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The unwillingness-to-buy electric vehicles and its impact on market diffusion – a German case study

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Abstract

Currently, with the rise of populism in politics, we are seeing a growing number of people influenced by conspiracy theories or fake news who discredit science and often only act in segregated networks. These could also negatively affect various enviromental challenges or prolong them. In this paper, we study the effect of these very pertinent adopter groups on the adoption of plug-in electric vehicles (PEVs) in Germany. For this purpose, we use results from a panel data questionnaire aiming at identifying these adopter groups and modify the market diffusion model ALADIN to determine changes in the future market diffusion of PEVs and their energy demand. We find a relatively large group (~15%) of potential vehicle buyuers that is not interested in electric vehicles and opposing changes in transport policy ("Verkehrswende"). However, due to high shares of cars sold to commercial users, the effect on PEV sales and stock is limited (-2.7% to -6.3% of BEV stock in 2035).

1 Introduction

Most of the world's countries have set goals to decrease their carbon emissions to zero by the mid of the century. All projections to reach these targets assume a carbon-free transport from a certain point in time – in Germany by 2045 [1]. Based on the European fleet targets, car makers must decrease their vehicle sales emissions to zero even by 2035 [2]. Next to these very ambitious targets, we experience a shift to right political parties, people influenced by fake news or conspiracy theories as well as other groups that do not take part in social life anymore [3,4]. The latter groups of people partly deny climate change and question mainstream trends, and, thus, might not be willing to buy electric vehicles (EVs) or even wait as long as they can before they adopt. Such societal changes question the assumptions of modelling studies on the diffusion of EVs which largely assume rational user behavior.

In this paper, we try to determine the size of these groups and their resistance towards electric mobility adoption and the potential impact on EV market diffusion in the close future (until 2035). We do this by using recent survey data [5] and integrating it into our market diffusion model ALADIN. For this exercise, we extend the current methodology by defining adopter groups with different buying intentions and decisions as in [6].

2 Data and Methods

The model ALADIN is based on a large number of vehicle driving profiles that contain the mobility movement of German car owners for at least one week. For private and company car owners, we use data from the German Mobility Panel (MOP, [7]) where we use the collected people movements and connect them to vehicles owned in the households (cf. [8] for details). Company-owned fleet vehicles are based on an own data collection [9]. For private and company cars, we combined the data sets with a data collection about the willingness-to-pay-more for an electric vehicle based on socio-demographic factors in the data set (for more details, refer to [10]). With this data bundle and several techno-economic assumptions, we identify the amount of electric driving per user for a plug-in hybrid-electric vehicle (PHEV) and the feasibility of the whole vehicle movements with a battery electric vehicle (BEV) for every vehicle driving profile. Based on that, a utility value including the total cost of ownership, the aforementioned willingness-to-pay-more, a limited vehicle brand choice and the cost for individual charging points is calculated and the vehicle type (e.g. gasoline, diesel, PHEV, BEV) with the highest utility is chosen. The share of vehicles within a user group and size class determines the market share and evolves into the vehicle stock.

