Agora Verkehrswende

The Bottom Line of Electric Cars

Comparing the Cost of Ownership of Electric and Combustion-Engine Vehicles

ANALYSIS

Publication Details

The Bottom Line of Electric Cars

Comparing the Cost of Ownership of Electric and Combustion-Engine Vehicles

STUDY UNDERTAKEN BY

Agora Verkehrswende
Anna-Louisa-Karsch-Str. 2 | 10178 Berlin
T +49 (0)30 700 14 35-000
F +49 (0)30 700 14 35-129
www.agora-verkehrswende.de
info@agora-verkehrswende.de

PROJECT MANAGEMENT

Maita Schade
maita.schade@agora-verkehrswende.de

Implementation

Layout: Juliane Franz
Translation: Lucais Sewell
Editor: Dr. Philipp Prein
Cover Image: Adobe Stock/prima91

Acknowledgements

We would like to thank the German automobile club ADAC for its assistance, not least for providing partial access to its vehicle cost database, as well as for supplying supplementary information.

First published in German in December 2021 as:
Agora Verkehrswende (2021): *E-Auto-Kostencheck. Gesamtkosten und Preise von Elektro- und Verbrennerfahrzeugen im Vergleich*

Publication date: March 2022
76-2022-EN

Please cite as:
Agora Verkehrswende (2022): *The Bottom Line of Electric Cars. Comparing the Cost of Ownership of Electric and Combustion-Engine Vehicles.*

www.agora-verkehrswende.de

Foreword

The electrification of the vehicle fleet will play a crucial role as Germany moves to net zero. By 2045, virtually the entire vehicle fleet will have to be run on green electricity. At the same time, to achieve the targets established by Germany's Climate Protection Act, it will be necessary to reduce reliance on personal vehicles while encouraging alternative modes of transport (including buses, rail, cycling and walking). According to the Coalition Agreement signed by the parties that took power in December 2021, some 15 million battery electric vehicles are to be on the road by 2030, and only a small percentage of vehicles will be non-electric in 2045.

Achieving these targets will entail tremendous growth in the number of electric vehicles sold each year. The market share captured by electric vehicles has already grown significantly in recent months. Between January and September 2021 nearly 24% of newly registered vehicles in Germany were battery electric vehicles (BEVs) or plug-in hybrid electric vehicles (PHEVs). The recent increases in market share have been primarily driven by the stricter emissions standards that now apply to newly registered vehicles (as part of the EU's fleet-wide emission targets). Yet sales have also been spurred by government purchase incentives: together, the Environmental Bonus and Innovation Premium (a pandemic stimulus measure) make electric vehicles up to 9,000 euros cheaper.

However, beyond initial purchase costs, vehicle owners must also consider running costs, including fuel, maintenance, insurance, and taxes. Yet another factor is the vehicle's depreciation over time. The true cost of vehicle ownership includes both of these cost elements – that is, initial purchase costs, plus costs that accrue during the ownership period, minus the subsequent resale value. While commercial vehicle fleet operators – who have a major influence on the new car market – are already taking running costs into account, households tend to overlook this issue.

How do electric vehicles stack up against their conventional counterparts in terms of total cost of ownership for consumers? To answer this question, we consulted the Car Cost Calculator of the German automobile club ADAC, a free online database that contains comprehensive cost data. The database covers all of the more than 8,000 models currently available in Germany. Our analysis provides insight into the current cost competitiveness of electric vehicles in the German market. We also spotlight the effectiveness of current incentive measures – and how they can be further developed to support the uptake of electric vehicles. The most important insight is that in many instances, electric vehicles are already a cost-competitive alternative.

Helping consumers to make educated purchase decisions is only one aim of this analysis. We also hope to inform policymakers who enact measures to promote the uptake of electric vehicles. We wish you a compelling and enlightening read.

Christian Hochfeld
Executive Director of Agora Verkehrswende on behalf of the Agora Verkehrswende Team
Berlin, 16 December 2021

Results and recommendations

1

In terms of total cost of ownership when factoring in subsidies, battery-electric vehicles are already cost competitive with their combustion-engine counterparts. "Total cost of ownership" includes all costs that accrue from initial purchase to resale, including depreciation, fuel costs, taxes, insurance, and repair and maintenance. A median gasoline model with a standard feature set in the medium size vehicle class (such as a VW Golf), costs just over 42,000 euros to own for a period of five years given initial purchase as a new car. By contrast, a comparable battery-electric vehicle costs just over 40,000 euros, when one takes government purchase incentives into account. Battery-electric vehicles are now available in all vehicle classes.

→ To enable consumers to conduct more accurate cost comparisons while also promoting market transparency, upcoming reforms to the Energy Efficiency Labeling Ordinance should require dealers to prominently display the total cost of vehicle ownership for consumers.

2

Initial purchase prices for battery-electric vehicles are now comparable to that of combustion-engine vehicles thanks to government purchase incentives. Most gasoline-powered cars cost between 29,000 euros and 53,000 euros to purchase. By way of comparison, battery-electric vehicles cost between 30,000 euros and 58,000 euros, when one takes the government purchase incentives into account (specifically, the Environmental Bonus and Innovation Premium).

→ Since the initial purchase price tends to be the most prominent and salient factor in consumer purchase decisions, policymakers should maintain existing purchase incentives for zero-emission vehicles – only reducing them once the cost gap between electric and combustion-engine vehicles has diminished considerably.

3

In executive and luxury vehicle classes, battery-electric vehicles are already cheaper than their combustion-engine counterparts, even without government purchase incentives – both in terms of initial purchase prices and total cost of ownership. In the executive class (e.g. BMW 5 series), the median price of a gasoline-powered car is 77,000 euros over the first five years of ownership, while the comparable figure for a battery-electric car in the same class is 71,000 euros. In most cases, purchase premiums do not play a role because only vehicles with a purchase price of less than 65,000 euros are eligible. In the medium, small, mini, and micro vehicle classes, by contrast, electric vehicles are significantly more expensive than comparable combustion-engine vehicles in the absence of subsidies.

→ In order to make battery-electric vehicles available to prospective buyers on a budget, government support measures should be enacted to ease the purchase of smaller vehicle models. In the executive and luxury classes, by contrast, purchase incentives could already be reduced today.

4

Plug-in hybrids are the most expensive option in terms of total cost of ownership. The total cost of ownership for plug-in hybrids without subsidies averages 61,000 euros, compared to 57,000 euros for diesel and non-subsidised battery-electric vehicles. Including government purchase incentives, the median total cost of ownership is around 58,000 euros for a plug-in hybrid and 51,000 euros for a battery-electric vehicle. In addition, their emissions scorecard depends heavily on how they are driven.

→ To ensure that government subsidies actually serve to protect the climate, policymakers should tie PHEV subsidy allocation to vehicle reliance on electrical operation. Specifically, only vehicles that are predominantly driven using electrical energy should be eligible.

5

In the future, government support measures for electric vehicles should also target the used car market. The analysis undertaken here is only concerned with new vehicle sales, as this is the starting point for their gradual penetration of the national vehicle stock. The purchase behavior of companies who operate vehicle fleets is particularly important for bringing electric vehicles into circulation, as some 64% of new vehicles sales in Germany are to businesses. Further incentives to support electric vehicle adoption in the used car market would be advised.

→ In addition to adopting purchase incentives for used battery-electric vehicles, policymakers could also establish incentives related to cost of use, such as additional taxes on fossil fuels or the stronger orientation of vehicle taxes to emissions. As electricity becomes cheaper in relation to gasoline and diesel, we can expect higher demand for electric vehicles in the used car market.

Contents

1 | Background and goal

The Innovation Premium, which has been in effect since 8 July 2020, encourages the purchase of battery-electric vehicles (BEVs) and plug-in hybrids (PHEVs). BEV and PHEV sales have experienced rapid growth in recent months due to this government purchase incentive in combination with the stricter emission standards that now apply to newly registered vehicles in the EU. Nearly 200,000 BEVs and just over 200,000 PHEVs were newly registered in 2020, representing an increase of more than 200% and 340%, respectively, over the previous year. BEVs are of particular importance for the success of the transition to sustainable transport. PHEVs rely in part on conventional combustion technology.[1] BEVs, by contrast, do not release any emissions during operation (when charged with green electricity). This makes BEVs a key technology for reducing the CO_2 emissions of passenger transport.

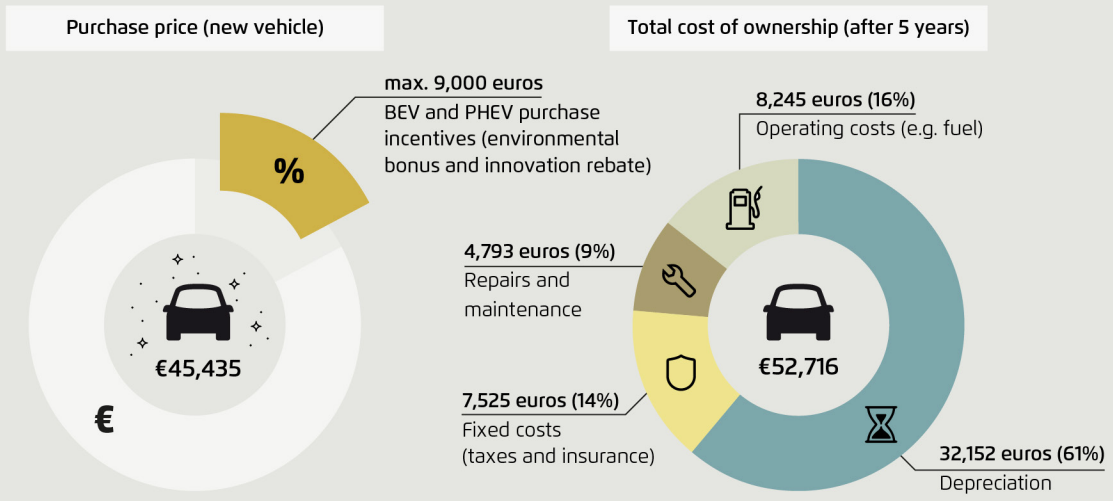
The majority of vehicles registered to private individuals in Germany are used vehicles. The current rate at which new electric vehicles are sold is nevertheless very important, as this determines the composition of the used vehicle market of the future. Businesses were responsible for some 64% of new vehicle purchases in 2020. In this way, business purchases represent an important factor for diffusion of electric vehicles. Ultimately, electric vehicles must be sold as new vehicles before they can gradual displace internal-combustion-engine vehicles (ICEVs) in the used car market.

There are two cost dimensions that influence vehicle purchase decisions: namely, the initial purchase price and running costs that accrue over time, which together yield the total cost of ownership (TCO). TCO includes depreciation, fuel costs, fees and taxes, and maintenance and repairs (see Figure 1).

Like most new technologies in their early adoption phase, electric vehicles have a reputation for being expensive. In addition to concerns about effective ranges and charging infrastructure, purchase prices are likely one of the key arguments against the purchase of an electric vehicle from a consumer perspective, as electric vehicles are generally more expensive than their ICEV counterparts.

