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ARE BATTERY ELECTRIC VEHICLES COST COMPETITIVE? AN INCOME-BASED ANALYSIS OF THE COSTS OF NEW VEHICLE PURCHASE AND LEASING FOR THE GERMAN MARKET

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EXECUTIVE SUMMARY

In Germany, battery electric vehicle (BEV) uptake has grown over the past few years but not equally among all consumers. Recent reports point to an imbalanced adoption of BEVs that is largely influenced by the total cost of electric vehicle ownership, access to charging infrastructure, and levels of awareness. In order to guarantee that all who are dependent on a car for their daily mobility needs can participate in the transition from internal combustion engine vehicles (ICEVs) to zero-emission models, the cost barrier to BEVs must be addressed. Broader access to BEVs would benefit German society by lowering road transportation emissions and levels of localized air pollution while simultaneously allowing those who are dependent on a vehicle to maintain levels of mobility.

This report seeks to clarify the costs of new BEVs in Germany by analyzing the total cost of ownership for selected vehicle models over a four-year holding period, with a focus on new passenger cars. We analyze two sets of comparable compact and mini car models: the Volkswagen (VW) ID.3 Pro (BEV) and the VW Golf VIII Style 2 (ICEV gasoline), and the Dacia Spring Extreme Electric 65 (BEV) and the Toyota Aygo X 1.0 (ICEV gasoline). A total cost of ownership (TCO) analysis is used to assess the costs of operation for both purchased and leased vehicles, including the base price, the value-added tax (VAT), costs of fueling and charging, maintenance, insurance, ownership taxes, and any relevant incentives that reduce these costs. The report then analyzes how these costs compare as a share of net household income in Germany, highlighting the costs of BEVs as a share of income for different income groups, and further discusses broader BEV access in the country given the results. Used vehicles are not considered in this report and costs evaluated are only applicable to individual consumers.

Figure ES1 shows the total cost of purchasing the selected vehicle models over four years.

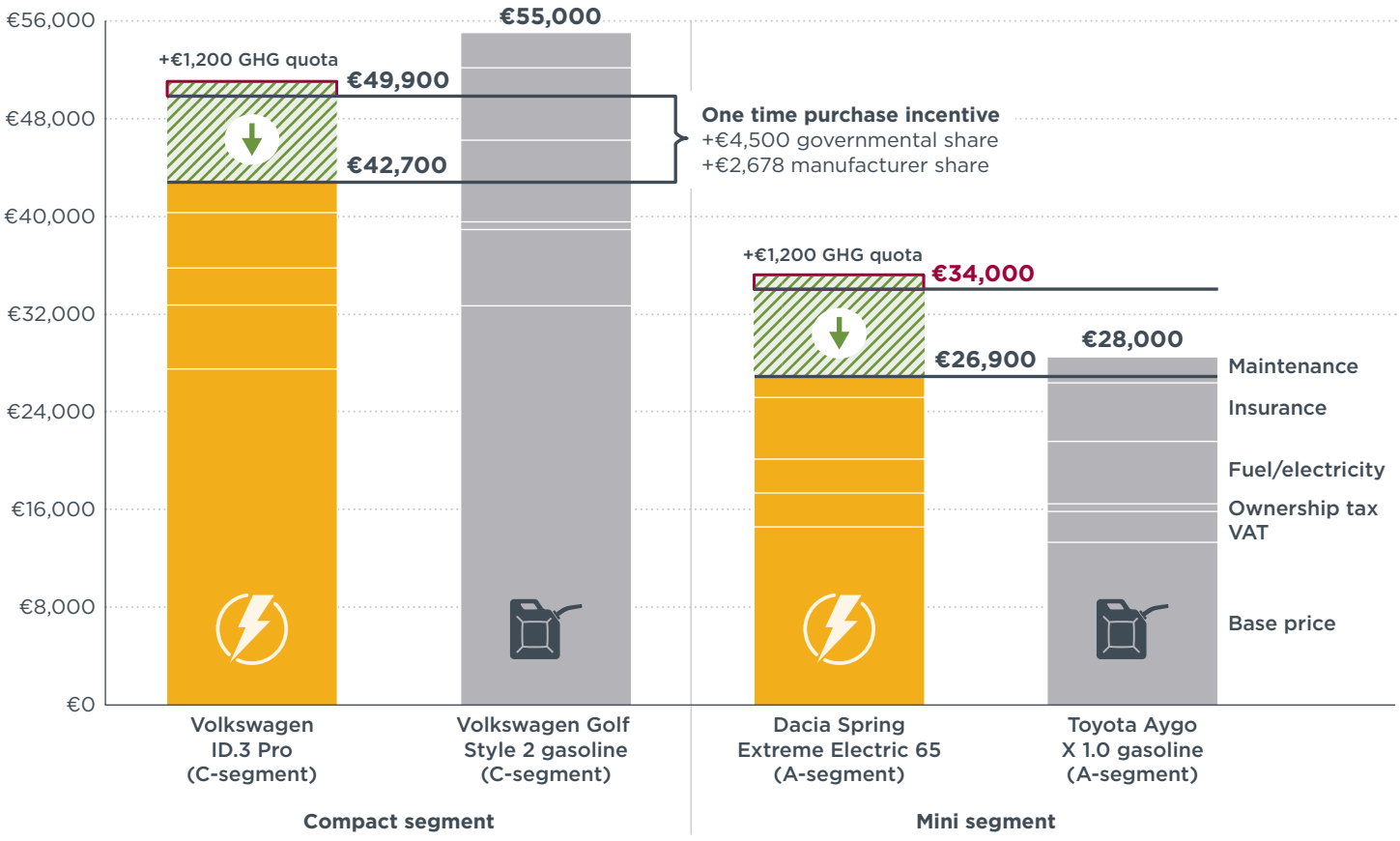

Figure ES1. Four-year total cost of ownership for selected vehicle models in the compact (C) and mini car (A) segments in Germany from 2023 to 2026, assuming 100% alternating current home charging. Costs are shown with and without the 2023 one-time purchase incentive and four-year application of the GHG quota.

Given the results of the analysis, we come to the following high-level conclusions:

- **Owning a BEV is more cost-effective than a comparable ICE gasoline model in the compact car segment (C), but not in the mini car segment (A) without the one-time purchase incentive.** The C-segment BEV has lower total ownership costs compared to the gasoline model, saving over €5,100 across four years, with the total cost amounting to around €49,900 without the one-time purchase incentive. In the A-segment, the BEV model is around €6,000 more expensive than the comparable ICE gasoline model, totaling above €34,000 without the one-time purchase incentive. The largest cost factors are the base prices, followed by the VAT for the C-segment BEV, fuel for the ICEV in both segments, and insurance for the A-segment BEV.
- **Applying the current one-time purchase incentive significantly reduces the costs of purchasing the BEV models in both segments and makes the BEV model slightly cheaper than the ICEV model in the mini car segment.** The one-time purchase incentive plays a crucial role in lowering the total costs of owning a BEV. When applied to the A-segment BEV, the costs are lowered from €34,000 to €26,900, making it around €1,100 cheaper to purchase than the ICE gasoline model. It reduces the costs of the C-segment BEV, which was already cheaper than the comparable ICEV, to nearly €42,700, or €12,300 cheaper.
- **Leasing costs over a four-year period for the selected BEV models are cheaper in the compact segment, but not in the mini car segment without incentives.** Leasing the C-segment BEV is cheaper than the comparable ICE gasoline model, at around €22,200 for the BEV versus €39,100 for the ICEV, when including the one-time purchase incentive. Leasing an A-segment BEV model is about 15% cheaper than the ICEV, at approximately €16,600 compared to €19,000. Monthly leasing costs constitute over 60% of the total costs for the C-segment BEV and ICEV, but only around 43% for the A-segment ICEV. Similar to vehicle purchase, the one-time purchase incentive made leasing the selected BEV models cheaper than the comparable ICEV in both segments. Although the overall costs of BEV leasing are cheaper than purchase, as this study does not consider resale, this could change if the hypothetical consumer resold their purchased car.
- **The vehicle ownership tax and the greenhouse gas (GHG) quota both have a marginal effect on total vehicle costs.** The vehicle ownership tax and the GHG quota, or the annual trading system payout to BEV drivers, both account for a small percentage of the total costs of both purchasing and leasing BEV and ICEV models. The vehicle ownership tax amounts to only 1% and 2% of the total purchase costs for the C-segment and the A-segment ICEV models, respectively, over four years. The GHG quota only accounts* for 3% of the total costs of purchasing the C-segment BEV and 4% for the A-segment BEV. Similar rates were seen for vehicle leasing.
- **Given a diverse range of charging scenarios, all BEV models were found to be cheaper to charge than fueling the comparable ICE gasoline models.** The analysis of various charging scenarios reveals that the total costs over a four-year period increase the more a user relies on public charging. For example, when charging the A-segment BEV ad hoc at alternating current (AC) public charging points 50% of the time and 50% with an AC home charger, the four-year costs rise to nearly €4,000 compared to almost €2,800 when only charging at home. The most expensive charging scenario for both BEV models was 80% AC public charging and 20% public direct current (DC) rate from a managed service provider, with costs reaching over €5,000 for the C-segment BEV and €4,700 for the A-segment BEV over four years. However, regardless of the charging strategies, the selected BEV models consistently have lower charging costs compared to fueling the comparable ICEV gasoline model within the same segment. Lower fueling and charging costs are observed for leased vehicles, as the assumed yearly mileage is lower compared to vehicle purchase.

» **For those with lower incomes, the costs of owning and leasing a new BEV are significantly higher than what these groups would on average pay for transportation costs.** For individuals in the lowest income bracket considered in this study, the annual cost of owning a C-segment BEV accounts for an unrealistically high share of the household net income—around 87% when including the one-time purchase incentive. In contrast, the annual cost for the C-segment BEV represents 6% of the highest income bracket's net income and 20% of the second highest bracket's net income. Even the much cheaper A-segment BEV amounts to 47% of the yearly household net income for the lowest income bracket when including the one-time purchase incentive and 33% for the second lowest bracket. This is still over five times higher than what the lowest income bracket would typically spend on transportation.

