Home-charged electric vehicles outperform combustion engine vehicles on price

A studio Gear Up Article

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Summary

Battery Electric Vehicles (BEVs) are more affordable than their combustion engine counterparts (ICEVs) and no longer require the support of the purchase subsidy, our total cost of ownership analysis shows. This is primarily the case for situations where home charging is available. Being dependent on public or fast charging may flip the coin. studio Gear Up argues that more should be done to accelerate the uptake of electric vehicles for lower income groups. Our analysis concludes that the selected EVs are already on par or cheaper in use compared to the equivalent vehicles with a combustion engine. Still, these models are, on basis of the catalogue price only within reach for the highest income quintile of households in the Netherlands.

The Netherlands passenger car sales market is dominated by sales of used cars. In 2023 Dutch car dealers and companies sold 1.39 million versus 0,37 million new vehicles.[1] Also at European level this trend is visible.[2] The further uptake of electric vehicles could be accelerated by redirecting the budgets and lowering the ceiling of the existing Private Electric Passenger Car Subsidy[3] towards the purchase of used electric vehicles, and in particular be targeted to households in the lower income quintiles.

Battery electric Vehicles: higher prices, but lower in cost

Even though battery-electric cars' (BEV) catalogue prices are still higher than those of their internal combustion engine vehicle (ICEV) equivalents, the price gap has narrowed down in the last few years in the Netherlands. To gain better understanding of the affordability of BEVs compared to ICEVs within the Netherlands, we have analysed six popular passenger cars – three battery electric vehicles and their three combustion engine equivalents - on the basis of their total cost of ownership (TCO).4

The results are showing that BEVs have lower costs based on a 5-year ownership period compared to their ICEV counterparts – even without an initial purchase subsidy. However, *where* the car is charged has a significant effect on the total cost of ownership as charging prices highly differ. The comparison of four charging modes – home charging with an energy contract, home charging with solar panel, public charging and public fast charging – unveiled that home charging with solar panels is the most cost-effective option.

The total cost of ownership is one of the most important indicators to judge affordability of vehicles. By comparing the total cost of ownership (TCO) of BEVs to the TCO of ICEVs a comprehensive understanding of the different cost elements and the interactions of those could be gained. We looked at six popular passenger car models in the Dutch market:

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[1] https://www.autoweek.nl/autonieuws/artikel/er-zijn-in-2023-veel-meer-tweedehands-autos-verkocht/ and https://mijn.bovag.nl/actueel/nieuws/2024/januari/autoregistraties-2023-groei-door-inhaalslag-zet-do#:~:text=Volgens%20de%20officiële%20cijfers%20van,vergeleken%20met%20het%20voorgaande%20jaar.

[2] Transport & Environment, 2023, How leasing companies can become a key driver of affordable electric cars in the EU - Electrifying the used car market. https://www.transportenvironment.org/wp-content/uploads/2023/11/How-leasing-companies-can-become-a-key-driver-of-affordable-electric-cars-in-the-EU.pdf

[3] Subsidieregeling Elektrische Personenauto's Particulieren (SEPP) https://www.rvo.nl/subsidies-financiering/sepp

[4] The total cost of ownership analysis was built by studio Gear Up in a bottom-up approach, utilising various data sources to create a comprehensive and detailed TCO calculation The approach, assumptions and data sources are described in Annex II - Methodology of Total Cost of Ownership (TCO) calculation.

Brand:	BEV model	ICEV model
Peugeot	e-208	208
Volkswagen	ID.3 Pro	Golf
Citroën	ë-C4	C4

The cars were selected based on their popularity (ICEVs) – not only in the Netherlands, but in seven other EU Member States as well – and whether they have a BEV equivalent.

Purchase subsidy for BEVs will need to be redirected

The purchase of the battery electric vehicles (BEVs) is subsidised by the Dutch government in order to support the achievement of its climate goals, particularly the ambition of 100% of new cars sold to be emission-free by 2030. The subsidy scheme largely entails tax exemption from registration tax (BPM) and road tax (until 2025) combined with a purchase subsidy (in 2024) equal to € 2,950 for newly bought passenger cars. The total budget of the purchase subsidy is € 58 million for 2024 for new vehicles, under the condition that the catalogue price is less than € 45,000. A purchase subsidy is also available for used BEVs in the form of a € 2,000 support from the government. The total budget for purchasing used BEVs is € 29.4 million for 2024 and only eligible for selected models with an original catalogue price up to € 45,000.

