Short study

E-Carsharing:
Ecological and Economic Effects

for the

Free Hanseatic City of Bremen

Ministry of Construction, Mobility and Urban Development

Unit for Strategic Transport Planning

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1 Abstract

In Germany, today's carsharing fleets are made up of a disproportionally large amount of electric vehicles (EVs). According to data from the German National Carsharing Association (BCS: Bundesverband CarSharing e.V.), 17.8 % of carsharing vehicles are currently EVs, a figure considerably higher than the 2.9 % of all registered cars in Germany[1]. According to data provided by the Free Hanseatic City of Bremen, EVs account for 2.7 % of all vehicles, and for 7.8 % of carsharing vehicles.

The national development over recent years is illustrated in Fig. 1[2]

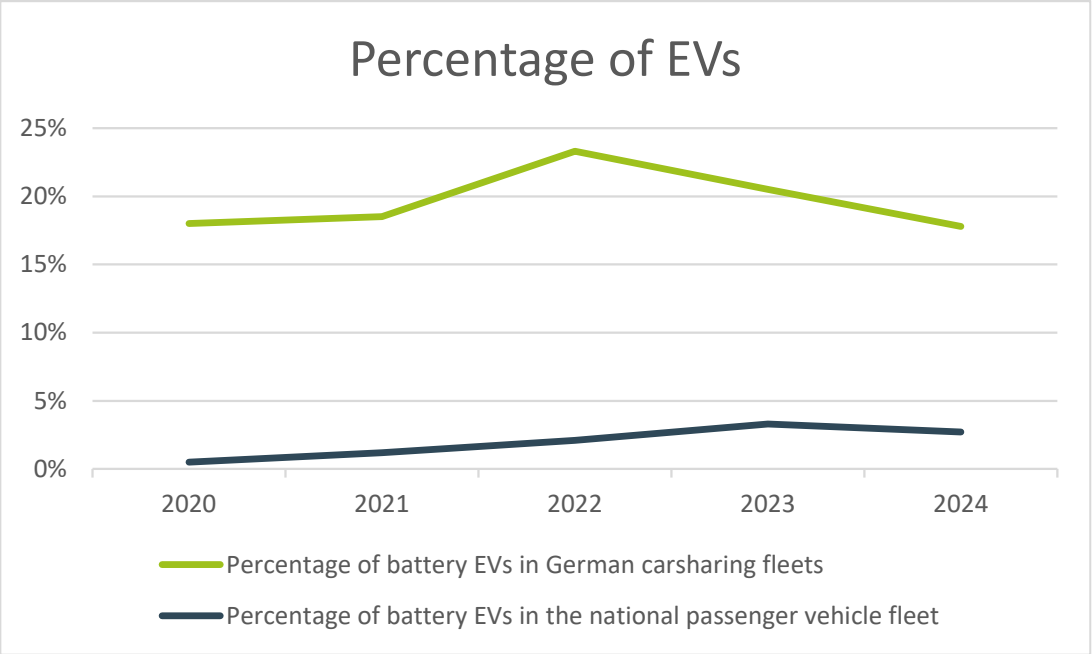

Figure 1 Development of percentage of electric vehicles in carsharing and the national fleet (Source: BCS):

Various factors had a dampening effect on this development: reduced or discontinued subsidies[3], but also the exponential growth of carsharing[4], with the number of vehicles almost doubling between 2020 and 2024, a rise with which the required charging infrastructure was unable to keep pace. This resulted in a slight reduction in the proportion of EVs in both the national passenger vehicle fleet and carsharing fleets. However, EVs continue to constitute a disproportionate share of carsharing fleets, carsharing thus being a clear driver in the electrification of vehicles.

The subject of this study is an estimation of the anticipated effects in a scenario in which carsharing providers would be state subsidized in order to accelerate the electrification process beyond their current pioneer role, whereby fleets would *exclusively* consist of EVs. Based on the current behaviour of carsharing users, the study investigates the potential ecological ef-

[1] See https://carsharing.de/e-carsharing, retrieved on 1.12.2024
[2] Data provided by Bundesverband CarSharing e.V., see https://www.carsharing.de/jahresberichte for annual reports
[3] Cf. "BAFA - Pressemitteilungen - Elektromobilität: Neue Förderbedingungen für den Umweltbonus ab 2023" of 9.12.2022
[4] Cf. https://carsharing.de/carsharing-statistik

fects of a full transition to EVs. These effects are then applied to the previously researched impact of a reduction of Car usage by carsharing users. The economic effects in terms of investment requirements and annual operating costs following a complete transition to EVs are also investigated. By contrast, the ecological effects in terms of vehicle production, as considered in studies by the Federal Environment Agency[5] or the VDI[6] (German Association of Engineers) are not investigated. Similarly, the potential impact on fuel prices due to future regulation of emissions trading[7] is not included in this short study. **This study represents a snapshot of the current framework conditions.** A more detailed analysis, including possible future scenarios, would go beyond the scope of this study and could be the subject of future studies of greater depth.

