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Shift to electric vehicles is gathering pace – but who is climbing into the driver's seat?

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Electric vehicle uptake in Germany is growing rapidly. Although so far just slightly more than 1% of all cars are electric, last year these vehicles accounted for nearly 14% of all new car registrations and the trend is rising. A special survey conducted as part of the KfW Energy Transition Barometer shows that high-income households in detached single-family homes are currently the main users of electric vehicles.

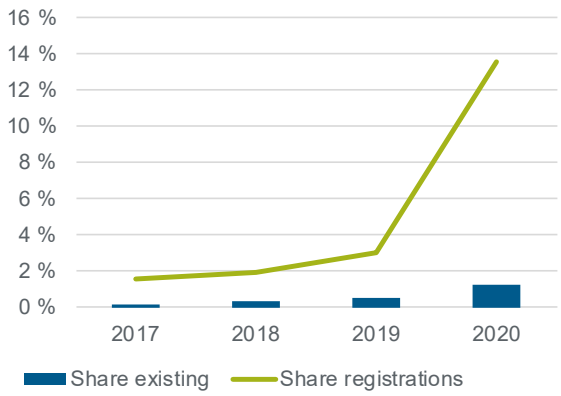
The primary motives for buying an electric car are concerns about climate change and the innovative nature of the technology. The main reasons not to buy one – besides the high price – are reservations about practicability, for example with regard to range and charging infrastructure. Doubts about the climate footprint of electric cars have grown over time and are now voiced by almost one in two households. Given the increasingly greener electricity mix and predominantly positive research findings about their climate impact, this is quite a surprising trend.

In order for the mobility transition to succeed, it will be important to mainstream electric mobility as an attractive option in all groups of society. The findings suggest that for one thing, the relative cost-effectiveness of electric vehicles must be improved further. For another, an efficient charging infrastructure must be developed and expanded and consumers' information deficits must be addressed, for example regarding the climate footprint of electric vehicles.

According to Germany's Federal Motor Transport Authority, last year almost one in seven newly registered passenger vehicles had an electric motor – not counting hybrid vehicles without an external charging port.[1] That rate was nearly four times as high as in the previous year (Figure 1). Almost half of newly registered vehicles were fully electric (194,163) and plug-in hybrid vehicles (200,469).

This impressive growth means that the number of electric cars more than doubled in the year 2020. At the end of the year, some 590,000 vehicles and thus around 1.2% of passenger cars registered in Germany had an external charging outlet.[2] This also meant that the target of one million electric cars in 2020 was missed but by a much smaller margin than had long been expected. Indeed, in the first four months of the year 2021, more than 20% of newly registered cars were electric.[3] If the trend continues, the one million mark will be reached before the end of 2021.

Figure 1: Electric cars are still a niche but one that is growing fast



Note: Fully electric and plug-in hybrid cars only.

Source: Federal Motor Transport Authority, own calculations.

So far, electric vehicles tend to be used more by high-income households

The official Federal Motor Transport Authority statistics document the rise of electric cars. But who are the consumers behind these aggregate figures? A special analysis of the KfW Energy Transition Barometer, which is representative of all households in Germany, provides deeper insights.[4] The first finding is that around 1.3% of households reported having a battery-electric or plug-in hybrid vehicle. In line with the overall statistics, that was more than twice as many as a year ago.[5] Another 1.1% of households had plans to use such a vehicle within 12 months after the survey. These figures indicate that the number of users will likely not quite double again but a continuing upward trend can nonetheless be expected.

