32nd Electric Vehicle Symposium (EVS32)
Lyon, France, May 19 - 22, 2019

Electrification of corporate passenger car fleets -a case study after 3M EV-kms

Steffen Bucher[1] , Dirk Braun[2]

[1]*BridgingIT, Marienstraße 17, 70178 Stuttgart, steffen.bucher@bridging-it.de*

[2]*BridgingIT, N7 5-6, 68161 Mannheim, dirk.braun@bridging-it.de*

Summary

The vehicle market, especially for combustion-engined passenger vehicles, is undergoing major changes. The driving bans, mandated by court decisions following continued health-threateningly poor air quality in urban areas, create uncertainty, also for corporate fleet operators.
This paper aims to provide data-driven insights on “living with e-mobility” in corporate fleets. Based on an analysis of real-life fleet data from the company bridgingIT in years 2014 to 2017 (over 3 mio EV-kilometers), is laid out by means of economic and ecological indicators. In addition, it was examined which modern drive technologies and vehicle concepts would currently be useful from a business management point of view. Finally, a forecast of possible, future scenarios of increasing number of electric vehicles in bridgingIT fleet is made.

Keywords: cost, BEV, emissions, user behaviour, PHEV, ICE

1 The object of the case study - BridgingIT GmbH, a consulting services company

BridgingIT GmbH (bIT) was founded at the beginning of 2008 as an independent consulting company in the field of information and communication technology.

Smart Mobility is an important part of the bIT history and the everyday life of the employees. bIT operates one of the largest long-distance EV-fleets in Germany and offers in addition a comprehensive mobility package for employees, which includes components such as individual vehicles, e-bikes, car sharing and “Bahncard” offers or combinations from the before named options.

The first EVs to join the bIT-fleet was one of the first electric Smarts (year 2009) and BMW i3 (year 2014). Today the bIT fleet of over 250 vehicles comprises 34 battery electric and plug-in hybrid vehicles and the total "electrified mileage" has already passed the 3-million-kilometer mark.

.

2 The corporate EV-fleet

The vehicle fleet currently contains over 250 vehicles. These vehicles are directly assigned to the employees and may also be used privately. Thereby (approx. 2/3 professional, 1/3 private use) for 3 years, approx. 35,000 km/year, full-service leasing.

The fleet consists mainly of vehicles of the German companies Volkswagen, Mercedes and BMW.

The company bridgingIT currently owns one of the largest long-distance electric car fleets (Tesla) in Germany, with which approx. 1 million electric kilometers are covered per year. Now we are increasingly working on implementing electric mobility for our customers.

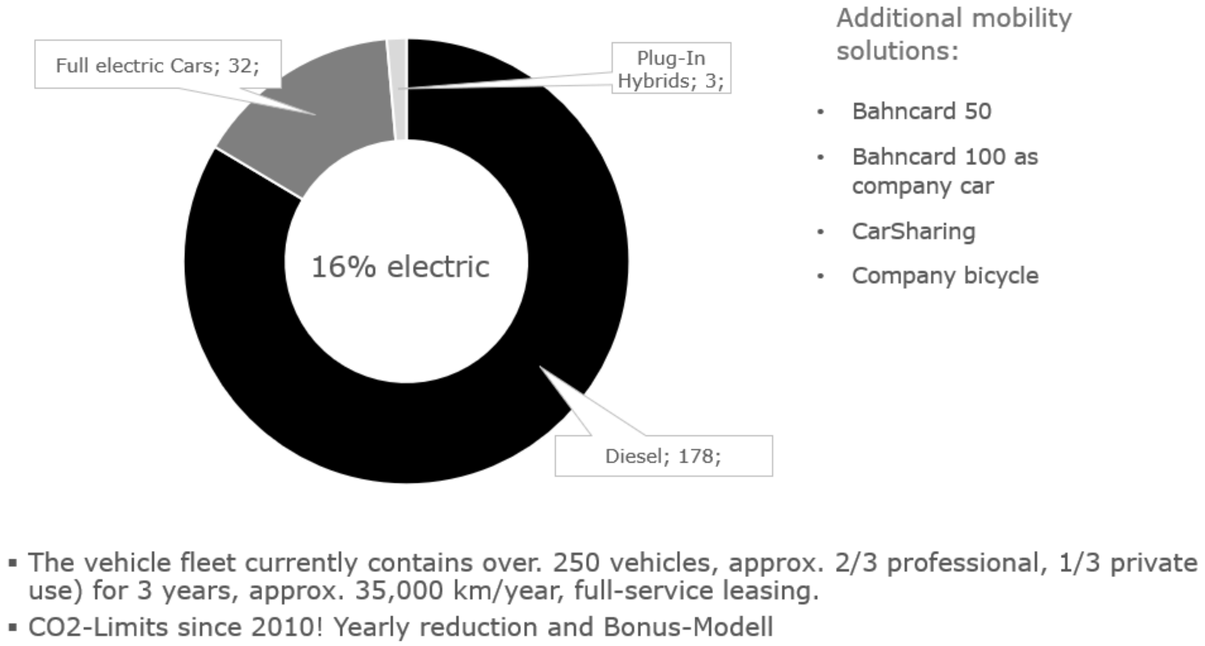


Figure1: The fleet

3 Emissions in Real World Use Cases

3.1 Total vehicle fleet excluding electric vehicles

In 2016 bridgingIT emitted (based on real vehicle consumptions) 650 tons of CO2. On average a vehicle emitted 211.98g CO2 per km. According to the NEDC, the average CO2 emissions per kilometre should be 131.9 grams.