The current study was conducted on the basis of the largest carsharing provider in Bremen. It should be noted that it is partly necessary to work with assumptions and estimates. The figures presented are therefore to be understood as estimates, which could be further refined in a more comprehensive and detailed investigation.

The following **ecological effects** of the carsharing offering in Bremen can be concluded:

- As a result of the **current number of registered carsharing users**, a total annual **reduction effect of 24,300 t CO_2 equivalents** can already be assumed.
- The same mileage covered exclusively by EVs in the existing carsharing offering would result in an additional reduction for the whole fleet of
  - between **990 t and 1,200 t CO_2 equivalents per year**, assuming the current average German electricity mix or
  - between **1,900 t and 2,300 t CO_2 equivalents per year, assuming zero local emissions.**
- However, these effects could only be realized if carsharing vehicles continued to be used in the same way as at present following the transition to a fully-electric fleet.
- Based on empirical observation of a significantly reduced usage of EVs, however, a similar continuation cannot be assumed. Considering the anticipated effects of reduced usage, **an obligatory transition would result in an annual negative CO_2 balance of approx. 2,000 t CO_2 equivalents.**

In terms of **economic effects**, the following estimates can be made:

- To achieve a complete EV transition, **investments in charging infrastructure of 4.1 € - 5.0 million € would be required.**
- The **operating costs** of the investigated vehicles would most probably be **similar**: While the acquisition costs and the corresponding debt service are higher than for internal combustion engine vehicles, this negative cost factor could be compensated by lower energy costs resulting from favourable contracts.
- **The liquidity of carsharing providers would be placed under considerable strain** by higher acquisition costs and the resulting increased borrowing requirements.
- It should also be noted that the current usage of EVs, being **significantly lower** than that of internal combustion engine vehicles, has a considerable negative impact on the

[5] https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_27_2016_umweltbilanz_von_elektrofahrzeugen.pdf
[6] VDI Verein Deutscher Ingenieure e.V. (2023): VDI-Analyse der $CO_{2äq}$-Emissionen von Pkw mit verschiedenen Antriebssystemen
[7] Cf. Agora Energiewende und Agora Verkehrswende (2023): Der CO2-Preis für Gebäude und Verkehr. Ein Konzept für den Übergang vom nationalen zum EU-Emissionshandel

operating result of carsharing providers. This effect cannot be offset on the cost side and would lead to a **dramatic deterioration of the operating** result.

In particular, the necessary infrastructure investments would not be affordable for carsharing providers. **Without public sector funding of a sizeable share of these investments, as well as compensation for significantly reduced revenue, the obligatory requirement to transition to a complete EV fleet would force carsharing providers to cease operations.**

Conclusion:

- **It is strongly advised against legally obliging carsharing providers to offer a fully-electric fleet.** This would require huge financial means as well as bind the capacity of both carsharing providers and public authorities, capacity which would no longer be available for the further expansion of carsharing schemes**.**
- **A legal obligation would be a misplaced measure:** Carsharing providers are not only open to adopting EVs, they already use these vehicles disproportionally. Growth of the EV fleet is organic and in line with the organizational and economic capacity of the provider, as well as user acceptance of EVs. Carsharing providers are expected to continue this development even without legal obligation.
- **Obligatory total electrification would eliminate the ecological effects already achieved.** Particularly from an ecological perspective, **the resulting negative CO_2 balance** would be counterproductive.
- **Stronger climate protection effects are to be expected from the further expansion of carsharing and the acquisition of new users.**
- **The state subsidies** required for the realization of a fully-electric carsharing fleet **should therefore rather be invested in the expansion of the existing carsharing offering,** e.g.: in
  - **communication strategies**
  - creation of **parking spaces**
  - **subsidizing of schemes** in economically-challenged locations (e.g.: city outskirts) during the introductory phase
  - consistent **integration of carsharing into public fleets**

2 Basic data

The evaluations presented in sects.3 and 4 are based on the assumption that carsharing usage would remain unchanged following a complete transition to EVs. Section 5 continues with an evaluation of the effects of anticipated reduced usage.