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INTRODUCTION

In Germany, the federal government has made significant efforts to promote the transition from internal combustion engine vehicles (ICEVs) to battery electric vehicles (BEVs). This support comes in the form of a one-time purchase incentive to reduce the costs of new BEVs, the development of a charging infrastructure network, and building awareness on the benefits of electromobility. The aim of these efforts is to reach 15 million BEVs on the road by 2030 (Bundesregierung, 2022a). This would reduce local air pollutant emissions from road transportation and help mitigate greenhouse gas (GHG) emissions from passenger cars. As a result of these efforts, progress on the electrification of passenger cars has already occurred. The BEV share of new passenger car registrations reached 18% in 2022, up from 14% in 2021 (Mock et al., 2023).

However, in the first quarter of 2023, the share of BEVs in new vehicle registrations in Germany stalled, falling to 14% from 18% in 2022 (Monteforte et al., 2023). This drop occurred after the one-time purchase incentive for consumers was reduced from €9,000 to €6,750. The German government also has signaled its intention to reduce the purchase incentive to €4,500 in 2024 and phase out the incentive at the end of 2025 (Bundesregierung, 2022b). Research shows that total vehicle costs stand as a key barrier to the adoption of BEVs, and that these vehicles are more likely to be owned by those with higher incomes (Krail and Plötz, 2023; Wappelhorst et al., 2022). Amid higher energy costs, inflation, and decreasing financial support from the government, the question of affordability of new BEVs in Germany becomes even more important.

If higher total cost of owning BEVs compared to ICEVs is left unaddressed by the German government, it could lead to a splintered transition where only those with higher incomes will see the benefits of BEV ownership (Wappelhorst et al., 2023). This could lead to a slower development of the used BEV market, as fewer BEVs will be brought on to the road to be resold. Additionally, CO_2 emission reduction targets may take longer to achieve if only a select part of the population can purchase a BEV. Experts estimate that the German government's goal of having 15 million BEVs on the road by 2030 will be missed by around 4 million vehicles (McGovan, 2023).

While there are many ways the BEV market could become more accessible from a cost perspective, such as through incentivizing a faster turnover of corporate fleets to bolster the used BEV market or offering affordable BEV carsharing, this report focuses on the new BEV market. This is only one aspect of improving access to BEVs, but as new BEV registrations currently do not make up a majority of total new vehicle registrations, it remains a key topic to explore. Against this background, we aim to answer two questions in this paper:

1. Is owning a new BEV cost competitive with a comparable new ICEV gasoline model, overall and independent of household income?
2. How does the monthly net household income influence the cost shares of owning a new BEV?

To answer these questions, this study compares the total costs of ownership (TCO) of both purchasing and leasing a new car over a four-year holding period. Additionally, it aims to show how affordability is influenced by current policy measures, like the one-time purchase incentive when buying a new BEV.

METHODOLOGY

We utilize a TCO analysis to better understand the cost competitiveness of new BEVs versus comparable new ICE gasoline models. The TCO analysis is applied to both new vehicle purchase and new vehicle leasing. The cost components are selected based on all costs applicable to a four-year ownership period for comparable BEV and gasoline models in two segments. We then utilize the results of the TCO to determine how the affordability differs by income groups in Germany. Costs are designated based on each vehicle component and assigned given the specified time frame (2023–2026), geographic region (Germany), and the other assumptions associated with vehicle ownership, which are described in detail in the following section. A four-year ownership period was selected to represent a middle ground between the average holding period in Germany of newly purchased vehicles (6.5 to 8 years) and typical leasing contracts (24, 36, or 48 months) (DAT, 2021). Prices are then assigned to each relevant vehicle component and totaled.

We utilize two TCO equations, one for vehicle purchase and one for vehicle leasing. The equations take into account the one-time purchase incentive and the GHG quota, which would reduce the total cost of ownership. The TCO for the newly purchased vehicle consist of fueling or charging, maintenance costs, insurance costs, and the vehicle ownership tax. It also includes a leasing rate, rather than new purchase cost, which involves specific conditions upon leasing such as a predetermined annual mileage and generally higher insurance rates. The equations for both scenarios are highlighted below.

$$TCO = (P - I) + (R - G)$$

Where:

TCO	Total Cost of Ownership for the purchase of a new car,
P	One-time purchase price including Value Added Tax (VAT),
I	One-time purchase incentive,
R	Regularly occurring ownership costs, and
G	Regularly occurring GHG quota

$$TCO = (M - I) + (R - G)$$

Where:

TCO	Total Cost of Ownership for the lease of a new car,
M	Monthly leasing rate including Value Added Tax (VAT),
I	One-time leasing incentive,
R	Regularly occurring leasing costs, and
G	Regularly occurring GHG quota

The TCOs for newly purchased and leased vehicles are then compared as a percentage of various net household income brackets in Germany to display the cost differences that purchasing or leasing a BEV and a comparable gasoline version has on different income groups. The steps of the analysis are highlighted in Figure 1.

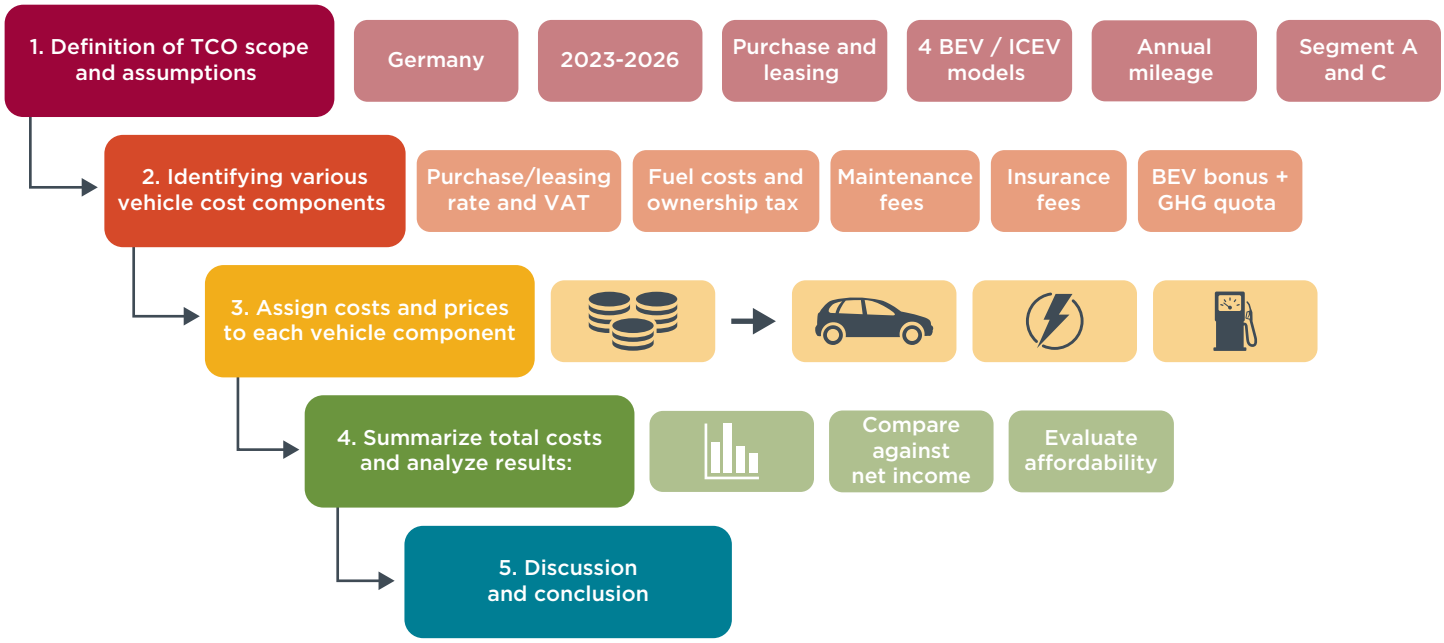

Figure 1. Overview of methodology and analysis steps.

VEHICLE SELECTION

To achieve an objective vehicle comparison, a BEV and a gasoline ICEV with similar vehicle specifications, including engine capacities and horse powers, were selected for the A and C vehicle segments. The A-segment, or the mini car segment, is the smallest vehicle segment as defined by the European Union passenger car classification system (EAFO, 2023). Due to their smaller size, mini cars are generally cheaper to purchase and operate. This makes analyzing the total costs of owning a vehicle within this segment important when considering accessibility of lower income groups. The C-segment, or the compact car segment, accounted for 15% of the new car registrations in the European Union in 2022 (ACEA, 2023). The high new registration share percentages of this segment also provide justification for conducting the TCO analysis within this segment, as it represents the largest share of new vehicles coming to the market, apart from SUVs. We do not analyze SUVs, as vehicles within the A- and C-segments are, on average, cheaper, which allows better access for households with lower incomes.

Within the C-segment, we selected two vehicles from Volkswagen, the ID.3 Pro, and the Golf VIII Style 2. Choosing vehicles within the same manufacturer allows for a more objective comparison, as this affects the overall purchase and maintenance costs. Due to a lack of comparable BEV and gasoline models from the same manufacturer within the mini car segment, we opted to analyze the Toyota Aygo X 1.0 gasoline and the Dacia Spring Extreme Electric 65. Automatic transmission was chosen for the vehicles when applicable, as BEV models do not have manual transmission. However, in the case of the Toyota Aygo X 1.0, the only available option as of May 2023 was a manual transmission. We additionally selected four-seat models so that they can accommodate families. This decision reflects that families in Germany can be at a higher risk of poverty due to higher monthly transport costs (Statistisches Bundesamt, 2022). The selected vehicles also have similar engine sizes and power, as this influences acceleration and energy consumption as well as the overall purchase price.

Real-world consumption values are obtained from two different sources. Values from the ADAC (General German Automobile Club) Eco Test are used for the Volkswagen ID.3 Pro, Toyota Aygo X 1.0, and the Dacia Spring Extreme Electric 65 (ADAC, 2023b). Values from Spritmonitor are used for the Volkswagen Golf VIII Style 2 due to a lack of test consumption values for this model from ADAC (Spritmonitor.de, 2023). The vehicle characteristics are shown in Table 1.