If the Dutch government were to discontinue the purchase subsidy for new BEVs (€ 2,950) then all BEVs considered in our analysis are still viable, de facto, cheaper choices for consumers on the basis of a 5-year TCO when they are enabled to charge their BEVs at home with energy contract. Figure 1 shows how the total cost of ownership of BEVs with and without purchase subsidy are compared to their ICEV counterparts for a 5-year ownership period driven 20 thousand km/year, on basis of home charging with an energy contract.

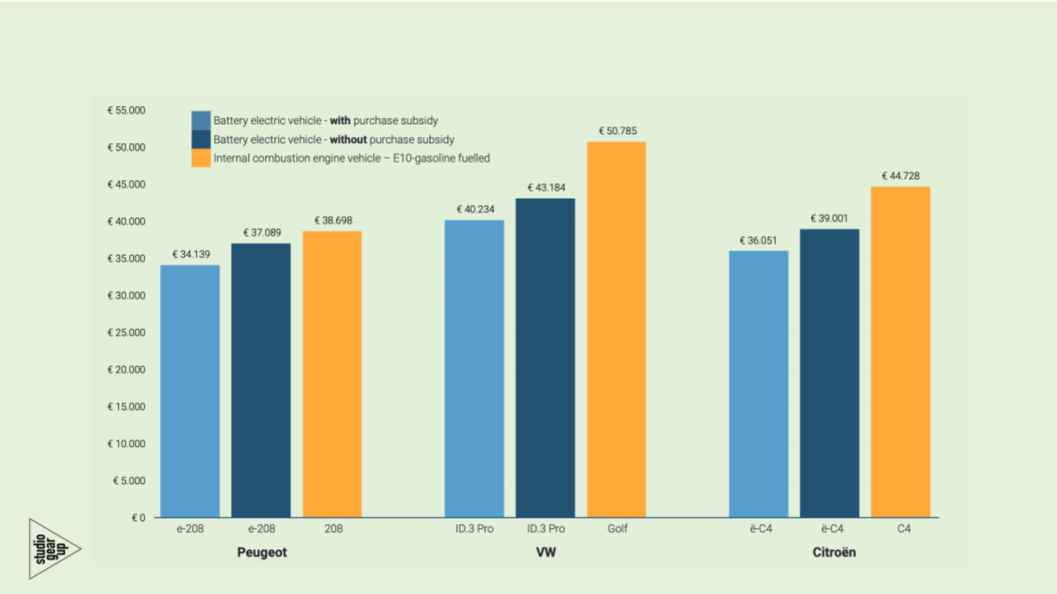

Figure 1. Comparing BEV and ICEV based on 5-yr total cost of ownership (TCO) of three passenger car models with a 20.000 km/yr mileage, where ***100% home charging with energy contract*** *is assumed for BEVs.*

Even without a purchase subsidy, both the Volkswagen ID.3 and Citroen ë-C4 are considerably cheaper options compared to their ICEV counterparts, while the Peugeot e-208 has somewhat lower costs during a 5-year ownership period when only regular home charging is assumed. This analysis should be extended to include models of other OEMS, but these selected BEVs are competitive and less costly choices in comparison to their ICEV equivalents regardless the presence of a purchase subsidy. However, if the road tax (Motorrijtuigenbelasting), which is set to be applicable to BEVs first with 25% in 2025 then 100% from 2026, will be based on the higher weight this will impact negatively the TCO of the BEVs compared to ICEVs.

For a detailed cost breakdown of the TCO of BEVs with home charging with energy contract and ICEVs, see Figure 8 and Figure 9 in the Annex.

The mode of charging determines the cost-effectiveness of BEVs

To illustrate the difference among the mode of BEV charging, Figure 2 shows that – when 100% public charging is assumed – the TCO of BEVs are increased due to the higher prices of electricity from public charging poles.

Noteworthy that only the TCO of Peugeot e-208 without purchase subsidy has turned over and rose over the TCO of Peugeot 208. In this case, the purchase subsidy could help to be on par with its ICEV counterpart.

Both the Volkswagen ID.3 and Citroen e-C4 stayed below the TCO of their ICEV counterpart even without the presence of governmental purchase subsidy, when 100% public charging is assumed. For a detailed cost breakdown of the TCO of BEVs with public charging and ICEVs, see Figure 10 and Figure 11 in the Annex.