The evaluations are based on the key data presented in our case study, respectively on basic assumptions, insofar as separate assumptions were not made in the individual analyses. Calculations regarding fuel or energy consumption and emissions are based on data provided by the manufacturers of both internal combustion engine vehicles and EVs. The authors are aware that the actual values tend to be much higher[8].

2.1 Number of users

At the time of conducting the study, 28,483 users were registered with the provider in question. For the calculations, it is initially assumed that neither the number of users nor their usage behaviour would change as a result of a shift to similar EVs.

Since the capacity utilization of EVs already operated in the fleet is under 80 % of that of internal combustion engine vehicles of the same category, Section 5 provides a modified estimation of the ecological effects assuming a reduction in usage and users following a complete EV transition. In this modified variant it is assumed that user numbers will decline to 26,000.

2.2 Mileage

Annual mileage figures were not supplied by the investigated provider. From a survey of carsharing providers conducted in 2015 an annual mileage of 25,000 km per carsharing vehicle can be derived. Alternatively, the calculations of emissions effects are based on a yearly mileage of 22,500 km and 27,500 km.

2.3 Existing fleet

2.3.1 Number of vehicles; usage period

The fleet in the case study consists of 639 vehicles. Of these vehicles, 50 are already fully electric (approx. 8 %, 3 different vehicle types). The fleet is most commonly made up of the following vehicle types:

- **Internal combustion engine vehicles:**
  - Ford Fiesta
  - Citroen C3
  - Opel Corsa
  - Ford Focus Kombi
  - Citroen Berlingo
  - Toyota Yaris
- **EVs:**
  - ZOE E-Mobil
  - ID.3
  - Opel Corsa-E

[8] Source: https://www.adac.de/rund-ums-fahrzeug/elektromobilitaet/elektroauto/stromverbrauch-elektroautos-adac-test/

All vehicles were purchased rather than leased by the carsharing provider. According to data from the provider, the average usage period is five years.

2.3.2 Consumption, emissions and purchase costs

The consumption, CO_2 emissions and purchase price of the vehicles in operation were calculated by means of the manufacturer's data and then weighted according to the case numbers supplied by the carsharing provider. In this weighted average, a mean value of 119 g/CO_2 per km is emitted with a consumption of 4.5 liters. The average purchase price of a vehicle is 23,500 €.

2.4 Hypothetical EV fleet

2.4.1 Composition

In order to investigate the effects of a full transition to an EV fleet, a comparable EV was defined for every vehicle currently operated in the fleet. In this case, battery electric vehicles (BEV) without an additional combustion engine were selected. Examples of such vehicles are listed in Table 1.

Vehicle type	Consumption (kWh/100 km)	CO_2 emissions (German electricity mix)	Purchase price
Fiat 500e	13.0 kWh	49 g/km	25,000 €
Citroen e-C3	17.4 kWh	66 g/km	23,500 €
Opel Corsa e	15.8 kWh	60 g/km	30,000 €
Opel Astra E Kombi	15.0 kWh	57 g/km	40,000 €
Citroen e-Berlingo	19.4 kWh	73 g/km	37,000 €
Renault Zoe	17.3 kWh	65 g/km	37,000 €

Table 1: Vehicles in all-electric fleet

2.4.2 Consumption, emissions and purchase costs

Technically, these vehicles are locally emission-free. However, for the ecological evaluations, the emissions value of 380 grams of CO_2 per kWh (as indicated by the German Federal Ministry for Environment for the electricity generation of the German electricity mix) is assumed[9]. On this basis, the following key figures are derived for the hypothetical e-fleet:

- Consumption per vehicle (manufacturer's figures): 15.8 kWh
- Emissions value per vehicle: 60 g/km
- Purchase price: 29,000 €

[9] Source: https://www.umweltbundesamt.de/themen/klima-energie/energieversorgung/strom-waermeversorgung-in-zahlen#Strommix, retrieved on 29.11.2024

2.4.3 Required infrastructure

47 parking spaces equipped with AC charging stations (11/22kW) are available for the current 50 fully-electric vehicles, i.e.: statistically, a charging station is available for virtually every EV. By deduction, it is assumed that a charging station is required for every further EV.

2.4.4 Purchase of charging electricity

In our case study, electricity is obtained locally in cooperation with the charging-infrastructure provider. On a national level, there is a cooperation with Shell Recharge. Electricity costs are calculated on the basis of the current tariff for local charging stations of 0.33 € / kWh[10]. Potentially higher costs for (Shell) charging, e.g.: on motorways, are not considered in the context of this study.