Table 1. List of selected vehicles and their individual characteristics

Vehicle	Powertrain	Transmission	Curb weight	Segment	Engine power	Engine capacity (cm^3) and battery capacity (kWh)	CO_2 value (g/km) at the tailpipe, based on the Worldwide harmonized Light vehicles Test Procedure	Real-world driving fuel or electricity consumption
Volkswagen ID.3 Pro	BEV	Automatic	1,815 kg	C	150 kW	62 kWh	0	19.3 kWh/100 km
Volkswagen Golf VIII Style 2	Gasoline	Automatic	1,437 kg	C	140 kW	1984 cm^3	148	7.26 l/100 km
Dacia Spring Extreme Electric 65	BEV	Automatic	1,050 kg	A	48 kW	27 kWh	0	17.9 kWh/100 km
Toyota Aygo X 1.0	Gasoline	Manual	1,090 kg	A	53 kw	998 cm^3	153	5.6 l/100 km

INPUT DATA

The TCO analyses utilize input data from various sources. In this section, we describe each of these cost components for the selected vehicle models, how the values for these components are sourced, and any assumptions that are associated with their costs. The analysis assumes that the vehicle is newly purchased or leased at the start of 2023 and held until the end of 2026. Resale values are not part of the analysis. The cost components considered in these scenarios included vehicle net purchase or monthly leasing prices, the applied VAT, the one-time purchase incentive, the annual greenhouse gas (GHG) quota, German vehicle ownership taxes, total cost of fueling or charging (gasoline or electricity), maintenance fees, and the cost of vehicle insurance. An overview of the input data and sources is found below in Table 2.

Table 2. Overview of input data, parameters, and sources

Input data	Parameters	Sources
Upfront costs		
Purchase price	Manufacturer's listed purchase price (gross and base)	Volkswagen Group (2023a), Volkswagen Group (2023b), Toyota Motor Corporation (2023), Automobile Dacia S.A. (2023)
Leasing rates	Manufacturer's listed monthly leasing rate	Volkswagen Group (2023a), Volkswagen Group (2023b), Toyota Motor Corporation (2023), Automobile Dacia S.A. (2023)
Subsidies		
One-time purchase incentive	Umweltbonus for BEVs (governmental and manufacturer's share)	Bundesregierung (2023)
Greenhouse gas quota	Annual trading quota incentive for BEVs	ADAC (2023 c)
Running costs		
Fuel prices	Gasoline E10 fuel prices, historical average applied from 2023 to 2026	ADAC (2023a)
Electricity prices and charging scenarios	Assumed cost of electricity, charging infrastructure scenarios, managed service provider subscription, and ad hoc charging cost add-ons	Eurostat (2023), EAFO (2023)
Maintenance fees	Monthly workshop fees	ADAC (2023d)
Insurance fees	Annual insurance fees	ADAC (2023e)

UPFRONT COSTS: PURCHASE PRICE AND LEASING RATES

The overall purchase price of a new vehicle involves several components, including the base price of the vehicle and the applicable VAT (Table 3). We derived purchase prices from the manufacturer's websites (Volkswagen Group, 2023a; Volkswagen Group 2023b; Toyota Motor Corporation, 2023; Automobile Dacia S.A., 2023). These give both the base price and the 19% VAT, which are added together to make up the gross price. For all vehicle models, the most basic configurations were selected.

Table 3. Gross and base vehicle purchase prices and value-added taxes in Germany for the selected vehicle models

Vehicle models	Base price	Value-added tax	Gross price
Volkswagen ID.3 Pro	€33,609	€6,386	€39,995
Volkswagen Golf VIII Style 2	€32,765	€6,225	€38,990
Dacia Spring – Extreme Electric 65	€20,630	€3,920	€24,550
Toyota Aygo X 1.0 gasoline	€13,353	€2,537	€15,890

The leasing rates shown in Table 4 are also derived from the manufacturer's website and are assumed to have no upfront or special payments applied to the contract, which when included would reduce the overall monthly payments. We assumed for vehicle purchasing, that the hypothetical users would drive an annual mileage of 12,843 km per year. This was derived from the latest estimate average yearly mileage from the German Motor Transport Authority (Kraftfahrt-Bundesamt, KBA) from 2021, the latest data available as of May 2023 (KBA, 2022). For leasing, the annual mileage allowance was assumed to be 10,000 km, which was the average annual mileage when leasing and leads to the cheapest monthly payment (LeasingMarkt.de, 2023).

Table 4. Leasing rates for the selected BEV and ICEV gasoline models in Germany

Vehicle models	Leasing rate (monthly)	Leasing total (four years)
Volkswagen ID.3 Pro	€430	€20,640
Volkswagen Golf VIII Style 2	€525	€25,200
Dacia Spring – Extreme Electric 65	€330	€15,840
Toyota Aygo X 1.0 gasoline	€169	€8,124

SUBSIDIES: ONE-TIME PURCHASE INCENTIVE AND THE GREENHOUSE GAS QUOTA

The overall purchase price for BEVs in Germany are reduced by the one-time purchase incentive in 2023 which provides a price reduction of €6,750, with €4,500 coming from the German government and €2,250 from vehicle manufacturers (Bundesregierung, 2023). As the manufacturers share reduces the list price, and therefore the 19% VAT, this brings the total reduction to €7,178. These rates only apply to BEVs with a gross list price of under €40,000. Any vehicles over this amount would receive a reduced incentive of €3,000 from the German government, with the manufacturer's share dropping to €1,500.

An additional reduction on the BEV cost components is the GHG quota, an instrument from the German federal government which pays consumers who utilize low emission-based modes of travel, including BEVs (BMUV, 2021). The bonus is obtained by opting into an emissions quota trading system at prices determined by the market and is available to both BEV purchasers and leasers. To calculate what the payout could be for BEV users, we utilize the GHG quota amount from ADAC (2023c), which guarantees users €300 per year in 2023. We apply this amount to each year that the BEV would be in use in this study, for a total of €1,200 for the four-year period.

The vehicle taxes and purchase incentive amounts are displayed in Table 5. The purchase incentive for leasing is obtained via an application process and is reimbursed later by the federal government. This process thus puts any upfront costs of leasing on the consumer until the bonus is received.

Table 5. Purchase incentive amounts and the yearly greenhouse gas quota in Germany for the selected battery electric vehicle models

Vehicle models	Government bonus	Manufacturer bonus	Bonus reduction in value-added tax from manufacturer	Total bonus	GHG Quota (per year)
Volkswagen ID.3 Pro	€4,500	€2,250	€428	€7,178	€300
Volkswagen Golf VIII Style 2	-	-	-	-	-
Dacia Spring – Extreme Electric 65	€4,500	€2,250	€428	€7,178	€300
Toyota Aygo X 1.0	-	-	-	-	-

MAINTENANCE

For the calculation of maintenance costs, we utilize rates from ADAC (2023d), which lists the workshop costs of the vehicle. These rates are given on a monthly basis and cover typical expenses such as repairs, workshop fees, tire costs, car washing, and oil changes in the case of the ICEVs. The costs given by ADAC are calculated assuming a mileage of 15,000 km per year. We display the costs in this analysis as a share of the percent mileage difference between ADAC's estimations and our annual mileage assumption. As this study assumes a yearly mileage of 12,843 km for purchase and 10,000 km for leasing, monthly maintenance costs have been altered to reflect the lower mileage impact on the vehicle. Detailed maintenance costs can be found in the appendix.

VEHICLE INSURANCE

The cost of insuring a vehicle in Germany varies based on the specific insurance plan, vehicle characteristics, and a driver's individual attributes and driving history, among other things. To estimate the insurance rates for each model considered, we utilize the ADAC car insurance online calculator (ADAC, 2023e). Insurance rates are derived utilizing the same user characteristics and vehicle usage assumptions in order to receive rates that reflect a difference solely based on the vehicle's technical characteristics, including the model attributes, brand, vehicle segment, and powertrain. The specific user attributes include that the vehicle is newly acquired and located in Berlin, with an average user age of 45, for private use only, a first registration date of January 1st, 2023, a standard license plate, a driver's license beginning January 1st, 2003, and without another vehicle being insured. For both vehicle purchase and leasing, the fully comprehensive insurance was selected, as this is often required when leasing a vehicle or financing a vehicle purchase, leading to higher insurance rates. For specific insurance costs, see the appendix.

FUEL AND ELECTRICITY

Fuel and electricity prices are not static and are prone to change over time given a multitude of different factors, including supply and demand, the costs of production, and government policies. To derive the costs for the selected gasoline models as part of our analysis, we utilize two different mileage assumptions based on vehicle purchase or leasing. To estimate what the cost of gasoline would be in Germany from 2023 through 2026, we use historical data derived from ADAC for gasoline E10. To estimate what future gasoline E10 prices would be, we take the average change of yearly costs from 2011 until April 2023 to receive an average yearly percent change in gasoline E10 prices of 1.22%. The price for 2023 is derived by taking the average of the first four months of the year, and the yearly percent change is then applied to each additional year in the analysis to formulate future costs of the fuel per liter. Prices beginning in 2011 are utilized, as this reflects the introduction of price values for gasoline E10 in this source. The price estimations are provided in Table 6.

Table 6. Gasoline E10 price projections in Germany from 2023 to 2026

Gasoline E10	2023	2024	2025	2026
Euros per liter	€1.77	€1.78	€1.79	€1.80

The estimation of increasing prices of gasoline E10 fuels are in line Krail & Leidenberger (2023), and reflect the cost-inflating effect Germany's carbon price instrument will likely have on gasoline E10 in the coming years, as the carbon price is intended to encourage more sustainable sources of fuel and power (Bundesfinanzministerium, 2022).

For the price of electricity, we utilize private household consumption rates. The selected range is based on a yearly consumption of between 5,000 kWh and 15,000 kWh. The average yearly consumption of electricity in Germany in 2018, the latest data provided as of May 2023, was 3,113 kWh per year (Statistisches Bundesamt, 2023). With the additional energy consumption coming from the selected BEV models, the consumption would reach above 5,000 kWh in both cases. We assume that the electricity rates will remain constant for the coming years and utilize the 2022 value of electricity in Germany of €0.30 per kWh, the most recent data from Eurostat as of June 2023 (Eurostat, 2023). This reflects a middle-ground scenario, where prices stay constant rather than significantly increasing or decreasing, as other studies predict uncertain costs of electricity in Germany in the medium term (Krail and Leidenberger, 2023).