In order to obtain a comparable value for all-electric vehicles, the average emissions are multiplied by the 35,000 km driven per year. This value is 7.42t CO2 per year.

To compensate for one tonne of CO2, 80 trees have to be planted. This means that for the emissions that an average vehicle emits at bridgingIT in one year for the calculated 35,000 km, 560 trees are needed to compensate these emissions.

There is an ICCT study on the standard consumption deviation of private and commercial vehicles. This came to a standard consumption deviation of 45 % for commercial vehicles. At bridgingIT, however, the average consumption of all vehicles is 58% higher than that of the NEDC.

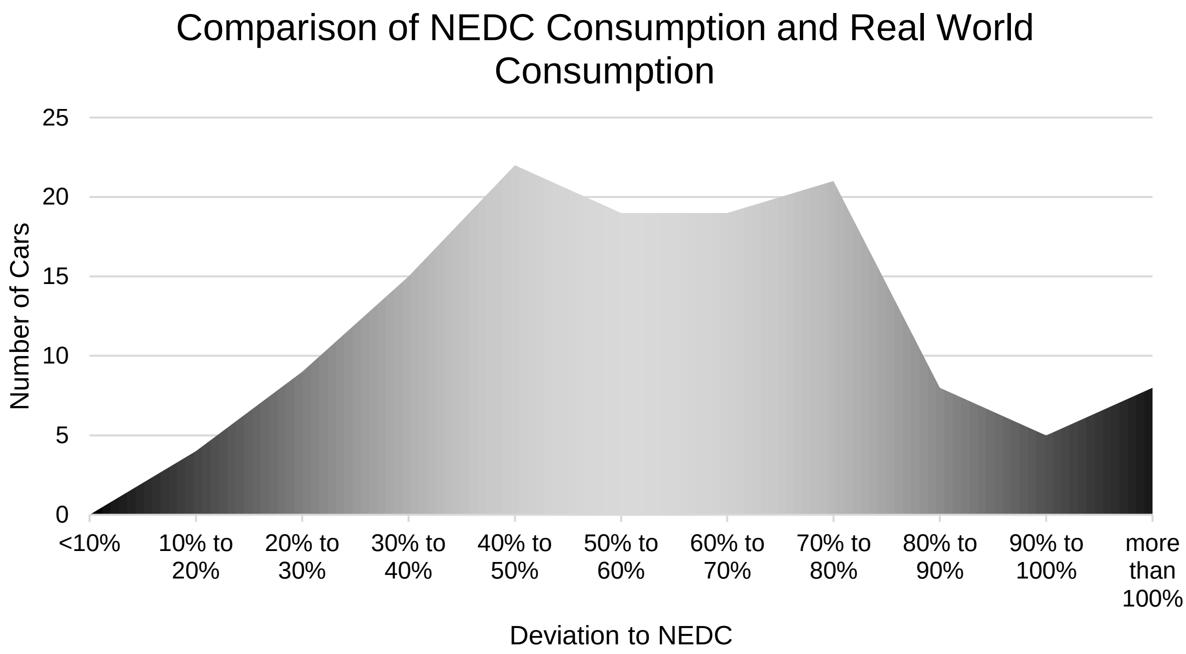


Figure 2: Deviation to the NEDC

3.2 Emissions in 2017 and 2018

The data so far is based on a comprehensive analysis of the 2016 data, but the interesting question is how it has developed in recent years. New emission standards have been published and emissions are to be further reduced.

Looking at the real world emissions, the emissions have fallen. However, if you look at the NEDC emissions, they rose in 2017 and fell again in 2018. The vehicles moved in the fleet, however, have not changed in their composition. Only older models have been replaced by newer ones.