[10] Data provided by the local carsharing provider

3 Assessment of ecological effects

For orientation, the first estimation concerns the impact of modified transport usage by the present carsharing users. Potential effects of a full transition to an EV carsharing fleet are then considered.

3.1 Specific input values

3.1.1 Transport usage

The assessment of changes in transport behaviour and modal split by carsharing users is based on a survey conducted for the federal state of Bremen in 2018[11]. The survey determined transport usage for three different travel purposes[12]. For simplification, the survey differentiates between car use, public transport and cycling / walking[13]. From the averages of the three considered travel purposes the following percentages are determined for carsharing users and the population as a whole:

Modal split share	CS users	Population
Car	14 %	43 %
Public Transport	17 %	13 %
Cycling / Walking	69 %	44 %

Table 2: Calculation basis modal split

3.1.2 Journeys per day

The following data regarding journeys per day was taken from the results of the study 'Mobility in Germany 2017'[14].

- Average number of journeys per person per day: 3.1[15]
- Average journey length[16]
  - Car: 17 km
  - Public Transport: 23 km
  - Cycling / walking: 3 km

[11] https://bau.bremen.de/sixcms/media.php/13/2017-Analyse-zur-Auswirkung-des-Car-Sharing-in-Bremen_Team-Red-Endbericht.pdfEQFnoECBsQAQ&usg=AOvVaw1GUQH9ikpZ4ITgOxiwN1SX
[12] Ibid. S. 62
[13] The 2018 study did not differentiate between bicycles and e-bikes
[14] https://www.mobilitaet-in-deutschland.de/archive/pdf/MiD2017_Ergebnisbericht.pdf
[15] Ibid. S. 3
[16] Ibid. S. 46

3.1.3 Journey-related emissions

The emissions calculations are based on the TREMOD analyses of the Federal Environment Agency[17]. For public transportation, the local transport data is used and averaged for railway, bus, suburban train and underground transport. The calculations are based on the following emissions values (CO_2 equivalents):

- Car: 166 g / km
- Public Transport: 71.3 g / km
- Cycling / Walking: 0 g /km

3.2 Reduction effects of carsharing users

To calculate the reduction effects, the annual journey distances of each transport category are determined. The equation below is applied to calculate the total journey lengths per person and year, as shown in Table 3:

$$\frac{3.1\ journeys}{day}\ x\ share_{transport\ means}\ x\ \emptyset\ journey\ length_{transport\ means} x\ 365\ days$$

Journey length per person / year	CS users	Population
Car	2,693 km	8,207 km
Public Transport	4,337 km	3,470 km
Cycling / Walking	2,387 km	1,482 km

Table 3: Journey length per person and year

The emissions (CO_2 equivalents) per person and year are calculated by multiplying the emissions values listed in Chapter 3.1.3. by each transport means (Table 4, Conversion to tonnes CO_2 equivalents)

t CO_2 / year	CS users	Population
Car	0.45	1.36
Public Transport	0.31	0.25
Cycling / Walking	0.00	0.00
Total (per person)	**0.76**	**1.61**

Table 4: Transport-related CO2 emissions per person and year

The result is an annual saving of 0.85 t of transport-related CO_2 equivalents per registered carsharing user. For the present 28,483 registered users in our case study, an **annual total reduction of transport-related CO_2 equivalents of approx. 24,300 t** can be assumed.

[17] https://www.umweltbundesamt.de/sites/default/files/medien/366/bilder/dateien/uba_emissionsta-belle_personenverkehr_2022_0.pdf

3.3 Emissions reduction through fleet conversion

The calculation of the emissions reduction following a full vehicle transition is based on the emissions values of the current fleet in our case study and the hypothetical fully-electric fleet (see Section 2.2). With a fleet of 639 vehicles and assuming annual mileages of 22,500 km, 25,000 km and 27,000 km, the emissions values listed in Table 5 are derived:

Fleet mix / annual vehicle mileage	22,500 km	25,000 km	27,500 km
Current fleet	1,883 t CO_2	2,093 t CO_2	2,302 t CO_2
Potential EV fleet, German electricity mix	891 t CO_2	990 t CO_2	1089 t CO_2
Potential EV fleet, locally emission-free	0 t CO_2	0 t CO_2	0 t CO_2

Table 5: Estimated annual emissions values of carsharing fleet (639 vehicles)

In our case study, converting to a fully-electric fleet could result in a **local total saving of up to 2,300 t CO_2 equivalents per year.**

3.4 Summary of ecological effects

As illustrated above, a full transition of the case study fleet could lead to an annual reduction in local transport-related emissions of up to 2,300 t CO_2 equivalents for the whole fleet. However, basing the calculation on the current German electricity mix (see Section 2.4.2), this effect is reduced to 1,200 CO_2 equivalents.