We note that the increasing share of electricity produced by renewables will likely reduce the costs of electricity in Germany and Europe more widely (Agora Energiewende, 2021). However, given the ongoing war in Ukraine, which led to a spike in electricity prices in the second half of 2022, it is not certain that electricity costs will drastically reduce in the coming years. In response to rising electricity prices, the German government instituted a price cap, which applies retroactively from January 1, 2023, limiting the costs of electricity to €0.40 per kWh for private households and businesses (Bundesregierung, 2022c). This law is set to expire until the end of 2023, after which prices could rise given ongoing inflation and energy supply chain concerns.

In order to represent the various ways in which BEV drivers can charge their vehicles, and the differences in price rates, we have developed four different charging scenarios. These scenarios differentiate rates between alternating current (AC) charging, referred to as normal charging, and direct current (DC) charging, or fast charging. Prices are further differentiated by whether consumers have access to a managed service provider subscription rate (MSP), which is generally cheaper than the standard ad hoc rate. The four designed scenarios reflect different user charging strategies and include:

1. 100% at-home charging (AC)
2. 100% public MSP charging (AC)
3. 50% public ad hoc (AC) and 50% at-home charging (AC)
4. 80% public MSP (AC) and 20% public MSP (DC)

The cost of electricity, at €0.30 per kWh, is assumed to be the rate incurred for at-home charging. In order to account for the additional costs of public charging (either MSP or ad hoc) add-on values were included to the price of electricity used. These additional costs were derived from the European Alternative Fuels Observatory (EAFO) recharging price calculator (EAFO, 2023), which provides country-wide price estimations for AC and DC charging based on whether the simulated charging session is utilizing an MSP subscription or ad hoc. The overall prices shown do not consider the additional cost that would come from the purchase and installation of wall box charging units for homes in Germany, which is around €2,000 (Bieker et al., 2022). Additionally, this study does not consider the use of smart metering, which allows for

optimization of power grid output and enables time-based charging, therefore lowering charging rates. The various charging rates are displayed in Table 7.

Table 7. Prices of electricity and managed service provider or ad hoc markup differentiated by normal alternating current (AC) and fast direct current (DC) charging in Germany

Cost of electricity per kWh (Home)	MSP add-on (AC) per kWh (Public)	Ad hoc add-on (AC) per kWh (Public)	MSP add-on (DC) per kWh (Public)	Ad hoc add-on (DC) per kWh (Public)
€0.30	+€0.19	+€0.26	+€0.29	+€0.40

OWNERSHIP TAX

In Germany, vehicle owners and leasers pay annual ownership taxes which are calculated based on the engine capacity and CO_2 emissions. BEVs with CO_2 emissions of 0 g/km are exempt from paying annual ownership tax for 10 years if they are registered for the first time before 2025 (Wappelhorst, 2020). Vehicles emitting up to 95 g of CO_2/km according to the Worldwide harmonized Light vehicles Test Procedure (WLTP) are exempt from CO_2 taxation. Vehicles emitting between 96 and 115 g of CO_2/km (WLTP) are charged a rate of €2 per gram. Those emitting between 116 and 135 g of CO_2/km are charged €2.2 per gram, and those emitting 136 to 195 g of CO_2/km are charged €2.5 per gram. Vehicles emitting 195 g CO_2/km or more of CO_2 are charged €4 per gram. The engine capacity also contributes to the costs with an additional €2 applied per 100 cm^3. Therefore, for example, the Golf VIII Style 2 with an engine capacity of 1,984 and CO_2 value of 148 g/km would be charged €40 for the engine capacity and €116.5 for the CO_2 value over a one-year period. Specific ownership tax amounts can be found in the appendix.

TCO RESULTS FOR THE PURCHASE AND LEASE OF A NEW CAR

This section presents the results of the TCO analysis, which aims to answer if new BEVs are cost competitive with comparable new ICEV gasoline models.

TOTAL COST OF OWNERSHIP: PURCHASE

The four-year TCO for the selected vehicle models are shown in Figure 2. The categories displayed consist of the base prices, VAT, the ownership tax for ICEV gasoline models, costs of fuel and electricity, insurance costs, and maintenance fees. All costs shown in this figure are projected for 2023 through 2026 and assume for the BEV models that 100% home charging occurs. We display this charging scenario as the baseline, as this is the cheapest scenario for charging the BEV models, but later analyze the other charging scenarios and the costs differences. The one-time purchase incentive, shown in the green striped box, lowers the overall purchase price and is therefore shown above the bar to reflect the costs that would occur without its application. The GHG quota, which gives additional money to consumers but does not directly lower the purchase price, insurance, or other costs, is displayed above this, and does not add to the total costs of ownership.

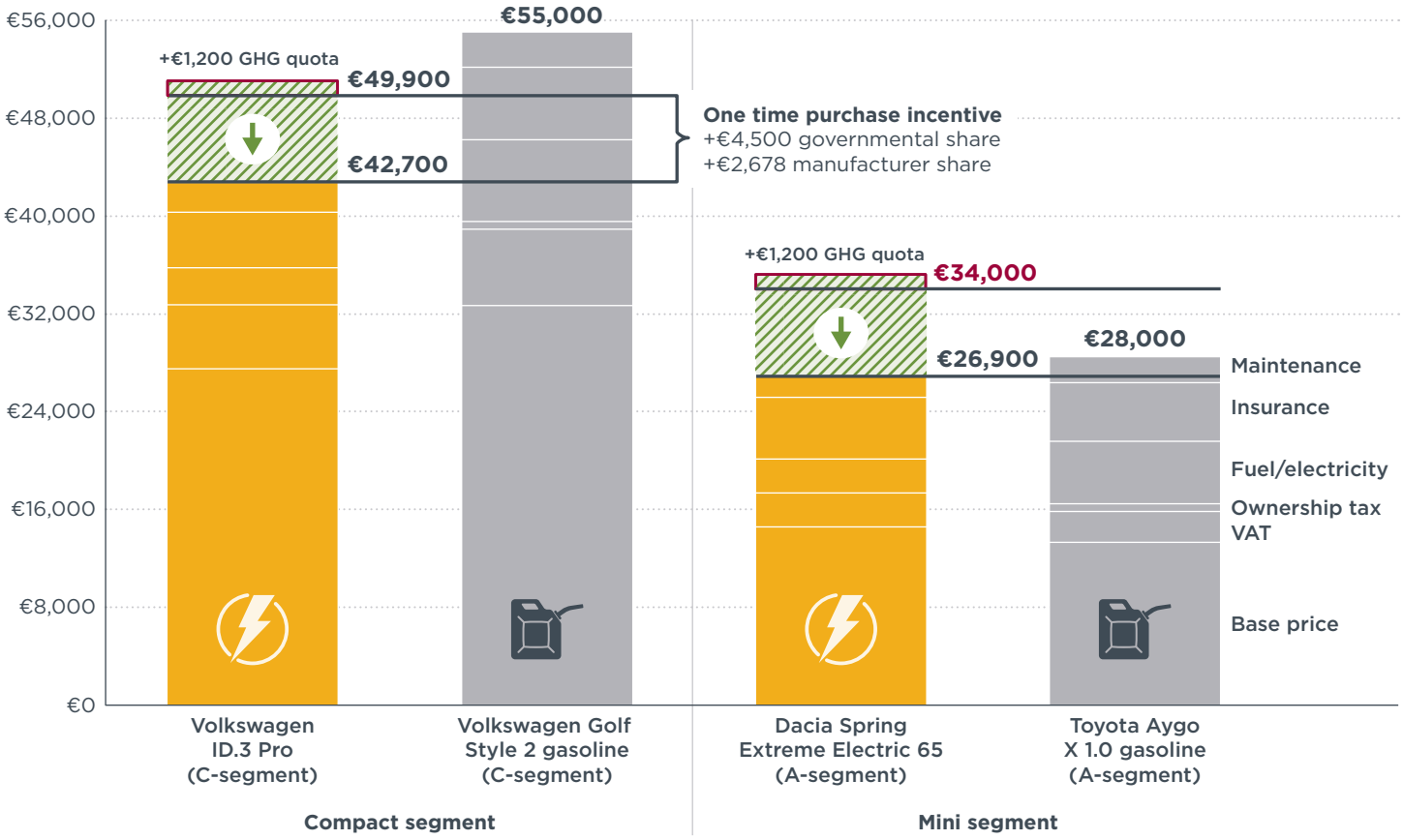

Figure 2. Four-year total cost of ownership in Germany from 2023 to 2026 assuming 100% alternating current home charging with and without the 2023 purchase incentive and four-year application of the GHG quota

The C-segment vehicles, which include the VW ID.3 and the Golf VIII Style 2 are significantly more expensive over the four-year period compared to the A-segment, with the costs of owning the Golf VIII Style 2 reaching around €55,000. This is almost double the costs of the Toyota Aygo X 1.0, which costs around €28,000 over the same period. Within the C-segment, the BEV VW ID.3 is around €12,300 cheaper than the

ICEV gasoline Golf VIII Style 2, at €42,700, when considering the one-time purchase incentive. Without the incentive, the ID.3 is about €5,100 cheaper at €49,900. This is not the case, however, for the Dacia Spring Extreme Electric 65, where the total costs are roughly €34,000 without incentives, or €6,000 more expensive over four years than the Toyota Aygo X 1.0. The Dacia becomes cheaper than the Aygo when the purchase incentive is applied, at €26,900, or about €1,600 cheaper.

The biggest contributor to the cost of ownership remains the base price. The second most expensive components are the VAT for the ID.3 and fuel for the Golf, and Aygo, and insurance for the Dacia. Both BEV models had higher base prices than the comparable ICE gasoline models. The vehicle with the largest base price was the ID.3, at around €34,000 without incentives, accounting for more than two thirds of the total cost. The base price of the Dacia Spring accounted for nearly 64% of the four-year costs, whereas the base prices of the Golf VIII Style 2 and the Toyota Aygo were lower than the BEV models, at around 60% and 47%, respectively. Fueling the ICE gasoline models was significantly more expensive than charging the BEVs at home. The cost of fuel was around €6,700 for the Golf VIII Style 2 and €5,100 for the Toyota Aygo over the four years. Charging the Volkswagen ID.3 at home costs around €3,000 over four years, which is less than half the price of fueling the Golf. The Dacia Spring is also significantly cheaper to charge compared to the Toyota Aygo, at around €2,800. The ownership tax for the ICEVs amount to only 1% and 2% of the total costs of the Golf and the Toyota Aygo, respectively. The GHG quota, like the ownership tax, also has a marginal effect on the total costs, equaling about 3% for the ID.3 and 4% for the Dacia Spring.