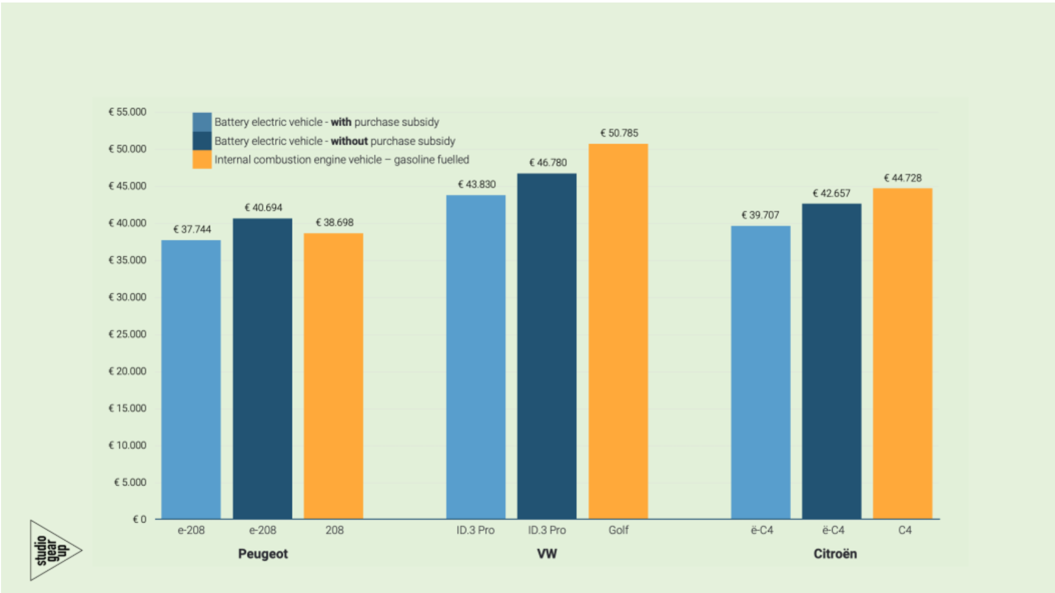

Figure 2. Comparing BEV and ICEV based on 5-yr total cost of ownership (TCO) of three passenger car models with a 20.000 km/yr mileage, where ***100% public charging*** *is assumed for BEVs.*

Charging profiles per car model

The affordability of BEVs is dependent of the mode of charging. Figure 3, Figure 4 and Figure 5 illustrate the impact of the energy costs on the whole TCO of the different car models. While the blue and orange columns represent other cost categories within the TCO for the BEVs and ICEVs respectively, the yellow bars are purely the energy costs including all taxes.

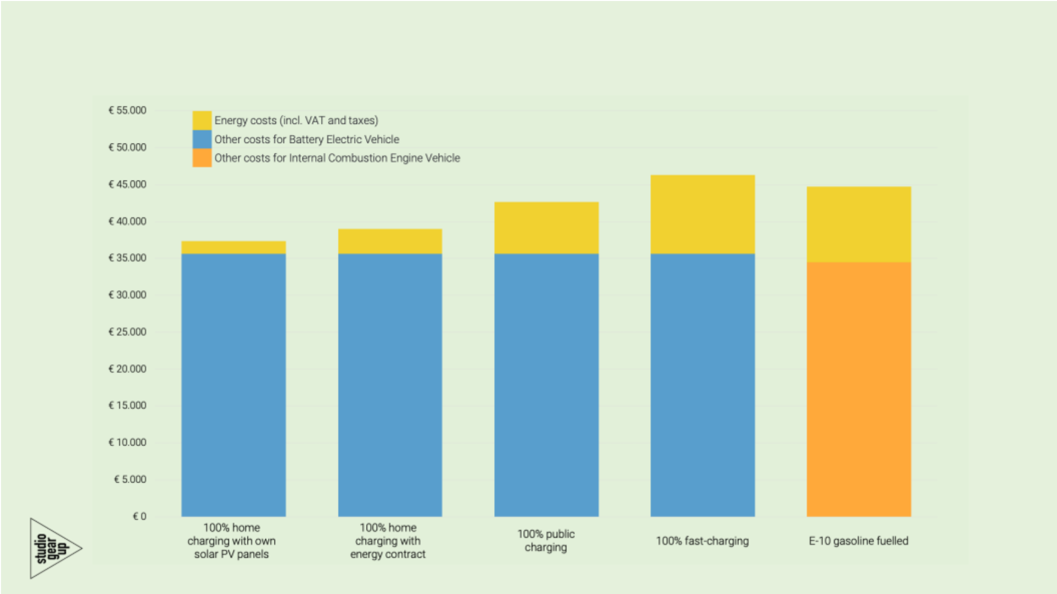

Figure 3 .Comparison of 5-yrs TCO with 20,000 km/yr mileage for Citroën ë-C4 and C4 with different charging profiles and without purchase subsidy for BEV.