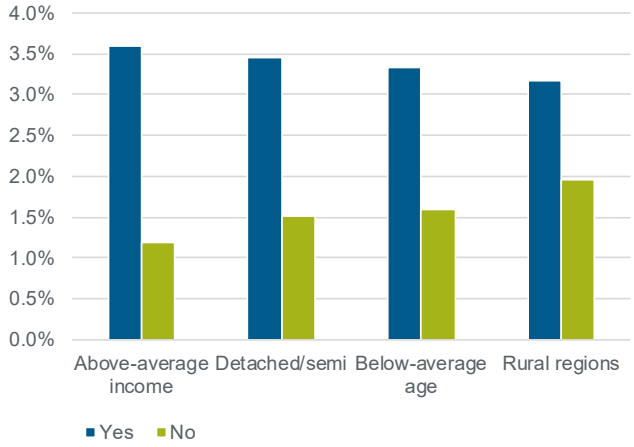
The survey also delivers a more accurate picture of users. Thus, more households own or plan to purchase an electric car in certain groups of the population than in others (Figure 2). This share is around 2.4% overall but around three times as high in households earning above-average incomes than in below-average income households. The same applies to households living in detached or semi-detached houses. Households with electric cars are more than twice as common here as in multi-family dwellings, which typically tend to have fewer on-site charging options as well.[6]

Age also plays a role. Electric cars are around twice as common in younger households as in older households. At 52.3 years, however, the average age of the users of electric cars almost exactly matches the average age reported by the

Federal Motor Transport Authority across all new car registrations. Thus, the observed age effects appear to be driven by the fact that new cars are generally registered by people in the medium or slightly below-average age bracket. Home location also makes a difference. In rural regions, the share is around 50% higher than in towns and large cities. This is likely due at least in part to charging and parking infrastructure, which is usually better in the countryside than in cities.[7]

Overall, significant differences exist across the various groups of households. The currently lower uptake by low-income households and those living in multi-family dwellings is particularly noteworthy – also with a view to the carbon price levied on fossil fuels from 1 January 2021. In the transition to electric mobility, it is important that no household groups be systematically left behind.

Figure 2: Well-heeled and younger households in particular currently use electric vehicles



Source: KfW Energy Transition Barometer.

Move to electric cars is motivated by concern over climate change and a love of innovative technology

The primary motivation stated for purchasing an electric vehicle was their contribution to saving the climate. More than three quarters of users (77.6%) reported that this was a decisive factor for their purchase. The second most common reason was the possibility to use an innovative technology (61.8%). Just under half of households (49.8%) mentioned the possibility of using green electricity to charge the car as a reason for the purchase. Only around 36% cited financial incentives as a critical factor in their purchase decision. This indicates that the first buyer groups were intrinsically motivated or financially independent.

Price and practicability remain the key barriers

The small group of electric vehicle users is currently dwarfed by the large group without electric vehicles. Asked about the crucial reasons against the purchase of an electric car, this large group continues to cite economic aspects, with 61.3% mentioning the high price as an obstacle.

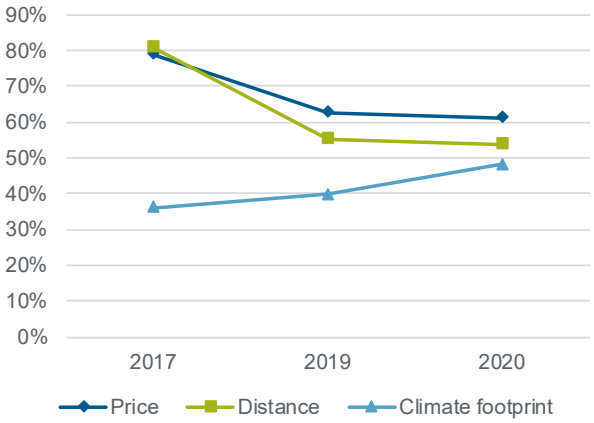
It is followed by reservations concerning practicability, such as range, which is perceived as too short (53.8%), and long charging times (47.2%). Limited access to charging infrastructure turned out to be a key obstacle and was mentioned by 68.5% of respondents. Insufficient public charging stations are regarded as the main issue here (59.8%). But there are inadequacies in the private domain as well. Around 40% of respondents complained that they had no suitable parking space at home. Not being able to charge the car at work was described as a reason not to purchase an electric vehicle by 33.8% of respondents.