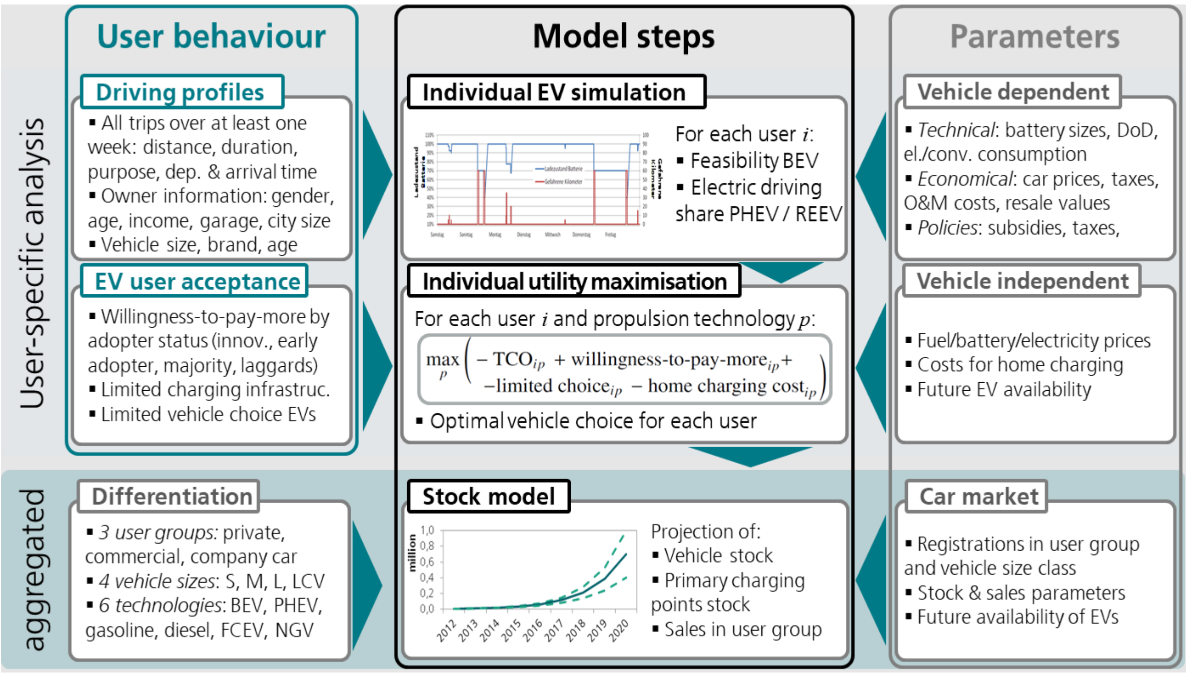

Figure 1: Description of the ALADIN model

In this paper, we slightly modify our approach with recent and representative survey data collection [5] and validated it with findings from the MobilKULT panel study, [11, 12], . The survey data contains information about the willingness-to-adopt electric vehicles as well as systematic attitude conflicts, socio-economic inequalities and segregated networks as well as the socio-demographic information of the users. For example, people were asked about their attitude towards electric vehicles, about their household income, as well as whether they belong to a group that does not engage in society anymore. Based on the data, we adapt the utility function for the market diffusion model to cover different attitudes, e.g. users that only base their decision on vehicle price or not on cost at all. The main changes are described after analysis of the data in the results section.

As a base case scenario, we use the O45-Electricity scenario from the German long-term scenarios which has recently been published [1]. All parameters remain unchanged in this scenario, and we focus on the changes in user behavior over time.

3 Results

The results section contains two parts: First, we analyze survey data with respect to BEV buying intentions and aspects of segregation into varying adopter groups. We further explore how an integration into ALADIN can work. Second, we run several calculations with ALADIN and compare results.

3.1 Analysis of survey data

The survey data contains N=2108 participants that finished the questionnaire during data collection in autumn 2024. They are representative for German households and were contacted through a professional polling institute (see [5] for details of the study design, sampling and sample characteristics) . As we focus on vehicle buyers in ALADIN, we filter out those that do not own a car and drive less than at least three days per week and receive N=1438 potential car buyers as the statistical population. In Figure 2, we show the results of the data set differentiating different vehicle buyer groups and compare it to earlier studies that were used in analyses with ALADIN [13,14,5].

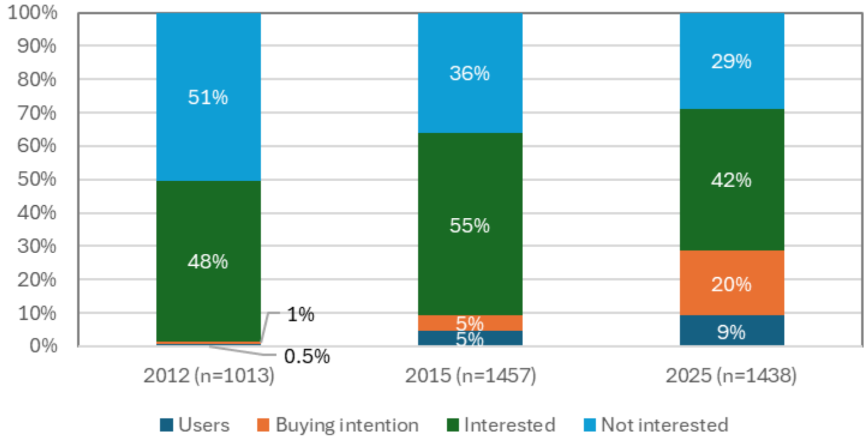

Figure 2: Interest in electric vehicle purchase over time (data from [13, 14, 5]).