1 Plötz 2020.

Breakdown of total cost of vehicle ownership — Figure 1



Agora Verkehrswende | Current to: 11/2021. Data: Median values for all new cars available in German in July 2021. TCO after five years assuming 15,000 km are driven each year; Source: ADAC.

Yet consumers are often quick to ignore the costs that accrue following purchase, including loss of value over time. This myopia among consumers is attributable at least in part to the fact that the initial purchase price is clear and highly visible, while future operating costs are nebulous and indefinite. The total cost of ownership for a vehicle is a statistical estimate based in part on historical data and in part on assumptions about the future. Various surveys have shown that German consumers greatly underestimate the total cost of owning and operating a vehicle. In fact, consumers estimate operating costs at half their true amount on average.[2] Business consumers, on the other hand, generally have a better understanding of total costs, because they systematically track their expenditures.

The literature on the total cost of electric vehicles has focused to date on when electric vehicle costs will fall below those of ICEVs.[3] In this context, many studies focus on manufacturing costs, often concluding that battery costs are responsible for the relatively higher purchase price of electric vehicles. By extension, electric vehicles should become cheaper as battery prices fall, these studies assert.

However, a broad range of electric vehicle models are now available, with new models regularly coming to market. Accordingly, it is now possible to extend the analysis beyond mere manufacturing costs, considering market prices and total costs from a consumer perspective. In Germany, the motor vehicle club ADAC maintains an online database with comprehensive vehicle cost data.[4] Drawing on this database,, we analysed the initial purchase prices and total cost of ownership for over 8,000 vehicle models currently available in Germany.

2020 saw unprecedented growth in first-time electric-vehicle registrations.[5] Material and manufacturing costs have been falling for many years.[6] Furthermore, government subsidy programs have reduced purchase prices for consumers. Numerous studies have forecast that user cost parity for electric vehicles will be reached in the coming years. This means that the manufacturing and total ownership costs for initial purchasers of new vehicles will be comparable to that of ICEVs.[7] Total cost of ownership is an important factor influencing purchase decisions, particularly for commercial vehicle fleet operators. At the same time, critics often point to the high cost of electric vehicles as an argument against government purchase incentives.

In light of such forecasts and associated debates, we aim to show how electric vehicles currently compare with ICEVs in terms of costs, and how far electric vehicles are from price parity. We also seek to identify the drivers of electric vehicle cost trends. To address these issues, we conduct an analysis of current microdata. Based on our findings, we recommend a series of actions for political decision makers. Our findings promise to be of interest not only to policymakers, but also to business and household consumers.

In order to shed light on the cost of electric vehicles in the German vehicle market, we analyzed ADAC cost data from the spring of 2021.[8] ADAC maintains a comprehensive database of all passenger car models available in the German market. The database, which contains data on numerous vehicle parameters, provides costs forecasts in relation to assumptions concerning how many years the vehicle is owned and how many kilometers are driven each year. Total costs include depreciation, operating costs, fixed costs, and maintenance and repair costs.[9] The unit of analysis is a single vehicle model, without consideration of sales volumes.

The database thus provides an excellent overview of current sales prices and total ownership costs in the German market, while also enabling differentiated comparison of motorisation technologies.

2 Andor et al. 2020.
3 See e.g. UBS 2017, BEUC (The European Consumer Organisation) 2021, Bundesverband Elektromobilität, Lutsey.
4 ADAC 2021.
5 Kraftfahrtbundesamt 2020.
6 Lutsey et al. 2019.
7 BEUC (*The European Consumer Organisation*) / Element Energy Limited 2021.
8 ADAC 2021.
9 These components are analysed individually in the appendix.

2 | Analysis

We analyse and compare the different powertrains while considering a range of factors, including retail prices, total costs, depreciation rates, fuel costs, available purchase incentives, and price trends. For the purpose of comparison we assume that a new vehicle is purchased and owned for a five-year period and driven 15,000 km each year.[10]

2.1 BEVs are available in all vehicle classes

At the time of the study (July 2021), the database contained a total of 8,571 vehicles, including all equipment and feature variants per powertrain type and vehicle class (see Table 1).

Notably, BEVs are no longer confined to the executive and luxury vehicle classes. Decent availability in the compact and medium vehicle classes means that most consumers are now offered BEVs in the class of their choice.

2.2 Considering overall costs, BEVs are already a cost-competitive alternative

The ADAC data clearly show that the type of powertrain is no longer the primary determinant of total costs, especially given available purchase incentives (see Figure 2). In the medium and large vehicle classes, the median total cost of a BEV (dark blue shading) is already comparable to or lower than gasoline-powered alternatives. Notably, larger BEVs (from the medium size upwards) offer the greatest savings for first-time owners. Compact BEVs, by contrast, are less cost competitive. Indeed, in the absence of current purchase incentives, they are more expensive than their ICEV counterparts. In our total cost estimates, BEVs are statistically indistinguishable from comparable ICEV models due to the broad cost range in virtually all vehicle classes.

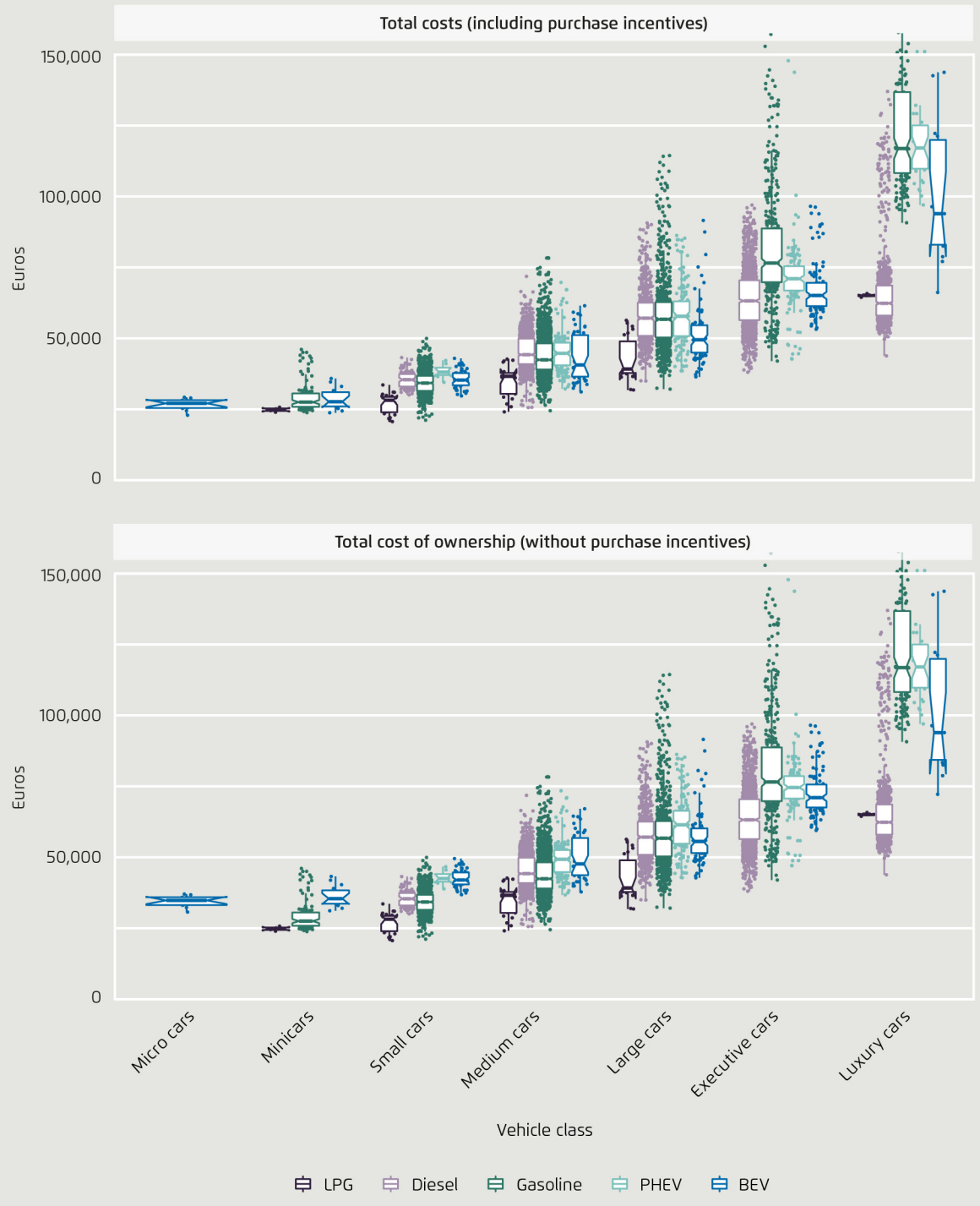
10 See the appendix.

Passenger car models in the German market by class and powertrain — Table 1

Vehicle class	Natgas/ LPG	Diesel	Gasoline	PHEV	BEV	Total
Micro cars (e.g. Smart)	0	0	0	0	12	12
Mini cars (e.g. Twingo)	4	0	101	0	16	121
Small cars (e.g. Polo)	33	114	683	5	51	886
Medium cars (e.g. Golf)	29	1,205	1,450	128	46	2,858
Large cars (e.g. BMW 3 series)	12	669	713	148	31	1,573
Executive cars (e.g. MB E-Class)	0	1,408	357	117	87	1,969
Luxury cars (e.g. S-Class)	5	955	153	32	7	1,152
Total	83	4,351	3,457	430	250	8,571

Agora Verkehrswende | Source: ADAC

Total cost of ownership (TCO) by vehicle class and powertrain Figure 2



Agora Verkehrswende | Current to: 11/2021. TCO after five years assuming 15,000 km are driven each year. The point clouds in the background represent individual models. The boxes show the second and third quartile; the vertical line the median value.
Source: ADAC.

2.3 Thanks to purchase incentives, median BEV purchase prices are comparable to that of ICEVs

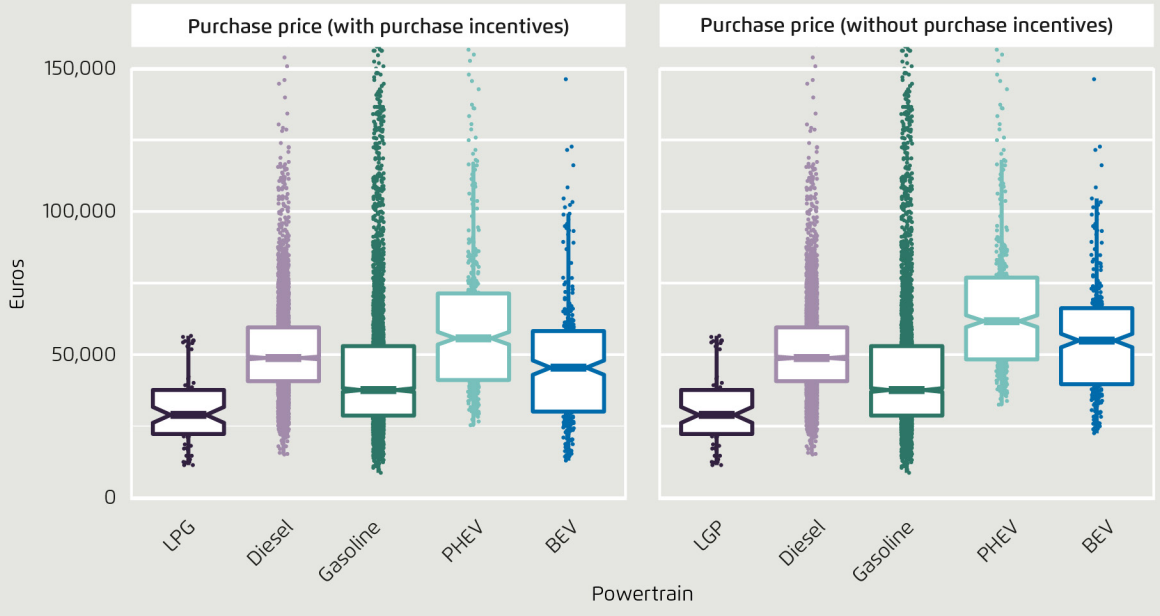
Retail prices are a major determinant of vehicle purchase decisions – and historically, they have been a factor hindering the adoption of electric vehicles. However, some BEV models can already compete with their ICEV counterparts in terms of initial purchase price (see Figure 3).