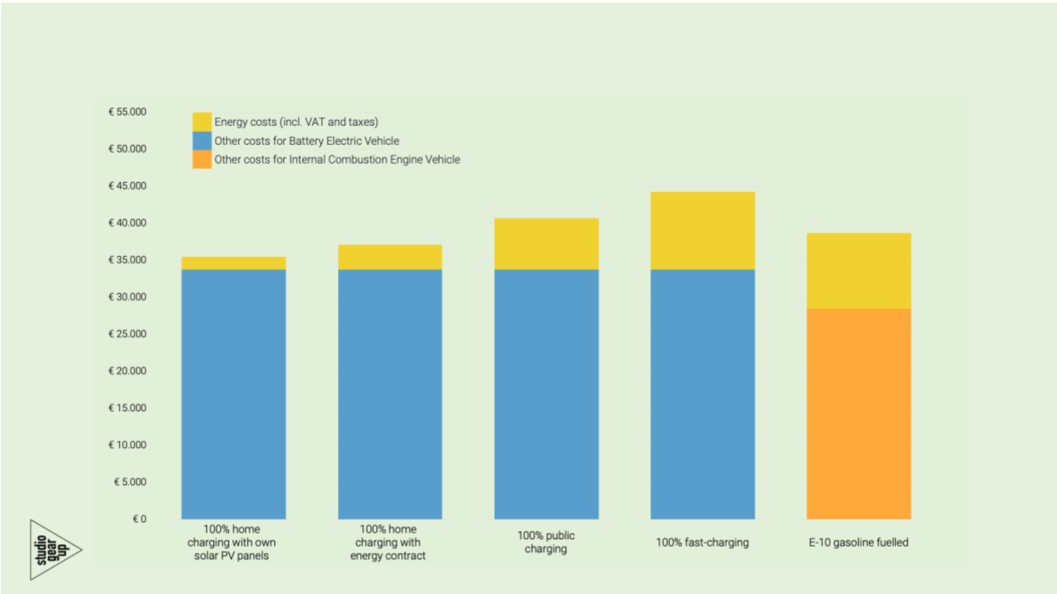

*Figure 4. Comparison of 5-yrs TCO with 20,000 km/yr mileage for **Peugeot e-208 and 208** with different charging profiles and without purchase subsidy for BEV.*

The least costly mode of charging a battery electric vehicle is at home with the presence of solar panels, while fast charging proves to be as expensive as fuel for ICEVs. In case of fast charging, the share of the energy costs within the total cost of ownership is 25%, which is significantly higher than other modes of charging. The energy costs entail electricity cost including all taxes and levies for BEVs and fuel costs including all taxes and levies for ICEVs. Costs of home charging with solar panels is based on initial costs of solar panels divided by the lifetime of their operation, therefore the current balancing scheme (salderingsregeling) is not taken into account.

Even though it is unlikely that BEV owners would only charge their cars at fast charging poles, it is undeniable that current fast charging prices significantly increases the TCO of BEVs.

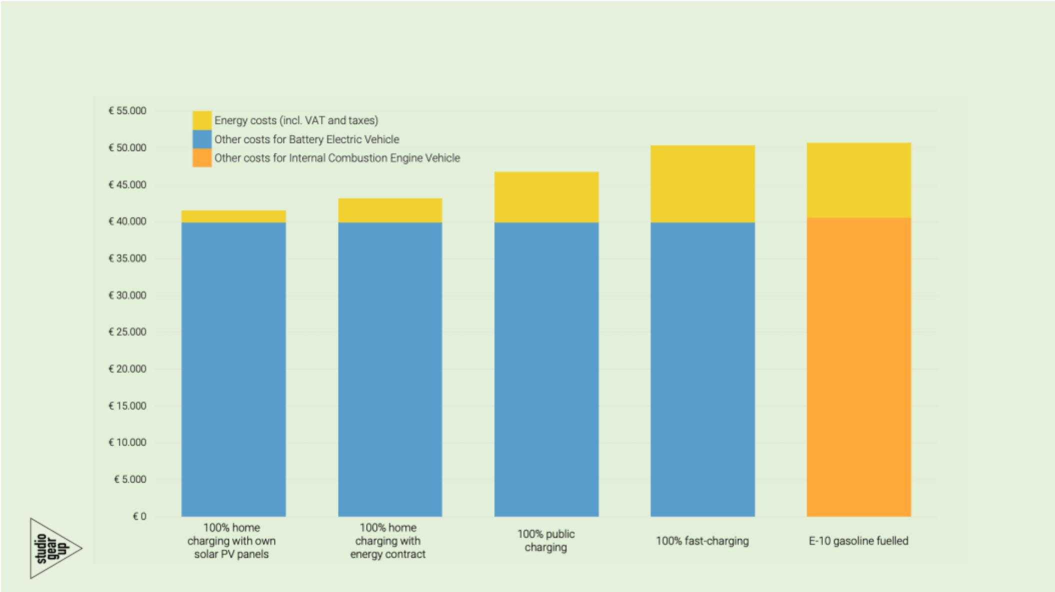

*Figure 5. Comparison of 5-yrs TCO with 20,000 km/yr mileage for **Volkswagen ID.3 and Golf** with different charging profiles and without purchase subsidy for BEV.*