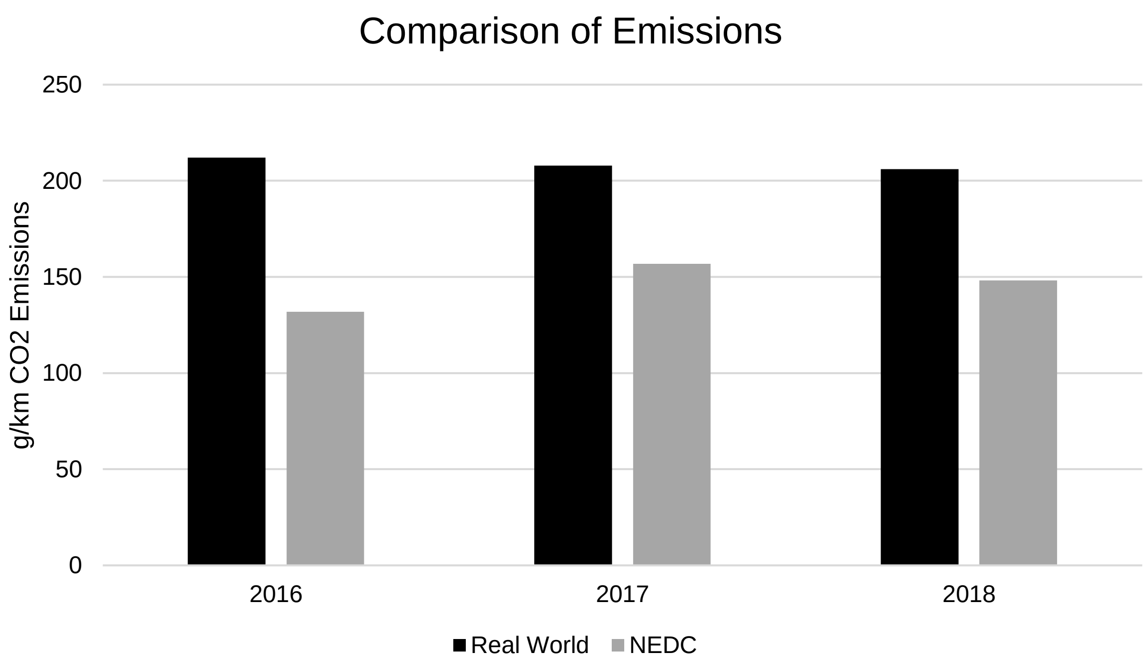


Figure 3: Emissions 2016, 2017, 2018

However, in percentage terms this is just under 2% from 2016 to 2017 and just under one percent from 2017 to 2018.

3.3 Battery electric vehicles

A Tesla Model S with the weighted emissions per kWh causes 100.34g CO2 per kilometer (based on the german energy mix) . All 18 electric vehicles had a total output of 56.25 tons.

In order to be able to compare the fully electric vehicles with the conventional vehicles, a mileage of 35,000 km per year is assumed. This results in 3.44t CO2.

In the year 2030 the calculation looks even better, since then CO2 emissions of 314g/kWh are assumed. By 2030, CO2 emissions can be almost halved from 100g to 60g per km.

Then a fully electric vehicle would produce 2.05t CO2 emissions in a complete year.

However, drivers of Tesla Model S vehicles are obliged by bridgingIT to use only green electricity for the operation of the vehicle. This would be less than 10g CO2 for one kilometre. But the extent to which it can be controlled which power comes from the charging cable is uncertain.

The use of a green electricity contract in private households is essential.

Compared to the average vehicles of bridgingIT, the CO2 emissions of the Tesla are significantly lower, even when considering the current electricity mix. A Tesla Model S with an annual mileage of 35,000 km emits only 60 % of the emissions in the current electricity mix, like a comparable vehicle with a combustion engine.

If green electricity is used, as directed by bridgingIT to electric car drivers, the value is reduced to only 5 %.