The challenge of accessing private charging infrastructure exists primarily in the cities, where many car owners do not have an own parking space to begin with, while suitable parking spaces are much more readily available in the country. Here, by contrast, the high purchase price and doubts about practicability such as charging times and lack of public charging stations are mentioned more often than in the cities.

Growing reservations about climate footprint

After financial obstacles and practicability concerns, doubts about the climate footprint of electric vehicles are the third major argument for not wanting one. Nearly half of households (48%) currently see this as a reason not to buy an electric car. It is also the only negative reason that has grown in the past three years (Figure 3).

Figure 3: Reasons given for not buying over time



Source: KfW Energy Transition Barometer.

This is a bit surprising because the climate footprint of electric vehicles has taken an opposite – positive – turn during the same period. Two elements are responsible for this. First, the production of batteries has become continuously 'greener' over the years, as a result of which the unfavourable emissions profile from the more energy-intensive production of electric vehicles, often referred to as carbon footprint, is shrinking.[8]

Second, the greenhouse gas footprint of a kilowatt-hour of electricity consumed in Germany has fallen yet again. While 36% of gross electricity consumption in Germany was based on renewable energy in 2017, that rate grew to around 42% in 2019 and, according to the latest estimates, was already 45.4% in 2020.[9] This improves the emissions profile of an electric motor while the car is being driven, when it is more

efficient and less carbon-intensive than an internal combustion engine.

Electric cars are already better for the climate

The two factors – carbon footprint and emissions during operation – mean that electric cars need to clock up a certain mileage before they generate a climate benefit. The necessary mileage thus constitutes a climatic break-even point which differs based on the underlying assumption. A sensitivity analysis conducted in 2017 on the basis of the electricity mix, which calculated various battery sizes and charging times, put the necessary mileage between 48,000 and 140,000 km.[10] If we base this calculation on more recent figures for the electricity mix of the year 2019, the mileage already drops to 38,000 to 95,000 km.

The figures demonstrate that even under unfavourable assumptions for electric cars, the amount of mileage they have to clock is shorter than the average useful life of a battery, so they usually benefit the climate already with today's electricity mix. If the expansion of renewables continues as currently planned, this benefit will even continue to grow the longer the car is used.[11] In an overall assessment, of course, electric cars are not zero-emissions vehicles and incentives for avoiding emissions should be provided here as well. Nonetheless, the literature leaves little doubt that electric mobility is the most efficient green technology for passenger vehicles in the foreseeable future.[12]

Green electricity and grid-friendly charging are the key

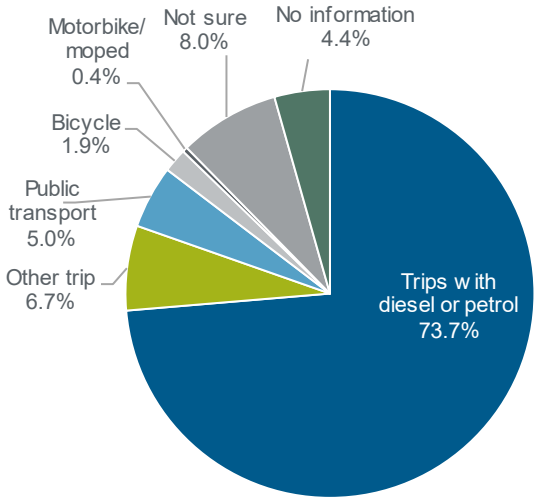
The electricity mix used is a major factor for the climate footprint of electric vehicles. Data collected under the KfW Energy Transition Barometer show that 60% of the time electric cars are charged exclusively with green electricity and the remaining 40% of the time from the German electricity mix typically assumed in studies.[13] Around one quarter of users even charge their car with electricity from their rooftop solar systems. When the use of electric cars is coupled with a corresponding expansion of renewables, they fulfil a major requirement for benefiting the climate.

