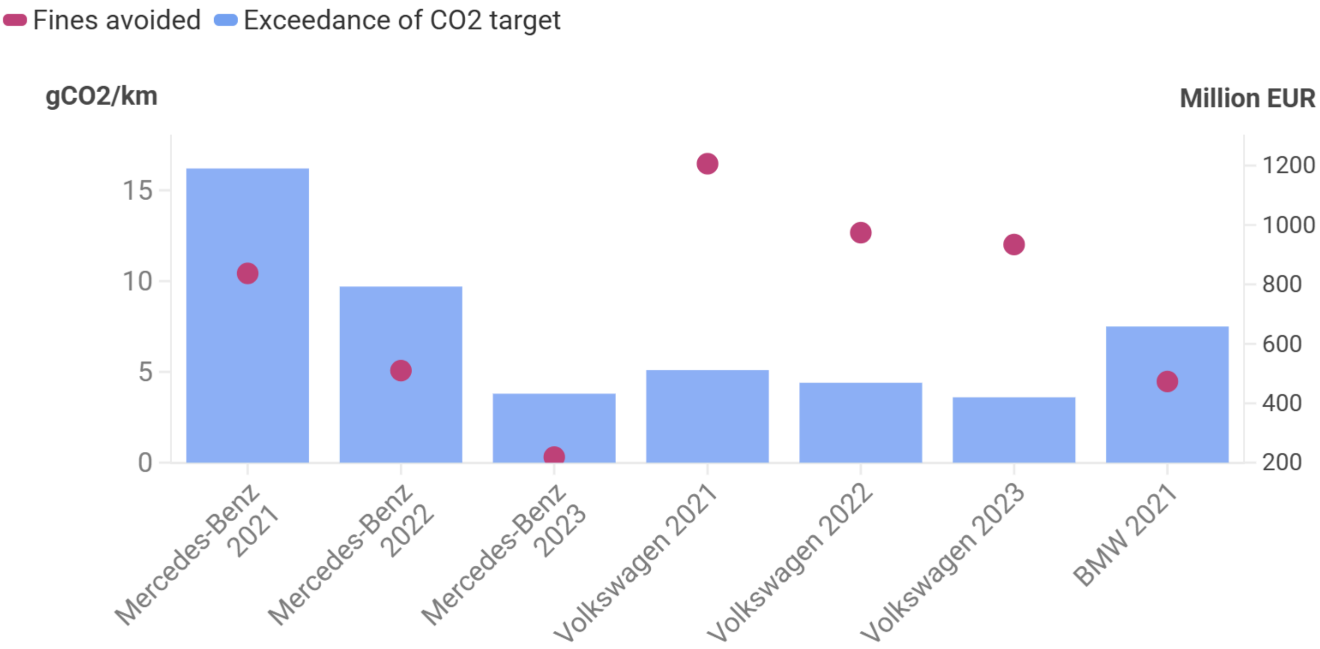
Source: T&E analysis of 2021-22-23 OBFCM data registered by European Environmental Agency (EEA) • Others*: Ford, Hyundai, JLR, Kia, Mazda, Mitsubishi, Nissan, Suzuki, Toyota. Gap size is weighted by sales. WLTP emissions are calculated using the utility factor applicable before 2025.
BMW**: sample size in the 2023 dataset is too small for reliable results.

This widening gap is driven by heavier and more powerful vehicles entering the PHEV fleet that also have longer ranges. For example, between 2021 and 2023 the GLC-Class, one of Mercedes-Benz' top-selling PHEV models, nearly tripled its average electric range from 44 km to 112 km. The brand's second most sold PHEV also exceeds 100 km of electric range, pushing the overall average electric range across the Mercedes-Benz PHEV fleet up by almost 45%. Yet despite this substantial increase, real-world emissions of the entire group only fell slightly from 136 gCO_2/km in 2021 to 128 gCO_2/km in 2023: a reduction of just 6%. This is far below what WLTP values suggest, which assume a drop in emissions of about 55%.

WLTP flaws have allowed four major carmaker groups to avoid more than €5 billion in fines between 2021 and 2023. The underestimation of emissions by the WLTP directly benefitted OEMs by making it easier to comply with fleet-average CO_2 targets. Between 2021 and 2023, real-world data shows that carmakers emitted nearly 52 million tonnes more CO_2 than official figures suggest. If PHEV sales shares had remained the same but compliance had been based on real-world emissions rather than WLTP values, OEM pools would have needed to compensate for this excess by increasing BEV sales to avoid penalties. The shortfall in necessary BEV sales over this period equates to 1.1 million vehicles.

Volkswagen, Mercedes-Benz and BMW account for the lion's share of fines avoided over the past three years, together responsible for 89% of the total. This presents a significant competitive advantage. By contrast, other carmakers such as Renault and Stellantis had little or no benefit, as they sell far fewer PHEVs, meaning the systematic underestimation of emissions has minimal impact on their compliance. For a detailed breakdown of target compliance information for each pool, please refer to the Annex.

Underestimation of PHEV emissions helped carmakers to avoid nearly €6 billion in fines



Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environmental Agency (EEA) • The exceedance of CO2 target is calculated by applying the real-world gap to PHEV WLTP emissions. WLTP emissions were calculated using the utility factor applicable before 2025.

1.5 High-emitters are heavy premium PHEVs with high engine power and limited e-motor power

PHEVs with the greatest real-world emission underestimation share three features: high electric range, high vehicle mass and a high combustion engine-to-electric motor power ratio. A closer look at individual models shows how these design choices widen the gap between official and real-world emissions.

Among PHEVs with over 10,000 registrations in 2023, the Mercedes-Benz GLE-Class shows the highest real-world emissions gap, exceeding its WLTP value by 611% (a 140.9 gCO_2/km gap). The Land Rover Range Rover and BMW X5 follow closely with gaps of 557% (159 gCO_2/km) and 486% (145 gCO_2/km), respectively. On average, these high-gap models weigh 2,555 kg, which is

28% heavier than the PHEV fleet average, and offer an average electric range of 87 km, 38% above the fleet average. Crucially, the combustion engines in these vehicles are more than twice as powerful as their electric motors, while the average PHEV sold in 2024 had an engine 1.6 times as powerful as its electric powertrain.

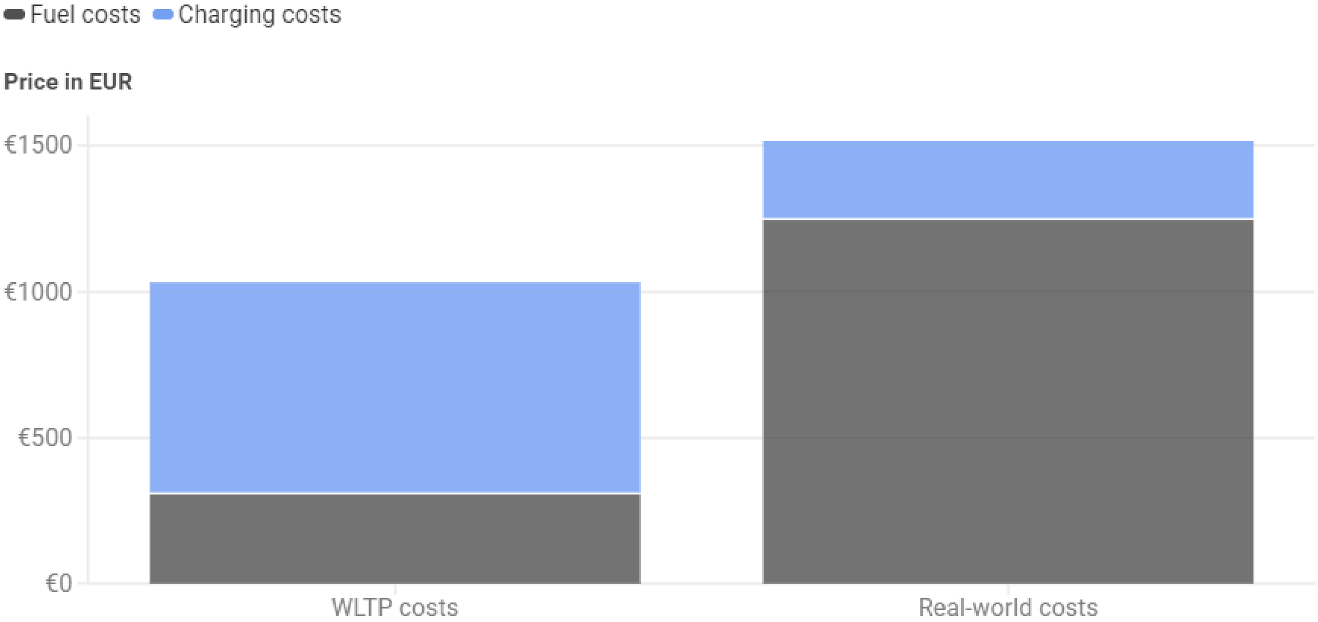
Weight and powertrain design impair real-world performance. Because PHEVs carry both a combustion engine and an electric drivetrain, they are inherently heavy. This high mass results in elevated emissions in charge-sustaining mode, when, in addition to the car body, the depleted battery must be carried by the combustion engine alone. A low-battery-to engine power ratio worsens the problem: the heavy PHEVs, especially SUVs, need powerful engines to maintain strong acceleration, but their e-motors are often underpowered. As a result, the combustion engine frequently kicks in during charge-depleting (CD) mode, pushing real-world emissions far above official figures. The Range Rover illustrates the consequences of this power imbalance. Its combustion engine delivers more than twice the power of its battery (a ratio of 2.2), driving real-world "electric" mode emissions up to striking 192 gCO_2/km.

Improved electric motor-to-engine power ratios are essential. To improve real-world emission performance, PHEVs must be designed with sufficiently powerful electric motors. A sound principle is that the electric motor should deliver at least twice the power of the combustion engine to ensure real electric driving while minimising combustion emissions. Today, no PHEV meets this standard with the maximum electric-to-engine power ratio being at 1.6, which explains part of the real-world emission estimation shortfall that policymakers must urgently address.

1.6 PHEVs cost consumers more than official figures suggest

The significant gap between WLTP values and real-world emissions not only jeopardises the EU's path to climate neutrality, but also tacitly burdens the wallets of PHEV owners. In practice, these vehicles consume far more fuel than laboratory tests suggest, resulting in drivers spending on average four times more on fossil fuel refuelling than WLTP estimates. These additional costs amount to around €940 extra per year. When taking into account the total energy costs, including charging, drivers have to pay about €500 more than expected, meaning that real-world expenses are almost 50% higher than official figures suggest. Among privately owned PHEVs, the best-selling model in 2023 was the Ford Kuga. While its gap between official and real-world performance is smaller than the average across all models, real-world fuel costs are still more than three times as high as those based on WLTP figures, which adds roughly €640 in extra annual fuel expenses for drivers and €360 overall additional energy costs.

Powering PHEVs costs drivers €500 more a year than claimed, on average



Source: T&E analysis of 2021-22-23 OBFCM data collected by European Environment Agency (EEA), EEA 2023 for registration data, EAFO, Weekly Oil Bulletin • Yearly mileage assumed at 12,730 km based on historical data. Average costs weighted by registrations across the EU26 (excluding Malta). WLTP emissions calculated using the utility factor applicable before 2025.

Not only are PHEVs expensive to drive, they are also more expensive to buy than clean alternatives. According to Bloomberg Intelligence, the average selling price of PHEVs in Germany, France and the UK in 2025 is €55,700. This is €15,200 higher than the average price of a BEV. Despite their higher upfront and running costs, carmakers continue to promote PHEV models. This raises concerns about their suitability for a clean transition, especially as consumers seek affordable options. Even in the case of larger vehicles, a study by the Boston Consulting Group (BCG) found that D-segment BEVs are €9,300 to €10,100 cheaper to own and operate over five years than their PHEV counterparts.

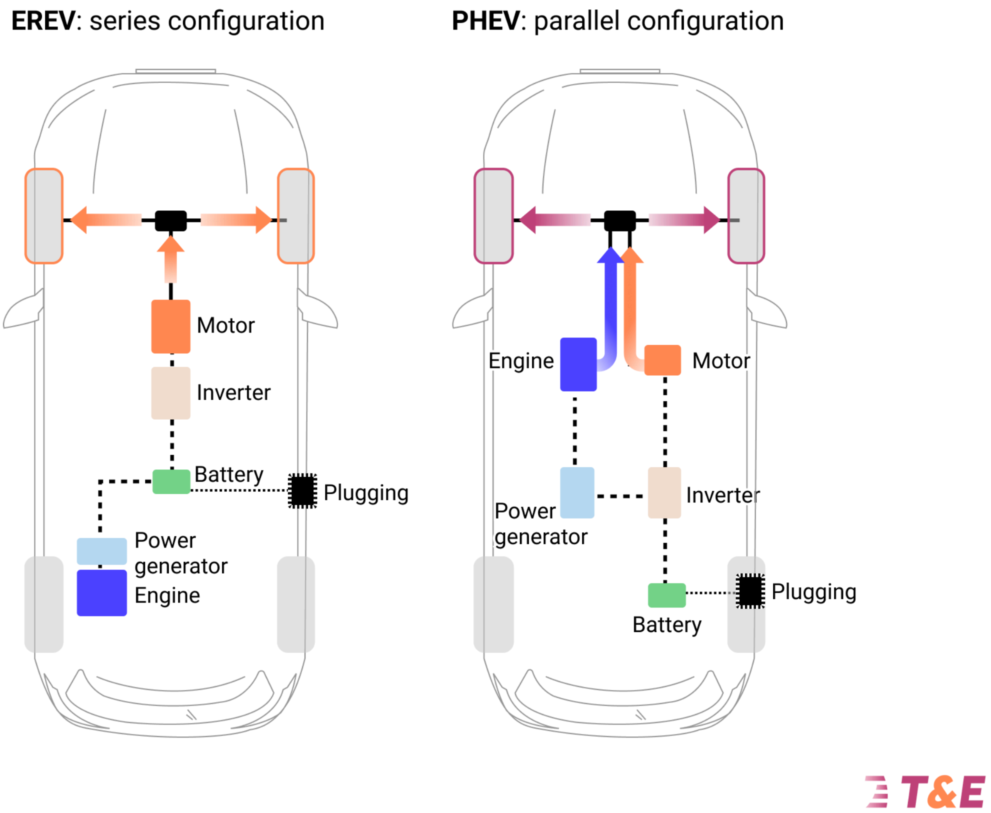
Section 2

2. EREV: a new bottle for an old wine?

2.1 Despite their limitations, EREVs have stronger specifications than PHEVs

Extended Range Electric Vehicles (EREVs) use a series configuration, unlike PHEVs which use a parallel configuration. EREVs are a specific type of plug-in hybrid vehicle. Traditional PHEVs are designed with a parallel hybrid configuration, in which both the combustion engine and the electric motor (e-motor) are connected to the wheels. EREVs, however, are designed with a series configuration, meaning the combustion engine can only recharge the battery and does not power the wheels directly. EREVs usually have larger batteries than PHEVs and can therefore provide a longer electric-only range. In this configuration, the combustion engine used for generating electricity is usually smaller than the engine required to power the wheels in a PHEV. Since the electric motor alone powers the wheels, it is much more powerful than typical PHEV electric motors. EREVs differ from hybrid electric vehicles (HEVs) with series configurations, such as Nissan's e-Power technology, in that the battery can be recharged by both the combustion engine and an external plug.