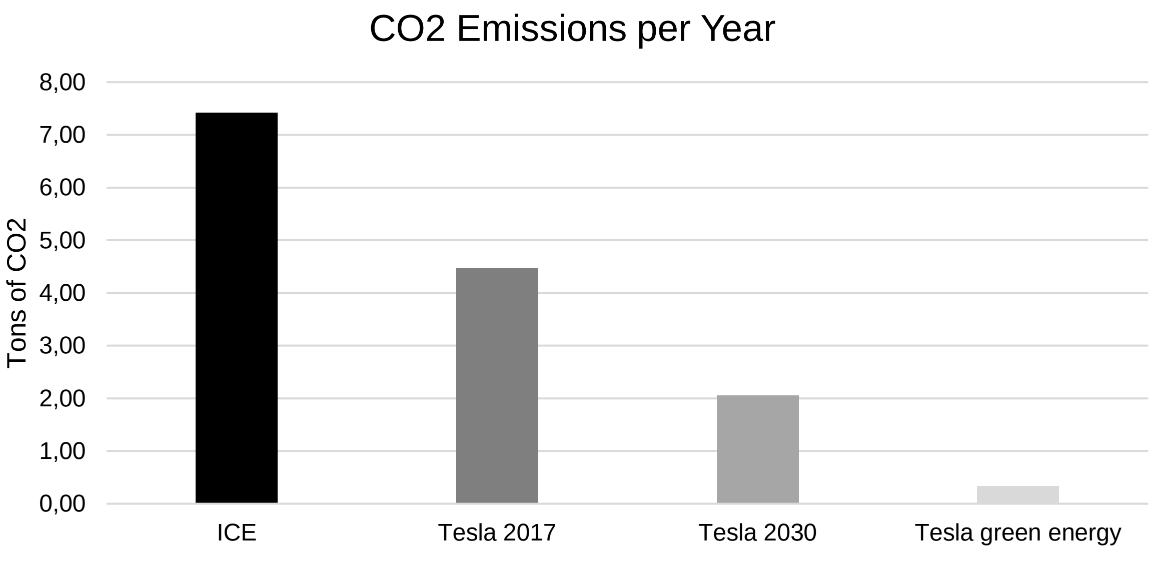


Figure 4: consumption and Real World emissions

4 The total Cost of Ownership Analysis for the ICE-Cars

The vehicle market, especially for diesel engines, is undergoing major changes due to the increase in politically-supported driving bans in inner cities, the compliance with stricter EU emission standards and the associated social rating. More than a third of the vehicles sold in Germany are company vehicles with a majority of diesel engines, which is why they are very important for registration numbers and thus have a high impact on the environment and the vehicle market. As a result, there is a need for action on the part of corporate fleet operators to achieve the agreed goals. Therefore, bridgingIT has analyzed the total cost of ownership of the fleet (diesel as well as electric) and the result for the environment (CO2 emissions).

The total costs incurred during the period during which the vehicle is kept are divided into two categories:

- acquisition costs
- operating costs

Investment costs and depreciation are considered in the acquisition costs. Operating costs include all costs incurred during operation. These include consumption costs, maintenance and repair costs, taxes and insurance.

4.1 Acquisition costs

The total acquisition costs and partly the operating costs are determined by the leasing costs for the vehicles in the considered fleet.

The leasing instalment is made up of:

- financing of the vehicle
- maintenance and wear
- inspections
- administration
- taxes

All costs, with the exception of the financing of the vehicle, are determined by the equipment. Larger rims cause larger tyre costs. Larger engines cause higher maintenance costs and taxes. The financing of the vehicle and the return of the vehicle manufacturer (OEM) or lessor are also included.

Insurance is already included for Volkswagen Group vehicles, but not for BMW or Mercedes. Therefore, the insurance costs are considered separately in the operating costs.

To illustrate this, two vehicles are compared. A BMW 520d and a BMW 530e.

The 530e has a business customer leasing rate of € 508.78 and € 602.61 for the 520d. The list price for the BMW 530e is €62,270 and for the BMW 520d €57,260.

An interest rate on the capital of 3 %, a rate of return of 5 % and a loss in value of 12 % p.a. were assumed.

Table 1: Comparison of Lease Costs

	530e	520d
list price	62.269,89 €	57.260,70 €
price except VAT	57.848,73 €	53.195,19 €
interest rate	3,00 %	3,00 %
rate of return:	5,00 %	5,00 %
total:	8,00 %	8,00 %
term	36	36
calculated residual value:	42.435,19 €	39.021,56 €
leas payment incl. VAT	711,38 €	654,23 €

The leasing rates for the assumed yield values and interest rates are significantly higher than the leasing rates shown in bridgingIT's offer.

With an assumed maximum discount of 30 %, lower leasing rates are the result. Depending on the vehicle, bridgingIT received between 7 and almost 30 % discount on the leasing price. With these leasing conditions the OEMs try to get the new vehicles on the roads.

4.2 Operating costs

The operating costs are based on the real fuel consumption and fuel costs incurred in 2018. These are recorded in the fuel card statements. This also includes fuel price fluctuations over the course of a year.

Insurance costs are divided into vehicles leased from the Volkswagen Group and vehicles leased from BMW or Mercedes. For BMW and Mercedes models, the insurance is not included in the leasing rate, but must be taken out separately. In order to keep administrative expenses as low as possible, the insurance of these vehicles is also taken out with the Volkswagen Group. This charges a standard rate of 118€ per month on every vehicle that comes from another make.

The insurance costs calculated by Volkswagen for its own vehicles vary. Old vehicles cost €83.52 and the newest vehicles up to €133.

The flat-rate insurance costs for third-party vehicles from Volkswagen are €7 per month or €84 per year more expensive. That is with the total costs of approx. 10,000€, a very small portion and is therefore not considered.

4.3 Performing the Total Cost of Ownership Analysis

In order to perform the total cost of ownership analysis, the acquisition costs are first treated in 2016. For this purpose, the monthly leasing instalments were collected from the individual manufacturers and leasing companies. For vehicles purchased via the leasing company Alphabet or Mercedes, the insurance costs are added to the leasing rate. This results in the total leasing instalment per month. In order to link the Excel table, each cost value is linked to the vehicle registration number. In another invoice, all fuel invoices for 2016 were entered and linked to the license plates of the corresponding vehicles. The individual fuel invoices show the current mileage, the fuelled quantity in litres, the price per litre and the invoice total. In order to arrive at a comparable basis, only vehicles driven for the entire year 2016 are considered in the calculation. This means that vehicles that have only been in operation for a few months are excluded.

For total costs, the operating costs and the vehicle costs are now added together.