New passenger cars are only affordable to a minority of consumers

The purchase of new vehicles remains only affordable for the top income quantiles regardless of whether a subsidy is included or excluded. More specifically, all models within this analysis are for the top income quantile (Q5), with or without the purchase subsidy (€ 2 950) as shown on Figure 6 and Figure 7.

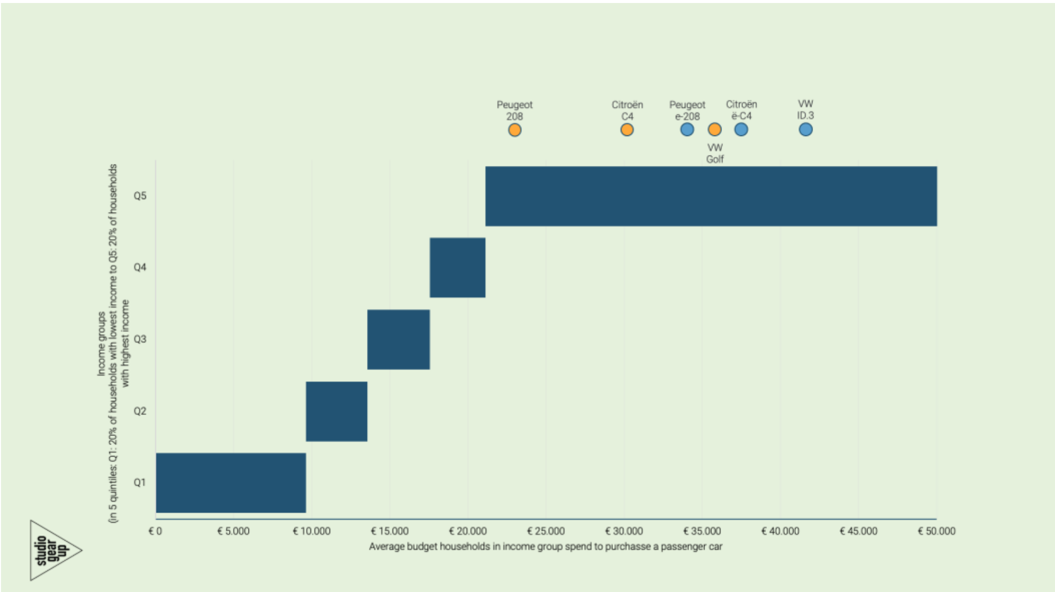

*Figure 6 .Available average car purchase budget per household income groups in the Netherlands and the catalogue prices – **excluding** purchase subsidy - of new ICEVs and new BEVs.*