To be sure, in the small (e.g. Renault Clio) and medium classes (e.g. VW Golf), BEVs remain more expensive than gasoline or diesel alternatives. However, current government purchase incentives are sufficient to make BEVs cost competitive with gasoline alternatives (which, in turn, are less expensive than average diesel models; see Figure 4). **By contrast, executive- and luxury-class BEVs are already price competitive, even without purchase incentives.** In these vehicle classes, other factors – especially the equipment and feature set – are stronger price determinants.

2.4 Depreciation is the largest component of total BEV costs

The initial purchase price in combination with depreciation are the largest determinants of the total cost of vehicle ownership. The purchase price set by the manufacturer is determined by material and manufacturing costs, as well as other variables, such as research and development. Contrary to prevailing opinion, BEV battery costs are already low, both in relation to initial purchase price and to total cost of ownership.

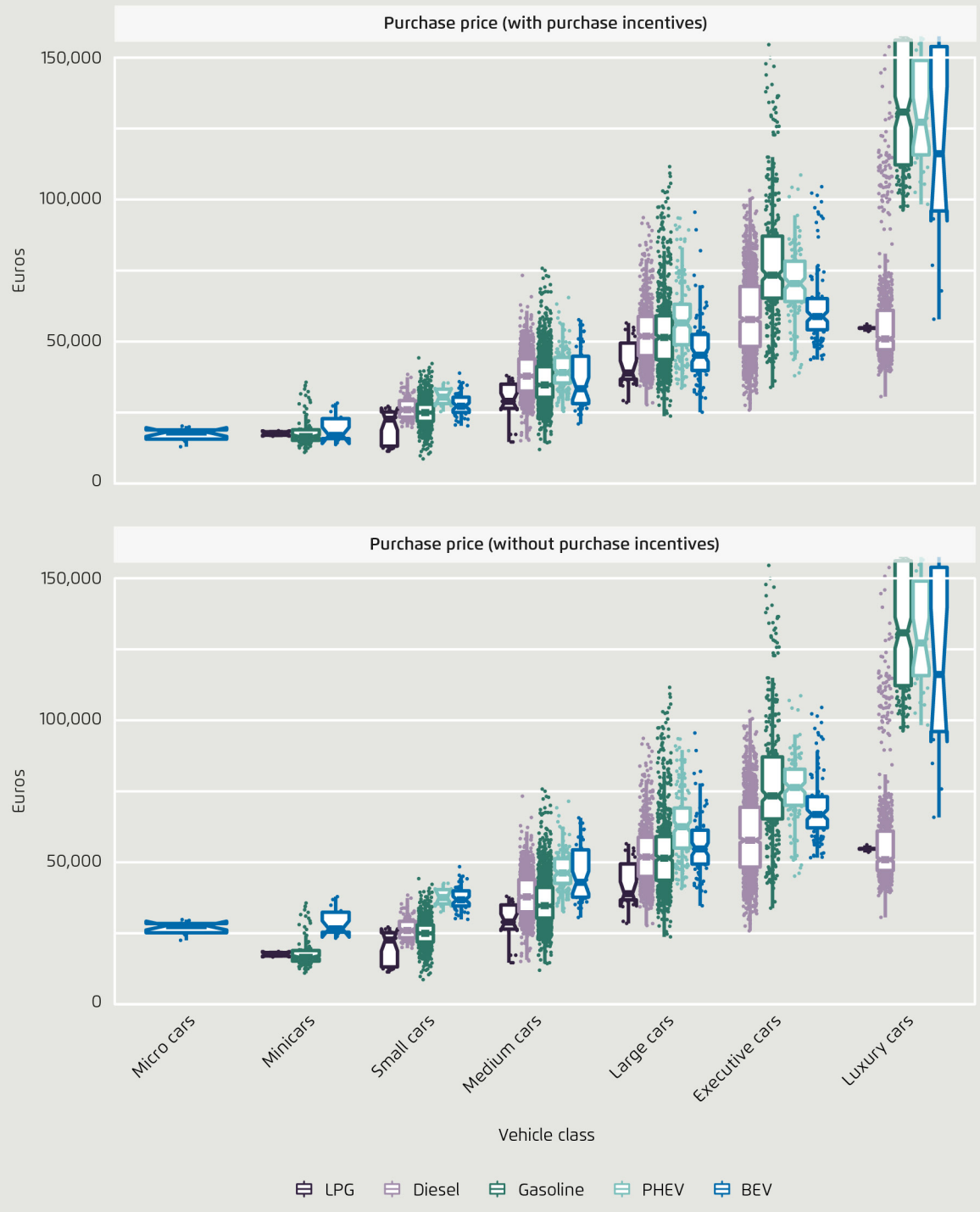
Car purchase prices by powertrain — Figure 3



Agora Verkehrswende | Current to: 11/2021. Data: Aggregation of all vehicle classes per powertrain. The boxes show the second and third quartile; the vertical line the median value. Source: ADAC.

Car purchase prices by powertrain and vehicle class

Figure 4



Agora Verkehrswende | Agora Vehrkehrswende. Current to: 11/2021. TCO after five years assuming 15,000 km are driven each year. The point clouds in the background represent individual models. The boxes show the second and third quartile; the vertical line the median value. Source: ADAC.

Figure 5 and Figure 6 show purchase prices and total cost of ownership in relation to manufacturer battery costs. The ADAC database lists battery capacities, but without indicating their cost. Based on existing literature, we assume average battery costs of 156 USD per kWh.[11]

Figure 5 shows that battery costs actually make up a rather small share of the vehicle purchase price (see Figure 5). Accordingly, even if manufacturers were to pass along cost savings to consumers as batteries become cheaper, this would not lead to a significant reduction in purchase prices, at least over the short to medium term. However, experts do anticipate electric vehicle purchase prices to decline over time as the various components installed in electric vehicles become better established.

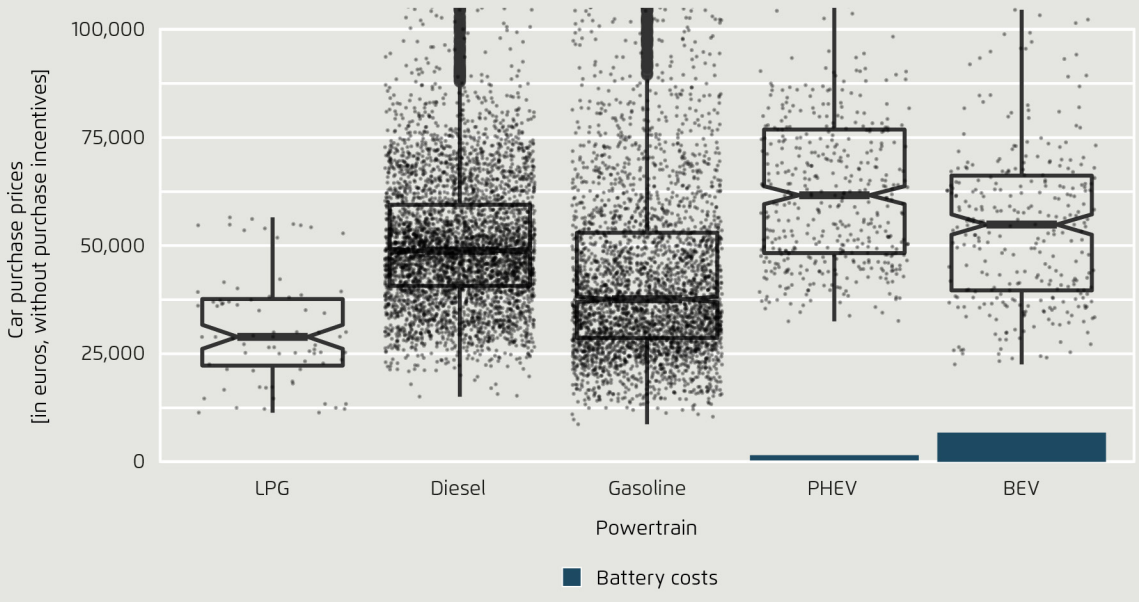
As lower battery costs are passed along to consumers, this also has an impact on depreciation, and, in turn, on total cost of ownership. If one looks at battery costs as a share of total costs (as shown in Figure 6), it becomes clear that even if the cost savings of rapidly falling battery prices were to be fully passed along to consumers, electric vehicles would not reach cost parity with ICEV on average.

Policy Recommendation

BEV purchase incentives, which have induced robust increases in BEV sales over the past year, **should be maintained for the time being – even given a significant decline in battery prices.**

11 To estimate battery pack prices in 2021, we have drawn on kWh data from 2019 (no author, 2019). This kWh figure was multiplied by the capacity of vehicle battery in each individual case.