Difference between EREV and PHEV hybrid configurations



EREVs are not exempt from PHEV shortfalls, especially extensive use in combustion mode
EREVs typically have large fuel tanks which allow for around 900 km of travel in combustion mode. As long as the size of the fuel tank is not limited, there is a significant risk that drivers would choose to drive mostly in combustion mode, rarely charging the depleted battery. This is a particular risk in Europe, where many drivers do not regularly charge their vehicles, for example when using a company car with a company fuel card.

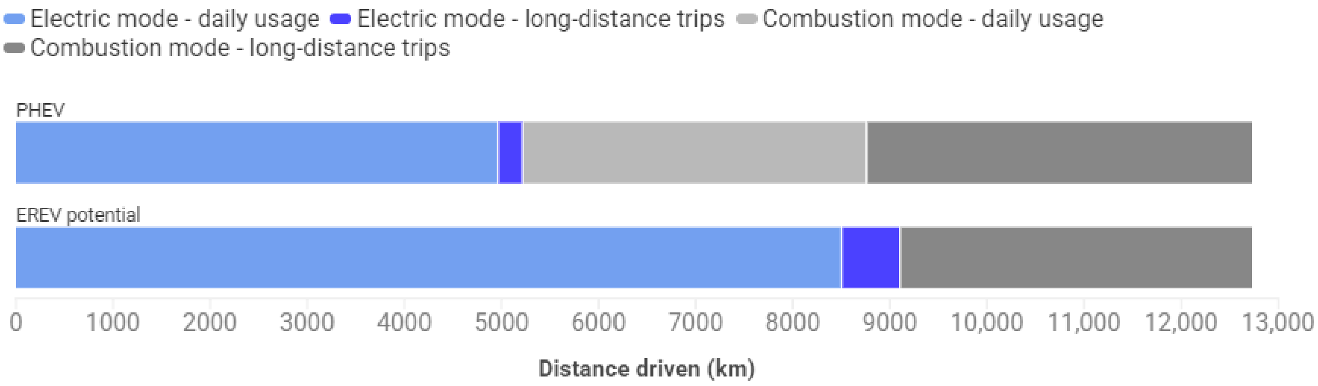
With reported values ranging from 15% to 70%, the utility factor that can be achieved in Europe is highly uncertain
In the 2025 EV Outlook, Bloomberg New Energy Finance (BNEF) estimated that 70% of the distance travelled by Chinese EREVs was in electric mode, using data from 2022 provided by the National Big Data Alliance of New Energy Vehicles of China, a Chinese think tank associated with car manufacturers and academic institutions in China. Further studies with more recent

data are needed to confirm whether this utility factor remains at this level when sales extend beyond early adopters from 2022. Moreover, the Boston Consulting Group (BCG) mentioned in a 2025 report that some OEMs and experts forecast a 15% utility factor for EREVs when projecting the utility factor of European customers. Therefore, there is a high level of uncertainty regarding the utility factor that would be achieved in Europe.

With four long-distance trips over 1,000 km per year and daily use in electric mode, EREV could potentially reach a 72% utility factor

The following figure shows the potential proportion of distance driven in combustion mode for a typical European use case. In this example, the utility factor is applied over the course of a full year, during which the driver would use the vehicle for 27 km per day for 45 weeks and take 4 long-distance trips of 1,050 km. If the owner charges every four days (similar to the charging frequencies for PHEVs achieving a 41% share in charge-depleting mode), and if the long-distance trips are done without charging along the way, then an EREV could reach a 72% utility factor over one year. This order of magnitude would be consistent with 2022 data observed in China. However, under the right conditions and with the EREV models designed to the highest standards, for instance by limiting the fuel tank size to incentivise charging during long-distance trips, then, a higher utility factor could potentially be reached.

Example of a typical use of PHEVs and EREVs



Typical use case with 4 long-distance trips (1,050 km) per year and 45 weeks with daily trips of 27 km. European PHEVs have a 41% share in charge-depleting mode. EREVs could reach a 72% utility factor if charged at the same frequency as PHEVs.

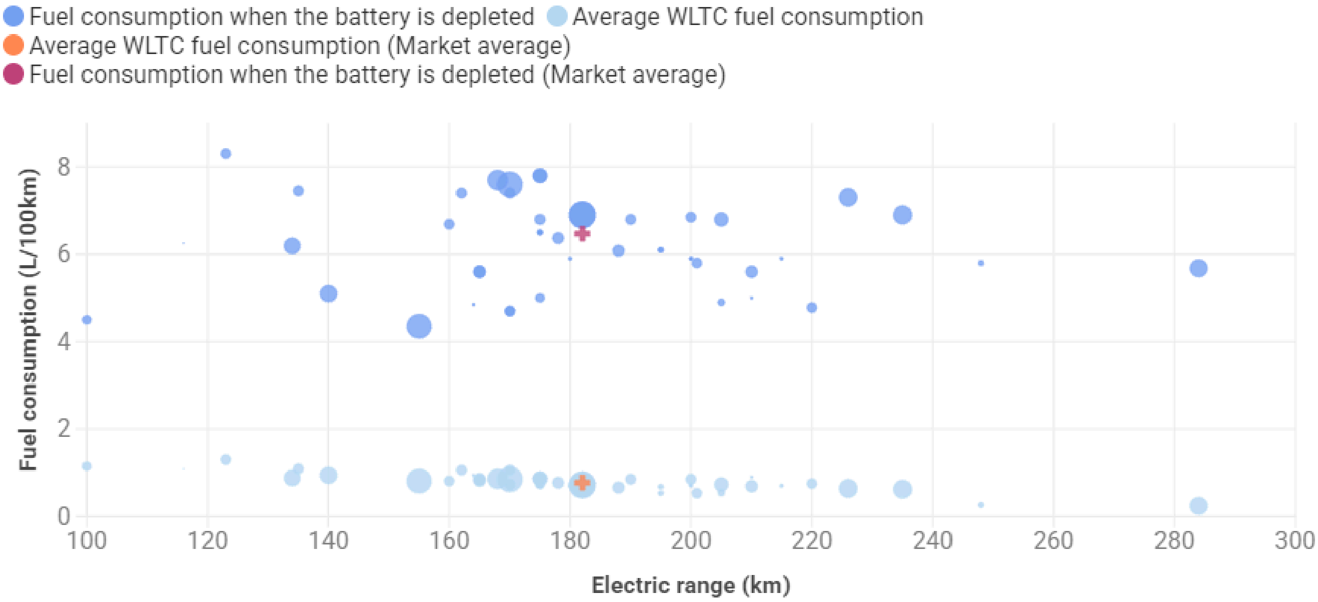
Despite optimised engine operating points, EREVs have high fuel consumption in combustion mode - in line with conventional petrol SUVs.

Based on the specifications of Chinese models (more details in Annex A.8), we calculated that EREVs in China consume 6.7 litres per 100 kilometres on average when the battery is depleted. This is no better than some European petrol SUVs. For example, the Volkswagen Tiguan has a petrol variant with combined fuel consumption of 6.0 L/100 km.

Since the combustion engine is not connected to the wheels in an EREV, it should theoretically operate at an optimal point. However, when the battery is fully depleted, the relatively small ICE needs to run at high power to provide enough energy to drive the large vehicle and its heavy depleted battery. Although PHEVs carry smaller batteries, the combustion engine of a PHEV generally operates at less than optimal points. Nonetheless, data analysed by T&E suggests that average EREVs in China and average PHEVs in Europe have similar fuel consumption when the battery is depleted, averaging close to 7 L/100 km. Therefore, in addition to the uncertainty surrounding the proportion of distance driven using electricity, EREVs do not offer any benefits in terms of CO_2 emissions once the battery is depleted.

In H1 2025, EREVs sold in China have an average electric range of 184 km

Once the battery is depleted, they consume an average of 6.7 L/100 km - no better than a conventional petrol SUV.



Source: T&E analysis of 23 Chinese EREV models representing 80% of the Chinese EREV car market in H1 2025. Fuel consumption data based on the Chinese Worldwide Harmonized Light Vehicles Test Cycle (WLTC).

Chinese EREVs show some design advantages over conventional PHEVs

Firstly, EREVs have e-motors that are 2.7 times as powerful as their combustion engines. In comparison, the e-motors of European PHEVs are 30% less powerful than their combustion engines (see Annex A.8 for details). This higher electric power is a significant advantage, given that an EREV can operate in fully electric mode during periods of strong acceleration. PHEVs, on the other hand, rely on combined ICE-electric operation in such conditions, with the combustion engine providing additional power to the e-motor. This increases overall emissions in real-world driving conditions, as the combustion engine is used for one third of the distance travelled in "electric" mode. With smaller combustion engines and no need to start the combustion engine during acceleration, EREVs could display lower real-world emissions in electric mode.

Secondly, due to the larger batteries in EREVs, most car manufacturers have chosen to design these models with fast-charging capability, typically DC charging with an output of over 100 kW. This fast-charging capability would encourage drivers to recharge their vehicles more regularly.

Thirdly, EREVs have a longer electric range, averaging 180 km in China compared to 80 km for European PHEVs. Among Chinese models, some even reach electric ranges well above 200 km, for instance the [Stelato S9] is a luxury sedan with an electric range reaching 290 km. While longer range alone does not guarantee the models would reach the lowest levels of real-world emissions, the combination of long range, a powerful electric motor and fast charging capability increases the likelihood that some drivers would operate in electric mode over longer distances when compared to the typical use of PHEVs.

Comparison of EREV and PHEV model characteristics

	Average EREV China	Average PHEV Europe
Electric range	180 km	80 km
Range driven with fuel	880 km	730 km
Total driving range	1070 km	810 km
Fuel consumption with battery depleted	6.7 L/100km	7 L/100km
Average WLTP emissions	0.8 L/100km	1.6 L/100km
Fast-charging	Fast DC charging	Limited
Electric motor power	255 kW	100 kW
Combustion engine power	95 kW	165 kW
Ratio e-motor power / engine power	2.7	0.7
Fuel tank size	59 L	51 L

Source: T&E analysis of public information for EREV models sold in China in H1 2025, and PHEV models sold in Europe in 2024.

2.2 Large EREV segments are growing fast in China

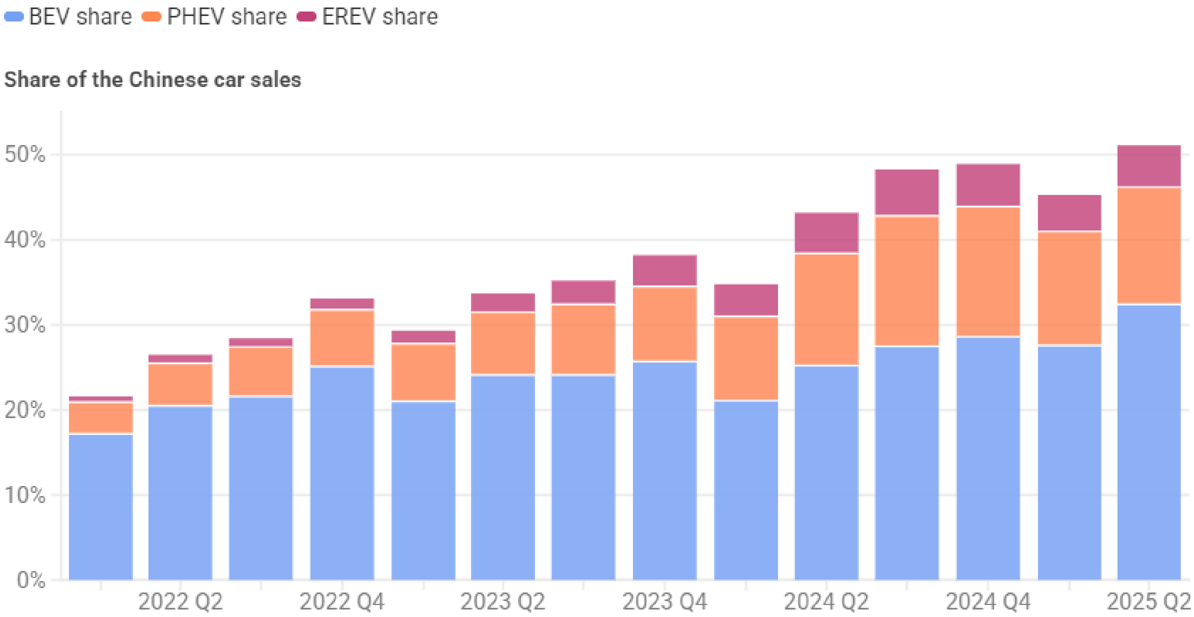
Sales of EREVs in China have grown sixfold since 2022

As the Chinese new energy vehicle (NEV) market exceeded 50% of the total car sales in Q2 2025, EREVs have reached 10% of the NEV market. In terms of sales units, EREV sales have increased sixfold since 2022, accounting for 5% of the total car market in China.