TOTAL COST OF OWNERSHIP: LEASING

The costs of leasing a vehicle differs from that of purchasing new, as the consumer pays a monthly leasing rate rather than a purchase price. Additionally, the annual mileage can also differ given the contract the consumer has agreed to, where in this study we assume 10,000 km are driven per year. The costs of leasing for the four selected vehicle models are shown in Figure 3.

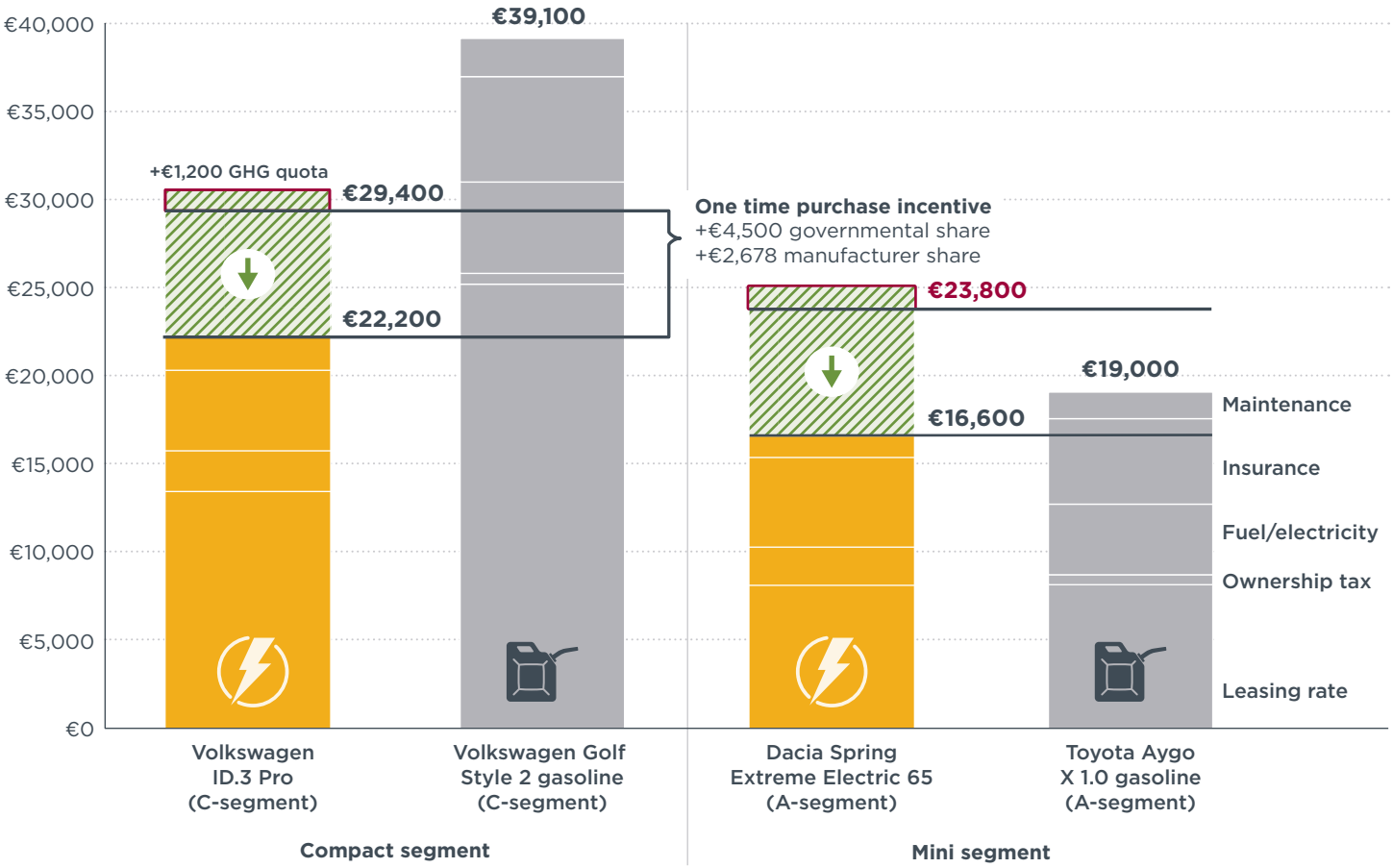

Figure 3. Four-year total cost of ownership for leasing vehicles in Germany from 2023 to 2026, assuming 100% alternating current home charging and including the 2023 one-time purchase incentive and a four-year application of the GHG quota

The total costs of leasing follow the general trend displayed for the purchase TCO, where the cost of leasing the C-segment BEV model, the VW ID.3, is cheaper over four years compared to the Golf VIII Style 2. Additionally, it is cheaper to lease a BEV over four years compared to purchasing new when not considering vehicle resale. The total costs for the ID.3 are around €22,200, versus roughly €39,100 for the Golf, with the application of the one-time purchase incentive. Within the A-segment, it is 15% cheaper to lease the Dacia Spring, at nearly €16,600 compared to almost €19,000 for the Toyota Aygo. However, without the incentive it would be more expensive to lease the Dacia compared to the Aygo, at €23,800 versus €19,000. For the Volkswagen ID.3 and the Golf, the monthly leasing cost makes up a majority of the total costs over the four-year period, at around 60% for the ID.3 and 64% for the Golf VIII Style 2. The Toyota Aygo has a significantly lower leasing rate and, therefore, has a lower share of the total costs at 43%. Similar to the vehicle purchase TCO, the costs for leasing are not greatly reduced by the GHG quota, as the GHG quota accounts for 4% of the total costs for the ID.3 and 5% for the Dacia Spring.

COSTS OF CHARGING AND FUELING

In this section we display the various charging scenarios for the selected BEV models and compare those costs to fueling the ICEV models with gasoline. The total costs of charging a C-segment BEV when considering vehicle purchase over four years becomes more expensive the more reliant a user is on public and fast charging. Figure 4 shows the fuel and electricity costs for the four charging scenarios described above for the VW ID.3 and VW Golf VIII Style 2. None of the charging scenarios for the VW ID.3 are more expensive than fueling the VW Golf VIII Style 2, which reached nearly €6,700 over the four-year period. The most expensive charging scenario is the 80% MSP (AC) and 20% MSP (DC) charging scenario at above €5,000. This scenario is still around 25% cheaper than fueling the Golf VIII Style 2. The least expensive charging scenario is the 100% at-home charging (AC) scenario, at almost €3,000, which is about 55% cheaper than the cost of fueling the Golf VIII Style 2.

Figure 4. Four-year costs of gasoline fueling versus electric charging scenarios in the compact car segment for vehicle purchase

When considering the mini car or A-segment, the cost of charging the Dacia Spring Extreme Electric 65 is still cheaper overall compared to fueling the Toyota Aygo X 1.0 (Figure 5). However, the cost differences as a percentage were smaller than those of the compact car segment due to a lower energy consumption difference between the two vehicle models. For example, the costs of fueling the Toyota are about €5,100, whereas the costs of charging the Dacia Spring with 100% at-home (AC) are almost €2,800, making this scenario 45% cheaper; this same scenario comparison is 55% cheaper in the compact car segment.

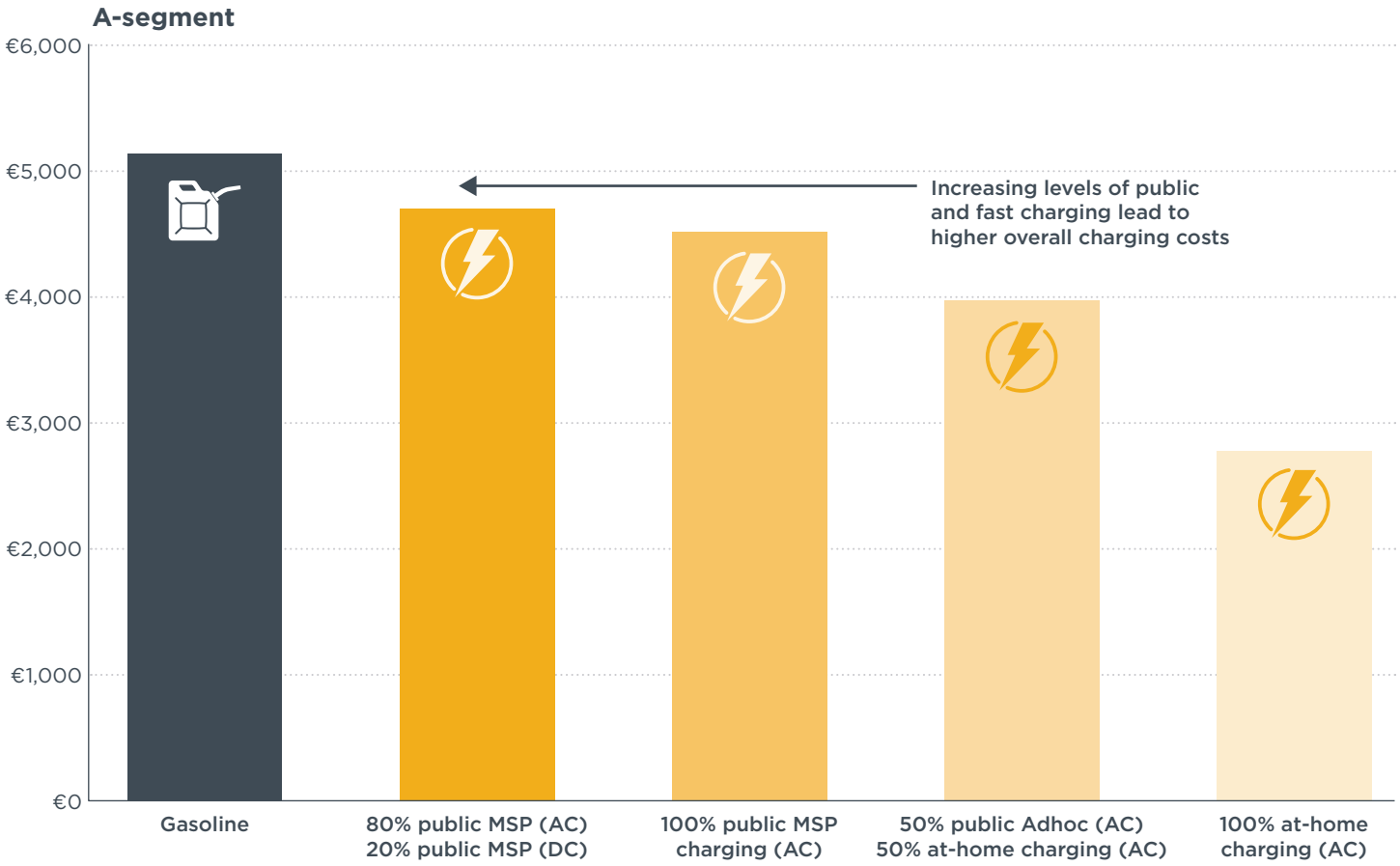

Figure 5. Four-year costs of gasoline fueling versus electric charging scenarios in the mini car segment for vehicle purchase

Given that the assumptions for electricity and gas prices remain the same, charging rates for leased vehicles follow a similar trend to the figures shown above but have lower overall fueling and charging costs over the four-year period due to the lower annual mileage.