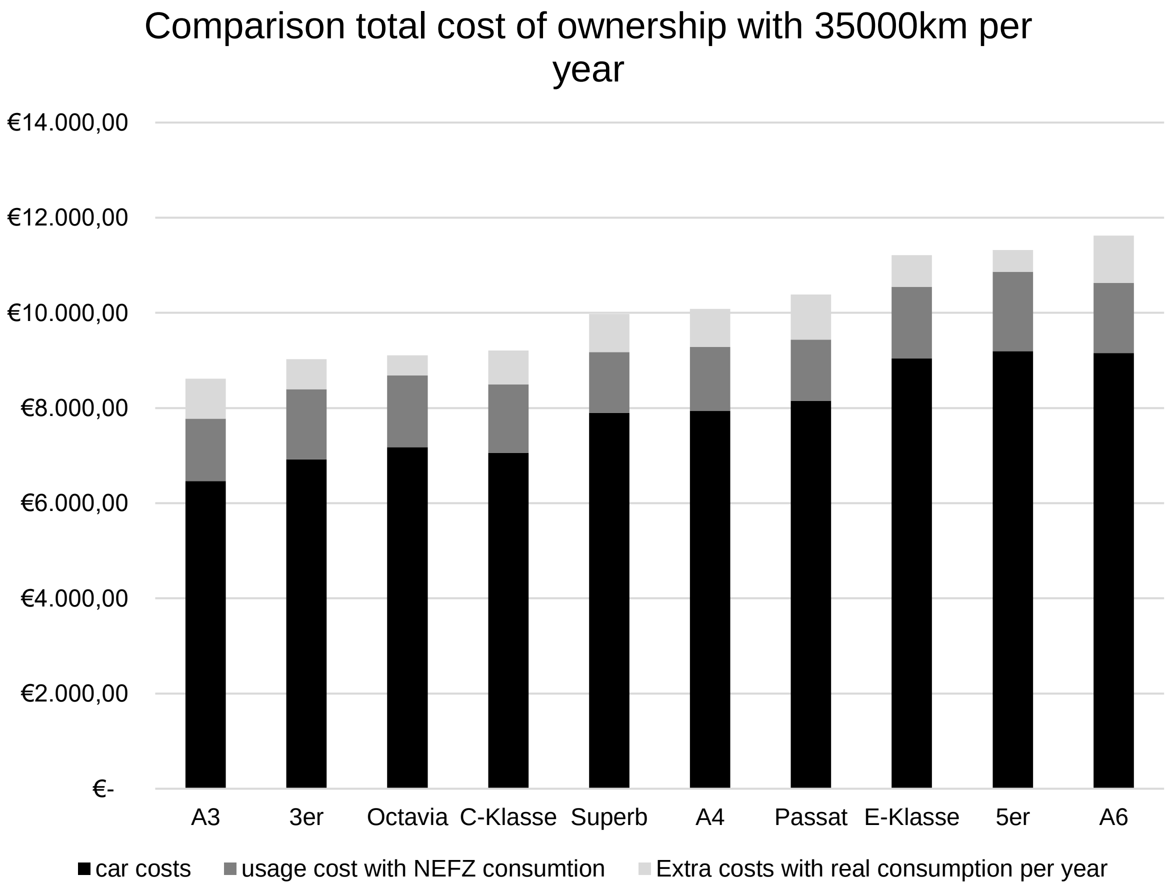


Figure 5: Total cost of Ownership

5 Battery electric vehicles

Tesla Model S are already in the fleet and can rely on real consumption. Consumption is shown on the displays of the vehicles' on-board computers.

The entire loading process of the vehicles is documented. In these we have a division of:

Table 2: charging locations

private	Supercharger (kostenlos)	The New Motion	intercharge	Ladenetz	Plugsurfing	other (free)
48,90 %	23,89 %	2,53 %	1,66 %	0,06 %	0,03 %	22,93 %

The New Motion, intercharge, chargenetwork or plugsurfing are roaming providers that enable charging at various public charging points. At home charging costs of 0,30€ per kWh are charged. The majority of the other charging processes take place at superchargers or other free charging facilities. With the privately loaded and free loaded charging processes 95.72% of all charging processes are covered.

Unfortunately there were strong price fluctuations for the purchase price of the vehicles in the past years with Tesla. Therefore the bridgingIT paid for the same Model S, leasing rates between 1.300€ and 1.800€. Internally for the calculation an average value of 1.581,74€ is set as leasing rate. At bridgingIT 31 Tesla

Model S are currently being moved. They drove very different total distances in the years 2016-2018. In total a median of 33,600 km.

The vehicles consume between 22 kWh and 26 kWh for 100 km. The median bridgingIT is 23.93 kWh for 100 km. The total costs amount to € 15,735 for 33,600 km of average annual mileage.

In terms of operating costs, however, it is important to differentiate where the vehicles are loaded. The privately loaded KWh cost 0.30€. Those at the Superchargers are free.

The model S, which was driven at bridgingIT, is mostly the vehicle with 85 kWh battery. This battery has a NEDC range of 502 km. From this a NEDC consumption of approx. 170 Wh/km can be calculated. From this value and the achieved consumption in the fleet, the average deviation from the standard consumption is 41%. The maximum deviation was 52%.