Although EREVs first appeared in the US in 2011 with the Chevrolet Volt and in Europe in 2013 with the BMW i3 REx, these models have since been discontinued as international carmakers focused their efforts on BEVs. Since 2022, EREV technology has increasingly been adopted by Chinese carmakers to support drivers who require a long range in areas with limited charging infrastructure.

EREVs have reached 10% of the new energy vehicle market in China

Chinese EREV sales have been multiplied by six since 2022



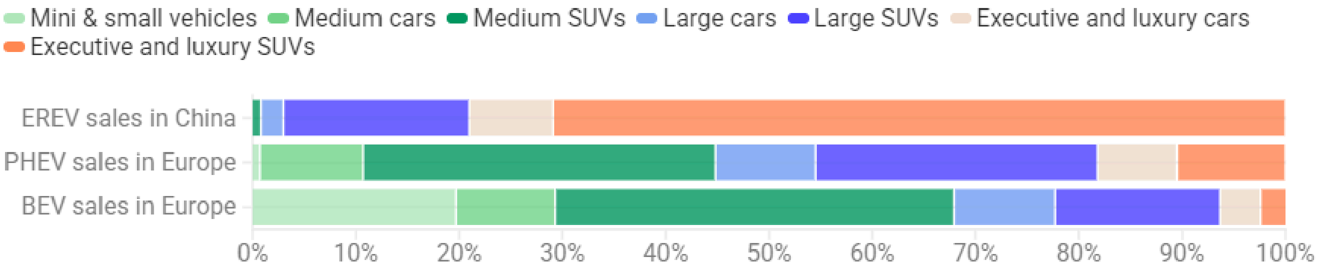
Source: T&E analysis based EV-Volumes and Bloomberg

Most Chinese EREVs would not match European needs

In China, 99% of EREVs are sold in the larger segments (segment D and above), predominantly in the executive and luxury SUV segments. However, these large SUV models would not meet the needs of the European market, where executive and luxury vehicles represent only 6% of BEV sales and 18% of PHEV sales. Furthermore, these vehicles would compete with similar-sized European PHEVs which have stronger brand recognition. From a technical perspective, SUVs and larger vehicles provide more space for a dual powertrain. Furthermore, buyers of larger vehicles can absorb the additional costs of an EREV drivetrain. Some medium-sized C-segment EREVs such as the Deepal SL03 (electric range of up to 165 km) are sold in China.

99% of EREVs sold in China are large and executive vehicles

Chinese EREVs are not adapted for the EU market, where more than two-thirds of BEV sales are in the small and medium segments



Source: T&E analysis based EV-Volumes. Car sales segments excluding MPVs, vans and commercial vehicles.

2.3 EREV plans for Europe are uncertain

While most carmakers have EREVs planned for the global market, focusing on China and the US, models launched or officially announced in Europe remain scarce (see details in Annex A.9).

Following the end of the BMW i3 REx sales, the Mazda MX-30 was the next EREV to be launched in Europe in 2023 (only 4,400 units sold across Europe in 2024). The Leapmotor C10 REEV, which will benefit from the partnership between Stellantis and Leapmotor, is set to launch in 2025. With an electric range of 145 km and a starting price of €37,400, this model will be the first to test the potential of EREVs with mass-market European drivers in the D-SUV segment. The SWM G03F Super Hybrid (the European name for the Brilliance Big Tiger) was sold in very low volumes in Italy during the first half of 2025. With a range of 46 km, this D-SUV EREV falls short of European PHEV models, which have an average range of 80 km.
Following these initial launches, we have identified nine EREV models that could potentially be launched in Europe. Among them, Chery has already started producing the Exeed Exlantix models for export. BYD presented a premium SUV, the Yangwang U8, in Geneva and it has announced plans to launch the brand in Europe. The Hyundai Group is also planning EREV models across its Hyundai, Kia and Genesis brands for the global market. Among European carmakers, BMW has announced that it is considering launching an EREV version of the iX5 SUV in Europe.

There is even greater uncertainty in the long term, and we have identified six major carmakers that could theoretically launch EREV models in Europe, as they have announced plans for other regions. Stellantis, Volkswagen and Ford have EREV models planned for the US market, so they will already possess the relevant technology should a European launch become relevant in future. Renault's Horse joint venture with Geely and Aramco has announced its commitment to EREVs, developing an EREV system based on its 1.0L HR10 engine for use initially in Brazil.

2.4 EREV outlook in Europe: pros and cons of this transition technology

EREVs have technical advantages over European PHEVs thanks to their longer range, more powerful e-motors and fast-charging capability. However, current EREV models have similar drawbacks, such as a large fuel tank that allows users to predominantly drive in combustion mode. Given the competition from European PHEVs and the fact that EREV technology is controlled by Chinese carmakers, the adoption of this transition technology in Europe remains highly uncertain.

EREVs offer technical advantages, but lack strategic fit for Europe's automotive industry

Theme	Pros	Cons
Electric range	Larger EV range than PHEV (EREV range ~180 km in China, and more with future tech).	Lower EV range than BEVs (~500 km in Europe).
Environmental performance	Powerful electric motor that can handle all situations. NOx emissions are lower than PHEVs in combustion mode.	Share of electric driving is uncertain (15% to 70%), which could lead to frequent use in combustion mode (as observed with PHEVs in Europe). 48% to 127% higher LCA emissions than BEVs (BCG analysis depending on the utility factor).
Charging & infrastructure	DC fast-charging capability (>50 kW). Extended range suitable in areas with low charging density.	Reliant on fossil fuel infrastructure and increasing price of fuels.
Cost	May allow for BEV-platform reuse (fitting a small ICE on the platform).	Uncertainty on EU pricing. Higher total cost for the driver compared to BEVs (BCG analysis).
Use cases	Offers flexibility for drivers lacking home or workplace charging and traveling long distances.	Not suited to affordable and mass market segments needed to compete in Europe and globally.
Carmaker strategy	Transitional technology for premium brands up to 2035.	Requires parallel investments in BEVs and EREVs at a time when OEMs must prioritize BEV scale-up and cost reduction. Chinese are the current leaders in EREV technology, whereas European OEMs have limited plans for Europe.

Source: T&E assessment

While EREVs can go further than PHEVs, they can't go as far as BEVs with current technology
As discussed in previous sections, the average electric range of Chinese EREVs is above 180 km, surpassing the 80 km range of PHEVs but falling short of the average 500 km range of BEVs in Europe. However, the best-in-class Volkswagen ID.ERA concept car is expected to reach 300 km, and future EREV models fitted with new battery technology could extend this further. CATL announced its new Freevoy battery could unlock electric range over 400 km. For example, the Stellar drive from IM Motor is expected to use a 66 kWh Freevoy battery to achieve an electric range of 450 km. These future long-range models with an electric range of over 300 km have the potential to offer a range comparable with that of today's entry-level BEVs.

While EREVs can be cleaner than PHEVs, today's model falls short of the high environmental standards required in Europe

EREVs benefit from powerful electric motors and a series configuration that enables emissions to be minimised in electric mode. This is an advantage over PHEVs, which have less powerful electric motors and therefore drive in combined electric-combustion mode for a significant proportion of their use.

EREVs could reduce NOx emissions compared to PHEVs. If engineered well, the EREV combustion engine would operate almost like a stationary generator with a steady load, reducing NOx emission spikes that occur during dynamic engine operation.

Due to their long ICE range capability, the average utility factor of EREVs could be between 15% and 70%. They may therefore exhibit similar charging behaviour to PHEVs, which travel more than half of their distance in Europe in depleted battery mode. Nevertheless, well-designed, long-range (300+ km) EREVs with a limited fuel tank size (e.g. 15 L) could be driven predominantly in electric mode, achieving a utility factor close to 70%.

Taking the whole lifecycle of the vehicles into account, including the production phase, BCG calculated that EREVs with a 15% utility factor emit, on average, 127% more CO_2 than similar BEVs. Even with a utility factor of 65%, EREVs would emit 48% more CO_2 than BEVs over their lifetime, making them suboptimal in terms of environmental performance.

EREVs benefit from fast-charging capability, yet they rely on fossil fuel infrastructure

With the ability to use DC fast charging at a rate above 50 kW, all EREV models have a significant advantage over PHEVs. Moreover, the ability of these vehicles to drive in combustion mode can be useful for a certain category of users during the transition, particularly those living in areas with limited charging access. However, as the transition progresses towards the end of the 2020s, European regulations such as the Alternative Fuel Infrastructure Regulation (AFIR) and the Energy Performance of Buildings Directive (EPBD) are expected to provide most drivers with sufficient access to public and private charging. While an ICE range is beneficial in the short term, it will not be a significant advantage for EREVs in the 2030s as fuel stations become scarcer. Furthermore, the implementation of carbon taxes as part of the Emissions Trading System for road transport (ETS2) is expected to increase fuel prices and therefore driver costs. Reliance on fossil fuel infrastructure could also become a disadvantage as Europe increasingly prioritises energy sovereignty.

The future price of the EREV powertrain is uncertain but operating costs will be a burden

Compared to PHEVs, these models have larger batteries and could initially be sold at a higher price. However, as battery prices are expected to decrease, accounting for a smaller proportion of the total car price, other factors could influence vehicle pricing. For example, well-designed EREVs with small combustion engines for emergency backup could be built on the same platform as BEVs with a lower complexity than PHEVs, benefiting from the economies of scale of the BEV platforms. In the European market, PHEVs will face an increasing cost burden as the production volume on ICE platforms decreases. Therefore, EREV could become cheaper than PHEVs in the medium term.

Despite smaller batteries than BEVs, EREVs would be more complex and costly due to the additional ICE components that would likely not benefit from significant economies of scale. Therefore, EREV prices in Europe are unlikely to fall below BEV prices. BloombergNEF long-term

modelling confirms this for the Chinese market as they show that, in the absence of subsidy, EREVs would never reach price parity with battery electric vehicles, but they could displace PHEV sales due to their lower price.
Overall, a well-designed EREV with a small combustion engine could be cheaper than a PHEV, but it is unlikely to be as affordable as a mass-market BEV. However, EREVs could provide cheaper options than BEVs in premium SUV segments where extra-large BEV batteries may be common.

In terms of total cost of ownership (TCO), reports from BCG highlight that EREVs incur higher costs than BEVs. BCG calculated that a D-segment EREV would cost €1,000–€1,200 more per year than a similar BEV over a five-year ownership period.

Based on sales price and TCO, EREVs appear to be better suited to premium segments, where users are less sensitive to operating costs and long electric ranges could limit the price benefits of BEVs.

EREVs are not suited to mass-market segments, but they could serve as a transition technology for certain users before 2035 when replacing combustion vehicles

Firstly, they can serve users driving long distances and living in remote areas, where charging infrastructure is expected to remain limited during the transition, and who lack access to private charging at home or at work. While this use case is quite common in China, explaining the popularity of EREV in the country, these conditions are far less common in Europe and should disappear by 2035 thanks to charging infrastructure coverage. In this use case, well-designed EREVs can provide an emergency backup drive in combustion mode. However, the fuel tank should not be oversized to prevent the vehicle from being used primarily in combustion mode.
Secondly, EREVs would be designed to target premium drivers seeking large vehicles with long-range capabilities and intermediate features between PHEVs and BEVs. A survey conducted by McKinsey has confirmed that the interest in EREVs was higher among owners of premium-brand vehicles. However, these use cases are expected to be relatively limited, given the increasing competition from long-range PHEV models (e.g. Lynk & Co has introduced a model with an electric range of 200 km) and new battery technology that enables ultra-long-range BEVs (e.g. Mercedes-Benz is testing a BEV prototype with a range of 1,000 km using a solid-state battery).

Chinese carmakers are leading the way with EREV technology, whereas European carmakers have limited plans in Europe

EREV technology does not appear to be a strategic priority for European carmakers. Many carmakers are already benefiting from, or planning to further develop, their PHEV technology, which benefits from the legacy ICE supply chain in Europe. In this context, carmakers have not focused extensively on EREV, a technology that is dominated by Chinese companies and would not significantly benefit the ICE supply chain in Europe.
This technology is being developed for the premium segment, with BMW considering selling an EREV version of the iX5 in Europe and luxury carmakers such as Lotus developing high-end EREV models. However, carmakers must prioritise investment in BEVs to develop the best BEV platforms for the market, and avoid making competing investments in PHEV or EREV

technologies. For example, the CEO of Volkswagen declared that it makes no sense to have both range extenders and plug-in hybrids in smaller European cars, whereas this technology is relevant for large vehicles sold in the US.

Finally, in the undesirable case where the EU allows for an exemption for the sale of vehicles running on carbon-neutral e-fuels under specific conditions after 2035, EREVs may be the preferred e-fuel compatible vehicle given that the high prices of e-fuels would limit such fuels to niche applications.

Section 3

3. PHEV and EREVs offer little potential and benefits as transition technologies up to 2035

In this section, we forecast emissions from long-range hybrid vehicles in two scenarios — business as usual versus a well-designed model — to assess the potential for reducing real-world emissions in future. We then calculated the additional emissions that combustion vehicles could produce after 2035 if proposals to weaken current CO_2 car regulations were implemented.