COMPARING TOTAL COST OF OWNERSHIP AS A PERCENT OF INCOME

The results of the TCO analysis show that owning or leasing a BEV in Germany over four years is cheaper than a comparable ICE gasoline model with the application of the one-time purchase incentive. Despite this, it is not clear whether these vehicles are affordable based on one's income. Here we examine these costs as a share of different income levels for private households in Germany. The income data is derived from the Statistisches Bundesamt 2021 Datenreport, where we utilize the grouped net income of private households (Statistisches Bundesamt, 2021). This data source defines households as a group of people who live together and jointly share household expenses. Those who live alone are considered independent households and are also included within the data. Net household income is the salary from employment after the deduction of the income tax, wage tax, church tax, the solidarity surcharge, and social security contributions. Utilizing net household income, rather than gross household income, gives a better picture of the money households in Germany have to spend on necessary expenses, such as transportation costs.

In 2018, as reported by Statistisches Bundesamt (2021), consumer spending on transportation in Germany increases as household net income goes up, shown in Figure 6. The largest share of the surveyed population occurred in the second lowest net monthly income bracket, €1,300–2,600, at 30%, followed by the largest net monthly income bracket of €5,000 and above, at 22%. The share of income spent on transportation, and in particular passenger cars, increases within the higher income groups, where the highest income group paid around 16% of their monthly net income on transport related costs and the lowest paid around 8% (Statistisches Bundesamt, 2021).

Figure 6. Household monthly net income groups by percent of the German population and consumer transport spending as a share of monthly net income in 2018

A more nuanced income group distribution within the same report from Statistisches Bundesamt utilizes the rate of ownership for new and used passenger cars, the share of new vehicles, and the percent of passenger cars leased in Germany in 2019, shown below in Figure 7. The figure shows a higher percent of new and used passenger car ownership amongst the highest income groups. For example, 97 percent of those making a net monthly income of €5,000–€18,000 owned at least one passenger car and over half were new vehicles. This is in contrast to the lowest income bracket, where new and used vehicle ownership did not surpass 50%, and only around 12% were new. Vehicle leasing saw significantly lower rates of participation compared to new vehicle purchases but followed the same trend where the higher income brackets had higher leasing rates.

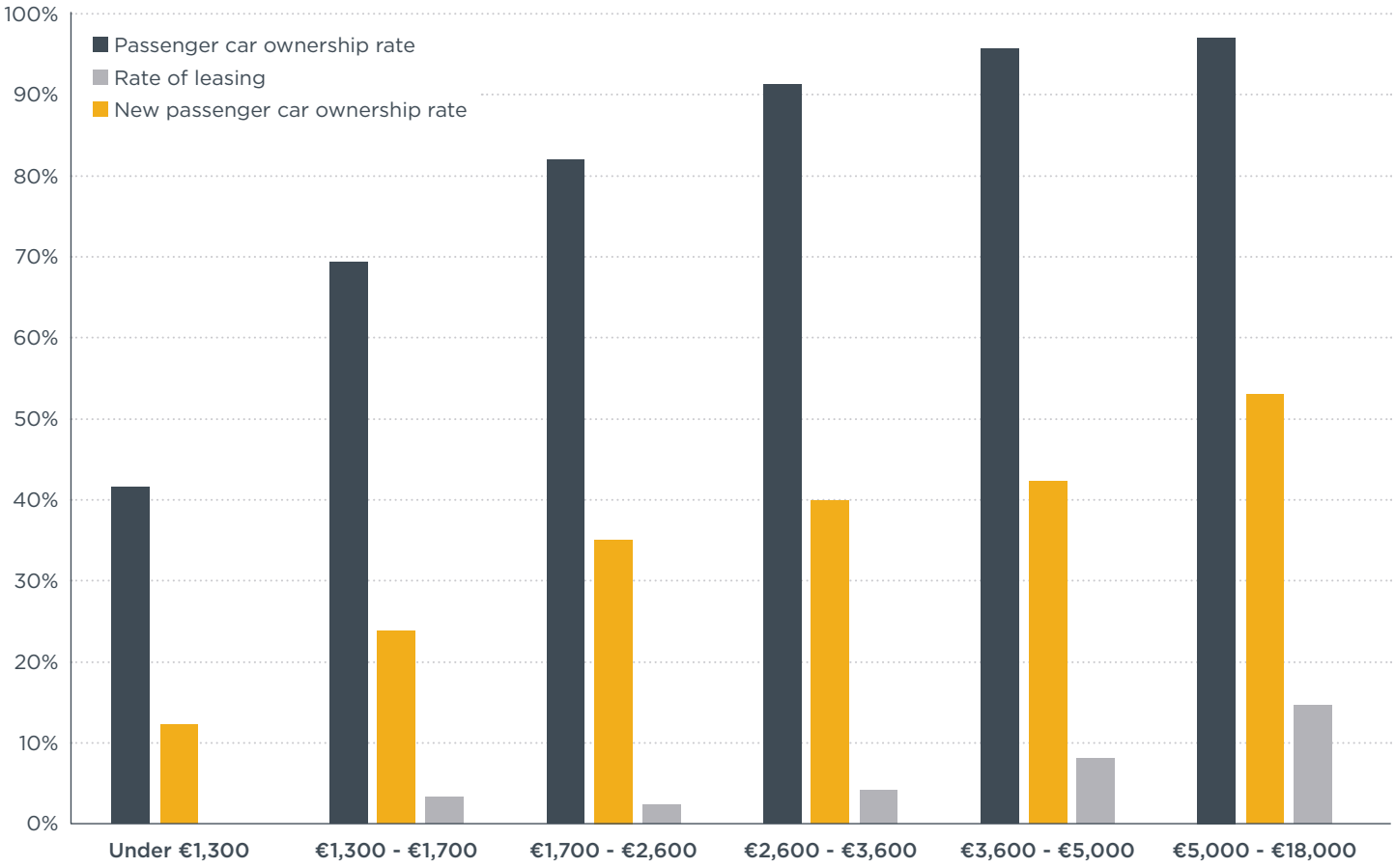

Figure 7. Total passenger car ownership rate, new passenger car ownership rate, and passenger car leasing rate in Germany in 2019

VEHICLE PURCHASE AND INCOME

To understand if the costs of purchasing the selected BEV models are affordable for consumers in Germany, we compare the monthly costs of vehicle purchase as a percent share of the monthly household net income, utilizing the six brackets highlighted above. Figure 8 displays these costs assuming a 100% at-home charging rate and the inclusion of the one-time purchase incentive for the BEV models. For those in the lowest monthly income bracket, €1,200–€1,300, the monthly costs of the ID.3 amount to an 87% share of the monthly household net income and the Golf accounted for a 96% share. For reference, in 2018 transportation accounted for 8% of private consumer expenditure within the same income bracket on average (Statistisches Bundesamt, 2021). In contrast, the costs of the ID.3 accounted for 6% of monthly costs for the highest income bracket and 21% for the second highest, a significantly lower share.

Figure 8. Total costs of purchasing selected vehicle models as a share of monthly household net income in Germany including the one-time purchase incentive

In the A-segment, the Dacia Spring amounts to 47% of the monthly household net income in the lowest income bracket when including government support, and about 33% for the second lowest income bracket. This is a significantly lower share of income than for the C-segment but remains a much higher amount than the average share of income spent on transportation-related expenses in Germany in 2018. For example, those making more than €5,000 net per month spent on average 16% of their household monthly net income on transport, whereas those making less than €1,300 net per month only spent 8% (Statistisches Bundesamt, 2021). This makes the costs of the Dacia Spring, the cheapest BEV model considered in this report, a more than five times higher share than what the lowest income bracket would pay on average, assuming the average transport cost shares remained roughly the same from 2023 to 2026 as in 2018.

The purchase cost reduction from the one-time BEV purchase incentive as a share of the household monthly net income is larger for those in the lower income groups, as shown in Figure 9. Taking the example of the Dacia Spring, the lowest income bracket with a monthly household net income of €1,200 sees a 13% reduction in the monthly costs of vehicle ownership. In comparison, the highest income bracket sees a reduction of just 1%, as the one-time purchase incentive amount for a BEV is the same amount for all income groups. Therefore, the cost reduction benefit for those making €1,200 net per month is nearly 13 times higher than those making €18,000 net per month.