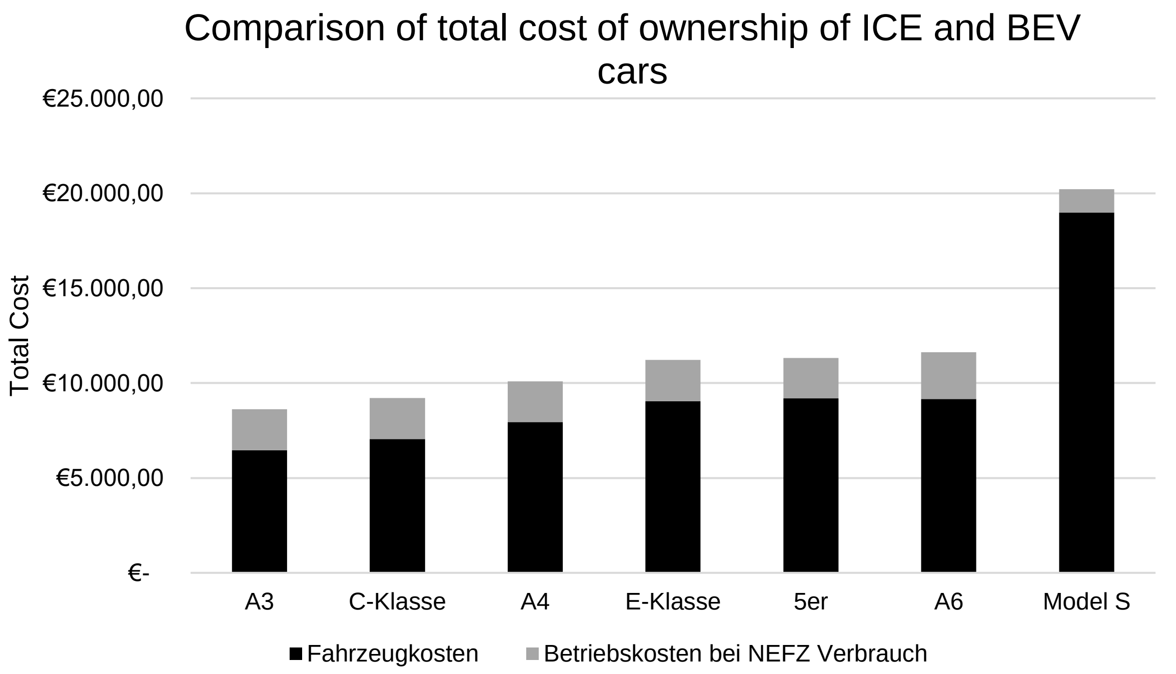


Figure 6: Comparison of total cost of ownership of ICE and BEV cars

6 Prospects of PHEVs in fleet use

Plug-in hybrid vehicles have not been used at bridgingIT so far, because they consistently wanted purely electric vehicles and PHEVs only have CO2 reduction potential in very special application scenarios but are more complex in terms of fleet organization.

Due to the discussion about a driving ban for diesel, the PHEVs have now become an option for bIT, as they are powered by gasoline engines and can also be electrically driven on a pro rata basis, especially in cities. The total cost of ownership and the potential use cases are developed during the poster session.

For these vehicles, the values determined by the NEDC cycle are very far depart from how much the vehicles actually consume in reality. In order to get closer to the real consumption, the petrol engine installed in the hybrid vehicle is taken and its real consumption is determined with the online tool Spritmonitor. In order to calculate the consumption of the hybrid, an electric driving portion is determined and a combined total consumption is calculated. This calculation is based on the assumption that the hybrid vehicle is either moved purely electrically until the battery is empty, or is moved only with the combustion engine and does not charge the battery.

This mixed consumption is then multiplied by the average fuel costs in 2016 to create a comparable database for conventional vehicles.

The problem with this calculation is that assumptions have to be made for the state of charge of the vehicle. For this calculation it is assumed that the employee has a charging facility at home, always charges the vehicle overnight at home and therefore drives off with a full battery in the morning. The charging infrastructure required for this, a charging cable for a household socket, is included with the plug-in hybrid vehicles when they are delivered. In between, no charging takes place at the public charging infrastructure. Charging in the office or at the customer's is not included in the calculation.

Electrical ranges of the vehicles in question

Plug-in hybrids of German manufacturers were considered for the expansion of the share of electric vehicles. From BMW the 330e and the 530e, from Mercedes the C 350e and the E 350e and from the Volkswagen group the Golf GTE.

For the vehicles, the purely electric NEDC ranges vary between 31 and 50 km. Since significant deviations in the NEDC consumption values for combustion vehicles have already been detected, the same deviations were also assumed for the possible electrical ranges. The calculated ranges vary between 15 and 25 km. This results in an average range of 21.36 km for hybrid vehicles.

Possible applications in the vehicle fleet

Now the possible use in the existing fleet is analysed. Hybrid vehicles can be driven fully electrically in city operation. It is also possible to drive some of the routes electrically on country roads and motorways. All vehicles have a maximum speed of well over 100 km/h in purely electric mode. Therefore, theoretically all kilometres would be electrically possible until the range of the battery is exhausted.