By contrast, the number of registered carsharing users so far results in a total reduction effect of around 24,300 t CO_2 equivalents per year. **As such, current carsharing users avoid CO_2 equivalents by a factor of 10 – 25 more than would be achieved by a complete transition to an EV fleet!**

Assuming that a full fleet transition would be possible within five years with the given usage period, the same reduction effect could be achieved with an annual acquisition of approx. 400 – 800 new carsharing users.

4 Economic effects

In terms of economic effects, the investigation focusses on the following key questions:

- What financial investment is required in order to create the necessary charging infrastructure for all vehicles in our case study?

  How do the operating costs of the current fleet compare to those of a fleet consisting entirely of battery-electric vehicles?

4.1 Investment requirements for charging infrastructure

To operate a fully-electric carsharing fleet it is necessary to provide the appropriate charging infrastructure. First, the charging requirements are calculated, from which the required charging infrastructure specifications can then be determined.

4.1.1 Charging requirements per vehicle and fleet

An annual average mileage of 25,000 km per vehicle is assumed. Depending on the vehicle model and operating conditions, the energy requirements of fully battery-electric vehicles can vary considerably. Together with the technical features of the vehicles, various usage and environment-specific conditions influence the actual individual energy consumption, which in practice is significantly higher than the manufacturer's figures listed in Section 2.4.2.[18]

Based on the manufacturer's figures and an average consumption of 15.8 kWh /100 km with an annual mileage of approx. 25,000 km, an annual charging requirement of around 4,000 kWh per vehicle can be determined[19].

4.1.2 Charging methods

There are basically two methods available for vehicle charging:

- **Charging with alternating current (AC)**
  is the standard method for fleets whereby usage involves fairly long breaks, allowing for slower charging with comparably low charging capacity. This method protects the battery and reduces the amount of investment required for charging infrastructure.

- **Charging with direct current (DC)**
  is the preferred method in cases where long distances need to be covered quickly. In the carsharing context, this is frequently the case for holiday trips. Charging with direct current usually takes place with a charging capacity between 50 and 300 kW, so that the battery can be charged from 20 % to 80 % in less than 30 minutes. DC charging requires a significantly more complex charging infrastructure, including the capacity of the network. DC charging stations are often found on motorways and other long-distance roads, but also increasingly in accessible semi-public locations such as supermarket carparks.

[18] See the above-mentioned ADAC study
[19] A charging requirement of approx. 20 kWh/100 km can be realistically assumed for the investigated vehicles, resulting in an annual charging requirement of approx. 5,000 kWh per vehicle. For the calculations, however, the manufacturer's figures are used in the same way as for combustion vehicles.

Further estimations are based on the following parameters:

- Every carsharing parking space is equipped with an AC charging station. It is not necessary that charging stations are exclusively assigned to an individual carsharing vehicle.
- The loading capacity should be 11 kW per charging station. As the battery size of the vehicles in the investigated categories is between 40 – 60 kWh, charging up to 90 % at 50 % remaining capacity is possible within three hours.
- Depending on the circumstances, the charging infrastructure will consist of a wall box or charging station.
- During long motorway journeys, charging is generally in the form of DC charging at charging stations provided by the contract partner Shell Recharge, offering high charging performance > 50 kW. The higher costs incurred in this case are not considered in the context of this study.

4.1.3 Charging infrastructure requirements for fleet and components

639 charging stations are required for the electrification of the investigated fleet consisting of 639 vehicles. Due to the location of the current parking spaces, it can be assumed that this charging infrastructure would also need to be localized in public space. Depending on the circumstances of the individual location, either charging stations or wall boxes can be installed.

This requirement is reduced by the 47 existing charging stations. As such, 592 new charging stations would need to be planned and installed.

4.1.4 Investment requirements for planning and implementation of the necessary infrastructure

For the implementation of the necessary charging infrastructure the following costs should be presumed:

- Acquisition costs: charging station AC – 2 x 11 kW 7,000 €
- Acquisition costs: wall box AC – 2 x 11 kW 2,500 €
- Installation costs: charging station AC 6,000 €
- Installation costs: wall box AC 2,500 €
- Costs for public space power connection 7,500 €

It should be noted that these figures are estimates made by experts based on experience from similar projects or recent research results. Depending on location and manufacturer, the individual costs for power connections, charging stations and wall boxes can vary greatly.