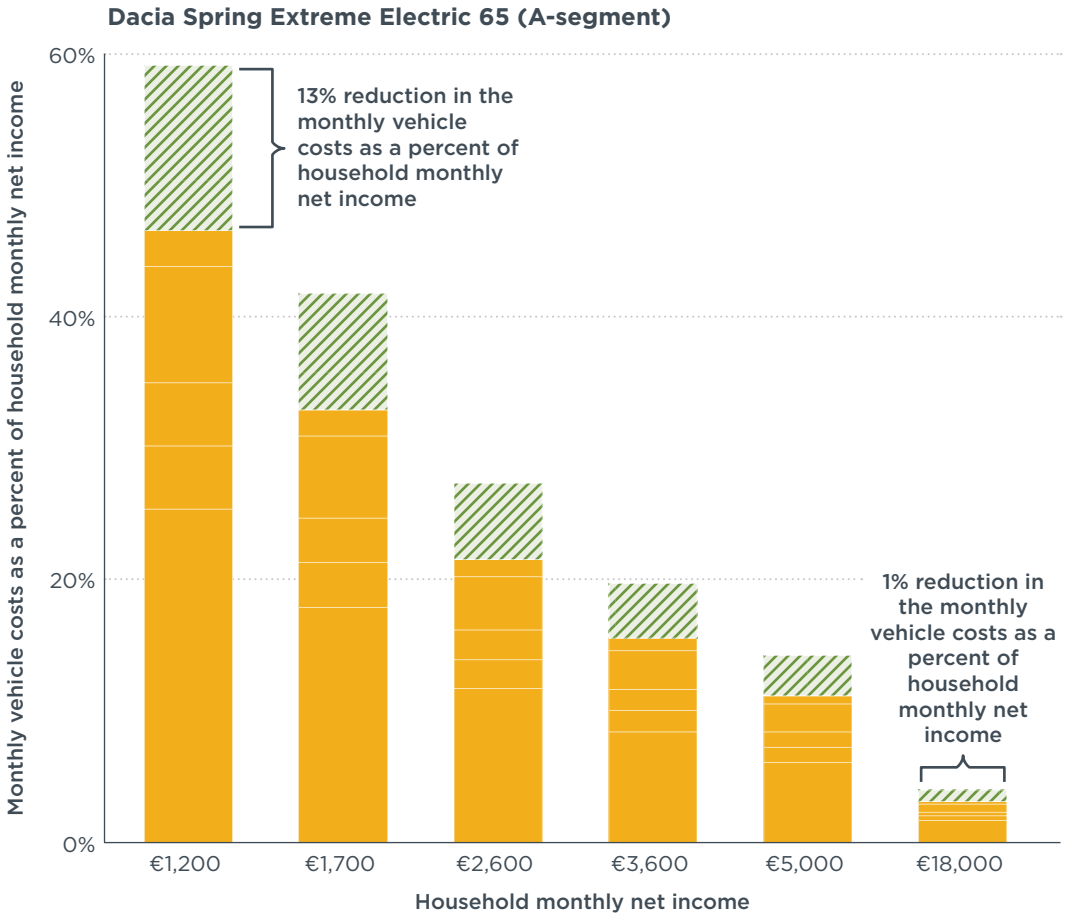

Figure 9. Monthly vehicle costs for the purchase of the Dacia Spring Extreme Electric 65 (A-segment) as a percent of household monthly net income in Germany

VEHICLE LEASING AND INCOME

We additionally explore the affordability of vehicle leasing and how this relates to household net income levels. The total costs of leasing the selected vehicle models as a share of the monthly household net income in Germany, including the one-time purchase incentive, is displayed in Figure 10. Compared to the purchase costs of the Volkswagen ID.3 Pro, the total leasing costs as a share of monthly household net income levels are lower, at around 38% for the households making €1,200 net per month. This is compared to over 82% for purchase for the same income level. The same holds true for the Golf VIII Style 2, where the costs of leasing were around 69% of the monthly net income for those making €1,200 net per month versus 89% for purchase. This difference between purchasing and leasing is reflected in the reduced costs of charging and fueling due to a lower annual mileage limit of 10,000 km and a lower monthly leasing rate compared to overall costs of vehicle purchase. Within the C-segment, the ID.3 is around 30% cheaper for the lowest income bracket to lease when compared to the Golf. However, like with vehicle purchase, these costs would still significantly outpace the highest average expenditure on transportation costs in Germany, where those making above €5,000 net per month in 2018 spent around 16% of their household net income, versus 38% for the lowest group to lease (Statistisches Bundesamt, 2021).

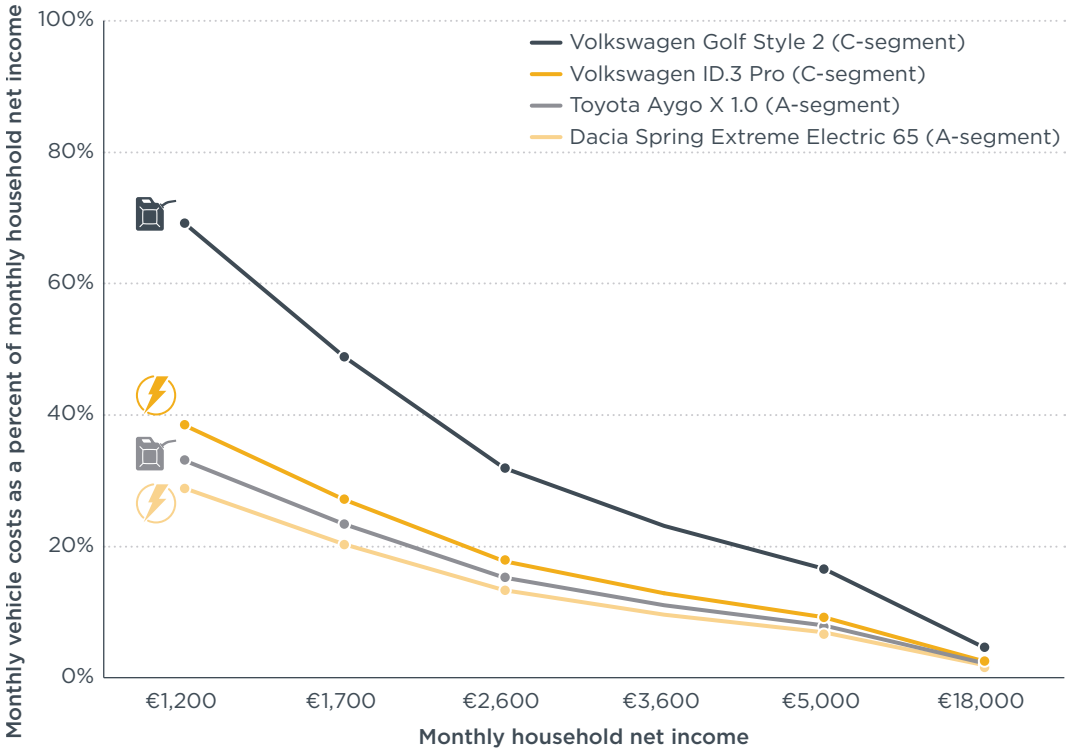

Figure 10. Total costs of leasing selected vehicle models as a share of monthly household net income in Germany including the one-time purchase incentive

Within the A-segment, the costs of the Dacia Spring and Toyota Aygo X 1.0 account for nearly the same share of the monthly household net income when the one-time purchase incentive is included. For those who have a monthly net household income of €1,200, the yearly leasing costs account for 29% of the yearly household net income for the Dacia Spring and 33% for the Toyota Aygo X 1.0. This is the lowest vehicle cost share of the four selected vehicle models.

DISCUSSION

The results of the paper show that with governmental support in the form of a one-time purchase incentive, new BEVs are cheaper than a comparable new ICEV gasoline model. However, both vehicle types remain significantly more expensive than what those with lower incomes would normally pay for transportation. Here we discuss some of the limitations to the scope of the paper and provide a more nuanced discussion on ways to enhance access to BEVs in Germany more broadly.

To start, the depreciated values of the four selected vehicle models are not considered in this paper. If the vehicles are resold at the end of the four-year period and the depreciated value is reduced from the total costs of owning the vehicle, those cost totals would be lower. However, this reduction would apply to both the ICEV and BEV models. It is not clear what the depreciated value of the four BEV and ICEV models would be, as vehicle depreciation is influenced by a multitude of factors, including the state of the vehicle market, the vehicle manufacturer and model, the condition of the vehicle, and the ownership history. However, even without considering vehicle depreciation, the costs for purchasing new ICEV and BEV vehicle models are still likely out of the range of affordability for a large part of the German population. This is true even when the current one-time purchase incentive is considered, which has a higher cost reduction effect as percent of income for those in lower income groups. Therefore, additional efforts that go beyond financial subsidies for new vehicles should be examined.

Additionally, we did not consider the total costs of purchasing used BEVs in this report. A large portion of consumers in Germany opt to purchase a used car, as it is often significantly cheaper than a new vehicle. However, waiting for a used electric vehicle market to develop organically and without supportive action from the government may prevent years of progress in reducing emissions from the vehicle stock. Currently, ICEVs still make up a large part of new registrations, and new BEVs in Germany only made up 14% of total new vehicle registrations in the first quarter of 2023 (Monteforte et al., 2023). With a 13-year average lifetime of vehicles in Germany, any new ICEVs coming to the market will likely continue to contribute to emissions from the stock for years to come (Bieker, 2021).

A robust used BEV market may take more time to develop and the phase out of new ICEV registrations in 2035 makes it essential for new and used BEVs to be accessible to a larger population group. A two-sided approach to the transition which promotes a rapid uptake in new BEV registrations while also encouraging the development of a used BEV market could significantly enhance access to BEVs overall. Germany currently supplements used BEV purchases through a one-time purchase incentive of €3,000 from the government and €1,500 from manufacturers. However, this only applies if the vehicle was not already subsidized when initially purchased (Bundesregierung, 2023). Therefore, many of the BEVs already in use would likely not qualify. One way to further bolster the used BEV market could be to promote the uptake and faster turnover of BEVs by companies; this topic could be the focus of future research.

A focus on actions financially supporting new BEV leasing could also aid in broadening access. One option could be an income-based BEV leasing incentive. To illustrate this, we show the costs of leasing the Volkswagen ID.3 with such an incentive (Figure 11). If the current one-time purchase incentive was capped to exclude the top two income groups considered in the paper, and the government doubled the incentive amounts for the two lowest income brackets of those making €1,700 or less, the costs as a share of the monthly net income would be significantly reduced. For example, if the one-time purchase amount for the lowest income bracket was doubled from €7,178 to €14,356, the cost share per month over a four-year ownership period would drop to

about 26%, where it is above 50% with no incentive and about 38% with the current purchase incentive reduction. The same effect would be seen on the second-lowest income bracket as well, where leasing costs would drop to around 19% of this bracket's monthly net income.