Car purchase prices and battery costs by powertrain — Figure 5



Agora Verkehrswende | Current to: 11/2021. Data: median purchase prices without purchase incentives; battery costs for manufacturers assuming battery pack prices of 156 US dollars per kilowatt hour (no author, 2019); Source: ADAC

2.5 BEVs compensate for high electricity prices with high energy efficiency

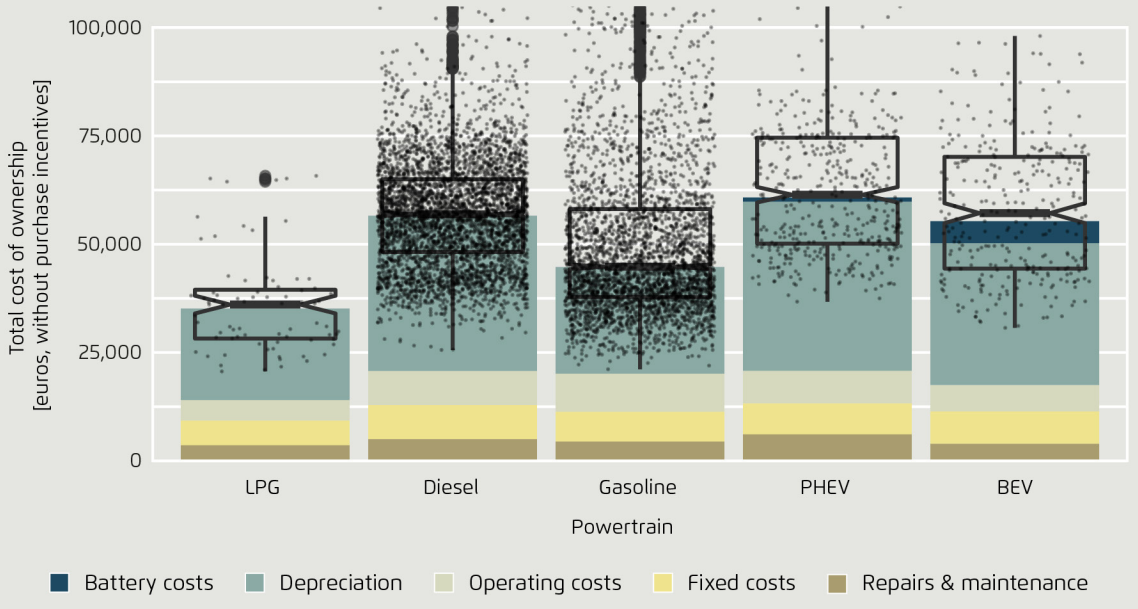
Currently, the price per kWh for electricity is significantly higher than that of fossil fuels. However, the energy consumption of electric vehicles is much lower than that of ICEV. These savings are so significant that the operating cost of BEVs, largely consisting of energy costs, is already equivalent to or lower than that of comparable ICEVs. In other words, gasoline and diesel fuel lose their price competitiveness once the rubber hits the road, because combustion engines consume significantly more energy than electric motors.

A sample calculation makes this dynamic clear: Even gasoline, which is taxed more heavily than diesel, costs only half as much per kilowatt hour (15.3 cents) as the cheapest electricity – that is, household electricity (31.9 cents). Nevertheless, a journey of 100 kilometers is typically cheaper if completed in a BEV (home charging: 5.1 euros, public charging: 5.6 euros) than in a gasoline vehicle (8.1 euros). This differential results from the fact that an electric vehicle only consumes about 16 kWh per 100 km, while a gasoline-powered car consumes 53 kWh per 100 km. At 5.7 euros, the cost of diesel is similar to that of electricity. Only in the case of fast charging at a public charging station can the cost per kilometer be higher than that of gasoline and diesel, because of the markups charged by infrastructure providers.[12]

This cost advantage enjoyed by electricity as an energy source will presumably increase over the next few years, given anticipated petroleum and carbon price trends. The market introduction of synthetic fuels would only boost the competitiveness of electricity, as synthetic fuels are likely to be much more expensive than today's fossil fuels for many years to come.

12 See Hörmandinger & Tausendteufel 2021: Blog post: "Strom- und Kraftstoffpreise bremsen Klimaschutz aus," https://www.agora-verkehrswende.de/blog/strom-und-kraftstoffpreise-bremsen-klimaschutz-aus/.

Total cost of ownership and cost components by powertrain — Figure 6



Agora Verkehrswende | Current to: 11/2021. Data: median TCO and key cost components, without considering purchase incentives; battery costs for manufacturers assuming battery pack prices of 156 US dollars per kilowatt hour (no author, 2019); Source: ADAC

Policy Recommendation

Policymakers should enact policies to support and strengthen the cost advantage enjoyed by BEVs with a view to energy costs. Incentives encouraging sustainable behavior following vehicle purchase are similarly called for. **Potential policy measures in this area include lower electricity prices for vehicle fueling (e.g. through EEG surcharge exemption) or more increased carbon prices for fossil fuels.**[13]

2.6 Purchase incentives should be reduced in premium vehicle classes, and tied to electric use in the case of PHEVs

If we compare subsidy volumes by vehicle class, it is clear that large sums go toward supporting the purchase of relatively expensive vehicles – for example, executive class vehicles (e.g. BMW 5 series) (see Figure 7). On the one hand, electric vehicles are already under consideration by consumers for whom price is a crucial factor.

On the other hand, premium vehicle classes are geared toward more affluent consumers for whom price often plays a secondary role. The price disparity between the BEV and ICEV models far exceeds projected battery costs, even in the case of smaller cars. Accordingly, purchase incentives remain necessary in the compact vehicle classes, even given the pass-through of reduced battery costs to consumers.

Policy Recommendation

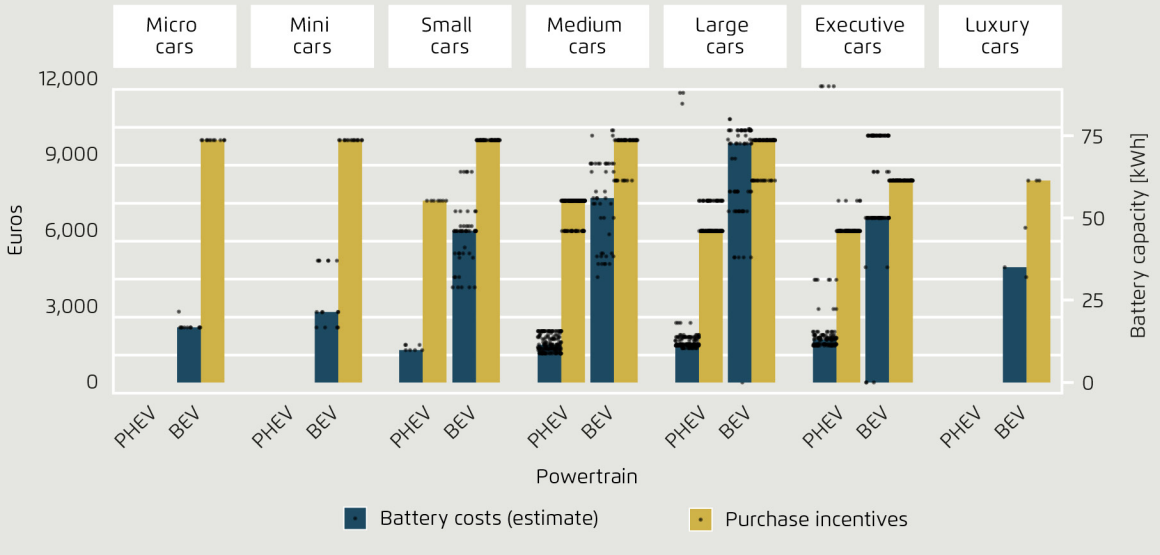
When adopting purchase incentives in the future, policymakers should prioritize support for smaller vehicle classes. This would support BEV adoption where it is least cost competitive while also assisting less affluent target groups.

PHEVs are controversial in terms of their climate impact, as their emissions depend heavily on usage patterns.[14] A PHEV powered solely by its internal combustion engine does not provide any environmental benefits. PHEVs also have a dual powertrain and a significantly higher number of components, resulting in higher manufacturing

13 Agora Energiewende et al. 2021.

14 Plötz 2020.

Battery costs and purchase incentives for BEVs and PHEVs by vehicle class — Figure 7



Agora Verkehrswende | Current to: 11/2021. Data: Estimated battery costs for manufacturers; Source: ADAC

costs. Nevertheless, purchase incentives are provided for all vehicle classes up to the executive class (E-class).

The battery capacities of BEVs and PHEVs differ greatly. While PHEV batteries typically have a capacity between 10 and 15 kWh, full BEVs usually have battery capacities of 50 kWh and up. On average, estimated battery costs are lower than that of current purchase incentives (see Figure 8). For PHEVs, lower battery capacities often also go hand-in-hand with low electric mileage. The purchase incentives for PHEVs far exceed battery costs.

Policy Recommendation

Future purchase incentives for PHEVs should be linked to electric mileage. For example, in the case of BEV, payout of half of the purchase incentive could be delayed for a period of three years and made contingent on at least 50% of mileage driven on battery power.[15] In this way, policymakers could avoid spending on unrealized emissions savings potential, while at the same time incentivizing climate-friendly driving behavior.

2.7 Outlook: Falling prices, differentiated subsidies

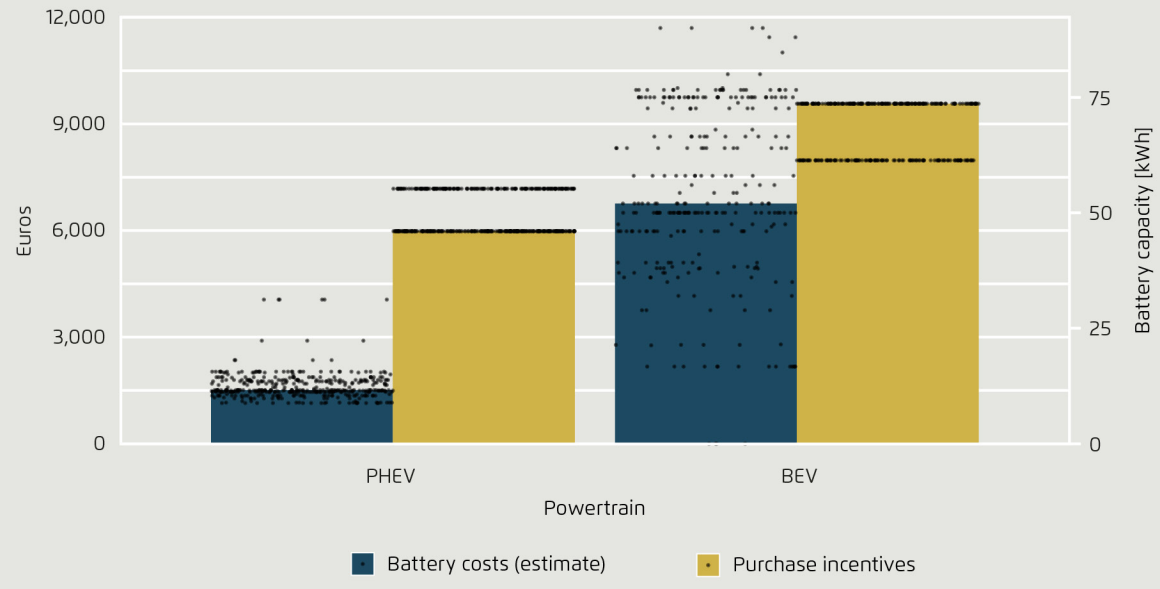
Battery prices, although they may fluctuate in the short term, will continue to fall in the long term. Insofar as these savings are passed along to consumers, this could improve the price competitiveness of BEVs. However, this would not be sufficient to close the current price gap between electric and combustion-driven vehicles, as described above.

Yet not only batteries are anticipated to become less expensive. All other electric vehicle components are expected to become cheaper over the coming years due to economies of scale.[16] At least some of the savings will be passed along to consumers. As a result, we can expect further declines in the purchase price and overall cost of ownership of electric vehicles.