Table 6 lists the estimated one-off investment requirements for the creation of the necessary charging infrastructure. In each case, one variant is shown for the exclusive calculation of the installation of wall boxes and charging stations.

Position	Unit price	Quantity	Variant Wall boxes	Variant Charging stations
Charging station AC	7,000 €	296		2,072,000 €
Wall box AC	2,500 €	592	1,480,000 €	
Installation charging station	6,000 €	296		1,776,000 €
Installation wall box	2,500 €	592	1,480,000 €	
Creation of power connection	7,500 €	148	1,110,000 €	1,110,000 €
Total			**4,070,000 €**	**4,958,000 €**

Table 6: Estimated investment costs for charging infrastructure required for 592 charging stations

On the basis of these assumptions, the installation of the described charging infrastructure would require **financial resources amounting to between 4.1 – 5.0 million €.**

Additional annual costs of 400 € per charging station would be necessary for the operation of the charging infrastructure installed for 592 charging stations. These costs result from the provision of the backend, customer support and annual maintenance, etc. These annual costs were calculated by the authors after interviewing operators of a similar charging infrastructure in January 2025. This would mean **additional financial resources of approx. 237,000 € being required as operating costs** for the planned charging network.

4.2 Fleet operating costs

In order to compare the operating costs of an e-carsharing fleet with the data of a similar internal combustion engine vehicle fleet, it is necessary to calculate the key cost drivers and corresponding calculation values of both fleets.

4.2.1 Input values

To arrive at a valid comparative calculation with secured input values, the determination of the cost items was based on the values shown in Table 7, derived from the expertise of the authors, experience from comparable projects and current sources. It should be noted, however, that several significant comparative values can vary considerably due to regulatory or market-related effects.

Vehicle type	internal combustion engine vehicle	EV
Average purchase price in €	23,500.00 €	29,900.00 €
Subsidies in €	- €	- €
Usage period in years	5	5
Mileage in km p.a.	25,000	25,000
Residual value as % of new price	45	45
Average residual value in €	11,475 €	15,570 €
Value loss in usage period	14,025 €	19,030 €
Fuel consumption per 100 km in l	4.5	
Fuel price in €/l[20]	1.67 €	

[20] Source: https://de.statista.com/statistik/daten/studie/779/umfrage/durchschnittspreis-fuer-dieselkraftstoff-seit-dem-jahr-1950/#:~:text=Im%20Jahr%202024%20(Stand%3A%20Dezember,auf%20rund%20166%2C5%20Cent

Vehicle type	internal combustion engine vehicle	EV
Energy consumption in kWh/100 km		15.8
Electricity price in €/kWh		0.33 €
Fuel tax in € p.a.	110 €	exempt
Vehicle insurance	1,000 €	1,000 €

Table 7: Input values: operating costs comparison

4.2.2 Cost drivers

The operation of an E-fleet is greatly influenced by various cost drivers. These cost drivers are described and compared to those of internal combustion engine vehicles below:

- **Purchase price and value loss**
  The vehicle purchase price and value loss during the usage period constitute the most substantial cost block. Research for our investigation suggests that this is 28 % higher than for comparable internal combustion engine vehicles (see Table 1, Section 2.2).

- **Energy costs for fleet operation**
  The financial resources required for the provision of fuel (internal combustion engine) and electricity (EV) constitute a further significant cost factor. Based on the manufacturer's figures for the investigated fleet, an average of 7.50 €/100 km should be budgeted for the operation of an internal combustion engine vehicle. By comparison, based on the manufacturer's figures and terms and conditions of the carsharing operator, 5.20 € should be budgeted for electric vehicles. Vehicle tax and insurance are further cost factors, albeit with a less significant impact on the total operating costs.

4.2.3 Comparative calculation overview

The table below shows the comparative calculation of the operating costs of internal combustion engine vehicles and EVs

	internal combustion engine vehicle	EV
Value loss p.a.	2,585.00 €	3,289 €
Vehicle insurance	1,000.00 €	1,000 €
Fuel costs / energy costs p.a.	1,878.75 €	1,303.50 €
Vehicle tax p.a.	110.00 €	exempt
Total costs per vehicle p.a.	**5,573.75 €**	**5,592.50 €**
Total costs per km	0.22 €	0.22 €
Total costs usage period 5 yrs	27,868.75 €	27,962.50 €
Cost benefit usage period 5 yrs	93.75 €	

Table 8: Comparative calculation: operating costs per vehicle and year

These results show that the total costs of operating an EV are very similar to those of operating an internal combustion engine vehicle. Over a usage period of 5 years, the difference amounts to a mere 94 € per vehicle.