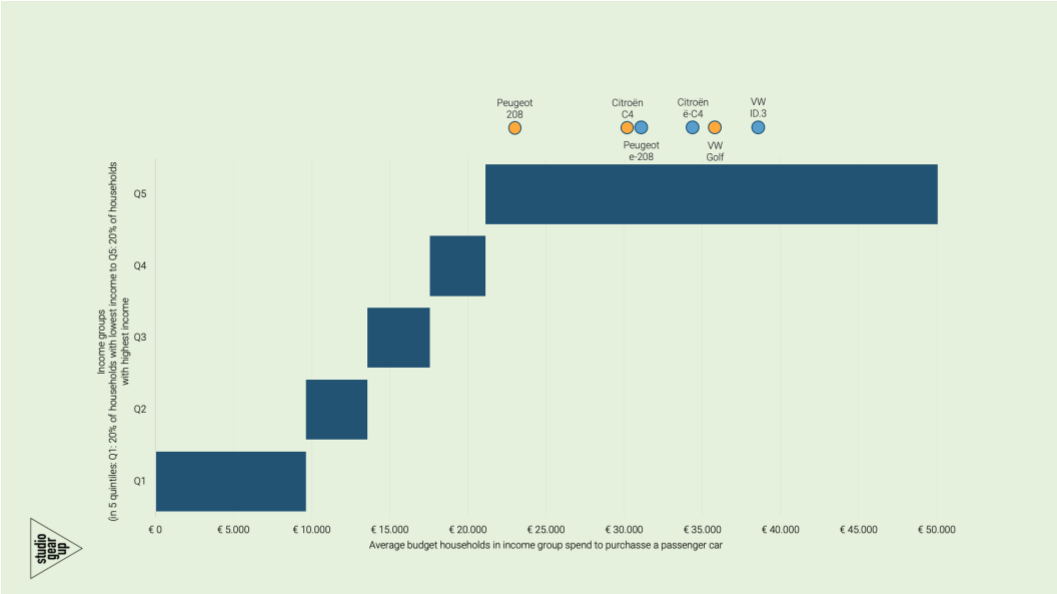

*Figure 7. Available average car purchase budget per household income groups in the Netherlands and the catalogue prices –**including** purchase subsidy - of new ICEVs and new BEVs.*

The implications of the constructed car purchase budget shows that the new car market is within reach only for the top 20% of the population. This further suggests that new cars – including BEVs – are still less accessible to the majority of the population. The current form of purchase subsidy does not serve the purpose of increasing the share of BEVs within the newly registered car fleet as only a minority of consumers could afford them. This is in line with the findings of Geerte et al. (2023)[5] uncovering barriers towards BEV uptake by private owners stating that new policy measures are needed to encourage the purchase of battery electric vehicles.

Key recommendations

Our recommendation, rooted in our analysis, of lowering the purchase price ceiling of the Private Electric Passenger Car Subsidy would convey the following indications:

- It would phase out unnecessary support for higher priced BEVs, as they are showing the most robust TCO advantage compared to ICEVs. They are already and will still be cheaper in the absence of the purchase subsidy.
- Redirecting the purchase subsidy towards lower-priced vehicles is also a shift towards income groups with lower subsidy support. They frequently rely on purchasing smaller cars and may lack the option to charge at home, depending on public charging which is potentially leading to a higher Total Cost of Ownership (TCO).
- It serves as a signal to car manufacturers that the Dutch government is inclined towards having smaller BEVs in its fleet. Therefore, the decision to subsidise only B-segment or smaller vehicles under € 35,000 reflects the government's intention, recognizing the ultimate need for these cars in the used car market.

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[5] Geerte L. Paradies, Omar A. Usmani, Sam Lamboo, Ruud W. van den Brink (2023). Falling short in 2030: Simulating battery-electric vehicle adoption behaviour in the Netherlands. Energy Research & Social Science. Volume 97/102968. ISSN 2214-6296. https://doi.org/10.1016/j.erss.2023.102968.

Annex I - cost breakdown of the total cost of ownership of BEVs and ICEVs

The following figures illustrates the cost breakdown of the total cost of ownership of BEVs and ICEVs, in case of home charging with energy contract and public charging.

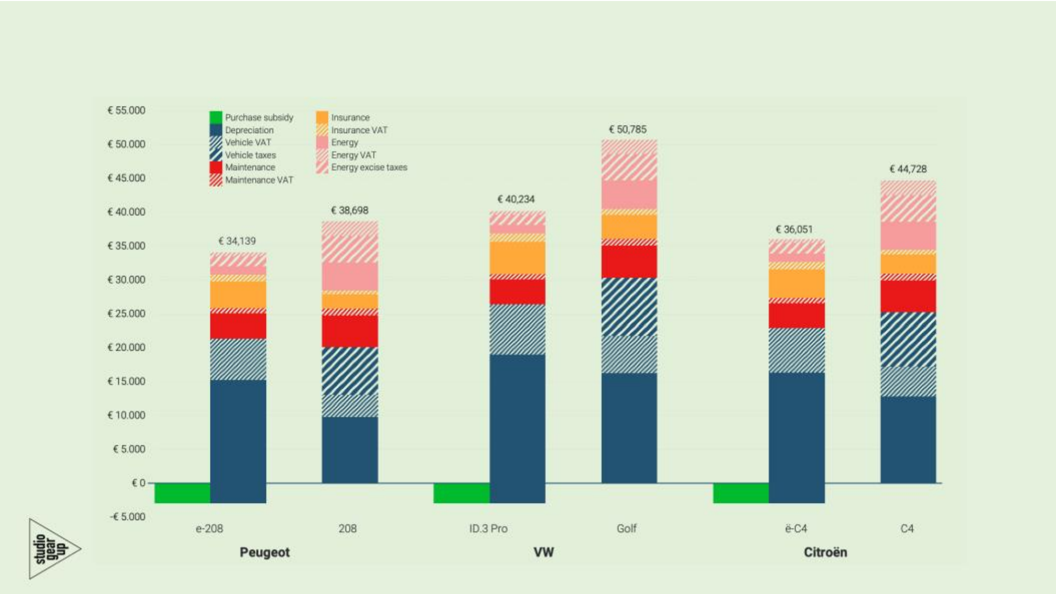

Figure 8. Cost breakdown of the TCO of BEVs and ICEVs which includes purchase subsidy. 100% home charging with energy contract is assumed for BEVs, while all cars are assumed to have a 5-year ownership period driven 20.000 km/yr.