First, the average daily kilometres per vehicle in 2016 are calculated. The total kilometres driven in 2016 are divided by 360 days a year, resulting in the average kilometres driven per day. In the range between 40 and 50 km, which were the average daily kilometres in the KIT mobility study, there are only 6 drivers in the bridgingIT fleet. The other employees drive significantly more kilometers per day. The problem is that only 21.36 km of this distance could be driven electrically. Then the combustion engine starts up additionally or the battery would have to be charged.

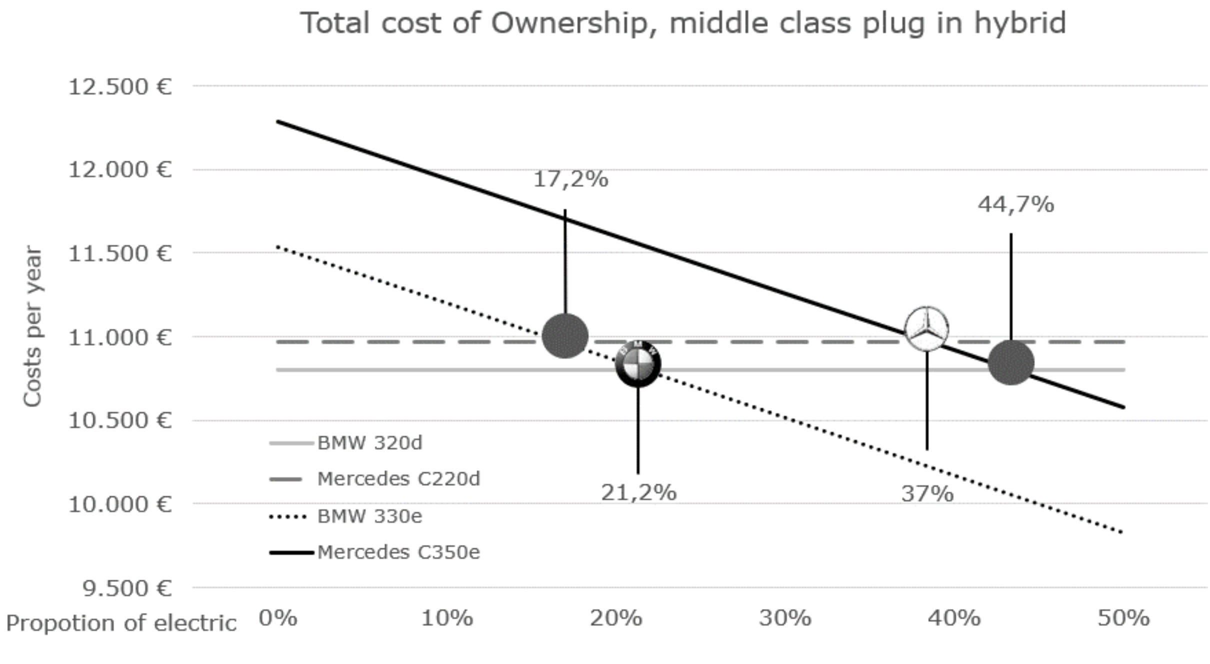


Figure3: Total Cost of Ownership – Plug In Hybrid

7 Experiences from around 3,000,000 electric kilometres

Based on the 3 million EV-kilometers so far, a great deal of experience has been gained about suitability for everyday use and, in particular, public charging. A great advantage of the electric car is that it is always fully charged in the morning when charging at home is possible. The stationary air conditioning is particularly comfortable, allowing the car to be heated before departure in winter and cooled in summer. The electric drive offers the drivers a noticeably higher driving comfort, more driving fun and at the same time peace in the vehicle as well as a good feeling.

The majority of the drivers have got along with the cruising range with every trip without any problems. Nevertheless, a large proportionhad problems during holiday trips due to the more frequent loading breaks on longer journeys.

When it comes to the topic of the distribution of loading processes, it can be seen that most loading processes took place at home.

24 % of all charging took place on superchargers. Almost no charging took place at other public charging points because they are too slow or not at the required locations compared to superchargers. However, a few were used. One employee is currently even moving the vehicle without a private charging infrastructure.

Of those who used the public charging stations, 50% found the current availability catastrophic and 38% poor This means that the public charging infrastructure still has room for improvement. The good news is that of the charging stations on offer

50% were mostly free and accessible. In addition, 50% authentication was problem-free and 3% was mostly possible. Only rarely were the charging stations unusable due to non-functioning authentication.

In the case of the public charging infrastructure, questions were also asked as to what anomalies had occurred. The big disadvantage of the public charging stations compared to the superchargers is the charging capacity and the unfortunately only punctual availability. Furthermore, the many different authentication systems of the individual electricity suppliers. The roaming cards did not always work without problems.

Whether supercharger or public charging station, a charging pause always occurs. This charging pause is also referred to as charging pause among the electromobilists. A mixture of charging time and boredom. 60 % of the Tesla drivers at bridgingIT say that this was always useful. 33 % say that they could not be used sensibly for private journeys. This is due to the fact that on holiday trips the destination should sometimes be reached as quickly as possible. The 20-minute loading breaks are rather annoying.