4.2.4 Cost effects for the car sharing fleet

The calculation of the cost effects is based on the fleet of 639 vehicles in our case study, of which 50 vehicles are already electric. As such, 589 vehicles are required in order to fully transition to an EV fleet.

With a view to the economic data for the whole fleet, the results of the comparative calculation indicate the following effects:

- **Total costs:**
  With the transition to an EV carsharing fleet, it is to be expected that – **without consideration of the borrowing costs – the costs remain virtually unchanged.**

- **Liquidity:**
  The average higher purchase price of 6,400 € per vehicle results in **increased liquidity or external borrowing requirements of 3.77 million €** for the purchase of 589 EVs. Considering the vehicle usage period, it can be assumed that the debt servicing for the additional borrowing requirements would further increase the total costs of the fleet.

The overall assessment shows that the transition to an EV carsharing fleet would have only minor impact on the operating costs compared to the status quo. However, considering the higher debt servicing due to the increased borrowing requirements to purchase the more expensive EVs, the bottom line is that higher costs are to be expected for a fully-electric fleet compared to the status quo.

5 Effects of reduced EV usage

5.1 Modified assumptions

According to the carsharing provider, the usage of EVs is less than 80% of that of comparable internal combustion engine vehicles. The following reasons can be assumed for this:

- Users‘ reservations regarding vehicle range
- Lack of charging infrastructure during the journey and at the destination
- Duration and convenience of vehicle charging

It can be assumed that such reservations would continue to apply when transitioning to an EV fleet. The users’ reservations can only be overcome if the objective reasons no longer apply, i.e. by a large-scale expansion of the (fast) charging infrastructure, e.g.: on motorways, or by a significant increase in vehicle range.

In order to investigate the possible effects of reduced EV usage, the following scenario is considered:

- **20 % reduction in carsharing mileage:**
  from 25,000 km / year / vehicle to 20,000 km / year / vehicle
- **10 % reduction in number of registered customers to 26,000:**
  assuming that customers who cannot or do not wish to use EVs in the same way as internal combustion engine vehicles will leave the carsharing scheme
- **Change in the modal split amongst remaining customers:**
  Increase in Car % from currently 14 % to 17 % (see Table 9)

Modal split share	CS users	Population
Car	17 %	43 %
Public Transport	15 %	13 %
Cycling / Walking	68 %	44 %

Table 9: Modified calculation basis modal split

5.2 Ecological effects

5.2.1 Modified reduction effects of carsharing users

To calculate the effects resulting from the modified assumptions, the annual journey length for each means of transport was first determined in the same way as in Section 3.2 Reduction effects of carsharing users. The calculation

$$\frac{3.1\ journeys}{day}\ x\ share_{transport\ means}\ x\ \emptyset\ journey\ length_{transport\ means} x\ 365\ days$$

produces the results shown in Table 10: Modified journey lengths per person and year:

Journey lengths per person / year	CS users	Population
Car	3,270 km	8,207 km
Public Transport	3,904 km	3,470 km
Cycling / Walking	2,308 km	1,482 km

Table 10: Modified journey lengths per person and year

The emissions (CO_2 equivalents) per person and year are calculated by multiplying the transport-specific emissions values listed in Section 3.1.3 (Table 11, converted into tonnes of CO_2 equivalent):

t CO_2 / year	CS users	Population
Car	0.54	1.36
Public Transport	0.28	0.25
Cycling / Walking	0.00	0.00
Total (per person)	**0.82**	**1.61**

Table 11: Modified transport-related CO2 emissions per person and year

The result is a modified saving of 0.82 t transport-related CO_2 equivalents (previously 0.85 t) per registered carsharing user and year. Projected onto the assumed reduced number of 26,000 registered users in our case study, the result is an **annual total reduction of transport-related CO_2 equivalents of approx. 20,000 t CO_2 equivalents** (previously approx. 24,300 t).

5.2.2 Comparison of reduction effects

The reduced carsharing usage and expected loss in users following a full transition to an EV fleet would result in additional transport-related emissions of approx. 4,300 t of CO_2 equivalents per year, emissions otherwise saved by the present number of carsharing users. This is offset by up to 2,300 t CO_2 equivalents, which would be reduced locally by the fleet transition. In total, the change in user behaviour following a transition to EVs would lead to a negative CO_2 balance of **approx. 2,000 t CO_2 equivalents emitted annually.**

5.3 Economic effects

The reduced usage of EVs compared to internal combustion engine vehicles also has economic effects. These can be characterized as follows:

- **Significantly reduced revenue due to lower usage intensity**:
  The revenue of the carsharing provider is significantly reduced by the lower usage intensity of customers (see Section 5.1).
- **Only minor reduction in costs**
  Throughout the sector, the cost structure of carsharing is dominated by an extremely high proportion of fixed costs. As such, a decrease in revenue has a direct negative impact on the operating result, since this can only be compensated to a limited extent by reduced variable costs. The purchase of electricity constitutes a substantial part of the variable costs. The reduced mileage shown above results in a reduction in the energy required to operate the vehicles of approx. 638,000 kWh p.a., with reduced energy purchase costs of approx. 210,000 € p.a.