We find 9% of electric vehicle users in the most recent sample from 2025, 20% that intend to buy a BEV in the next three years, 42% of interested users and 29% that are not interested at all. When comparing these groups to the earlier studies, we find a growing interest in electric vehicles over time as well as growing BEV ownership. Still, about 30% of potential vehicle buyers are not interested in electric vehicles, which is supported by a recent data collection from Forsa [15]. The four groups also differ in terms of socio-demographic characteristics as well as attitude towards certain BEV characteristics (see Table 1). The non-interested people are older, have a lower share of respondents with an academic degree and a lower share of high household incomes. While we find a clear difference in their attitude towards a change in transport policy ("Verkehrswende") compared to the whole sample, we cannot find a clear difference in the attitude to climate change. For this reason, we focus on the group of non-interested vehicle buyers and characterize them in more depth.

Table 1: Characteristics of BEV adopter groups in the sample

Attribute	User	Buying intention	Interested	Not interested	All
Total number/share	132	281	610	415	1438
Average age	38.2	46.5	51.7	54.8	50.3
Women share	54%	46%	51%	58%	52%
High avg. household income [> 3,500 €/month]	70%	53%	41%	32%	43%
Share of respondents with academic degree	41%	30%	25%	18%	25%
Against change in transport policy ("Verkehrswende")	2%	4%	11%	15%	10%
Considering climate change not a problem	14%	10%	11%	21%	14%

In Figure 3, we show the attitude towards three central BEV differences compared to conventional cars: purchase price in the upper panel, vehicle range in the central panel and charging infrastructure in the lower panel. Here, we further distinguish the four vehicle buyer groups on the left and the non-interested, differentiated by their attitude towards a change in transport policy on the right. Note, that the group that favor a change in transport policy and are not interested in electric vehicles with three observations is too small to be evaluated (the left bar on the right panel).