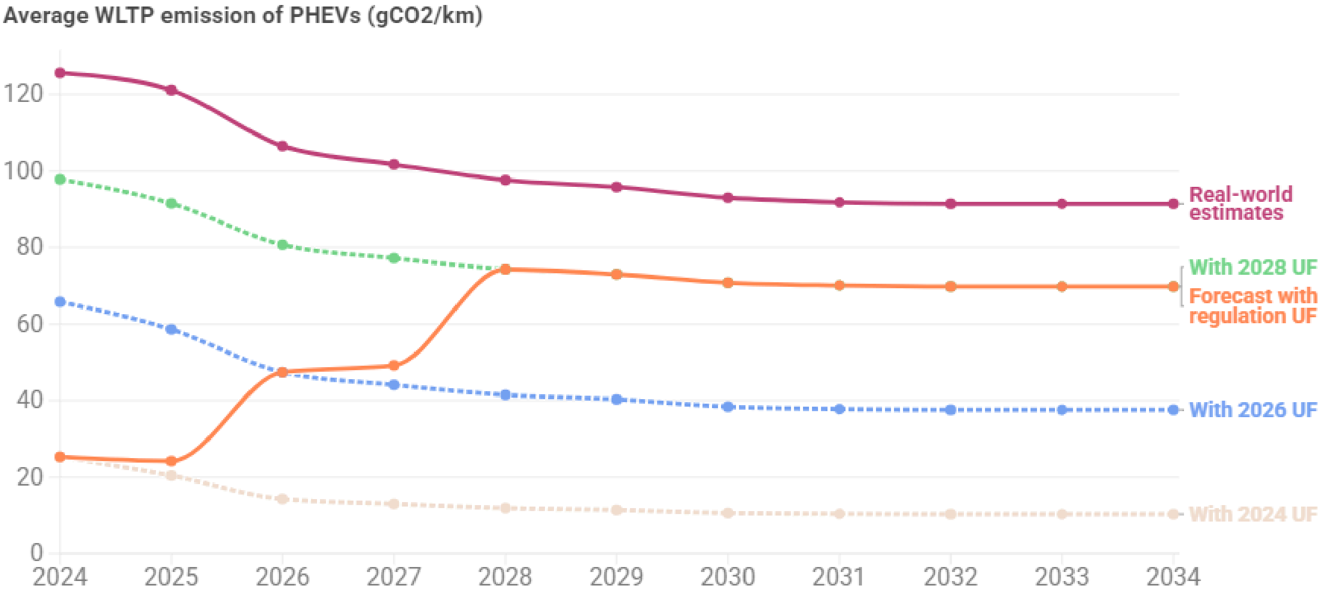
3.1 PHEV emissions 2025-2035: business-as-usual scenario

While the electric range should increase, PHEV real-world emissions will still be significant after 2030

We forecasted the range and emissions of PHEVs by projecting current market trends. In this scenario, we assumed that the PHEV electric range would increase by an average of 9% per year during the 2020s. After this period, the range would then stagnate between 2031 and 2034, which is the final year of ICE sales. An average annual improvement in range of this magnitude has been observed in the European market between 2021 and 2024. It would lead to a market average range of 140 km by 2034. The increase in electric range would result in an average WLTP emission level of 71 gCO_2/km in 2030. However, we expect real-world emissions to be 31% higher than the WLTP average (see Annex A.10 for details), reaching 93 gCO_2/km in 2030 (down from 135 gCO_2/km in 2023). We assume that emissions in combustion mode will remain at the 2024 level. This is justified by the fact that the increased range in 2024 led to stagnating emissions in charge-sustaining mode between 2023 and 2024.

While the electric range should increase, PHEV real-world emissions will still be significant after 2030

Additional updates of the PHEV utility factor are needed



Source: T&E forecast for PHEV sold in Europe in a business-as-usual scenario.

Planned utility factor corrections avoid drastically underestimating PHEV emissions

Our forecast of 71 gCO_2/km for 2030 is based on the planned correction of the utility factor curve in 2027/28 (see Section 1.1). Using the current utility factor (the 2025/26 UF curve) would result in average PHEV emissions at 38 gCO_2/km, while real-world emissions would remain 2.4 times as large. If the utility factor curve were weakened and reverted to the curve used prior to 2025, the average PHEV emission would be set artificially to 11 gCO_2/km, despite real-world emissions being nearly nine times as high. This assessment confirms the importance of safeguarding the planned correction to the utility factor curve as part of the Euro 6e-bis-FCM standard, although further strengthening of the curve would be needed to close the remaining gap.

If the pre-2025 WLTP utility factors were kept, real world emissions would be nearly 9 times higher than official values by 2030

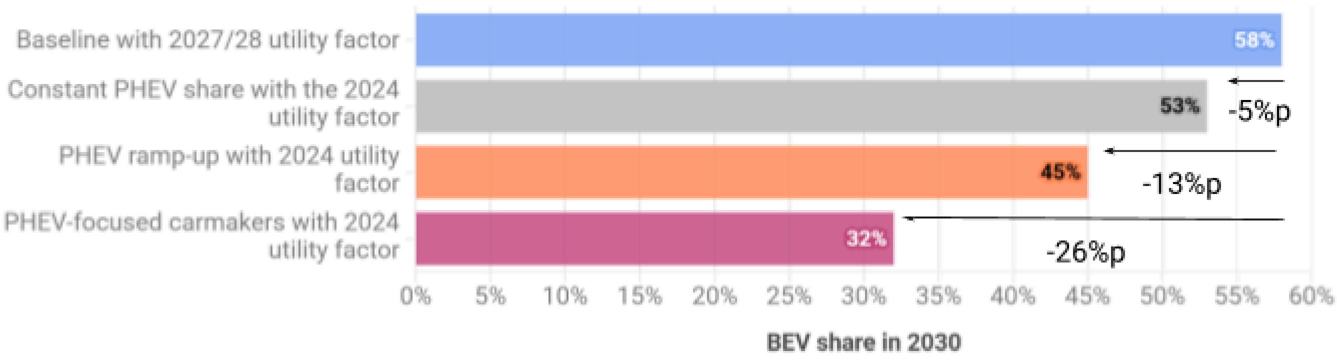
The utility factor curve must be fixed. This is even more crucial as the range increases.

Source: T&E emission forecast in a business-as-usual scenario where the average range reach 140km in 2030. The 2024 utility factor refers to the curve used for all years before 2025. 2025-26 utility factor from the Euro 6e-bis and 2027-28 utility factor from Euro6e-bis-FCM.

Weakening or cancelling the utility factor correction would not only drastically underestimate PHEV emissions, but also reduce the incentive for BEV sales, slowing the transition to zero-emission mobility. If the utility factor corrections are not safeguarded, carmakers could rely heavily on overstated PHEV performance to meet their CO_2 targets, slowing the pace at which they increase BEV sales. As a result, fewer electric vehicles enter the market. Assuming a constant PHEV share, carmakers would need an average BEV share of 53% if both the 2025 and 2027 corrections of the utility factor are cancelled, instead of 58% under the planned utility factor updates. If PHEV production ramps up until 2030, with the market share of PHEVs doubling compared to 2025, the required BEV share could fall to just 45%, representing a shortfall of 13 percentage points (%p) in electric vehicles entering the market. Carmakers that have a stronger focus on PHEVs would benefit the most from the weakening of the utility factor and would be encouraged to sell more PHEVs if the utility factors are weakened. In this scenario of PHEV-optimised compliance, carmakers could sell the same number of PHEV than BEV with a 32% share for both, resulting in a 26%p reduction in the BEV share. A supplementary scenario modelling the cancellation of the 2027 correction while retaining the 2025 correction is provided in Annex A.10.3.

Rolling back utility factor updates slows BEV uptake

Cancelling the utility factor corrections could reduce BEV share by up to 26 percentage points (%p) in 2030



Source: T&E emission forecast in a scenario where the average range of PHEVs reaches 140 km in 2030 • The 2024 utility factor refers to the curve used for all years before 2025. For the 2027/28 utility factor scenario, a market forecast is being used for the PHEV share. The constant-share scenario assumes a stable PHEV share of 9%. The ramp-up scenario assumes an increase to 17% by 2030. PHEV-focused carmakers are expected to sell 32% PHEV in 2030.

3.2 PHEV emissions 2025-2035: shift to well-designed models

As discussed in Section 1, there are many parameters that can affect real-world emissions. Electric range alone does not guarantee a reduction in real-world emissions. In this section, we assume that future policies and incentives encourage the adoption of well-designed hybrid models with longer ranges. Such policies are based on a set of criteria on the vehicle design and we calculate below the expected impact on future PHEV emissions.

The best criteria to identify and encourage well-designed PHEVs would be the following:

- **E-motor vs engine power ratio of at least 3:** The power of the electric motor must be at least three times that of the combustion engine. This ensures that the vehicle can operate in pure electric mode under all conditions. This also ensures that the combustion engine is not too powerful, as the real-world emissions of PHEVs are partly correlated with engine power.
- **Real-world electric range of at least 200 km by 2030:** Although an increased range does not necessarily lead to lower emissions, combining a minimum range of 200 km with other stringent design criteria should boost the likelihood of achieving a higher real-world utility factor. Best in class models should have at least 300 km electric range. An electric range above 200 km would be sufficient to drive in electric mode over one week assuming a daily mileage of 30 km.
- **Fast charging capability:** The vehicle must have fast-charging capability and be compatible with DC charging above 100 kW. This ensures that drivers are incentivised to charge regularly using fast charging during longer trips or when conventional charging is unavailable at home or work.
- **Maximum fuel tank size of 15 litres.** Without this limitation, some drivers could use the vehicle extensively in combustion mode without strong incentives to recharge. Limiting the tank size ensures that drivers are incentivised to charge. With a fuel tank capacity of

15 litres and a fuel consumption rate of 6.7L/100km, an EREV could travel 220 km in combustion mode, which is equivalent to the electric range.

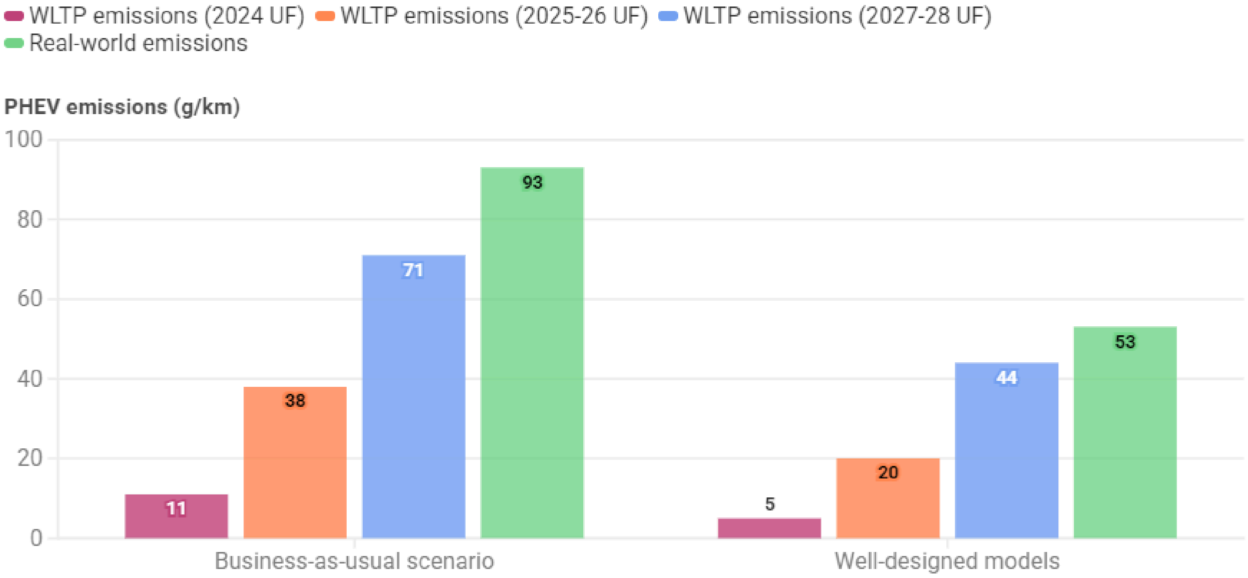
Design criteria would limit the increase in the real-world gap

In the business-as-usual scenario, we estimated that the gap between real-world emissions and the WLTP emissions calculated with the 2027-28 utility factor could increase from the 18%, which was observed for models released between 2021 and 2023, to 31% by 2030 because of the shift toward longer range models which have the highest gap (44% based on 2023 OBFCM data), see details in Annex A.10. However, we expect that implementing design criteria would prevent this increase as new long-range models would benefit from fast-charging capability and powerful electric motors. Therefore, once regulatory measures favouring well-designed PHEV models have been implemented, we assumed the real-world gap would converge to 18%.

If the market shifted towards well-designed models, average real-world emissions could approach 50 gCO_2/km in 2030

If the annual average range increase is maintained at 13% (the increase observed between 2023 and 2024), most models would reach 200 km by 2030. If this increase in range is accompanied by a significant improvement in engine efficiency and battery energy density, we could expect emissions in combustion mode to improve by an average of 2.2% per year — the average improvement observed between 2021 and 2024. Under these conditions, the WLTP average emissions of well-designed PHEV models would fall to 44 gCO_2/km by 2030. Real-world emissions could reach 53 gCO_2/km if the design criteria effectively reduce the real-world emission gap.

Well-designed PHEV models could reach an average real-world emissions close to 50 g/km in 2030



Source: T&E forecast of PHEV emissions (2030) • In the well-designed scenario, hybrid vehicles are designed with higher e-motor power than combustion engine power, fast-charging capability, and small fuel tank. They reach an average range of 200 km compared to 136 km in the business-as-usual scenario.

The real-world emissions of the best-in-class models with a range of over 300 km could reach 25 gCO_2/km by 2034

In the best-in-class scenario, we estimated the emissions of a well-designed segment C hatchback with a 300 km electric range. This well-designed long-range hybrid could achieve real-world emissions of 25 gCO_2/km, with WLTP emissions at 21 gCO_2/km.