- **Lower operating result:**
  With all probability, a reduction in revenue of approx. 20 % with only a slight reduction in fixed costs will lead to a significantly lower operating result (fall in revenue minus the reduced variable costs).
- **Increased marketing efforts:**
  The anticipated reduction in usage would have to be counteracted with additional marketing efforts, e.g.: a communication campaign in order to counter existing reservations regarding EVs.

- **Restructuring requirements:**
  To effectively compensate for lower revenue, personnel, organizational and technical restructuring processes might be necessary.

There are no figures available to accurately assess fiscal effects in this short study. However, the following calculations are plausible:

- If a carsharing provider were to currently achieve a profit margin of 20 %, this margin would be totally consumed by a revenue loss of 20 %.
- If the profit margin were currently under 20 %, reduced usage would result in a negative operating result and therefore in insolvency in the medium term.

To the authors' knowledge, the profit margins of carsharing providers are predominantly in the low single-digit range. Within the current parameters, it can therefore be presumed that the expected lower revenues of a fully-electric fleet, vis-à-vis those of an internal combustion engine vehicle fleet, would most probably result in current carsharing providers ceasing operations.

6 Summary

6.1 Ecological effects

Compared to the effects of a change in mobility behaviour, the calculated ecological effects of a transition to a fully-electric fleet are minor. The same effects could already be achieved by a moderate increase in users of approximately 400 – 800 new customers per year.

It should, however, be considered that the calculated effects only apply if the transport usage of current users remains unchanged. In fact, this is doubtful, as the demand for EVs continues to be limited for significant travel purposes such as long holiday trips. Empirical reports indicate that EVs are used at approximately 20 % less capacity than internal combustion engine vehicles, and that reservations concerning EVs persist. Taking into account the assumed reduced vehicle usage and the associated fall in registered users, the result is **an annual negative balance of approx. 2,000 tonnes of additionally emitted CO_2 equivalents.**

6.2 Economic effects

Substantial investment in charging infrastructure would be required for a complete transition to EVs. Whereas the total fleet costs are similar for both variants, the lower energy costs are offset by higher borrowing requirements and debt servicing.

In addition, it should be noted that the currently significantly lower revenue for EVs compared to internal combustion engine vehicles has considerable negative impact on the operating result of carsharing providers. **From an economic perspective, an obligatory transition to a fully-electric fleet would most probably result in the providers ceasing operations.**

6.3 Overall assessment

The national vehicle registration figures indicate that the share of EVs is considerably higher in carsharing fleets, confirming that the carsharing sector is **not only open to EVs in principle, but has already assumed a pioneer role, making a valuable contribution to the electrification of private transport**. However, an obligatory EV transition would be counterproductive, as the advantage of zero local emissions is countered by the following arguments:

- The ecological advantages of a fully-electric fleet are minor compared to those gained from the acquisition of further customers.
- The capacity of providers and state administration would be bound by the necessary infrastructure development and would be no longer available for the acquisition of new customers and the development of further service areas.
- The development of new areas would be made additionally difficult, as it would no longer be possible to test such areas with low investment and then close them in the event of lack of demand. Instead, major investments in charging infrastructure would be immediately required in order to test locations.
- Vehicle usage is made more difficult for customers due to limited vehicle range and the comparatively complicated and long charging process. This particularly impacts fleet usage for holiday trips, a form of usage which is economically attractive for the carsharing provider. These aspects could result in a considerable share of current users no longer using the fleet for these purposes.
- The required investments and operating costs are unaffordable for carsharing providers. It is therefore to be expected that an obligatory transition to EVs would lead to services being discontinued.

All in all, stronger climate-protection effects are to be expected from the further expansion of carsharing and the acquisition of new customers. The government funding necessary for the realization of a fully-electric carsharing fleet should therefore rather be invested in the development of the existing carsharing offer.

As a result of organic growth, a disproportionally large number of EVs are already integrated into carsharing schemes. It is advised to promote this organic growth by targeted support.