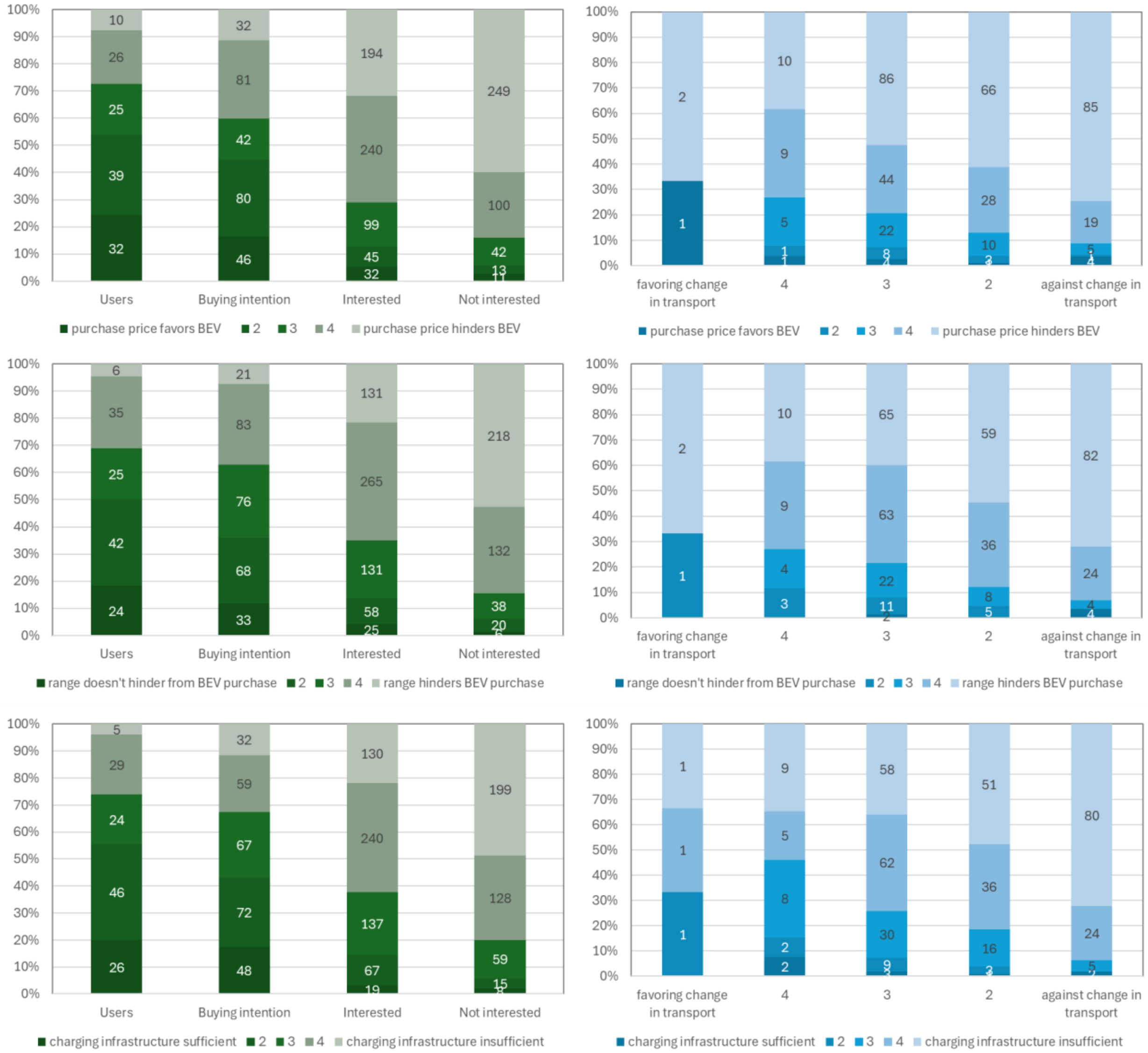

Figure 3: Differentiation of BEV adopter groups and their evaluation of different BEV characteristics and attractiveness criteria. Left panel: BEV adopter groups differentiated by purchase intention (N=1438). Right panel: Non-interested only (N=415) differentiated by people's acceptance of change in transport policy ("Verkehrswende"). Upper panel: Evaluation of purchase price. Middle panel: Evaluation of range. Lower panel: Evaluation of charging infrastructure availability.

The results highlight that in all three panels on the left, purchase price, range and charging infrastructure is perceived less of a problem by BEV interested people and is much more problematic for the non-interested. When distinguishing the non-interested even further with respect to their attitude towards a change in transport policy, the ones that clearly oppose to a change in transport policy ("Verkehrswende") are most unsatisfied with price, range and charging infrastructure of and for electric vehicles.
While the evaluation of purchase price perception could be related to income differences (see above), the worse evaluation of range and charging infrastructure by non-interested might be solved with higher procurement, it could also be a problem of wrong perception or insufficient knowledge about current

average ranges and infrastructure availability. The negative attitude to a change in transport policy further supports this evaluation.

3.2 Use of data in ALADIN and scenario definition

As the data does not contain information about an adopter group specific willingness-to-pay-more or even less for an electric vehicle, we assume a small group of vehicle buyers that stronglyresist to buy electric vehicles. We assume that this group is difficult to persuade and will buy conventional vehicles independent of their best vehicle choice based on the utility function in ALADIN. We assume this group to be best described by being against a change in transport policy (values 1 or 2 on the survey item, see Figure 3) which sums up to 15.4% of the whole statistical population. Two scenarios are analyzed in the following:

- In scenario “constant resistance", we assume that this group remains constantly large until 2035 when the European fleet targets don’t allow the purchase of conventional cars anymore.
- In scenario “decreasing resistance”, a change of attitude is assumed to linearly decrease the resisting buyers to 0% until 2035.

3.3 Simulation in ALADIN

We simulate the above-mentioned scenarios and show them in the following paragraphs. First, note that the base case scenario from the long-term scenarios aims at reaching Germany’s climate targets of climate neutrality in 2045 and meeting the CO_2 performance standards of 0 g CO_2/km for new sold cars in 2035. Thus, the sales development of electric vehicles in this scenario is quite ambitious until 2035, but well suited to see changes due to resisting buyers (Figure 4).

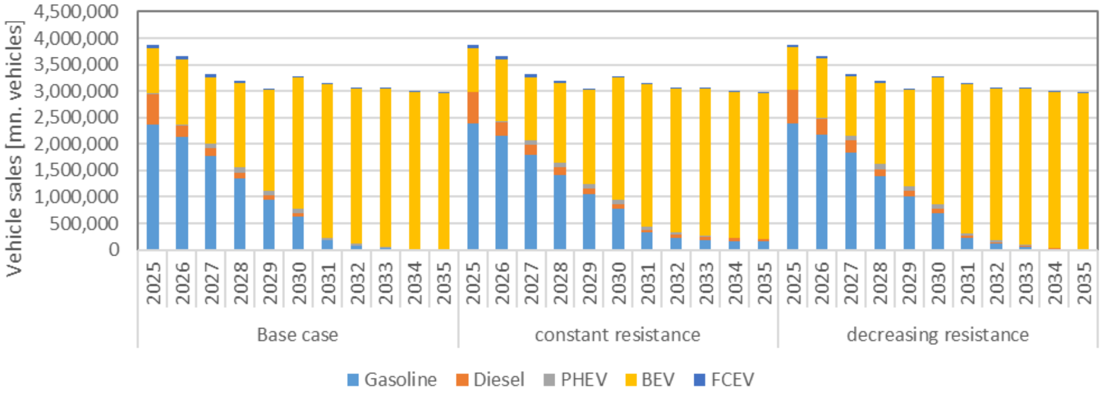

Figure 4: Vehicle sales from 2025 to 2035 in scenarios base case, constant resistance and decreasing resistance.