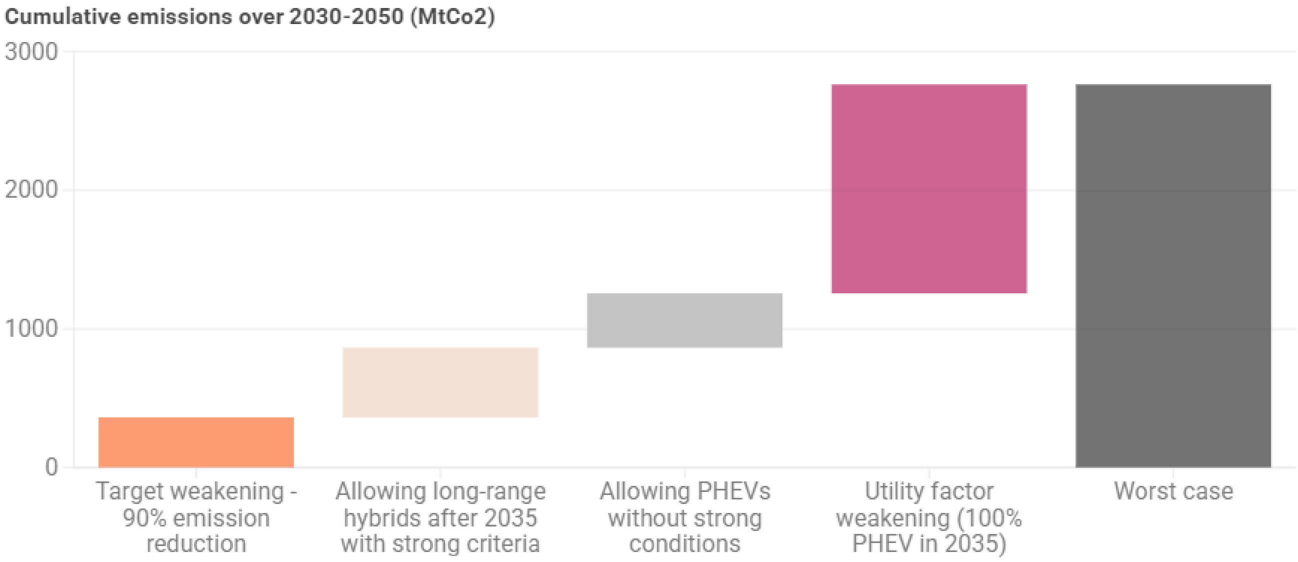
3.3 Assessment of VDA proposals on hybrids

The VDA's proposals on hybrids could increase car fleet CO_2 emissions by 64% after 2030

In June 2025, the German Association of the Automotive Industry (VDA) presented a comprehensive 10-point proposal to weaken the car CO_2 regulation. We have selected three measures related to hybrid models from their proposal and assess them. Combining these three measures could lead to an additional 2.8 $GtCO_2e$ being emitted by European cars between 2030 and 2050, posing a major threat to the EU's climate targets. This represents a 64% increase compared to emissions from a baseline scenario based on current car CO_2 regulations. For reference, the European Scientific Advisory Board on Climate recommends that the EU's greenhouse gas emissions budget for the period 2030–2050 should be kept within a limit of 11–14 $GtCO_2e$, in order to limit global warming to 1.5 °C. Therefore, if the VDA's proposal on hybrids is adopted, additional European cars sold after 2030 would consume a fifth of the total EU remaining carbon budget while the whole car fleet would consume half of the carbon budget. The VDA proposal would therefore derail the EU's path to carbon neutrality. Further information on this section can be found in Annex A.11.

VDA's proposals could increase car fleet CO2 emissions by 64% after 2030

In the worst case, 100% PHEVs could be sold by 2035 if the utility factor curves were weakened



These scenarios illustrate the VDA's proposal to give greater consideration to the role of PHEVs beyond 2035. In scenarios where PHEVs are permitted after 2035, we assumed that the VDA would cap PHEV sales at 33%. However, if the utility factor is weakened under a 90% target, then, in the worst case, up to 100% of PHEVs emitting 11 g/km could be sold.

Adjusting the reduction target to -90% from 2035 would increase emissions by 360 $MtCO_2e$

The VDA proposal would significantly weaken the regulation by replacing the 100% CO_2 emissions target with a -90% target in 2035. This measure would result in an additional 360 $MtCO_2e$ of cumulative emissions between 2030 and 2050 — a 8% increase compared to the regulatory baseline. This is the equivalent of half a year of emissions from the 2022 car fleet. In a scenario where PHEV emissions are calculated based on the 2027/28 utility factor curve, this measure would allow carmakers to sell 10% ICEs (including all hybrid powertrains) in 2035.

Allowing a third of sales to be long-range hybrids after 2035 could result in an additional 500–890 $MtCO_2e$

The VDA has proposed giving greater consideration to the role of PHEVs beyond 2035 by defining PHEVs with long electric ranges as a new vehicle category. Up to a certain fleet volume, these vehicles would be eligible for registration as ZEVs after 2035. Assuming PHEV sales are capped at one-third of the new car fleet and the new vehicle category is defined based on the long-range scenario in section 3.2, we estimate that new long-range hybrids sold between 2030 and 2050 could emit 500 $MtCO_2e$, a 12% increase compared to the regulatory baseline. This is equivalent to 1.1 years of emissions from the 2022 car fleet.

However, the situation could be worse if the definition of 'long-range hybrid' is not robust. For example, in a business-as-usual scenario in which the average range is limited to 140 km in 2031 (see Section 3.1), total additional emissions could reach 890 $MtCO_2e$, which is a 21% increase compared to the regulatory baseline. This would represent 2.3 years of emissions from the 2022 car fleet. Combined with the 90% reduction target for 2030, this weakening would result in an additional 1.3 $GtCO_2e$ of emissions between 2030 and 2050.

Weakening the utility factor could have the worst impact, resulting in an additional 2.8 $GtCO_2e$.

The VDA has proposed suspending the planned adjustment of the utility factor (including the 2025 adjustment). Cancelling the correction to the utility factor curve from 2025 onwards would result in PHEV emissions being artificially reduced to an average of 10 gCO_2/km in 2035. A 90% reduction in emissions compared to the 2021 baseline would mean that the 2035 CO_2 target would be 11 gCO_2/km. Therefore, weakening the UF would effectively give PHEVs a free pass. Combined with other hybrid incentives, the worst-case scenario could see 100% PHEV sales from 2035 onwards, despite these models having real-world emissions close to 90 gCO_2/km. These vehicles would lead to total additional emissions of 2.7 $GtCO_2e$, a 64% increase compared to the regulatory baseline.

Conclusion

In a context where the automotive industry is seeking to increase sales of hybrid models beyond 2035, this study reveals that the emissions of most plug-in hybrid electric vehicles (PHEVs) are no better than those of conventional internal combustion engines (ICEs) in real-world conditions. Meanwhile, new EREV models face similar challenges, as their design would still allow drivers to predominantly drive in the combustion mode with a depleted battery. Proposals from the German carmakers' lobby group VDA, would – if accepted – derail the EU's path to climate neutrality by allowing the sale of hybrid vehicles disguised as zero-emission vehicles, potentially enabling them to make up 100% of new sales even after 2035.

Europe must urgently establish global electric car leadership to sustain economic value and create new jobs across its automotive value chain. To avoid setting the European car industry into a doomed future based on outdated and ineffective hybrid technology, the EU must stand firm during the upcoming regulatory review. The 2030 and 2035 targets must both be maintained to prevent significant climate-harmful emissions, and any proposal to create specific vehicle categories for hybrids should not be accepted.

In order to protect the integrity of the targets, every step of the planned correction of the utility factor curve must be safeguarded, in particular the 2027/8 correction. Furthermore, the utility factor methodology must be strengthened further to close the remaining gap with real-world emissions. OBCFM data must be used to calibrate the utility factor curve every two years from 2029 onwards. Additionally, carmaker-specific utility factors should be applied to prevent those with higher-than-average real-world emissions from benefiting from an unfair competitive advantage. Given that the EEA has noticed many OBFCM errors, we also recommend making over-the-air data transmission mandatory, and investigating and correcting the cause of data transmission errors. In addition, we recommend updating OBFCM devices to measure the electric energy entering the vehicle at the plug, as this is an essential parameter for understanding charging losses and assessing the vehicle's energy-based utility factor. This utility factor provides the most accurate methodology for understanding the factors contributing to the significant discrepancy between WLTP and real-world emissions, and for monitoring its evolution throughout the vehicle's lifetime and between generations.

During the transition period up to 2035, car manufacturers are expected to continue to rely to some extent on hybrid vehicles. Policies and tax incentives based could encourage a shift towards the best models which can lead to a decrease in real-world emissions of PHEVs if designed correctly. We propose the following list of criteria:

- The electric motor must have at least 3 times the power of the combustion engine.
- The electric range should reach at least 200 km by 2030.
- The vehicle must have fast-charging capability and be compatible with DC charging above 100 kW.
- The fuel tank size should be limited to 15 litres to incentivise drivers to charge their vehicles, as their combustion range would otherwise be limited.

Recommendations

1	Maintain the 2030-2035 car CO_2 targets in the upcoming car CO_2 regulatory review, with no derogation for hybrids after 2035.
2	Safeguard both the 2025/26 and 2027/28 corrections of the utility factor curve to close the PHEV loophole.
3	Strengthen the utility factor curve with biannual corrections based on real-world data from 2030, and OEM-specific correction factors.
4	Design policies that accelerate the BEV uptake, while preventing the further uptake of poorly performing hybrids, and encouraging the ICE and plug-in market to shift towards best-in-class plug-in hybrid models.

Annex

A.1 OBFCM dataset: cleaning procedure

The dataset provided by the European Environment Agency (EEA) contains information from on-board fuel consumption monitoring (OBFCM) devices, hereafter referred to as real-world data. The most recent data is from 2023 and covers vehicles registered from 2021 until 2023, including internal combustion engine vehicles, hybrid electric vehicles and plug-in electric vehicles.

In total, the raw dataset comprises 7,791,120 entries, of which 1,027,156 are PHEVs. The dataset had already undergone an initial cleaning process by the European Commission, as described in this document. However, several inconsistencies and implausible values remained, requiring additional cleaning and filtering as described below:

1. **Harmonisation of model names**: Vehicle model names were standardised to the model family.
2. **Filtering by EEA inclusion criterion**: Only entries retained in the EEA's own analysis were kept. These were identifiable via the column "Used in calculation".
3. **Derivation of charge-sustaining mode values**: The dataset did not directly provide distance travelled or fuel consumed in CS mode. Instead, we calculated these values out of the given data:
   $CS\ distance\ =\ Total\ distance\ -\ (CD\ distance\ +\ CI\ distance)$
   Fuel consumption in CS mode was derived using the same approach for the corresponding fuel values.
4. **Removal of inconsistent PHEV driving-mode entries**: Some PHEV entries displayed inconsistencies such as zero distance travelled in charge-depleting mode with the engine running but a non-zero corresponding fuel consumption. As no reliable correction could be applied, these entries were deleted.
5. **Filtering of extremely high CS mode consumption values**: Extremely high CS mode fuel consumption values could be identified in the dataset. Since consumption is expressed per 100 km, short distances can lead to distorted values. To address this, all records with CS mode mileage below 100 km were removed.
6. **Removal of very high electric range values**: In a small number of cases (2,018) PHEVs displayed implausibly high electric ranges. Manual verification of the affected models indicated that these entries were erroneous and they were therefore excluded from the dataset.

After the filtering steps, 6,486,437 entries remain, of which 821,220 are PHEVs. These are the data points used in the following PHEV analysis.

A.2 Modelling WLTP scenarios

Central to our report is the application of upcoming utility factors to the 2021-2023 PHEV fleet in order to estimate the alignment between official WLTP values and real-world emissions. To understand this calculation process, it is essential to comprehend the structure of the official test procedure used to determine PHEV emissions.

The Worldwide Harmonised Light Vehicles Test Procedure (WLTP) is a standardised laboratory test used for measuring fuel consumption, CO_2 emissions and other pollutant levels of vehicles. A central feature of the WLTP is its division into multiple driving cycles with a specific speed profile representing urban, rural and motorway driving conditions. To account for the different driving modes and the according fuel consumptions the WLTP tests PHEVs in both charge-depleting (CD) mode and charge-sustaining (CS) mode separately. As explained in section 1.1 the concept of utility factor (UF) is then being introduced for representing the proportion of driving powered by electricity. A thorough explanation of the exact procedure is present in a briefing and white paper by ICCT.

The final CO_2 emission value for the PHEV is a weighted average based on the UF (see page eight of the ICCT briefing):

$$(1)\ e_{WLTP} = UF \times e_{CD} + (1 - UF) \times e_{CS}$$

e_{CD} represents the emissions in CD mode, e_{CS} the emissions in CS mode and e_{WLTP} are the average emissions (gCO_2/km). In the datasets such as the new vehicle registration dataset by the European Environment Agency (EEA) or the real-world dataset (OBFCM dataset), only the average emissions e_{WLTP} are provided. However, in order to assess the impact of a varying utility factor, both e_{CS} and e_{CD} must be known. Without at least one of these values, the equation contains two unknowns, making it impossible to isolate the effect of the utility factor. This presents the first difficulty in modelling WLTP emissions

A second challenge involves the calculation of the utility factor itself. UF represents the share of distance driven in CD mode. In WLTP testing, the PHEV begins fully charged and is driven over repeated cycles until the battery is nearly depleted. When the battery's energy level drops by less than 4% during a cycle (the break-off criterion), it indicates the vehicle is no longer operating in CD mode. The driving cycle in which this happens is referred to as *confirmation cycle*. It is then assumed that in the previous cycle the transition from CD to CS mode has taken place and it is therefore called the *transition cycle*. The distance driven up to and including the transition cycle is given by R_{CDC} and it is by this metric that UF is calculated.

However, the dataset only provides the equivalent all-electric range ($EAER$). This metric represents the portion of the CD mode distance that can be attributed to the use of the electric energy from the battery during the lab test (see the ICCT report for further details). R_{CDC}, which is needed for calculating the official utility factor, is not present in the dataset.

So, to calculate WLTP emissions with different UF scenarios the following two problems need to be approached:

1. Calculation of UF using data available in the dataset

2. Calculation of e_{CS} and e_{CD} using data available in the dataset

A.2.1 Calculation of UF

To estimate R_{CDC} from the available data, we assume that $EAER$ and R_{CDC} are always in the same cycle, so R_{CDC} is the final distance at the end of the cycle where $EAER$ is reached. Under this assumption, R_{CDC} can be calculated as:

$$R_{CDC} = c \times n$$

c is the cycle length (23.267 km) and n the number of WLTP test cycles required to switch from CD to CS mode, including the transition cycle. Since $EAER$ and R_{CDC} are assumed to be both in the same cycle, n is determined by rounding up the ratio of $EAER$ to c:

$$n = \lceil \frac{EAER}{23.267} \rceil$$

(as long as $EAER$ is not a whole-number multiple of c).

Once R_{CDC} is known, UF can be derived using the WLTP utility factor curve from the [Commission Regulation 2023/433](). Depending on the scenario of interest, the UF curve for 2024 (utility factor applicable for all years before 2025), 2025/26 (Euro 6e-bis) or 2027/28 (Euro 6e-bis-FCM) should be applied. These curves are approximated from data generated from the regulation formula (Appendix 5) using fourth-degree polynomials. They are used both to infer UF as a function of R_{CDC} (as described here), but also as a function of $EAER$ as will be addressed in the following section. This approach provides an accurate approximation within the dataset, including for longer driving ranges beyond 150 km, where a different polynomial approximation is employed.