Figure 9. Cost breakdown of the TCO of BEVs and ICEVs which excludes purchase subsidy. 100% home charging with energy contract is assumed for BEVs, while all cars are assumed to have a 5-year ownership period driven 20.000 km/yr.

Figure 10. Cost breakdown of the TCO of BEVs and ICEVs which includes purchase subsidy. 100% public charging is assumed for BEVs, while all cars are assumed to have a 5-year ownership period driven 20.000 km/yr.

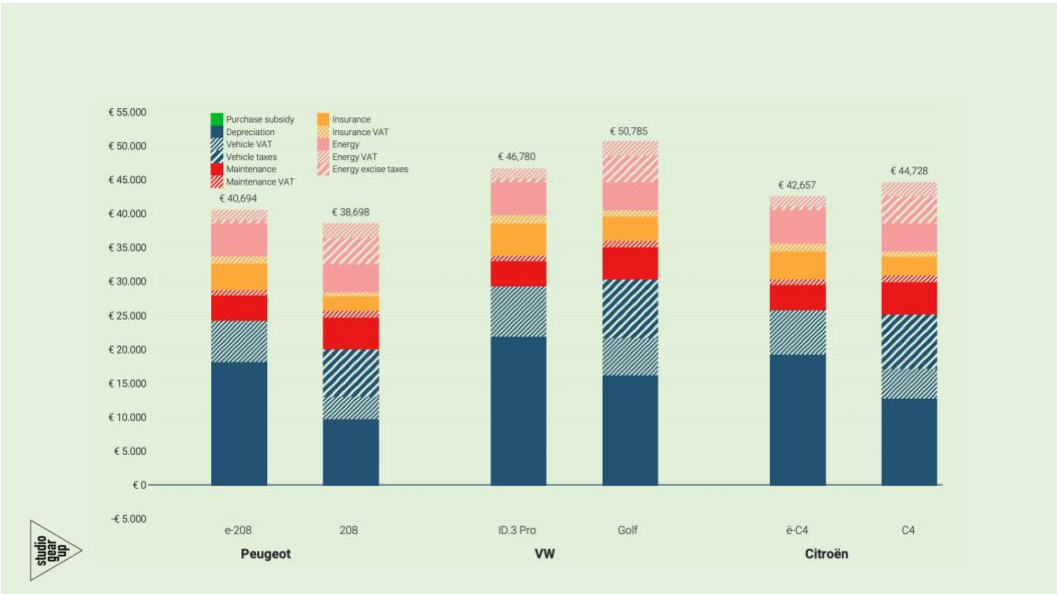

Figure 11. Cost breakdown of the TCO of BEVs and ICEVs which excludes purchase subsidy. 100% public charging is assumed for BEVs, while all cars are assumed to have a 5-year ownership period driven 20.000 km/yr.

Annex II - Methodology of Total Cost of Ownership (TCO) calculation

studio Gear Up developed its own Total Cost of Ownership (TCO) calculation tool, on basis of a bottom-up approach, where in total ten cost factors were included: fixed depreciation, variable depreciation, registration tax, ownership tax, fixed maintenance, variable maintenance, tyre costs, insurance, fuel/electricity costs, fuel/electricity excise, as well as all Value Added Taxes of these. Having grouped these components, results roughly in five categories: depreciation, maintenance, insurance, taxes and subsidies, and energy costs, which are elaborated below.

Depreciation

Definition of depreciation: the difference between purchase cost and resale value. This TCO model employs depreciation to account for the car's value loss and the amount lost by the owner, whereas other TCO models (like ICCT) use the entire purchase price in their model. Since a portion of the car's price will be recouped when it is sold, this offers a more accurate representation of the true costs to the owner.

The strategy was to generate a formula for the depreciation rate based on the number of kilometres travelled (variable deprecation rate) and the duration of ownership in years (fixed depreciation rate) using the data from the ANWB TCO calculator.[6] The ANWB TCO calculator's numbers for both depreciation rates were 'reverse engineered' applied for ICEVs and BEVs.

The catalogue prices of the vehicles were taken from the corresponding car manufacturer's website during the course of January 2024 as well as the depreciation data from ANWB calculator.

Maintenance and insurance

The maintenance costs were determined by the same approach as the depreciation costs, thus reverse engineering with data from ANWB to design a formula for the maintenance costs of cars depended on the number of kilometres driven and the ownership period of the car.