15 Agora Energiewende/Agora Verkehrswende 2020.

16 Cf. UBS 2017.

Battery costs and purchase incentives for BEVs and PHEVs — Figure 8



Agora Verkehrswende | Current to: 11/2021. Data: estimated battery costs for manufacturers assuming battery pack prices of 156 US dollars per kilowatt hour (no author, 2019); Source: ADAC

Policy Recommendation

For electric vehicles to make a contribution to the attainment of climate goals, **additional government incentive measures** are **needed over the near term**. Incentive measures should be designed to focus in particular on smaller and less expensive vehicles, and an emphasis should also be placed on emissions-free BEVs (as opposed to PHEVs). Existing incentives should only be reduced given market and price trends that warrant such a decision. The anticipated drop in battery prices alone is not a sufficient condition for reducing subsidies. In addition, sales of energy-efficient vehicles (that are therefore low in emissions as well as cost-effective) could be supported through **measures to inform consumers and improve transparency**. If consumers were in a position to more easily compare the total costs of ownership, they would be in a better position to select low-cost and efficient vehicle models. The German federal government should take this into account when **implementing the EU Energy Efficiency Labeling Directive**.

3 | Conclusion

Thanks to the current purchase incentives, BEVs are already an economical alternative to ICEVs, both in terms of their initial purchase price and overall costs of ownership. BEVs in the premium market segments are particularly cost competitive, while PHEVs tend to be more expensive than their ICEV counterparts. In this context, battery costs – which, as part of the purchase price, factor into the depreciation bucket – account for a significant share of total costs. Battery costs are, however, lower than current purchase premiums, and also lower than the cost differential between electric and ICE vehicles. Significantly lower battery costs would thus not be sufficient to eliminate the need for government-financed incentives. To be cost competitive across all vehicle classes in the absence of subsidies, the prices of BEVs as a whole – and not just that of batteries – will need to fall continuously over the coming years. There is a good chance this will occur, because electric vehicles will become cheaper to produce as the market grows, technologies mature, and component costs continue to decline.

4 | Appendix

4.1 ADAC vehicle cost comparison: Underlying data for estimations

Duration of ownership

24 to 60 months (standard: 60 months).

Distance driven per annum

5,000 to 60,000 kilometers per year – max. 160,000 kilometers total (standard: 15,000 kilometers per year).

Base price

Manufacturer's suggested retail price (MSRP). The current purchase incentives for electric vehicles and PHEVs are taken into account when calculating depreciation. Likewise, the vehicle is assumed to have a standard feature set in order to improve comparability between the diverse models.

Fixed costs

- Liability insurance* with flat-rate coverage up to 100 million euros; Beitragssatz (premium rate): 50%; region class: R6; and class rating;
- Comprehensive insurance with 500 euro deductible; Beitragssatz (premium rate): 50%; region class R4; and the respective type class rating;
- Vehicle taxes (while taking into account tax exemptions for EV);
- a lump sum of 200 euros per year for general costs such as parking fees, maps, small accessories, MOT test, etc.

* Average normal rates are applied without additional discounts (e.g. for garaged or single-driver vehicles). Additional assumptions include insurance payment in in annual intervals as well as average regional classes.

Repair and maintenance

- Oil changes and inspections: Different maintenance intervals and scopes according to manufacturer specifications as well as material and labor costs are taken into account;
- typical wear-and-tear repairs that, in ADAC's experience, occur particularly frequently – for example, brakes, battery replacement, small parts such as bulbs, etc;
- Costs for tire replacement based on tire mileage determined by ADAC (empirical values) and average tire prices for the respective vehicle class sizes;
- additional flat-rate repair charge set by the ADAC, graded according to vehicle class, from a holding period of more than three years or an odometer reading of 80,000 kilometers or more.

The repair and maintenance costs are calculated on the basis of the average hourly mechanic rates of the respective manufacturers according to the Zentralverbandes Deutsches Kfz-Gewerbe e. V. (Central Association of the German Motor Trade) and surveys conducted by the ADAC, including statutory value-added tax.

Note: In practice, actual repair costs may be higher or lower.

Operating costs

- Fuel costs are calculated based on average fuel consumption figures (according to WLTP or NEDC) and the average fuel prices per liter at the time of last update (regular/super gasoline: 1.48 euros; SuperPlus: 1.56 euros; diesel: 1.30 euros; bioethanol: 1.12 euros; LPG: 0.70 euros; natural gas: 1.10 euros per kg; electricity: 0.36 euros per kWh; hydrogen: 9.50 euros per kg. To estimate the average cost of electricity, 5 cents per kilowatt-hour was added to average household electricity prices to reflect occasional charging at public locations;
- Oil change costs for engine oil and AdBlue® (diesel with SCR catalytic converter);
- flat rate for car cleaning in the amount of 250 euros per year;
- additional flat-rate repair charge set by the ADAC, graded according to vehicle class, from a holding period of more than three years or odometer reading of 80,000 kilometers or more.

Important note on fuel consumption and prices: The calculation is always based on the WLTP cycle for vehicles with standard features. However, if we do not yet have the manufacturer's WLTP values at the time of preparation, the calculation is based on the previous NEDC cycle. Both the cost of consumption and vehicle tax – and thus the total cost – will generally be higher as a result. The average fuel prices we use can vary significantly from region to region within Germany.

Depreciation

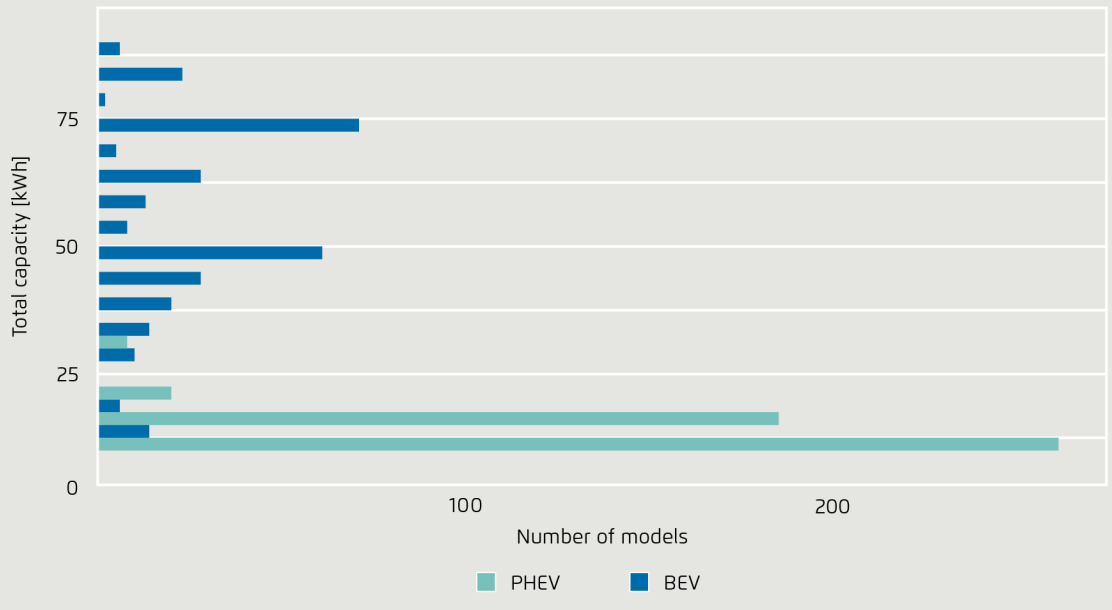
Our depreciation figures are derived from the used car price data published by Deutsche Automobil Treuhand (DAT). In this connection, we pay attention to price-reducing model changes that may take place during the calculation period. The base figure for determining the residual value of the vehicle is the recommended retail price ex works, to which an equipment allowance determined by the ADAC is added, which is made up of standard comfort and safety extras such as air conditioning, metallic paint, stability control features, and more. These are extras that have a positive impact on the value of a used car and make it easier to resell later. The costs of transferring ownership and renewed registration were set at a flat rate of 500 euros.

No discounting adjustment for the time value of money is applied, but this is probably negligible in the current low interest rate environment.

4.2 Battery capacities

Figure 9 shows the distribution of battery capacities for electric vehicle models in the data set, broken down by powetrain type. The vast majority of all PHEVs have batteries with capacities below 25 kWh. There is a wide range of battery capacities for all-electric cars, with many at or above 50 kWh. This shows that many PHEVs are not yet designed for electric use over long distances.

BEV and PHEV battery capacities — Figure 9



Agora Verkehrswende | Current to: 11/2021; source: ADAC

4.3 LPG and natural gas vehicles: Inexpensive niche product without great prospects

The data set also includes 83 natural gas and LPG vehicles, which tend to have particularly low purchase prices and overall ownership costs. On the whole, these cars seem to occupy a niche for particularly price-conscious consumers.

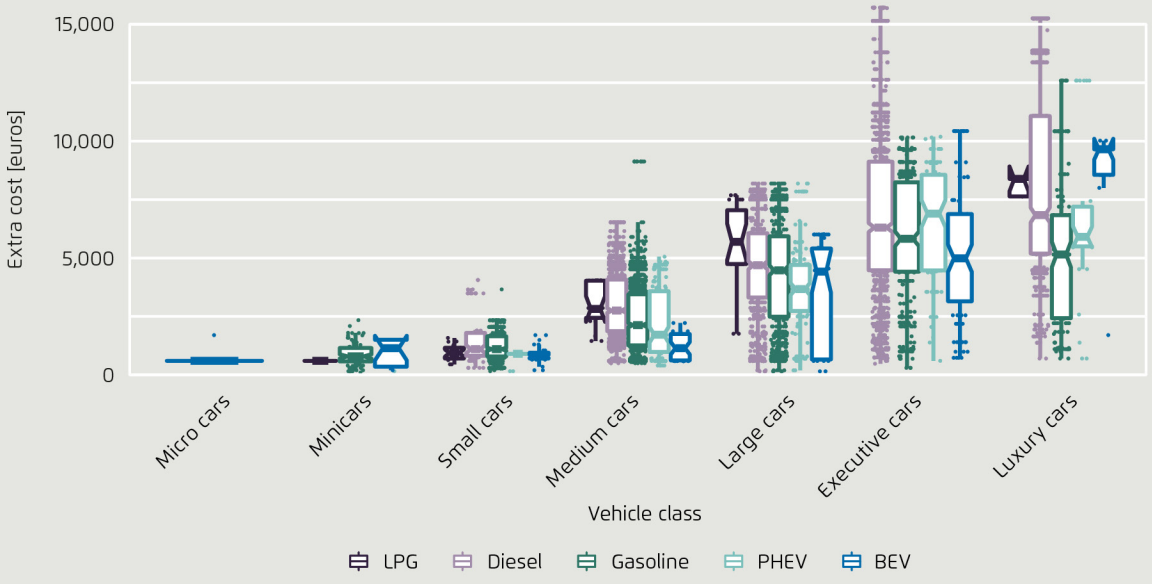
Two factors support this view: the often lower standard feature set and the mostly below-average performance of these vehicles in their respective classes.

Examining the additional costs for equipment that is standard in the class allows conclusions to be drawn about the overall features and equipment of the model in question: the lower the sum estimated for extras, the higher the value of the equipment already included as standard in the model. While larger electric vehicles are often comparatively well equipped, natural gas and LPG cars often have relatively low standard features sets (see Figure 10).