We find gasoline and diesel vehicles to decrease steadily in vehicle sales until 2035, yet with some small differences in vehicle sales for the two scenarios with resisting vehicle buyers. The differences are small since only one third of vehicle buyers are private users in Germany while two thirds of new vehicles are first registered by companies [16]. Thus, the overall effect of resisting users seems to be small for vehicle sales on first view. When summing up the vehicle sales differentiated by drive train (see Figure 5), we find about 1.5 million BEV less until 2035 in a scenario with constant resistance and about 0.7 million in a scenario with decreasing resistance. Instead, users buy 1.1 million gasoline and 0.4 million diesel vehicles in the constant resistance scenario and 0.4 million gasoline and 0.3 million diesel vehicles in the decreasing resistance scenario. PHEV and FCEV are mainly unaffected by these changes.

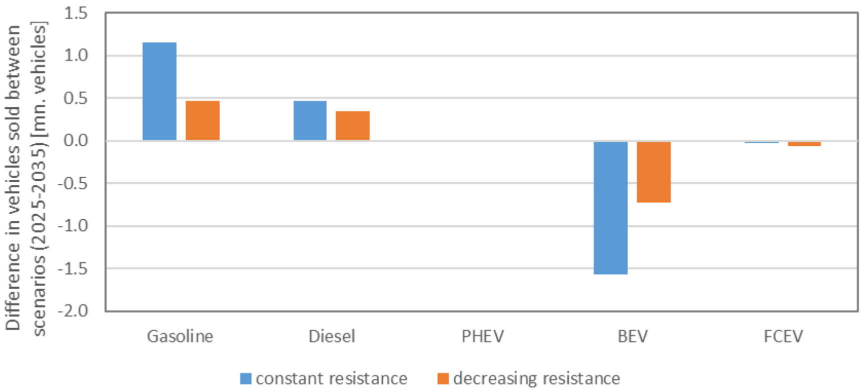

Figure 5: Differences of cumulated vehicle sales from 2025 to 2035 in scenarios constant resistance and decreasing resistance compared to base case.

The changes are equal in BEV stock in 2035, and around 0.4 and 0.5 million BEV less in 2030. Energy consumption and CO_2 emissions over time certainly change much more as these vehicles are held for about 15 years. The changes until 2045 are shown in Figure 6. The higher conventional energy consumption to the account of electric energy consumption reaches 150 TWh additional conventional fuels in the constant resistance scenario and about 100 TWh additional conventional fuels in the decreasing resistance scenario. Although these are partly produced from renewable energy sources, the additional cumulated CO_2 emission differences sum up to 25 Mt CO_2 in the constant resistance scenario and 20 Mt CO_2 in the decreasing resistance scenario.

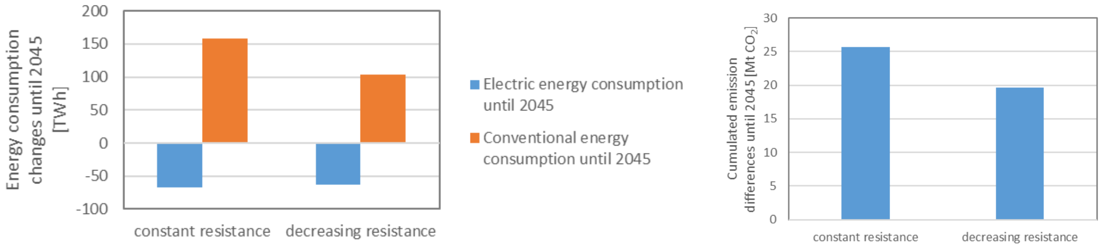

Figure 6: Left panel: Differences of cumulated energy consumption from 2025 to 2035 in scenarios constant resistance and decreasing resistance compared to base case. Right panel: Differences of cumulated CO_2 emissions from 2025 to 2035 in scenarios constant resistance and decreasing resistance compared to base case.