The insurance costs needed to be estimated as there are great differences between regions and insurance companies within countries. Data was generated for the selected models and a relation was found between the catalogue price and the insurance costs. Assuming a linear dependence of insurance costs to the catalogue price, a fixed percentage of 2.82% of the catalogue price was applied to all cars in the model.

The maintenance costs were calculated using the same method as the depreciation costs, which used reverse engineering with data from ANWB to create a formula for the maintenance costs of cars based on the amount of km driven and the car's ownership tenure.

The insurance prices had to be estimated because there were significant variances across locations and insurance providers within countries. Data was collected for four of the selected models from ANWB, and a correlation was discovered between the catalogue price and the insurance costs. Assuming a linear relationship between insurance costs and the catalogue price, a set percentage of 2.82% was applied to all cars in the model.

All data was accessed in January 2024 from the ANWB website.

Taxes and subsidies

The TCO model has three main tax categories: VAT, registration, and ownership taxes. Registration and ownership taxes take numerous forms and are based on a variety of factors such as cylinder volume, horsepower, weight, CO_2 emissions, and so on.

[6] https://www.anwb.nl/auto/autokosten

In case of the Netherlands, the BPM was considered as registration tax. For BEVs, this is a zero as the BPM is calculated based on the CO_2 emission of the car. Furthermore, BEVs are exempt from ownership tax, which is a yearly amount in the form of road tax (Motorrijtuigenbelasting) in the Netherlands. However, this exemption will last until 2025 after which BEVs also have to pay the road tax. This is not yet taken into the model as the amount for BEVs is not yet known.

The VAT was applied on four different variables: maintenance costs, insurance costs, energy price, and vehicle purchase price.

Countries apply different benefit schemes to stimulate BEV car sales, divided in tax benefits and subsidies. The Netherlands provide a purchase subsidy of € 2,950 if the purchase price of the vehicle is maximum € 45,000. While the abovementioned exemption from BPM and road tax is considered as a tax benefit.

The taxes and benefits applied in the TCO model is based on the year 2024, therefore not accounting for future changes within the taxation and subsidy schemes.

Energy costs

The TCO covers energy expenses per energy carrier, with the overall energy price comprising fuel wholesale/electricity charges, fuel or electricity excise duty, and VAT. The energy consumption of ICEVs and BEVs is determined using the manufacturer's technical standards (as defined by the new WLTP standard). Furthermore, fuel prices are based on the European Commission's weekly oil bulletin. The assumption was that the difference between the fuel price with and without taxes, minus VAT, would equal the fuel excise.

For BEVs, the fuel economy is expressed in kWh per 100 km. Four types of electricity prices were included in the TCO model:

- the electricity price for households based on data from Eurostat, CBS.nl (Netherland Statistics) and Independer.nl websites. These prices related to energy contracts with energy companies,
- public charging price based on data from Autoweek.nl, Consumentenbond.nl and Independer.nl websites,
- fast charging price based on Autoweek and service providers (e.g. Fastned) data;
- home charging price with solar panels based on solar panel investment prices.

Due to significant price decrease compared to 2023 and the abolishment of the electricity price ceiling, household electricity prices were determined using data from Dutch electricity providers for 2024 accessed on the first of February 2024. The determination of public charging prices was based on 2023 summer data by taking the average prices of the biggest cities in the Netherlands. Fast charging prices were also drawn from average 2023 data of fast charger providers.

For the public and fast charging prices, excise duty per kWh were calculated based on Belastingdienst data on the excise values for electricity. For home charging with solar panels, zero excise and VAT was assumed as those were paid already when making the investment for the solar panel installation.

Public charging suppliers often offer subscriptions for (fast) public charging. Including these subscription schemes in the TCO model would have required further assumptions concerning how effectively the BEV owner utilises them. In general, there is a lack of transparency concerning the public charging composition, which rendered the data acquisition challenging at times.

Car purchase budget

It is interesting to study the vehicle budgets of households in various income groups in different nations because not every car is accessible to every type of home. Lower-income households have less money to spend on consumption. Furthermore, if these households were to acquire a car, they would do so on the used car market because the new car market is too expensive. To assess and visualise whether different income classes in the Netherlands can purchase different passenger cars (ICEVs and BEVs), we developed the notion of a "car purchase budget", which indicates how much a household (in a given income class) would typically spend on the purchase of a passenger vehicle. To construct this budget the disposable income data, the share of vehicle purchase of total average consumption and the average saving values per income quintile data of 2022 from Eurostat and CBS.nl websites were used.