The usage behaviour was also surveyed. This has changed little by the electric vehicle, the electric car drivers have a better conscience also with shorter driving distances with the car, since they emit no CO2 emissions. What has changed greatly, however, is the general driving behaviour of employees with an electric vehicle. All of them said that with the Model S they drive much slower on the motorway and generally much more relaxed than with the vehicle before. However, some of them accelerate more often, due to the significantly higher performance compared to the combustion engine vehicle that was driven before. The lack of engine noise was consistently rated as very positive and relaxing. One of the interviewees even found it so pleasant that he drove without a radio just to enjoy the peace and quiet. An important point that is very often dealt with in the media is the lower pedestrian safety due to the lack of engine noise in electric vehicles.

Experience to date has shown, however, that the lack of background noise is only relevant to safety in supermarket car parks and multi-storey car parks. However, even modern cars with petrol engines are not louder there.

With the technological innovations, all the software updates assess as meaningful, but still improvements are possible. For example, a better information policy before installation. This information can currently only be obtained from forums of other test drivers who have already downloaded the update.

The new operating concept is called intuitive throughout. Some people are a little more distracted by it, many however much less or shorter than other infotainment systems. The only disadvantage is that it is very difficult to keep the screen clean.

The autopilot is used very often by the employees and is very pleasant as long as its limits are known. However, the autopilot should not be used in the city or on poorly visible white roadsides and median strips. Then the term autopilot can become very dangerous, as the vehicle cannot drive completely itself in every situation. It is very important to stay alert during use so that you can intervene at any time.

The most important question, however, is whether drivers would drive an electric vehicle again or switch back to a conventional vehicle.

80% of respondents would drive an electric vehicle again. Only 13.3% would switch back to a combustion engine. This is particularly detrimental to the range on holiday trips, the significantly higher gross driving times on longer journeys and the significantly higher costs incurred by the employee due to the taxation of the monetary advantage.

During the interviews also some special features occurred:

- the autopilot is much more economical than if you drive yourself

- the availability of the service centers is still too low

- in a traffic jam it would be better if the Model S in autopilot mode would leave a rescue lane free

- In case of an accident Tesla is immediately on the spot by telephone and tries to support you.

- only preferably electric vehicle parking spaces are not useful, as they are parked by conventional vehicles

- in Stuttgart, many parking spaces for electric vehicles are free of charge, which saves time in travel expense accounting at the end of the month and costs

8 Conclusion

Furthermore, in the dialogue session we will point out the development in the electric car market and how it will influence the vehicle fleet of companies. In addition, it was examined which modern drive technologies and vehicle concepts would currently be useful from a business management point of view. Another important element in the purchase decision is the assessment by the customer (= employee), which is why another feature for decision-making was developed by questioning selected customers. Finally, a forecast of possible, future scenarios of electric vehicles in fleets is made.

References

[1] International Council on Clean Transportation Europe (2016): From Laboratory to Road 2016, accessed on 2017-05-31

[2] Martin, Daniel; Treiber, Martin; TU Dresden (2014): Sind Elektroautos wirklich umweltfreundlich?, accessed on 2017-04-27

[3] Union of concerned Scientists (2015): Cleaner Cars from Cradle to Grave. How Electric Cars Beat Gasoline Cars on Lifetime Global Warming emissions, accessed on 207-04-26

[4] International Council on Clean Transportation Europe (2016): From Laboratory to Road 2016

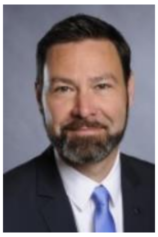
[5] Bäurle, R.; Schulte, C. (1992): Effektives Kostenmanagement: Anforderungen und neue Ansätze, in Schulte, C (Hrsg.): Effektives Kostenmanagement - Methoden und Implementierung. Stuttgart.

[6] Klöpffer, Walter; Grahl, Birgit (2009): Ökobilanz (LCA). Ein Leitfaden für Ausbildung und Beruf. Weinheim: Wiley-VCH-Verl.

[7] Union of concerned Scientists [(Hrsg.)] (2015): Cleaner Cars from Cradle to Grave. How Electric Cars Beat Gasoline Cars on Lifetime Global Warming emissions, zuletzt geprüft am 26.04.2017.

Authors

Steffen Bucher studied international technical business management with a focus on sustainable mobility. Since March 2017 he has been working for bridgingIT GmbH, where he first wrote his thesis on "Electrification of company car fleets". The dialogue session to be heard was based on these and other findings. After his thesis he is working as an consultant for electrification and mobility concepts.



Dirk Braun is working with bridgingIT GmbH as Senior Consultant Innovation, Technology und Trends since 2014. In his role as leader for the bridgingIT Center of Excellence Smart Mobility, he also promotes his knowledge in eMobility, charging infrastructure, energy and mobility management to different customers. Beside this he is responsible for the management and development of the companys fleet of electric cars.

Before working with bridgingIT, he was working with various consulting companies as consultant and project manager in different functions and industrial sectors.