3.4 Sensitivities with higher resistance

To test the sensitivity of results, we additionally assume that all non-interested vehicle buyers don’t buy an electric vehicle independent of their attitude towards a change in transport policy. Thus, the group of private non-buyers is now 28.9% and in one case constant (scenario “constantly high resistance”) and decreasing in the other (decreasing high resistance).

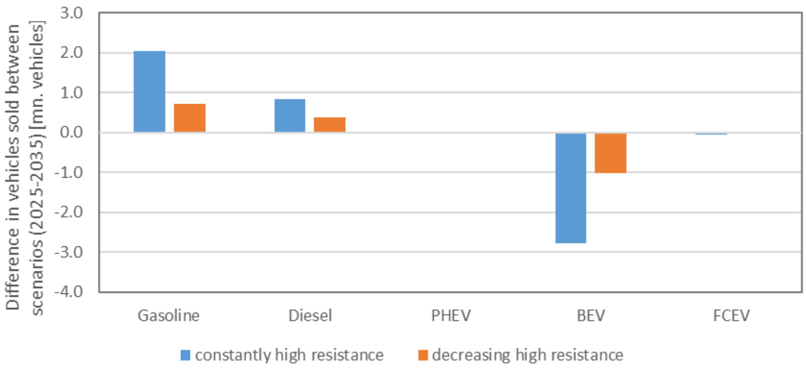

Figure 7: Differences of cumulated vehicle sales from 2025 to 2035 in scenarios constantly high resistance and decreasing high resistance compared to base case.

For vehicle sales, we see BEV almost decreasing by 3 million vehicles until 2035 in the constantly high resistance scenario and by about 1 million vehicles in the decreasing high resistance scenario. These changes are also visible in vehicle stock in 2035. The additional conventional cars need about 300 or 120 TWh of additional conventional fuels emitting 40 or 20 Mt CO_2 by 2045. So, for both scenarios, we can see an almost linear effect for vehicle sales (roughly doubling the share of non-buyers leads to about doubling the sales for conventional cars instead of BEV) while the energy consumption and emissions increase slightly less.

4 Discussion and conclusions

The aim of this modeling exercise was to study the effect of vehicles buyers that are especially opposed to electric vehicles. Here, we used a recent data collection on EV adoption as well as attitudes towards several EV characteristics and attributes describing tendencies of an attitude-based resistance towards BEV adoption. We used the rejection of a change in transport policy paired with a non-interest in electric vehicles to determine an adopter group that does not buy electric vehicles even if it was beneficial in our market diffusion model ALADIN.

This approach might be criticized as the variable “rejection of a change in transport policy” might reflect a fluid and temporary opinion of the participants in the survey data. As the evaluation of certain EV related aspects (e.g., range, price, infrastructure availability, see Figure 3) are correlated with the variable that measured peoples approval or rejection towards transport policy transition variable, we think our approach is a good first step. We will follow up on this work by trying to directly determine the height of unwillingness-to-pay or the negative willingness-to-pay for electric vehicles in future consumer surveys. The general approach of the ALADIN model has been discussed in detail in [10].

The data f we used was well-suited to get a first idea of how resisting users can be identified and impact EV market diffusion. However, this approach required a workaround instead of user-specific factors as described above which is a limitation and therefore any generalization should be made with caution. Our chosen scenarios, however, showed that the effect on market diffusion is not as large as expected before the analysis. The relatively low changes in vehicle sales, due to private users being only a small group of new vehicle buyers, were not surprising. However, the question is what will happen in 2035 when resistance towards EVs remains constantly high and fleet targets require carmakers to only sell carbon-neutral cars. Literature suggests, however, that neighboring effects are expected to decrease this barrier over time [17].

Albeit these shortcomings, we can retain the following findings for Germany:

1. A large number of potential buyers are already using, intending to buy or are interested in electric vehicles (> 70%). The non-interested group decreased over the past 15 years but is still at a medium level of 30%. A share of these users may be convinced by lower costs over time (see e.g. [18]), while today about 15% that don’t support transport policy changes are more difficult to persuade.
2. The relatively large group of non-EV-interested and rejecting changes in transport policy might be less harmful when looking at vehicle sales and changes in stock (-2.7 to -6.3 %). Referring to energy consumption and CO_2 emissions, the effect is more considerable as cars remain in stock for about 15 years on average.
3. Extreme assumptions in a sensitivity analysis still don’t change the picture by large as most new vehicles are sold to commercial users (about two thirds).

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