Strictly speaking, however, a systemic analysis is required to determine how much greenhouse gas would be avoided without the charging process. Ideally, that would require identifying what electricity is crowded out during charging. The most climate-friendly case is the use of surplus green electricity that would otherwise not have been used. Therefore, it ultimately comes down to the timing of the charging. Idle times at the home or workplace generally offer scope for optimising the charging time in order to avoid peak periods and use excess capacity to charge electric vehicles.

Such solutions, also referred to as ‘smart charging’, require a corresponding legal framework which does not yet exist. A legislative proposal for peak shifting with a forced shutdown of electric vehicle charging sessions was recently rejected. Therefore, it is crucial to have users agree to a contractual arrangement under which the charging process does not begin immediately after plugging in but the main portion of the charge is fed in only at the optimal moment.

The KfW Energy Transition Barometer has revealed that just under one quarter (23%) of households that use an electric car or can at least imagine using one in the future would use a ‘smart charging’ scheme. A further 45% would do so if the electricity were cheaper. Only 27% disapprove of the technology. This is a further indication that electric mobility is well on the way to making a valuable contribution on the path to climate neutrality.

Figure 4: Electric cars are mainly displacing internal combustion engine cars



Source: KfW Energy Transition Barometer.

Specific climate benefit depends on user profile

Climate balance analyses are based on the assumption that an electric vehicle replaces trips with an internal combustion engine (ICE) car and is not purchased additionally. So far there is little empirical evidence of this. The KfW Energy Transition Barometer addresses this gap and shows that around 30% of households in Germany that possess or plan to acquire an electric vehicle currently use only one vehicle.

It also shows that electric cars are indeed mainly replacing ICE cars (Figure 4). The surveyed households indicated that nearly three quarters of the trips undertaken with their electric car would otherwise have been done with an ICE car (73.7%). Only around 6.7% of trips were additional trips and the cannibalisation of mass public transport (5%) and bicycles (1.9%) is also moderate. This is another important finding. After all, achieving climate-neutral mobility will also require reducing the number of trips or transferring them to ecologically more efficient means of transport such as mass public transport or bicycles.[14]

Many households still consider an electric vehicle as an option only for the medium-term future

As described, 1.3% of households in Germany currently use an electric vehicle and a further 1.1% plan to purchase one within the next 12 months. In order to estimate future use, the remaining households were asked whether or when they expected to use an electric vehicle.

Around half of them expect to use an electric car on a day-to-day basis in the future. Roughly 6% expect to purchase one within the next two to three years and 21% within four to 10 years. A further 22% expect to do so after that. Roughly one third (32%) of households do not expect to switch to an electric car any more. Even so, some 15% also do not expect to use one in future but generally get by without a car in any case (see table).

These percentages are basically the same as in the previous year, so there appears to be no change in the rate of uptake. The same is true with a view to differences between groups of households. Households with above-average incomes as well as those in detached or semi-detached homes expect to purchase an electric car sooner or later. Furthermore, the proportion of households that generally cannot imagine buying one is slightly higher in cities but at the same time the proportion of households that do not need a car is above average here as well. Older households are not just less likely to use electric cars today but are also much less likely to imagine using one later on. Just under 30% expect to be using an electric car on a regular basis at some point.

Table: Outlook on future use

When will you begin to drive an electric vehicle on a regular basis?

	All	City	DH/ SDH	High income	High age
Two to three years from now	5.7%	5.4%	7.4%	7.7%	4.8%
Four to 10 years from now	20.7%	20.8%	24.1%	23.4%	14.1%
More than 10 years from now	21.8%	17.1%	25.5%	25.8%	10.8%
Never	32.0%	34.0%	30.7%	31.5%	43.4%
I do not need a car	14.8%	17.9%	5.8%	7.2%	20.4%
Don't know/ can't say	5.0%	4.8%	6.5%	4.5%	6.6%

Note: The group 'high income' comprises households with above-average net household income, the group 'high age' comprises households in which the person who makes the technical decisions is older than the average of surveyed households (57 years).

Source: KfW Energy Transition Barometer.