For technical reasons, natural gas engines also generally lag behind other powertrain types in terms of performance. In addition, the particular manufacturers who produce natural gas and LPG cars suggests lower price segments are being targeted here: The manufacturer with the most gas car models in the present data set is the Romanian company Dacia – the manufacturer whose mid-range model is the least expensive of all the manufacturers represented.

Regardless of the prices and characteristics of natural gas and LPG cars, this motorization type has dim prospects for the future, as all conventional combustion engines are likely to be phased out over the course of the broader transition to net zero.

Cost for additional features and equipment by vehicle class and powertrain — Figure 10



Agora Verkehrswende | Current to: 11/2021; Source: ADAC

4.4 Tables

4.4.1 Numerical basis: Figure 2

Total cost of ownership including purchase incentives (in euros), by powertrain type and vehicle class — Table 2

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas	Mini cars (e.g. Twingo)	24,822.90	24,828.15	23,967.00	25,699.80	24,384.15	24,822.90	25,266.90
Natgas	Small cars (e.g. Polo)	28,173.30	27,035.78	20,634.60	33,561.60	23,952.90	28,173.30	29,341.80
Natgas	Medium cars (e.g. Golf)	36,622.80	34,924.77	24,087.60	42,661.20	30,412.20	36,622.80	37,772.40
Natgas	Large cars (e.g. BMW 3 series)	39,171.00	42,249.52	31,789.20	56,325.60	37,796.55	39,171.00	48,934.80
Natgas	Luxury cars (e.g. S-Class)	65,166.60	65,076.12	64,445.40	65,784.00	64,818.00	65,166.60	65,166.60
Diesel	Small cars (e.g. Polo)	35,397.00	35,409.36	30,058.80	43,208.40	33,022.20	35,397.00	37,380.00
Diesel	Medium cars (e.g. Golf)	44,212.80	45,385.15	25,591.80	71,825.40	40,902.30	44,212.80	49,854.00
Diesel	Large cars (e.g. BMW 3 series)	57,097.80	57,715.15	34,952.40	90,624.00	50,889.60	57,097.80	62,542.50
Diesel	Executive cars (e.g. E-Class)	63,190.80	63,853.18	38,032.20	96,967.20	56,407.80	63,190.80	70,434.30
Diesel	Luxury cars (e.g. S-Class)	62,341.20	66,996.48	43,815.00	170,944.20	57,998.85	62,341.20	68,604.75
Gasoline	Micro cars (e.g. Twingo)	27,498.90	29,540.66	23,810.40	46,074.00	25,874.70	27,498.90	30,556.05
Gasoline	Small cars (e.g. Polo)	34,243.80	34,378.33	21,140.40	49,949.40	31,504.80	34,243.80	36,762.60
Gasoline	Medium cars (e.g. Golf)	42,411.00	44,111.24	24,476.40	78,387.00	39,020.70	42,411.00	48,197.70
Gasoline	Large cars (e.g. BMW 3 series)	56,695.80	58,593.92	32,085.60	114,395.40	50,287.50	56,695.80	62,747.70
Gasoline	Executive cars (e.g. E-Class)	76,514.40	81,702.82	41,975.40	164,611.20	69,775.20	76,514.40	88,722.00
Gasoline	Luxury cars (e.g. S-Class)	116,857.80	124,259.78	90,721.80	204,085.20	108,228.00	116,857.80	136,787.70
Electric	Microcars (e.g. Smart)	27,076.80	26,666.02	22,896.00	29,219.40	25,409.40	27,076.80	28,207.50
Electric	Micro cars (e.g. Twingo)	27,657.60	28,609.16	23,761.20	35,827.20	26,020.80	27,657.60	31,002.90
Electric	Small cars (e.g. Polo)	35,291.70	35,669.18	29,700.00	42,931.80	33,433.20	35,291.70	37,725.45
Electric	Medium cars (e.g. Golf)	40,615.80	43,369.55	31,122.00	61,479.00	36,486.30	40,615.80	51,091.80
Electric	Large cars (e.g. BMW 3 series)	49,448.10	51,481.44	36,402.00	91,536.60	44,970.90	49,448.10	54,595.65

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Electric	Executive cars (e.g. E-Class)	65,089.80	67,483.04	53,191.20	96,523.20	61,368.00	65,089.80	69,533.40
Electric	Luxury cars (e.g. S-Class)	93,931.20	100,121.40	66,163.20	143,736.00	82,977.60	93,931.20	119,912.70
PHEV	Small cars (e.g. Polo)	38,074.80	38,294.91	34,491.60	42,184.20	37,038.30	38,074.80	39,618.60
PHEV	Medium cars (e.g. Golf)	44,727.00	45,005.45	32,185.80	69,702.60	40,466.40	44,727.00	48,458.70
PHEV	Large cars (e.g. BMW 3 series)	57,738.60	58,328.53	38,516.40	86,235.00	50,779.20	57,738.60	63,044.40
PHEV	Executive cars (e.g. E-Class)	70,994.40	71,238.09	42,672.60	147,828.00	66,817.50	70,994.40	75,399.30
PHEV	Luxury cars (e.g. S-Class)	117,077.40	120,538.70	96,998.40	164,956.80	109,776.00	117,077.40	125,029.95

Agora Verkehrswende | Source: ADAC

Total cost of ownership without purchase incentives (in euros), by powertrain type and vehicle class

Table 3

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/ LPG	Mini cars (e.g. Twingo)	24,822.90	24,828.15	23,967.00	25,699.80	24,384.15	24,822.90	25,266.90
Natgas/ LPG	Small cars (e.g. Polo)	28,173.30	27,035.78	20,634.60	33,561.60	23,952.90	28,173.30	29,341.80
Natgas/ LPG	Medium cars (e.g. Golf)	36,622.80	34,924.77	24,087.60	42,661.20	30,412.20	36,622.80	37,772.40
Natgas/ LPG	Large cars (e.g. BMW 3 series)	39,171.00	42,249.52	31,789.20	56,325.60	37,796.55	39,171.00	48,934.80
Natgas/ LPG	Luxury cars (e.g. S-Class)	65,166.60	65,076.12	64,445.40	65,784.00	64,818.00	65,166.60	65,166.60
Diesel	Small cars (e.g. Polo)	35,397.00	35,409.36	30,058.80	43,208.40	33,022.20	35,397.00	37,380.00
Diesel	Medium cars (e.g. Golf)	44,212.80	45,385.15	25,591.80	71,825.40	40,902.30	44,212.80	49,854.00
Diesel	Large cars (e.g. BMW 3 series)	57,097.80	57,715.15	34,952.40	90,624.00	50,889.60	57,097.80	62,542.50
Diesel	Executive cars (e.g. E-Class)	63,190.80	63,853.18	38,032.20	96,967.20	56,407.80	63,190.80	70,434.30
Diesel	Luxury cars (e.g. S-Class)	62,341.20	66,996.48	43,815.00	170,944.20	57,998.85	62,341.20	68,604.75
Gasoline	Mini cars (e.g. Twingo)	27,498.90	29,540.66	23,810.40	46,074.00	25,874.70	27,498.90	30,556.05
Gasoline	Small cars (e.g. Polo)	34,243.80	34,378.33	21,140.40	49,949.40	31,504.80	34,243.80	36,762.60
Gasoline	Medium cars (e.g. Golf)	42,411.00	44,111.24	24,476.40	78,387.00	39,020.70	42,411.00	48,197.70

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Gasoline	Large cars (e.g. BMW 3 series)	56,695.80	58,593.92	32,085.60	114,395.40	50,287.50	56,695.80	62,747.70
Gasoline	Executive cars (e.g. E-Class)	76,514.40	81,702.82	41,975.40	164,611.20	69,775.20	76,514.40	88,722.00
Gasoline	Luxury cars (e.g. S-Class)	116,857.80	124,259.78	90,721.80	204,085.20	108,228.00	116,857.80	136,787.70
Electric	Micro cars (e.g. Smart)	34,809.00	34,435.15	30,702.00	37,025.40	33,178.80	34,809.00	35,920.80
Electric	Mini cars (e.g. Twingo)	35,415.00	36,136.56	31,150.80	43,241.40	33,645.30	35,415.00	38,355.90
Electric	Small cars (e.g. Polo)	41,974.50	42,625.44	36,810.60	49,544.40	40,433.10	41,974.50	44,660.40
Electric	Medium cars (e.g. Golf)	47,682.00	49,934.44	37,808.40	67,090.20	43,680.00	47,682.00	56,804.85
Electric	Large cars (e.g. BMW 3 series)	55,586.40	57,269.19	42,760.80	91,536.60	51,507.45	55,586.40	60,174.90
Electric	Executive cars (e.g. E-Class)	71,025.00	72,716.32	59,467.80	96,523.20	67,548.00	71,025.00	75,628.20
Electric	Luxury cars (e.g. S-Class)	93,931.20	101,354.76	72,183.00	143,736.00	84,321.00	93,931.20	119,912.70
PHEV	Small cars (e.g. Polo)	42,540.60	42,714.43	38,862.60	46,668.60	41,409.30	42,540.60	44,055.30
PHEV	Medium cars (e.g. Golf)	49,296.60	49,331.60	36,737.40	73,439.40	44,792.40	49,296.60	52,569.90
PHEV	Large cars (e.g. BMW 3 series)	61,452.60	61,813.72	42,796.80	86,235.00	54,780.00	61,452.60	66,341.40
PHEV	Executive cars (e.g. E-Class)	74,586.00	74,495.41	47,022.00	147,828.00	70,679.40	74,586.00	78,602.10
PHEV	Luxury cars (e.g. S-Class)	117,077.40	120,538.70	96,998.40	164,956.80	109,776.00	117,077.40	125,029.95

Agora Verkehrswende | Source: ADAC

5.4.1 Numerical basis: Figure 3

Purchase prices including purchase incentives (in euros), by powertrain type — Table 4

Powertrain	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/LPG	28,912.00	30,834.83	11,390.00	56,535.00	22,266.25	28,912.00	37,640.00
Diesel	48,806.50	51,347.33	15,084.00	213,902.00	40,705.25	48,806.50	59,469.50
Gasoline	37,600.00	46,383.06	8,690.00	243,934.00	28,650.00	37,600.00	52,970.00
Electric	45,435.00	48,548.59	12,970.00	196,321.00	30,075.00	45,435.00	58,210.75
PHEV	55,689.00	61,507.41	25,323.00	214,310.00	41,108.00	55,689.00	71,324.25

Agora Verkehrswende | Source: ADAC

Purchase prices without purchase incentives (in euros), by powertrain type — Table 5

Powertrain	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/LPG	28,912.00	30,834.83	11,390.00	56,535.00	22,266.25	28,912.00	37,640.00
Diesel	48,806.50	51,347.33	15,084.00	213,902.00	40,705.25	48,806.50	59,469.50
Gasoline	37,600.00	46,383.06	8,690.00	243,934.00	28,650.00	37,600.00	52,970.00
Electric	54,880.00	56,686.14	22,540.00	196,321.00	39,645.00	54,880.00	66,185.75
PHEV	61,670.00	67,049.23	32,500.00	214,310.00	48,285.00	61,670.00	76,862.50