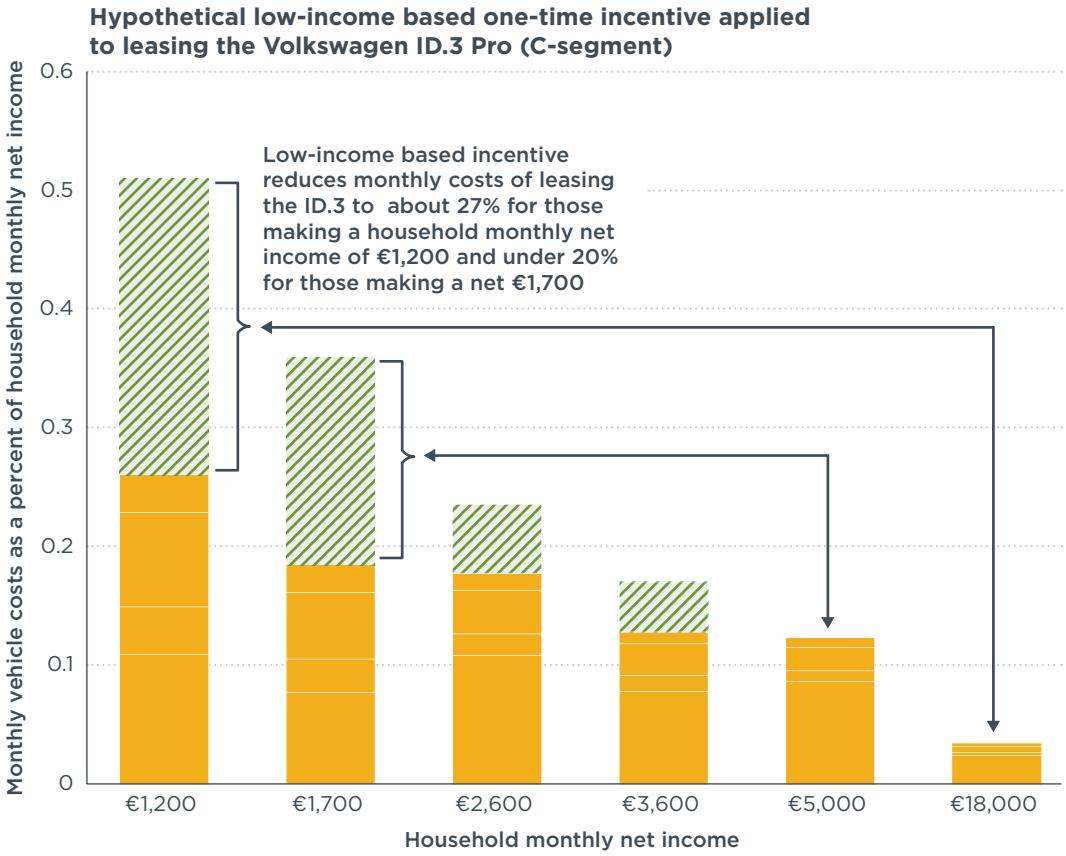

Figure 11. Hypothetical low-income based one-time incentive applied to leasing the Volkswagen ID.3 Pro (C-Segment)

The hypothetical incentive is just one example of many options that the German government could implement to reduce the costs of owning or leasing both new and used BEVs. These could come in congruency with regulations on manufacturers to produce smaller and lower cost BEVs. A multitude of actions will be necessary to achieve Germany's climate change goals, as no single approach can deliver on its own.

CONCLUSIONS

Ensuring people of all income groups have access to battery electric vehicles is critical to guarantee that no one is left behind in the transition from fossil fuel-based cars to electric. Costs remain a major barrier to BEV uptake and are for many in Germany a significantly higher portion of their net income than what these groups would on average pay for transportation. Understanding the costs of new BEV ownership in comparison to ICEVs can help the German government make informed decisions on transportation policy going forward. However, supporting vehicle electrification goes beyond just new registrations and decarbonizing the private passenger car fleet will not be achieved with a single approach. From this analysis, the following conclusions can be drawn:

The total cost of ownership of a BEV over four years without the one-time purchase incentive can be cheaper than an ICE gasoline model, but this is dependent on the vehicle segment. Within the compact car segment (C), the total costs of owning a new BEV, the Volkswagen ID.3 Pro, without additional financial support from the one-time purchase incentive, is lower than for the comparable ICE gasoline model, the Golf VIII Style 2. At around €49,900, the costs to purchase the ID.3 were over €5,100 cheaper than the Golf, which totaled to nearly €55,000 over four years. Within the mini car segment, the Dacia Spring Extreme Electric 65, at above €34,000, was about €6,000 more expensive than the comparable Toyota Aygo X 1.0, with costs of around €28,000. The biggest cost factor for all models was the base price, followed by the VAT for the ID.3, gasoline fueling for the Golf and Toyota Aygo, and insurance for the Dacia Spring.

With the current one-time purchase incentive, both BEV models have a lower cost of ownership over four years than the comparable ICEV models. The purchase incentive, which provides €4,500 from the government and €2,678 from manufacturers, plays a crucial role in reducing the total costs of the Dacia Spring of around €26,900 to below those of the Toyota Aygo, which is approximately €28,000. Additionally, it significantly lowers the costs of the Volkswagen ID.3 to nearly €42,700 over four years, or €12,300 cheaper than the Golf with costs of €55,000.

The total costs of leasing a BEV without the one-time incentive are cheaper than leasing an ICEV within the compact car segment but not the mini car segment. Leasing costs for the C-segment BEV ID.3 were lower compared to the ICEV Golf VIII Style 2, at around €22,200 versus nearly €39,100 when including the one-time purchase incentive. It is still cheaper to lease the ID.3 without the incentive, with total costs of about €29,400. In the A-segment, leasing the Dacia Spring is cheaper than the Toyota Aygo at €16,600 versus €19,000 with the application of the purchase incentive. However, without the incentive, the costs are higher at €23,800. Monthly leasing costs constitute over 60% of the total costs of leasing for the ID.3 and the Golf. The overall costs of BEV leasing are cheaper than purchasing; however, as this study does not consider resale, this could change if a consumer resold their purchased vehicle after four years.

The vehicle ownership tax and the GHG quota both have a marginal effect on total vehicle costs. The vehicle ownership tax and the GHG quota account for a small percent of the total costs of both purchasing and leasing BEV and ICEV models. The vehicle ownership tax amounts to only 1% and 2% of the total purchase costs for the Golf VIII Style 2 and the Toyota Aygo over 4 years. The GHG quota only accounts for 3% of the total costs of purchasing the ID.3 and 4% for the Dacia Spring over the same period. Similar rates are seen for vehicle leasing as well. Strengthening these two instruments to charge a higher tax rate on ICEV models and provide a higher GHG quota amount could help lower BEV costs.

Given a diverse range of charging scenarios, the BEV models are cheaper to charge than fueling comparable ICE gasoline models. The analysis of various BEV charging scenarios reveals that the total costs over a four-year period increase as users rely more on public and fast charging. For example, when charging the Dacia Spring ad hoc at public AC charging points 50% of the time and 50% of the time using at-home AC charging, the four-year costs rise to nearly €4,000 compared to almost €2,800 when only charged at-home. The most expensive charging scenario for both models was an 80% MSP public AC charging rate and a 20% public (DC) rate, where costs reach over €5,000 for the ID.3 and €4,700 for the Dacia over four years. However, regardless of the circumstances, the selected BEVs consistently have lower charging costs compared to fueling the comparable ICE gasoline model within the same segment. Lower costs are observed for charging and fueling when leasing, as the assumed yearly mileage is lower compared to vehicle purchase.

For those with lower incomes, the costs of owning and leasing a new BEV are significantly higher than what these groups would pay for transportation on average. For individuals in the lowest income bracket considered in this study, net €1,200 per month, the monthly costs of owning an ID.3 reaches 87% of the household net income, even when including the one-time purchase incentive of €7,178. In contrast, the monthly costs for the ID.3 represent 6% of the highest income bracket's monthly net income of €18,000, and 21% for the second highest bracket of €5,000, a significantly lower proportion of the net income. The situation changes in the A-segment, where the Dacia Spring amounts to 47% of the monthly household net income for the lowest income bracket, including the one-time purchase incentive, and 33% for the second lowest bracket. The costs of the Dacia Spring, however, are still over five times higher than what the lowest income bracket would typically spend on transportation.

The focus of this paper was on new vehicles for private individuals. Further research could focus on the affordability and access of the used BEV market in Germany and the expansion of financial support for BEV leasing. Additionally, understanding the affordability of BEVs for businesses and enterprises, especially small businesses, can also help to understand economic access from a firmographic standpoint. Furthermore, an in-depth analysis on the influence of vehicle depreciation on the affordability of BEVs could be considered.

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APPENDIX

Estimated mileage for each insurance estimation followed the assumptions outlined previously in this paper, where the annual mileage for purchase was 12,843 km and 10,000 km for leasing. Price estimations of insuring the individual vehicle models are shown below in Table 8.

Table A1. Insurance fees for both vehicle purchase and lease

Vehicle type	Volkswagen ID.3 Pro	Volkswagen Golf VIII Style 2	Toyota Aygo X 1.0	Dacia Spring – Extreme Electric 65
Insurance fees per year	€1,139	€1,487	€1,206	€1,275

Table A2. Monthly maintenance fees for the selected vehicle models in Germany

Vehicle Model	Monthly purchase maintenance fees	Monthly leasing maintenance fees
Volkswagen ID.3 Pro	€49	€38
Volkswagen Golf VIII Style 2	€58	€45
Dacia Spring - Extreme Electric 65	€33	€26
Toyota Aygo X 1.0	€41	€32

Table A3. Ownership tax rates for internal combustion engine vehicles from 2023 to 2026 in Germany

Vehicle type	Engine capacity	Engine capacity price (€2/100 cm^3)	CO_2-value (g/km)	CO_2-value price	Total ownership tax per year
Volkswagen Golf VIII Style 2	1984	€40	148	€117	€156
Toyota Aygo X 1.0	998	€20	153	€129	€149