A.2.2 Calculation of e_{CS} and e_{CD}

To implement the different utility factor scenarios, the values of e_{CS} and e_{CD} must be determined from the available data. [This ICCT report]() provides a useful equation for this purpose (see page 35):

$$e_{CS} = \frac{e_{WLTP}}{1-UF_{el}}$$

Here, the utility factor used (UF_{el}) differs from the previously introduced utility factor (UF). Specifically, UF_{el} represents the share of the total driven distance that is powered exclusively by electric energy, that is $EAER$. Using the utility factor curves described earlier, but now with $EAER$, UF_{el} can be calculated allowing for the determination of both e_{CS} and e_{CD} as follows:

$$e_{CS} = \frac{e_{WLTP}}{1 - UF_{el}}$$

Then, the WLTP CD emissions measured in the test cycle can be calculated using equation (1), where the utility factor is defined based on R_{CDC}:

$$e_{CD} = \frac{e_{WLTP} - e_{CS} \times (1 - UF)}{UF}$$

Once e_{CS} and e_{CD} are calculated based on the 2024 utility factor curve (utility factor applicable for all years before 2025), the average emissions e_{WLTP} can be recalculated with the different utility factor curves that will be implemented in 2025/26 and 2027/28.

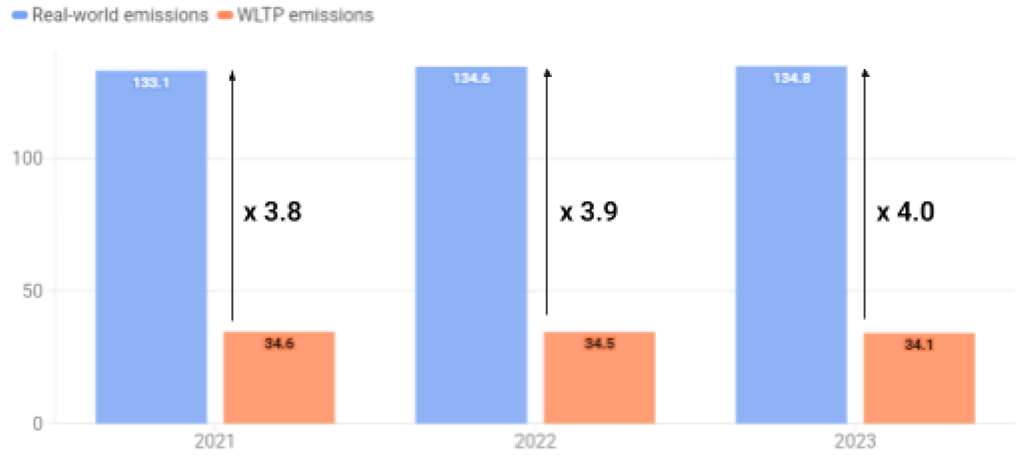
A.3 Calculation of the weighted emission gap

In the first figure of section 1.2, the emission gap is calculated as the ratio of the average real-world emissions from the OBFCM dataset to average WLTP emissions, without applying weighted averages.

The OBFCM data can be considered broadly representative of new car registrations. However, some distortions remain, as certain brands are either over- or underrepresented. To address this, the average model emissions from OBFCM data has been weighted according to registration numbers reported by the EEA. When looking at all registrations from 2021 to 2023 together, the OBFCM dataset includes enough data points for each model to calculate a representative average emission value. In this case, we can reliably apply registration weights from the EEA database. This is what we have done for example in the second graph in Section 1.2.

However, when the data is split by registration year (2021, 2022, 2023 separately), some brands are very sparsely represented in the OBFCM data for certain years; in some cases, specific brands barely appear at all (for example, BMW in 2023). In these cases, sales weighting cannot improve representativeness because there is too little or no underlying model data to weight. Therefore, we report the simple average (unweighted) for the year-by-year analysis in the first figure of section 1.2. This is the same approach used by the EEA in their OBFCM assessments. Nevertheless, for completeness, a graphic presenting the weighted figures is also included below:

Analysis of real-world vs. WLTP emissions by registration year recalculated by T&E using a weighting by sales

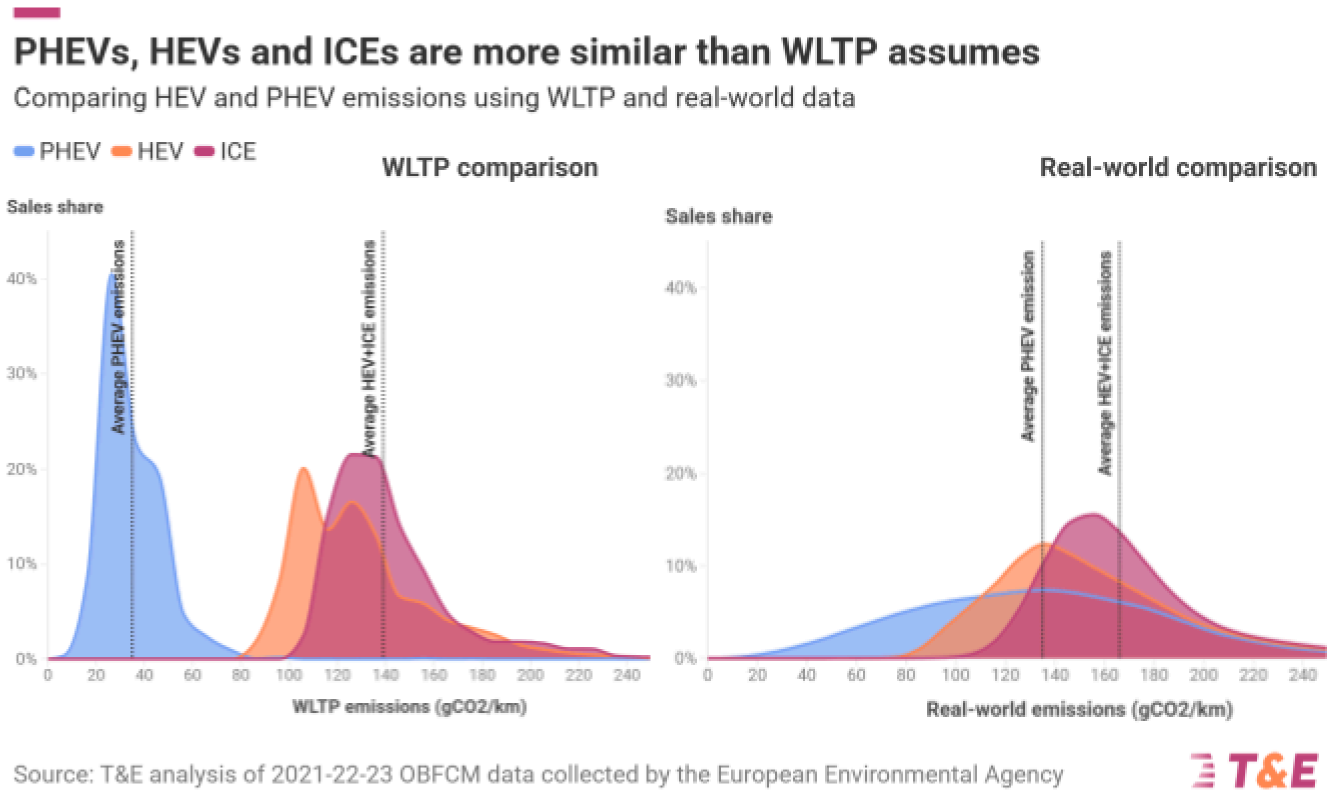


Source: T&E analysis of 2021-22-23 OBFCM data collected by the European Environmental Agency - WLTP emissions are based on the utility factor that was applicable before 2025. Emission values are weighted by registration numbers from the EEA. However, the absence of certain models particularly in the 2023 OBFCM data still results in distortions.

The overall trend remains the same, showing an increasing gap for newer PHEV models, although the effect appears less pronounced. To avoid the data being incomplete, carmakers should ensure that their OBFCM data is correctly transmitted.

A.4 Comparison of PHEV, HEV and ICE vehicle emissions

In Section 1.2 we discussed the similarities in real-world emissions among PHEVs, HEVs and ICE vehicles, which are not fully captured by official values. The following graph also provides a clear illustration of this:



We compared the distribution of CO_2 emission for PHEVs, HEVs and ICEs using both WLTP values and on-road data. In the OBFCM database, HEVs are identified as vehicles with the parameter Fm=H (fuel mode = 'not off-vehicle charging hybrid electric vehicle'), which generally refers to full and mild hybrid electric vehicles. Based on official WLTP figures, PHEVs are heavily concentrated below 50 gCO_2/km, while HEVs and ICEs have overlapping distributions at much higher emission levels. But when real-world data is used instead, the picture changes considerably: the distributions for PHEVs, HEVs and ICEs overlap strongly, especially the PHEV distribution becomes much wider showing a far greater spread of real-world emissions. Depending on how they are driven, a significant share of PHEVs emits more CO_2 than some HEVs or even ICEs. More than one third of PHEVs in the dataset emits more CO_2 than the median HEV value of 157 gCO_2/km and nearly 25% emit more than the median ICE, which stands at 162 gCO_2/km.

A.5 Correlation analysis: Finding the best real-world emission predictor

To investigate why PHEV emissions are underestimated under the WLTP it is useful to examine the specific vehicle characteristics that influence real-world emissions: both those that tend to increase them and those that help keep them low. In essence, our aim is to identify which vehicle properties serve as strong predictors of real-world emissions, thereby enabling us to propose design criteria that could contribute to reducing PHEV emissions.

For this purpose, we use the OBFCM dataset, which provides different vehicle characteristics for all PHEVs. Among these the most important for our analysis are:

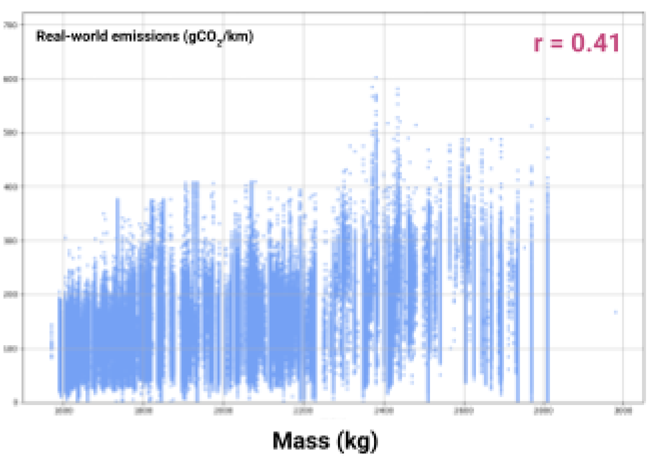
- Electric range (km)
- Vehicle mass (kg)
- Power of the internal combustion engine (kW)
- Engine capacity (cm^3)

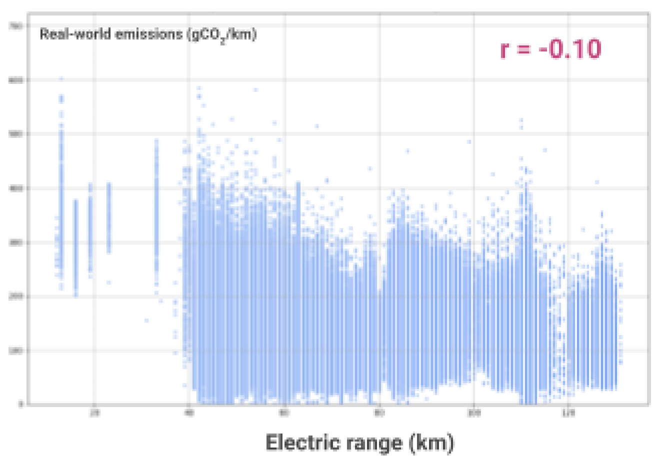
For each PHEV in the dataset, we have both the properties enumerated above and the corresponding real-world emission data. To identify which vehicle characteristics are most strongly associated with real-world emissions, we conducted a correlation analysis. This method allows us to quantify the strength and the direction of associations between individual vehicle properties and observed emissions.

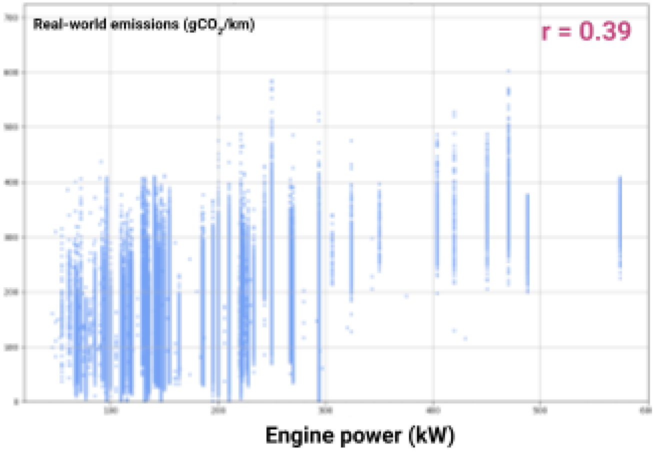
While such an analysis can reveal statistically significant relationships, it is important to note that correlation does not necessarily imply causation. Moreover, real-world data is inherently noisy, meaning that strong correlations are unlikely. Nevertheless, this analysis provides useful insights into the factors probably influencing PHEV emissions.