Agora Verkehrswende | Source: ADAC

5.4.2 Numerical basis: Figure 4

Purchase prices without purchase incentives (in euros), by powertrain type and vehicle class — Table 6

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/ LPG	Micro cars (e.g. Twingo)	17,630.00	17,630.00	16,660.00	18,600.00	17,020.00	17,630.00	18,240.00
Natgas/ LPG	Small cars (e.g. Polo)	22,662.50	20,246.46	11,390.00	27,200.00	13,165.00	22,662.50	25,200.00
Natgas/ LPG	Medium cars (e.g. Golf)	28,942.00	28,436.90	14,640.00	38,030.00	26,470.00	28,942.00	34,990.00
Natgas/ LPG	Large cars (e.g. BMW 3 series)	38,930.00	41,629.77	28,500.00	56,535.00	36,757.50	38,930.00	49,447.50
Natgas/ LPG	Luxury cars (e.g. S-Class)	54,710.00	54,796.40	53,545.00	56,163.00	54,710.00	54,710.00	54,854.00
Diesel	Small cars (e.g. Polo)	25,970.00	26,517.65	19,755.00	38,440.00	23,446.00	25,970.00	29,205.00
Diesel	Medium cars (e.g. Golf)	37,853.00	38,384.46	15,084.00	73,286.00	32,572.50	37,853.00	43,896.00
Diesel	Large cars (e.g. BMW 3 series)	51,900.00	53,135.43	27,730.00	93,650.00	45,045.00	51,900.00	58,835.75
Diesel	Executive cars (e.g. E-Class)	57,741.50	58,983.54	25,884.00	103,200.00	48,296.75	57,741.50	69,391.00
Diesel	Luxury cars (e.g. S-Class)	50,935.00	58,285.26	30,625.00	213,902.00	47,133.00	50,935.00	60,979.50
Gasoline	Micro cars (e.g. Twingo)	16,540.00	18,319.56	10,990.00	35,670.00	15,195.00	16,540.00	18,947.50
Gasoline	Small cars (e.g. Polo)	25,000.00	25,116.73	8,690.00	44,250.00	21,927.50	25,000.00	27,942.50
Gasoline	Medium cars (e.g. Golf)	34,710.00	36,211.15	11,990.00	75,786.00	30,342.50	34,710.00	41,175.00
Gasoline	Large cars (e.g. BMW 3 series)	51,473.00	53,623.30	23,750.00	111,600.00	43,687.50	51,473.00	59,074.00
Gasoline	Executive cars (e.g. E-Class)	73,370.00	79,373.17	33,860.00	204,538.00	65,285.00	73,370.00	87,130.00

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Gasoline	Luxury cars (e.g. S-Class)	130,811.00	137,826.11	96,300.00	243,934.00	112,217.00	130,811.00	156,165.00
Electric	Microcars (e.g. Smart)	27,700.00	26,850.00	22,540.00	29,830.00	25,185.00	27,700.00	28,445.00
Electric	Micro cars (e.g. Twingo)	26,540.00	28,818.67	23,290.00	37,900.00	25,385.00	26,540.00	32,410.00
Electric	Small cars (e.g. Polo)	36,800.00	37,485.00	29,900.00	48,450.00	34,597.50	36,800.00	39,962.50
Electric	Medium cars (e.g. Golf)	42,940.00	45,888.98	30,580.00	65,650.00	37,712.50	42,940.00	54,386.25
Electric	Large cars (e.g. BMW 3 series)	54,677.50	56,324.64	34,700.00	95,544.00	49,386.25	54,677.50	61,308.75
Electric	Executive cars (e.g. E-Class)	66,810.00	69,219.40	51,630.00	104,530.00	62,146.00	66,810.00	73,100.00
Electric	Luxury cars (e.g. S-Class)	116,139.00	123,501.47	65,843.00	196,321.00	96,034.00	116,139.00	153,886.50
PHEV	Small cars (e.g. Polo)	37,600.00	37,742.86	32,500.00	42,600.00	35,350.00	37,600.00	40,400.00
PHEV	Medium cars (e.g. Golf)	46,250.00	46,968.41	32,590.00	71,486.00	42,602.00	46,250.00	51,268.50
PHEV	Large cars (e.g. BMW 3 series)	62,540.00	63,136.54	40,780.00	93,509.00	55,020.00	62,540.00	69,118.00
PHEV	Executive cars (e.g. E-Class)	76,350.00	77,363.95	45,140.00	189,192.00	70,077.00	76,350.00	82,769.00
PHEV	Luxury cars (e.g. S-Class)	127,241.00	137,216.39	98,335.00	214,310.00	115,725.00	127,241.00	149,025.00

Agora Verkehrswende | Source: ADAC

Purchase prices including purchase incentives (in euros), by powertrain type and vehicle class Table 7

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/ LPG	Micro cars (e.g. Twingo)	17,630.00	17,630.00	16,660.00	18,600.00	17,020.00	17,630.00	18,240.00
Natgas/ LPG	Small cars (e.g. Polo)	22,662.50	20,246.46	11,390.00	27,200.00	13,165.00	22,662.50	25,200.00
Natgas/ LPG	Medium cars (e.g. Golf)	28,942.00	28,436.90	14,640.00	38,030.00	26,470.00	28,942.00	34,990.00
Natgas/ LPG	Large cars (e.g. BMW 3 series)	38,930.00	41,629.77	28,500.00	56,535.00	36,757.50	38,930.00	49,447.50
Natgas/ LPG	Luxury cars (e.g. S-Class)	54,710.00	54,796.40	53,545.00	56,163.00	54,710.00	54,710.00	54,854.00
Diesel	Small cars (e.g. Polo)	25,970.00	26,517.65	19,755.00	38,440.00	23,446.00	25,970.00	29,205.00
Diesel	Medium cars (e.g. Golf)	37,853.00	38,384.46	15,084.00	73,286.00	32,572.50	37,853.00	43,896.00

Power-train	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Diesel	Large cars (e.g. BMW 3 series)	51,900.00	53,135.43	27,730.00	93,650.00	45,045.00	51,900.00	58,835.75
Diesel	Executive cars (e.g. E-Class)	57,741.50	58,983.54	25,884.00	103,200.00	48,296.75	57,741.50	69,391.00
Diesel	Luxury cars (e.g. S-Class)	50,935.00	58,285.26	30,625.00	213,902.00	47,133.00	50,935.00	60,979.50
Gasoline	Micro cars (e.g. Twingo)	16,540.00	18,319.56	10,990.00	35,670.00	15,195.00	16,540.00	18,947.50
Gasoline	Small cars (e.g. Polo)	25,000.00	25,116.73	8,690.00	44,250.00	21,927.50	25,000.00	27,942.50
Gasoline	Medium cars (e.g. Golf)	34,710.00	36,211.15	11,990.00	75,786.00	30,342.50	34,710.00	41,175.00
Gasoline	Large cars (e.g. BMW 3 series)	51,473.00	53,623.30	23,750.00	111,600.00	43,687.50	51,473.00	59,074.00
Gasoline	Executive cars (e.g. E-Class)	73,370.00	79,373.17	33,860.00	204,538.00	65,285.00	73,370.00	87,130.00
Gasoline	Luxury cars (e.g. S-Class)	130,811.00	137,826.11	96,300.00	243,934.00	112,217.00	130,811.00	156,165.00
Electric	Microcars (e.g. Smart)	18,130.00	17,280.00	12,970.00	20,260.00	15,615.00	18,130.00	18,875.00
Electric	Mini cars (e.g. Twingo)	16,970.00	19,248.67	13,720.00	28,330.00	15,815.00	16,970.00	22,840.00
Electric	Small cars (e.g. Polo)	27,230.00	27,915.00	20,330.00	38,880.00	25,027.50	27,230.00	30,392.50
Electric	Medium cars (e.g. Golf)	33,370.00	36,665.72	21,010.00	57,675.00	28,142.50	33,370.00	44,816.25
Electric	Large cars (e.g. BMW 3 series)	45,212.50	47,530.58	25,130.00	95,544.00	39,816.25	45,212.50	52,503.75
Electric	Executive cars (e.g. E-Class)	58,835.00	62,191.92	43,655.00	104,530.00	54,171.00	58,835.00	65,125.00
Electric	Luxury cars (e.g. S-Class)	116,139.00	121,906.47	57,868.00	196,321.00	96,034.00	116,139.00	153,886.50
PHEV	Small cars (e.g. Polo)	30,423.00	30,565.86	25,323.00	35,423.00	28,173.00	30,423.00	33,223.00
PHEV	Medium cars (e.g. Golf)	39,073.00	40,013.19	25,413.00	65,505.00	35,425.00	39,073.00	44,386.00
PHEV	Large cars (e.g. BMW 3 series)	56,559.00	57,499.59	33,603.00	93,509.00	48,919.00	56,559.00	63,137.00
PHEV	Executive cars (e.g. E-Class)	70,425.00	72,136.47	37,963.00	189,192.00	64,096.00	70,425.00	78,277.50
PHEV	Luxury cars (e.g. S-Class)	127,241.00	137,216.39	98,335.00	214,310.00	115,725.00	127,241.00	149,025.00

Agora Verkehrswende | Source: ADAC

5.4.3 Numerical basis: Figure 5

Estimated battery costs (in euros), by powertrain type — Table 8

Powertrain	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/LPG	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Diesel	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gasoline	0.00	5.02	0.00	208.00	0.00	0.00	0.00
Electric	6,760.00	7,319.99	0.00	11,700.00	5,980.00	6,760.00	9,750.00
PHEV	1,508.00	1,663.53	1,144.00	4,056.00	1,456.00	1,508.00	1,794.00

Agora Verkehrswende | Source: ADAC

5.4.4 Numerical basis: Figure 6

Estimated battery cost as a share of depreciation (in euros), by powertrain type — Table 9

Powertrain	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Electric	5,115.50	5,103.69	0.00	8,868.60	4,197.96	5,115.50	6,219.64
PHEV	989.25	1,024.03	696.07	2,393.04	908.47	989.25	1,121.33

Agora Verkehrswende | Source: ADAC

5.4.5 Numerical basis: Figure 7

Battery capacity (kWh) and purchase incentives (in euros), by powertrain type and vehicle class — Table 10

Power-train	Vehicle class	Cost type	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Electric	Micro cars (e.g. Smart)	Battery capacity	16.70	17.14	16.70	21.50	16.70	16.70	16.70
Electric	Micro cars (e.g. Smart)	Purchase incentives	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00
Electric	Mini cars (e.g. Twingo)	Battery capacity	21.40	26.38	16.70	37.00	19.00	21.40	37.00
Electric	Mini cars (e.g. Twingo)	Purchase incentives	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00
Electric	Small cars (e.g. Polo)	Battery capacity	46.00	44.94	28.90	64.00	39.20	46.00	47.50
Electric	Small cars (e.g. Polo)	Purchase incentives	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00	9,570.00
Electric	Small cars (e.g. Golf)	Battery capacity	56.00	54.96	32.00	76.60	39.20	56.00	66.50