Conclusion

The market for electric cars is on the move and there is much evidence that the decade of the 2020s could bring a breakthrough in electric mobility. The rapid growth is good for the climate because, as a rule, the vehicles' climate footprint is clearly positive already and steadily improving with the expansion of renewable energy. Continuing to electrify passenger vehicles is thus a key pillar for achieving climate targets in the transport sector.

The findings of the KfW Energy Transition Barometer illustrate that well-heeled households – especially homeowners in rural regions – are currently among the main users of electric cars. For the mobility transition to succeed, however, electric mobility must be mainstreamed as an attractive option in all groups of society.

The cost-efficiency of electric cars is an essential aspect. Targeted incentives, such as the introduction of a price on greenhouse gas emissions in the transport and heating sectors on 1 January 2021, support the transition to climate-friendly technology.

In addition, an efficient charging infrastructure must be put in place to make electric cars a viable form of day-to-day mobility. This also includes addressing areas in which implementation faces particular challenges, such as multi-family dwellings.

Time-shifted grid-friendly charging can enable vehicles to make an important contribution to the optimal integration of renewables and hence climate action. According to the KfW Energy Transition Barometer, households generally agree with this, particularly in combination with financial incentives. It is important to create the conditions for technical and legal implementation.

Finally, more transparency on the climate footprint of electric mobility would be desirable, for example on the greenhouse gas footprint of the relevant battery in use and ultimately enables optimal incentives as well. For one thing, this is important with a view to the emission thresholds for the EU vehicle fleet, which today sweepingly classify electric cars as emissions-free independent of their performance. For another, more climate transparency also helps to dispel households' doubts and correct their information deficits, enabling more climate-friendly mobility.

The KfW Energy Transition Barometer
is a representative survey of around 4,000 private households in Germany on decisions relating to energy supply and energy consumption. It has been published annually since 2018.

[1] We will use this definition of 'electric car' for the whole text. If we include hybrid vehicles whose batteries cannot be charged externally, the share of new registrations even increases to one fourth (24.75%). Cf. Federal Motor Transport Authority (2021), Press release No. 02/2021 – Fahrzeugzulassungen im Dezember 2020 – Jahresbilanz (*Vehicle registrations in December 2020 – annual total* – our title translation, in German only).

[2] Cf. https://www.kba.de/DE/Presse/Pressemitteilungen/2021/Allgemein/pm01_2021_E_Antrieb.html.

[3] According to the Federal Motor Transport Authority, the share of (externally chargeable) electric cars registered was more than 20% in the first months of 2021 (January: 21.7%, February: 20.7%, March: 22.5%, April: 22.2%).

[4] This probably covers most of the existing passenger vehicles, as 89% of vehicle owners are currently private individuals. Cf. Federal Motor Transport Authority (2020), Bestand an Pkw am 1. Januar 2020 nach Bundesländern sowie privaten und gewerblichen Haltern absolut (*Total number of passenger cars on 1 January 2020 by federal states, private and commercial owners* – our title translation, in German only).

[5] A year ago it was 0.5%. This applies to battery-electric and plug-in hybrid vehicles only. The figures reported by the KfW Energy Transition Barometer 2020 also include hybrid vehicles that cannot be charged externally and therefore deviate from these figures; cf. Römer, D. and Steinbrecher, J. (2020), KfW Energy Transition Barometer 2020, KfW Research, in German only.

[6] For one thing, the income situation is often likely to be above-average here as well. For another, many owner-occupiers probably have their own charging stations on their property.

[7] Cf. Römer, D. and Steinbrecher, J. (2020), Private Ladeinfrastruktur ist eine wichtige Säule für den Ausbau der Elektromobilität (*Private charging infrastructure is an important pillar for expanding electric mobility* – in German only), Focus on Economics No. 304, KfW Research.

[8] Cf. Emilsson, E. und L. Dahllöf (2019), Lithium-Ion Vehicle Battery Production, Status 2019 on Energy Use, CO2 Emissions, Use of Metals, Products Environmental Footprint, and Recycling.

[9] Erneuerbare Energien in Zahlen: (*Renewable energy in figures:* – our title translation, in German only) https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen#uberblick, 4 March 2021.