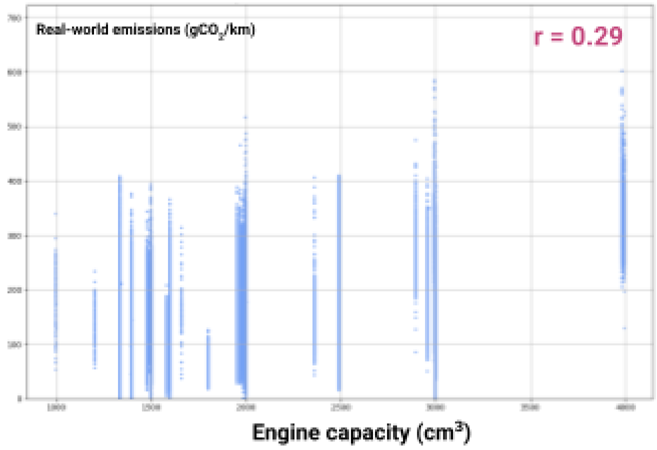
To quantify the strength of the relationships, we employed Pearson's correlation coefficient *r* to assess if there is a linear relationship between parameters. This coefficient measures the degree of covariance between two variables, normalised by the product of their standard deviations. The resulting value ranges from -1 to 1, where 0 indicates no linear correlation, -1 a perfect negative linear correlation and 1 represents a perfect positive linear correlation.

The results of the correlation analyses between real-world emissions and the mentioned vehicle properties are the following:









The calculated *r* values range from -0.10 for electric range to 0.41 for vehicle mass, confirming that none of the correlations are particularly strong. In relative terms however, the weakest linear relationship is observed when electric range is used as the predictor variable. While a higher electric range is generally associated with lower real-world emissions, this relationship is less pronounced than the positive correlations observed for mass or engine power. In these latter cases, greater vehicle mass or higher internal combustion engine power is linked to increased real-world emissions and these associations are notably stronger than that between electric range and emissions.

Possible explanations for the observed relationships are the following: Heavier PHEVs require more energy in all driving modes. In charge-depleting (CD) mode, the internal combustion engine (ICE) is then more likely to kick in because the electric motor alone often cannot provide sufficient power. In charge-sustaining (CS) mode, higher vehicle mass directly increases fuel consumption, resulting in higher overall emissions.
When the ICE has a high-power output, the ratio of electric motor power to combustion engine power tends to be low. In such cases the electric motor needs support from the ICE more often, leading to increased emissions.

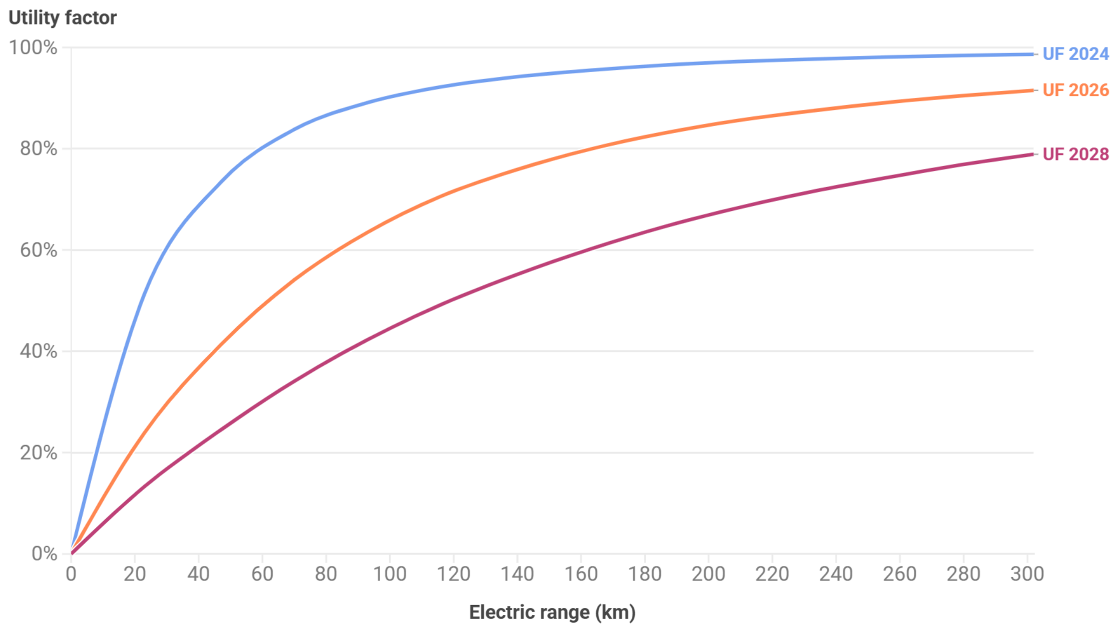
A.6 High emissions in charge-depleting mode

Emissions in charge-depleting mode are substantially higher in real-world driving conditions than those officially reported: Measured values average around 68 gCO_2/km, compared with an official average of 8 gCO_2/km. Several factors contribute to this discrepancy. First, the electric motor is not always capable of sustaining high-load situations on its own. Second, even when the motor could theoretically provide the required power, the battery might present a further limitation, as its maximum deliverable power can be insufficient to meet demand. When the battery cannot supply sufficient power to the motor, the internal combustion engine engages to sustain propulsion, resulting in increased CO_2 emissions. High-load situations include uphill driving, acceleration, high-speed operation or the use of auxiliary systems such as cabin heating.

While the electric motor power is a key limiting factor, it is important to acknowledge that the battery's power output likewise influences system performance.

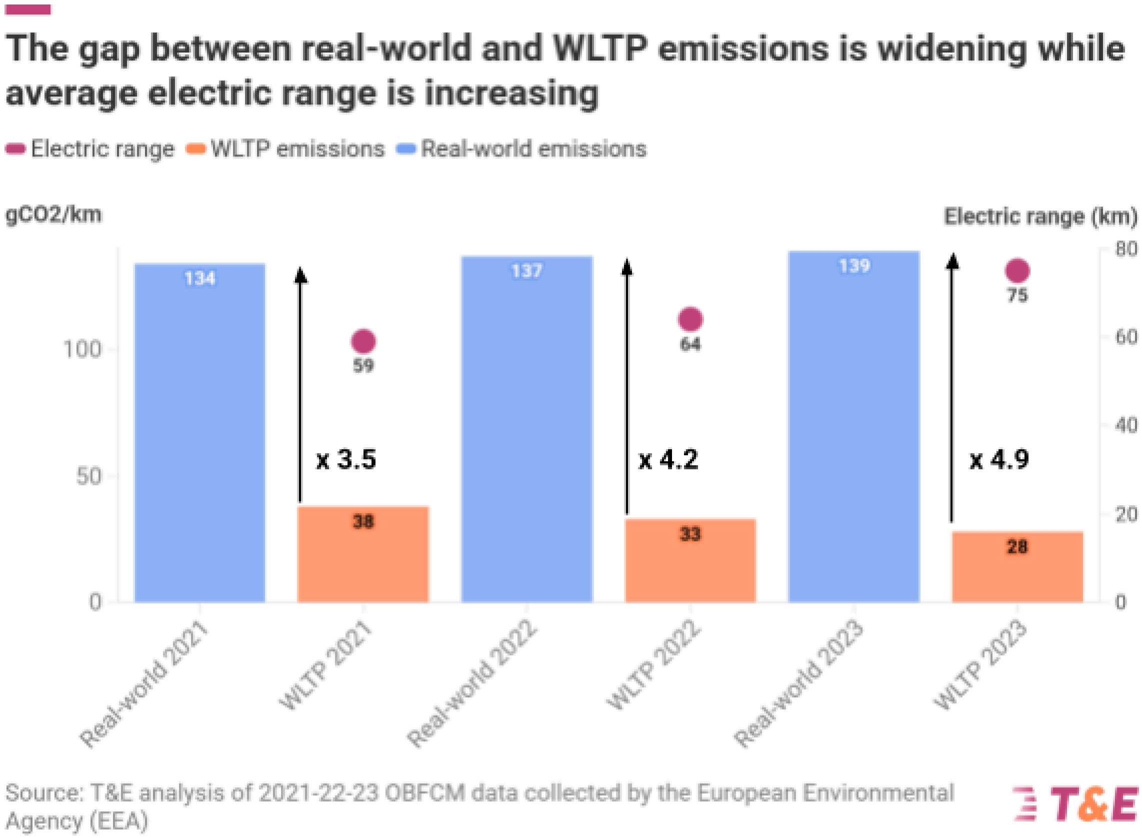
A.7 PHEV section: additional findings

A.7.1 Utility factor curve up to 300 km



Source: WLTP test data

A.7.2 Increase in electric range compared to increase in real-world emissions



A.7.3 Target compliance breakdown

Additional official data from the European Commission can be found here for the different years.

BMW

	2021	2022	2023
Real-world vs WLTP gap	272%	314%	*356%**
Emissions with real-world PHEV data	133.4	127.2	120.5
Target exceedance with real-world PHEV data	7.5	0	0
Fines avoided (million EUR)	473	0	0

*: Estimate as sample size is too small for reliable result

Mercedes-Benz

	2021	2022	2023
Real-world vs WLTP gap	302%	357%	494%
Emissions with real-world PHEV data	141.4	136.3	132.1
Target exceedance with real-world PHEV data	16.2	9.7	3.8
Fines avoided (million EUR)	837	510	219

Renault-Nissan-Mitsubishi

	2021	2022	2023
Real-world vs WLTP gap	149%	208%	174%
Emissions with real-world PHEV data	110.6	107.6	109.5
Target exceedance with real-world PHEV data	0.2	0	0
Fines avoided (million EUR)	23	0	0

Stellantis

	2021	2022	2023
Real-world vs WLTP gap	247%	260%	296%
Emissions with real-world PHEV data	115.7	110.2	109.5
Target exceedance with real-world PHEV data	0	0	0
Fines avoided (million EUR)	0	0	0

Volkswagen Group

	2021*	2022	2023
Real-world vs WLTP gap	276%	294%	300%
Emissions with real-world PHEV data	125.9	126.0	125.1
Target exceedance with real-world PHEV data	5.1	4.4	3.6
Fines avoided (million EUR)	1206	974	934

*: In 2021 Volkswagen had a pool together with SAIC

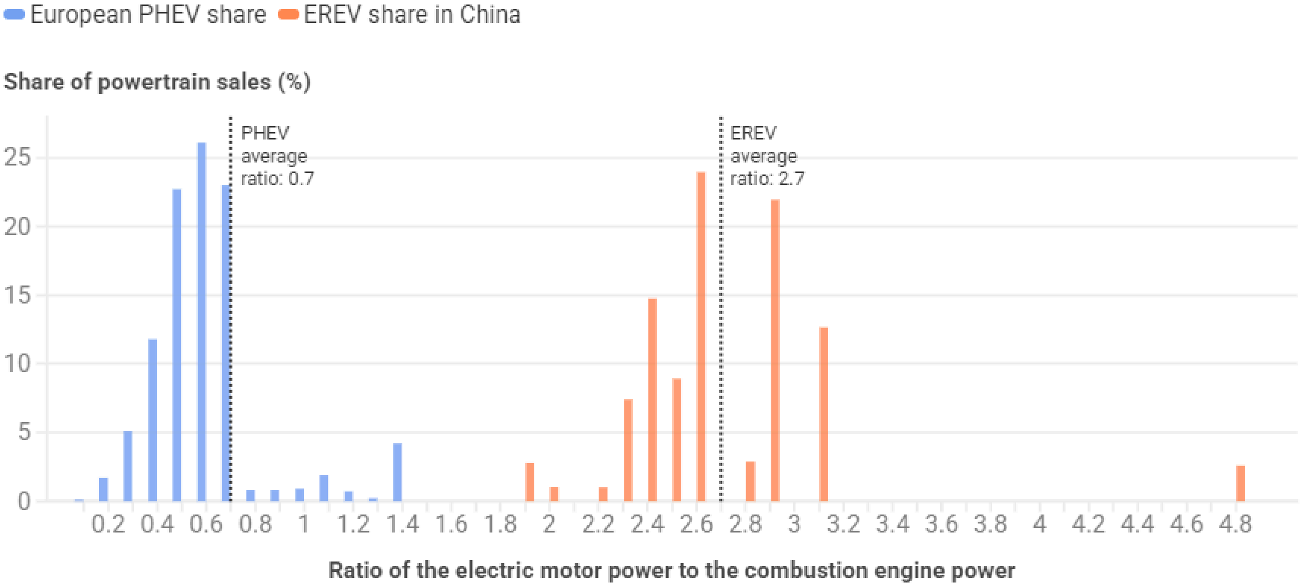
A.8 Chinese EREV models

T&E gathered specifications for EREV models sold in China from the autocango.com website. Data extracted by T&E includes the electric range (WLTC Electric range), the e-motor power (Total Motor Power battery), the engine power (Maximum Horse Power), the average fuel consumption (WLTC Fuel Consumption), the fuel consumption in charge sustaining mode (Min. State Of Charge Fuel Consumption) and the fuel tank size (Fuel Tank Capacity). Data from 23 EREV models (total of 49 model-variants), representing 80% of the Chinese EREV market, has been analysed. The average values provided in this report are weighted based on EREV model sales volume in the first half of 2025, according to EV-Volumes sales data.

The figure below depicts the distribution of EREV sales in China, based on the ratio of the electric motor power to the combustion engine power from EREV model specifications and EV-Volumes sales data. It is compared to the distribution of PHEV production in Europe, based on data acquired from a data analytics and consulting company.