Power-train	Vehicle class	Cost type	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Electric	Medium class (e.g. Golf)	Purchase incentives	9,570.00	9,223.26	7,975.00	9,570.00	9,570.00	9,570.00	9,570.00
Electric	Large cars (e.g. BMW 3 series)	Battery capacity	72.60	65.03	0.00	88.00	52.00	72.60	76.60
Electric	Large cars (e.g. BMW 3 series)	Purchase incentives	9,570.00	9,165.63	7,975.00	9,570.00	8,772.50	9,570.00	9,570.00
Electric	Executive cars (e.g. E-Class)	Battery capacity	50.00	60.27	0.00	90.00	50.00	50.00	75.00
Electric	Executive cars (e.g. E-Class)	Purchase incentives	7,975.00	7,975.00	7,975.00	7,975.00	7,975.00	7,975.00	7,975.00
Electric	Luxury cars (e.g. S-Class)	Battery capacity	35.00	38.00	32.00	47.00	33.50	35.00	41.00
Electric	Luxury cars (e.g. S-Class)	Purchase incentives	7,975.00	7,975.00	7,975.00	7,975.00	7,975.00	7,975.00	7,975.00
PHEV	Small cars (e.g. Polo)	Battery capacity	9.80	10.49	9.80	11.40	9.80	9.80	11.40
PHEV	Small cars (e.g. Polo)	Purchase incentives	7,177.50	7,177.50	7,177.50	7,177.50	7,177.50	7,177.50	7,177.50
PHEV	Small cars (e.g. Golf)	Battery capacity	11.40	11.80	8.80	15.60	9.80	11.40	13.80
PHEV	Small cars (e.g. Golf)	Purchase incentives	7,177.50	6,955.68	5,981.25	7,177.50	7,177.50	7,177.50	7,177.50
PHEV	Large cars (e.g. BMW 3 series)	Battery capacity	11.60	12.16	10.40	18.10	11.20	11.60	13.50
PHEV	Large cars (e.g. BMW 3 series)	Purchase incentives	5,981.25	6,249.97	5,981.25	7,177.50	5,981.25	5,981.25	5,981.25
PHEV	Executive cars (e.g. E-Class)	Battery capacity	13.00	14.06	11.20	31.20	11.60	13.00	14.38
PHEV	Executive cars (e.g. E-Class)	Purchase incentives	5,981.25	6,035.62	5,981.25	7,177.50	5,981.25	5,981.25	5,981.25

Agora Verkehrswende | Source: ADAC

5.4.6 Numerical basis: Figure 8

Battery capacity (kWh) and purchase incentives (in euros), by powertrain type — Table 11

Power-train	Cost type	Median	Average	Min.	Max.	1st quartile	2nd quar-tile	3rd quar-tile
Electric	Battery capacity	52.00	54.16	0.00	90.00	46.00	52.00	72.60
Electric	Purchase incentives	9,570.00	8,903.10	7,975.00	9,570.00	7,975.00	9,570.00	9,570.00
PHEV	Battery capacity	11.60	12.51	8.80	31.20	11.20	11.60	13.80
PHEV	Purchase incentives	5,981.25	6,470.36	5,981.25	7,177.50	5,981.25	5,981.25	7,177.50

Agora Verkehrswende | Source: ADAC

5.4.7 Numerical basis: Figure Annex #1

Battery capacity (kWh), by powertrain type — Table 12

Powertrain	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Electric	54.30	57.22	16.70	90.00	46.00	54.30	75.00
PHEV	11.60	12.80	8.80	31.20	11.20	11.60	13.80

Agora Verkehrswende | Source: ADAC

5.4.8 Numerical basis: Figure Annex #2

Additional costs (in euros) for standard feature set, by powertrain type and vehicle class — Table 13

Powertrain	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Natgas/LPG	Mini cars (e.g. Twingo)	600.00	600.00	600.00	600.00	600.00	600.00	600.00
Natgas/LPG	Small cars (e.g. Polo)	935.00	975.00	450.00		700.00	935.00	1,160.00
Natgas/LPG	Medium cars (e.g. Golf)	2,820.00	2,919.90	1,450.00	4,047.00	2,440.00	2,820.00	4,030.00
Natgas/LPG	Large cars (e.g. BMW 3 series)	5,690.00	5,506.14	1,760.00	7,685.00	4,740.00	5,690.00	7,047.50
Natgas/LPG	Luxury cars (e.g. S-Class)	8,384.00	8,084.00	7,634.00	8,384.00	7,634.00	8,384.00	8,384.00
Diesel	Small cars (e.g. Polo)	1,100.00	1,532.47	300.00		817.50	1,100.00	1,795.00

Powertrain	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
Diesel	Medium cars (e.g. Golf)	2,750.00	2,978.40	500.00		1,870.00	2,750.00	4,080.00
Diesel	Large cars (e.g. BMW 3 series)	4,690.00	4,582.07	195.00	8,185.00	3,311.75	4,690.00	6,060.00
Diesel	Executive cars (e.g. E-Class)	6,304.00	6,827.99	476.00		4,475.00	6,304.00	9,119.00
Diesel	Luxury cars (e.g. S-Class)	6,835.00	8,360.00	700.00	15,252.00	5,190.00	6,835.00	11,076.00
Gasoline	Mini cars (e.g. Twingo)	790.00	870.94	150.00		575.00	790.00	1,150.00
Gasoline	Small cars (e.g. Polo)	1,100.00	1,197.02	200.00		790.00	1,100.00	1,650.00
Gasoline	Medium cars (e.g. Golf)	2,130.00	2,420.08	500.00		1,260.00	2,130.00	3,450.00
Gasoline	Large cars (e.g. BMW 3 series)	4,470.00	4,278.73	195.00		2,490.00	4,470.00	5,928.00
Gasoline	Executive cars (e.g. E-Class)	5,822.00	5,777.37	300.00		4,414.00	5,822.00	8,237.50
Gasoline	Luxury cars (e.g. S-Class)	5,150.00	5,255.60	700.00	12,590.00	2,425.00	5,150.00	6,835.00
Electric	Micro cars (e.g. Smart)	600.00	700.00	600.00	1,700.00	600.00	600.00	600.00
Electric	Mini cars (e.g. Twingo)	1,145.00	949.17	200.00		350.00	1,145.00	1,500.00
Electric	Small cars (e.g. Polo)	790.00	859.48	200.00		700.00	790.00	950.00
Electric	Medium cars (e.g. Golf)	1,140.00	1,172.89	590.00		620.00	1,140.00	1,746.00
Electric	Large cars (e.g. BMW 3 series)	4,415.00	3,310.31	595.00		660.00	4,415.00	5,406.25
Electric	Executive cars (e.g. E-Class)	4,989.00	5,161.21	731.00	10,430.00	3,150.00	4,989.00	6,880.00
Electric	Luxury cars (e.g. S-Class)	9,652.00	8,698.93	1,702.00	10,021.00	8,557.00	9,652.00	9,652.00
PHEV	Small cars (e.g. Polo)	900.00	900.00	900.00		900.00	900.00	900.00
PHEV	Medium cars (e.g. Golf)	1,716.50	2,213.59	400.00		980.00	1,716.50	3,581.50

Powertrain	Vehicle class	Median	Average	Min.	Max.	1st quartile	2nd quartile	3rd quartile
PHEV	Large cars (e.g. BMW 3 series)	3,670.00	3,812.25	195.00		2,739.00	3,670.00	4,700.00
PHEV	Executive cars (e.g. E-Class)	6,901.00	6,467.90	600.00		4,470.00	6,901.00	8,557.50
PHEV	Luxury cars (e.g. S-Class)	5,905.00	6,606.58	700.00	12,590.00	5,500.00	5,905.00	7,195.00

Agora Verkehrswende | Source: ADAC

5 | Bibliography

ADAC Car Cost Calculator (2021): Data export: July 2021, https://www.adac.de/rund-ums-fahrzeug/auto-kaufen-verkaufen/autokosten/.

Agora Energiewende/Agora Verkehrswende (2020): Dual-Benefit Stimulus for Germany:

A Proposal for a Targeted 100 Billion Euro Growth and Investment Initiative, p. 48.

Agora Energiewende/Agora Verkehrswende/Stiftung Klimaneutralität (2021): Das Klimaschutz-Sofortprogramm. 22 Eckpunkte für die ersten 100 Tage der neuen Bundesregierung.

Andor, Mark A./Gerster, Andreas/Gillingham, Kenneth T./Horvath, Marco (2020): Running a Car Costs Much More than People Think – Stalling the Uptake of Green Travel, in: Nature 580(7804), pp. 453-455, https://doi.org/10.1038/d41586-020-01118-w.

BEUC (The European Consumer Organisation) (2021): ELECTRIC CAR OWNERSHIP: AN AFFORDABLE OPTION FOR ALL CONSUMERS, https://www.beuc.eu/publications/beuc-x-2021-040_electric_car_ownership-an_affordable_option_for_all_consumers.pdf (MAY 10, 2021).

BEUC (The European Consumer Organisation)/Element Energy Limited (2021): Electric Cars: Calculating the Total Cost of Ownership for Consumers, https://www.beuc.eu/publications/beuc-x-2021-039_electric_cars_calculating_the_total_cost_of_ownership_for_consumers.pdf (May 10, 2021).

Bundesverband Elektromobilität: 210122-press-release.pdf, https://www.bem-ev.de/wp/wp-content/uploads/2021/01/210122-Pressemeldung.pdf (Feb. 18, 2021).

Federal Motor Transport Authority (2020): New Motor Vehicle Registrations by Environmental Characteristics, FZ14, p. 69.

Lutsey: Nic Evaluating Electric Vehicle Costs and Benefits in China in the 2020–2035 Time Frame, p. 36.

Lutsey, Nic/Nicholas, Michael/Jelle Smekens/Noshin Omar/Lieselot Vanhaverbeke/Joeri Van Mierlo (2019): Update on Electric Vehicle Costs in the United States through 2030, ICCT, https://theicct.org/sites/default/files/publications/EV_cost_2020_2030_20190401.pdf (Oct. 27, 2021).

No author (2019): Battery Pack Prices Fall As Market Ramps Up With Market Average At $156/KWh In 2019, BloombergNEF, https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/ (Apr. 21, 2021).

Plötz, Patrick (2020): Real-World Usage of Plug-in Hybrid Electric Vehicles: Fuel Consumption, Electric Driving, and CO_2 Emissions, p. 57.

UBS (2017): Q-Series: Tearing Down the Heart of an Electric Car Lap 2: Cost Parity a Closer Reality?, Investment Bank, https://www.ubs.com/global/en/investment-bank/in-focus/2020/heart-of-electric-car.html (May 4, 2021).

76-2022-EN

Agora Verkehrswende collaborates with stakeholders from the domains of politics, business, academia and civil society to lay the foundations for the decarbonisation of the transport sector in Germany by 2045. To this end, we develop climate protection strategies and support their implementation.

Agora Verkehrswende
Anna-Louisa-Karsch-Str. 2 | 10178 Berlin
T +49 (0)30 700 14 35-000
F +49 (0)30 700 14 35-129
www.agora-verkehrswende.de
info@agora-verkehrswende.de

Agora Verkehrswende

Agora Verkehrswende is a joint initiative of Stiftung Mercator and the European Climate Foundation.