[10] The figures provided are from a sensitivity analysis conducted by Lessmann, C. and Steinkraus, A. (2019), »Zero Emission«? CO_2-Emissionen von Elektroautos (»Zero Emission«? *Carbon emissions of electric cars* – in German only), ifo Schnelldienst 12 / 2019, p. 3–6. A best-case scenario takes into account domestic consumption including upstream chains and a 30 kWh battery, a worst-case scenario considers a carbon footprint with unfavourable charging times when little renewable energy is available as well as a larger 45 kWh battery and more carbon-intensive battery production. It must be noted that in practice, a large battery is still an exception. According to NOW (2020), Elektromobilität in der Praxis (*Electric mobility in practice* – in German), only 17% of vehicles had a battery with 40 kWh or more capacity (according to most recent data for the years 2018 and 2019). Calculations by KfW Research resulted in a mileage of 80,000 to 100,000 km for a typical battery size in the purchase year 2018, cf. Römer, D. (2018), Die Verkehrswende – Einblicke in die Mobilität der Zukunft (*The mobility transition – insights into the mobility of the future* – in German only), Focus on Economics No. 201, KfW Research.

[11] Initial calculations made for the year 2020 already show a further decline in the carbon intensity of the electricity mix to 362 gCO_{2e}/kWh, cf. Agora Energiewende (2021), Die Energiewende im Corona-Jahr: Stand der Dinge 2020 (*The energy transition in the coronavirus year: state of affairs in 2020* – our title translation, in German only), p. 36.

[12] For a comparison between electric cars and internal combustion engine vehicles cf. for example Wietschel, M., Kühnbach, M. and Rüdiger, D. (2019). Die aktuelle Treibhausgasemissionsbilanz von Elektrofahrzeugen in Deutschland (*The current greenhouse gas footprint of electric vehicles in Germany* – our title translation, in German only), Fraunhofer ISI Working Paper Sustainability and Innovation No. S 02/2019, Karlsruhe. Agora Verkehrswende (2019), Klimabilanz von Elektroautos. Einflussfaktoren und Verbesserungspotenzial (*Climate footprint of electric vehicles. Influencing factors and potential for improvement* – our title translation, in German only). Individual dissenting opinions are usually based on extreme exceptions whose plausibility is difficult to validate, cf. for example Schmidt, U. (2020), Elektromobilität und Klimaschutz: Die große Fehlkalkulation (*Electric mobility and climate action: the great miscalculation* – our title translation, in German only), IfW Policy Brief. With respect to comparisons with fuel cell vehicles see for example the statements by Agora Verkehrswende (2019): Klimabilanz von strombasierten Antrieben und Kraftstoffen (*Climate footprint of electricity-based drives and fuels* – our title translation, in German only), which also confirm that battery-electric vehicles are better for the climate. The Fraunhofer ISE study conducted on behalf of H2-mobility in 2019 entitled Treibhausgas-Emissionen für Batterie- und Brennstoffzellenfahrzeuge mit Reichweiten über 300km (*Greenhouse gas emissions for battery and fuel cell vehicles with ranges exceeding 300 km* – our title translation, in German only) did identify constellations in which fuel cells have a climate benefit, but only with very large batteries (60 and 90 kWh) and for the electricity mix of the 2020s. Moreover, the energy supplied to fuel cell vehicles during the phase of operation is significantly higher because of conversion losses, which makes the implementation of a purely green electricity scenario more difficult in practice.

[13] Cf. Römer, D. and Steinbrecher, J. (2020), Private Ladeinfrastruktur ist eine wichtige Säule für den Ausbau der Elektromobilität (*Private charging infrastructure is an important pillar for expanding electric mobility* – in German only), Focus on Economics No. 304, KfW Research.

[14] Cf. Römer, D. (2020), Der lange Weg zu nachhaltiger Mobilität (The long road to sustainable mobility – our title translation, in German only), Focus on Economics No. 290, KfW Research.