On average, Chinese EREVs' electric motors are 2.7 times more powerful than their combustion engines

European PHEVs suffer from low electric motor power and oversized combustion engines



Source: T&E analysis of EREV specifiction from autocango.com ; Chinese sales data from EV-Volumes ; PHEV data for cars produced in Europe

A.9 EREV models planned in the European markets

The launch of most EREV models in Europe is uncertain

EREV models	Launch	EV range	European status
Mazda MX-30 R-EV	Launched in 2023	85 km	Launched
Leapmotor C10 REEV	Launched in 2025	145 km	Launched
SWM G03F SUV (Brilliance Big Tiger)	Launched in 2025	46 km	Launched
Chery Exeed Exlantix models	Production for export started in 2025	~160 km (China)	Plausible
Mazda EZ-60 SUV	Global launch in H2 2025	~130 km (China)	Plausible
Xpeng 'Kunpeng Super Electric System'	Launch in 2025 in China, target the global market	~340 km (China)	Plausible
BYD Yangwang U8 SUV	Presented in Geneva, plausible in 2026	124 km (China)	Plausible
BMW iX5 SUV	Possible launch in China in 2026, "considered" in Europe	TBC	Plausible
Lotus 'Super Hybrid' models	Possible launch in 2026	TBC	Plausible
Hyundai Group (e.g. Genesis GV70 SUV, Hyundai Santa Fe, Kia SUVs)	Global launch from 2027	TBC	Plausible
SAIC's IM Motors	Brand launched in Europe with BEVs in 2025	450 km	Speculative
Renault's Horse JV	Confirmed for Brazil	TBC	Speculative
Stellantis SUVs (e.g. Jeep Grand Wagoneer)	Announced in the US	TBC	Speculative
VW (e.g ID.Era concept & Scout SUVs)	ID.Era concept (China), Scout models (US)	TBC (e.g. 300 km)	Speculative
Ford SUVs	Announced in the US	TBC	Speculative
Li Auto models	Munich R&D center = start of global strategy	TBC	Speculative
Nissan	EREV models may be based on the ePower technology	TBC	Speculative

Source: T&E assessment based on public information

A.10 PHEV emission forecast

The emission forecast can be summarised by the following parameters:

	Business-as-usual scenario	Well-designed models scenario	Best-in-class models
Input - Average annual electric range increase up to 2031	8.7%	13.2%	
Resulting electric range in 2034	140 km	210 km	300 km (input)
Resulting UF (2024 UF curve)	94%	97%	98%
Resulting UF (2025-26 UF curve)	76%	85%	92%
Resulting UF (2027-28 UF curve)	55%	68%	79%
Input - Average annual change in charge-sustaining emissions	0%	-2.2%	-2.2% for a typical C-segment model such as the Volkswagen Golf eHybrid
Resulting CS emissions in 2034	161 g/km	138 g/km	97 g/km
Resulting average WLTP emissions in 2034 (with utility factor applicable before 2025)	10 g/km	4 g/km	2 g/km
Resulting WLTP emissions (2025-26 UF)	38 g/km	19 g/km	9 g/km
Resulting WLTP emissions (2027-28 UF)	70 g/km	42 g/km	21 g/km
Input - Gap between real-world and WLTP emissions (2027-28 UF)	31%	18%	18%
Resulting real-world emissions	91 g/km	50 g/km	25 g/km

A.10.1 Definition of the business-as-usual scenario

Electric range: In the business-as-usual scenario, the annual improvement in electric range is based on the average annual improvement achieved between 2021 and 2023.

Emissions in charge-sustaining mode: In theory, an increase in range should lead to an increase in emissions in charge-sustaining mode, since a larger battery increases the vehicle's mass, thereby increasing emissions once the battery is depleted. However, this can be offset by improvements in engine efficiency and energy recovery systems, as well as improvements in battery energy density, which limit the increase in battery mass. Due to the uncertainty surrounding future trends, we have assumed that CS emissions could remain constant in this baseline scenario.

Average WLTP emissions: Once we know the electric range, we can estimate the utility factor using different curves (before 2025, between 2025 and 2026, and between 2027 and 2028). While Section 1 used detailed modelling of emissions per PHEV model, this section deals with market averages. We have opted for a simplified approach in which we use the utility factor corresponding to an average EAER, whereas the exact approach used in the previous section considered a discrete UF value for each R_{CDC} value. Knowing the UF and emissions in charge-sustaining models allows us to derive the annual reduction in average WLTP emissions as electric range (and WLTP UF) increases. To ensure accuracy with historical values, we apply these annual emission improvements to the actual average emissions observed in 2024 using EEA data.

Real-world gap: The analysis of the gap between real-world and WLTP emissions (using the 2027–28 utility factor), presented in Section 1.3, shows that models with a range of over 75 km, registered between 2021 and 2023, have an average real-world gap of 44%, which is significantly higher than the market average of 18%. Based on Spritmonitor data, we estimated that the average real-world gap for five C-segment long-range models available in 2024 would be 37% (by estimating the WLTP emissions of these models based on the 2027–28 utility factor curve). However, the development of charging infrastructure could favour a further reduction in the real-world utility factor. Therefore, we opted for a conservative approach, assuming a real-world gap of 31% by 2030 — the midpoint between the 44% observed for models with an electric range of over 75 km and the 18% observed for the average of models released between 2021 and 2023.

A.10.2 Definition of the well-designed model scenario

Electric range: In the well-designed model scenario, we assumed that design criteria are implemented as part of policies and facilities to encourage the ICE market to shift towards best-in-class hybrid models. In that case, we considered the largest annual increase in electric range in previous years (13% increase in range between 2023 and 2024) and we have applied this assumption up to 2031. This assumption is technology-neutral as electric range could potentially increase both in conventional parallel hybrids (PHEVs) and/or with an increase in the share of series hybrids (EREVs).

Emissions in charge-sustaining mode: The annual CS emission forecast is based on the average improvement in CS emissions between 2021 and 2024. Historically, this improvement was achieved through the early development of PHEV technology. However, we have assumed that a 2% improvement in CS emissions can now be maintained through downsizing the combustion engine (a design criterion aimed at increasing the ratio of electric motor power to combustion power) and/or increased adoption of a series hybrid configuration, in which the engine runs at a high-efficiency operating point.

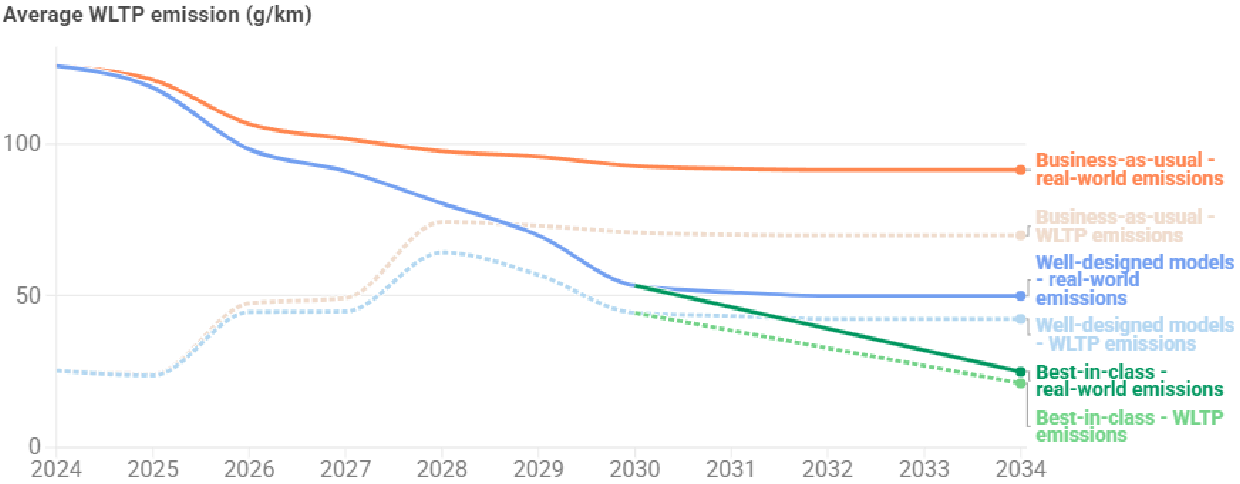
Best-in-class scenario: The best-in-class scenario is a variant of the well-designed model scenario in which we assume that, after 2030, the market will converge towards best-in-class models with a range of 300 km. In this scenario, CS emissions are calculated based on a mass-market model in segment C: the Volkswagen Golf eHybrid. The same 2% annual improvement is applied as in the well-designed model scenario.

Real-world gap: In this scenario, it is assumed that new, well-designed models will limit the increase in the real-world gap. We have assumed that a 18% gap, comparable to the average observed for vehicles registered between 2021 and 2023, will apply to the market in 2030. For reference, the real-world gap for ICEs is 19%, so it is unlikely that the real-world gap for PHEVs could decrease much further than 18% on average.

The resulting forecast for each year is shown in the following figure:

With strict design criteria, the average real-world emissions of long-range models could tend towards 50 gCO_2/km

Best-in-class models with more than 300 km range could reach real-world emissions of 25 gCO2/km by 2034

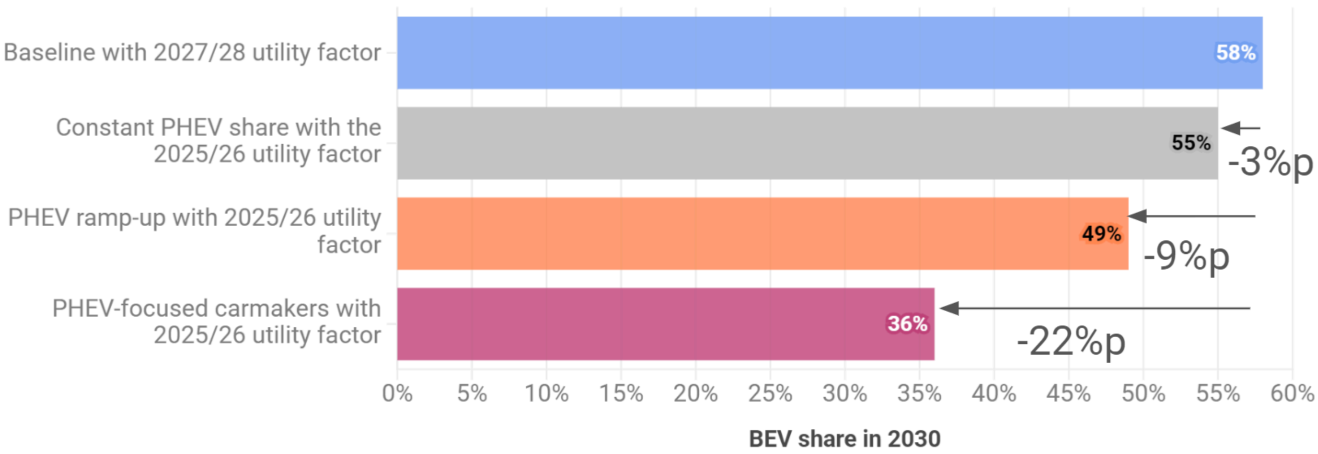


In the well-designed scenario, hybrid vehicles are designed with strict criteria (e.g. higher e-motor power than combustion engine power, fast-charging capability) and reach an average range of 210 km by 2034. In the best-in-class scenario, the market converge to medium-sized models with a 300 km electric range by 2034.

A.10.3 Cancelling the 2027 correction of the utility factor

Cancelling the planned utility factor updates slows BEV uptake

Cancelling the utility factor corrections could reduce BEV share by up to 22 percentage points (%p) in 2030



Source: T&E emission forecast in a scenario where the average range of PHEVs reaches 140 km in 2030 • For the 2027/28 utility factor scenario, a market forecast is being used for the PHEV share (7%). The constant-share scenario assumes a stable PHEV share of 9%. The ramp-up scenario assumes an increase to 17% by 2030. PHEV-focused carmakers are expected to sell 36% PHEV in 2030.

A.11 Modelling of VDA proposals

The analysis in Section 3.3 is based on an Excel tool for forecasting emissions. The regulatory baseline forecast of 100% BEV sales in 2035 is modelled using T&E EUTRM Python tool, as presented in the "Clean solution for all" report. We then derive the additional CO_2 emissions of the car fleet for scenarios in which additional ICEs are sold. These scenarios are modelled using an Excel tool that aligns car fleet activity with the EUTRM Python model. This Excel model is based on an average European car driving around 225,000 km over a 20-year lifetime, with a decreasing annual mileage over this period.

The following scenarios have been modelled in this report:

- **Regulatory baseline**: Under the current regulation, BEV sales would increase from 58% in 2030 to 100% in 2035. The breakdown of PHEV, HEV and conventional ICE powertrains in the ICE powertrain group is based on a market forecast obtained from a data analytics and consulting company (forecast released in Q2 2025). The emissions of conventional ICE and HEV powertrains are projected using a segment forecast. Starting from the emissions per segment in 2024 (EEA data), the forecast of the sales share per segment is used to derive the average emissions forecast for the HEVs and ICEs. According to EEA OBFCM data, real-world emissions are expected to be 19% higher than WLTP data for ICE and HEV powertrains. The PHEV emission forecast aligns with the business-as-usual scenario in Section 3.1. The cumulative emissions of the EU car fleet between 2030 and 2050 are estimated at 4,300 $MtCO_2e$.

- **90% target**: The VDA's proposal is to replace the 100% emission reduction target for 2035 with a 90% target. This would allow the sale of 10% ICE vehicles with an average WLTP emission of 113 g/km in 2035, while real-world emissions would be 135 g/km. The ICE powertrain group is composed of 0.9% PHEVs, 7.5% HEVs and 1.4% conventional ICEs. The additional ICEs sold compared to the regulatory baseline would lead to cumulative emissions of 363 $MtCO_2e$ between 2030 and 2050.

- **Allowing long-range hybrids after 2035:** In this scenario, we assume that the VDA proposal to give greater consideration to PHEVs would result in a 33% share of PHEV sales share in 2035, while the BEV share would be reduced to 67%.

  - Business-as-usual: In a first sub-scenario, we assume that the range increase from the business-as-usual scenario (Section 3.1) is applied, enabling PHEVs to achieve an electric range of 140 km in 2035. This equates to 70 gCO_2/km using the 2027–28 utility factor, with real-world emissions amounting to 91 gCO_2/km. The additional PHEVs sold compared to the regulatory baseline would lead to an additional cumulative emission of 894 $MtCO_2e$ over the period 2030–2050.

  - Well-designed models: In a second sub-scenario, we apply the range increase from section 3.2 so that PHEVs reach an electric range of 210 km in 2035. This results in 42 gCO_2/km with the 2027–28 utility factor and real-world emissions of

50 gCO_2/km. The additional PHEVs sold compared to the regulatory baseline would lead to an additional cumulative emission of 500 $MtCO_2e$ over 2030–2050.

- **Weakening of the utility factor:** In this scenario, we start with the 90% target and assume that the utility factor would be weakened, using the curve applicable before 2025. In this case, a plug-in hybrid electric vehicle (PHEV) would have a rating of 10 gCO_2/km with an average range of 140 km, whereas real-world emissions would be nine times as high at 91 gCO_2/km. An additional 2,764 $MtCO_2e$ of cumulative emissions would result from the additional PHEVs sold compared to the regulatory baseline over the period 2030–2050.