EVS36 Symposium
Sacramento CA, USA, June 11-14, 2023

The European BEV driver: a comparative analysis

Dennis Verbist[1], Gabriela Barrera, Lieselot Vanhaverbeke

[1]Dennis Verbist (corresponding author), MOBI Research Group, Vrije Universiteit Brussel, Pleinlaan 5, 1050 Brussels, Belgium, Dennis.verbist@vub.be

Executive Summary

The BEV-market is growing fast and the BEV drivers are becoming more numerous. This conference paper describes the European (BEV-)drivers of 2022: their socio-economic profile, mobility behaviour, charging behaviour, attitudes towards alternatively fuelled (electric) vehicles, their driving and consumer motivations. The paper will focus specifically on BEV-drivers and non-BEV drivers as subgroups and their differences. The goal is to provide an overview of the results and their consistency with previous research.

1 Introduction

As of the September 2022, the European Union's car fleet amounted to 280 million passenger cars. Of those cars, about 2% were considered Electric Vehicles (EV), i.e. either Plug-in Hybrid Electric Vehicles (PHEV) or Battery Electric Vehicles (BEV) [1]. These numbers perpetuate the upwards trend observed in previous years in terms of EV adoption. Indeed, compared with the previous year (2021), we notice a registration increase in BEVs of 33.74% and in PHEVs of 116.67% [1]. To sustain this progress and in order to achieve the objectives set by the European Commission to tackle climate change, i.e. ensuring that all new cars and vans registered in the EU after 2035 are zero-emission [2], it is crucial to understand the socio-demographic aspect that influences this shift in mobility solutions. Indeed, understanding and identifying the potential users of BEVs could allow for targeted and tailored policy measures. For example, understanding recharging behaviour to optimize recharging systems accordingly. The socio-economic profile of the European (BEV-)drivers and their behavioural attributes, knowledge and personal motivations are discussed in this paper. To this end, an extensive pilot survey among European drivers was conducted, which resulted in two separate samples. The first survey sample encompasses drivers of traditional ICEV vehicles as well as drivers of alternatively fuelled vehicles, BEVs in particular, allowing for a comparison between subgroups and a general picture of a specific country's status quo. The second survey sample was distributed solely to BEV drivers, allowing for a more robust analysis of this particular group of interest.

2 Methodology

The pilot survey was carried out across 10 European countries[1] (Austria, Belgium, Denmark, France, Germany, Hungary, Italy, Netherlands, Slovenia and Spain) and the administrative region of Brussels Capital, by usage of online consumer panels. In total, 18039 complete and valid surveys were obtained. The survey logic was adapted accordingly for BEV-specific questions, depending on whether the respondent was a BEV driver or an ICEV driver. Both surveys were combined into consolidated datasets, in order to

[1] Will now be referred to as EU in the context of this paper.

have a sufficient number of respondents in the BEV driver group. Therefore, the proportion of each group is not representative of the population. The goal of this research however is not to estimate the population proportion of each group, as there are more efficient ways to achieve that (registration of vehicles), but to analyse each group separately and to compare them on a socio-economic and behavioural level.

The respondents were surveyed on the four main question categories detailed below.

1. **Socio-demographic data**: gender, age, income, education level, accommodation type, ownership accommodation, renewable energy devices (REDs) at home, etc.
2. **Mobility behaviour**: number of cars, type of vehicle (fuel), ownership type, travel behaviour, parking availability, driven kilometres per year, price paid for the vehicle, range satisfaction (BEV), travel abroad with a BEV, etc.
3. **Attitudes and motivations**: general attitude towards EVs, perceptions about EV charging and costs, knowledge about governmental incentives, desired range, willingness-to-pay for an ICEV/BEV, timeframe of buying an EV, disadvantages/advantages of driving a BEV, etc.
4. **Recharging behaviour (BEV specific)**: charging locations, payment methods, battery threshold for recharging, important characteristics of public recharging points, waiting times at recharging points, experience with travelling abroad, barriers for recharging abroad.

3 Results

3.1 Sample Statistics

Table 1 gives an overview of the number of respondents per country after the validation process, as well as the proportion of BEV drivers and non-BEV Drivers. Keep in mind that the proportions are not representative of the true proportions of the population.

Table 1: Sample Statistics of the Consolidated Results

Country	*BEV Drivers*	*Proportion of BEV Drivers*	*Non-BEV Drivers*	*Proportion of Non-BEV Drivers*	*Total*
Austria	206	11,32%	1614	88,68%	1820
Belgium	49	2,89%	1644	97,11%	1693
Denmark	63	4,12%	1467	95,88%	1530
France	274	14,15%	1663	85,85%	1937
Germany	94	5,22%	1707	94,78%	1801
Hungary	321	16,53%	1621	83,47%	1942
Italy	63	3,29%	1852	96,71%	1915
The Netherlands	124	6,84%	1690	93,16%	1814
Slovenia	84	4,98%	1604	95,02%	1688
Spain	100	5,41%	1749	94,59%	1849
EU (10)	1378	7,66%	16611	92,34%	17989
Brussels	*58*	7,63%	*702*	92,37%	760

3.2 Preliminary aggregated results and discussion of the socio-economic profile (EU)

The results are analysed on an aggregated level, the ten participating countries (EU).

Gender, Age, Education

Based on the aggregated sample data analysed (Fig. 1.), it was found that the male participants owned a greater number of BEVs (81.27% of BEV drivers were male) compared to their female counterparts. The findings of this study are consistent with previous research that has highlighted gender differences in BEV ownership patterns [3][4]. Middle-aged individuals, ranging from 35 to 55 years old, are more likely to drive BEVs than their younger or older counterparts. This is consistent with existing literature [5]. The education levels results support the existing research, where higher education levels have been linked with higher levels of BEV uptake [6][7]. Accommodation type and ownership results (Fig. 2.) depict BEV drivers as being more likely to live in detached housing and being home-owners, consistently with previous research [5][8].

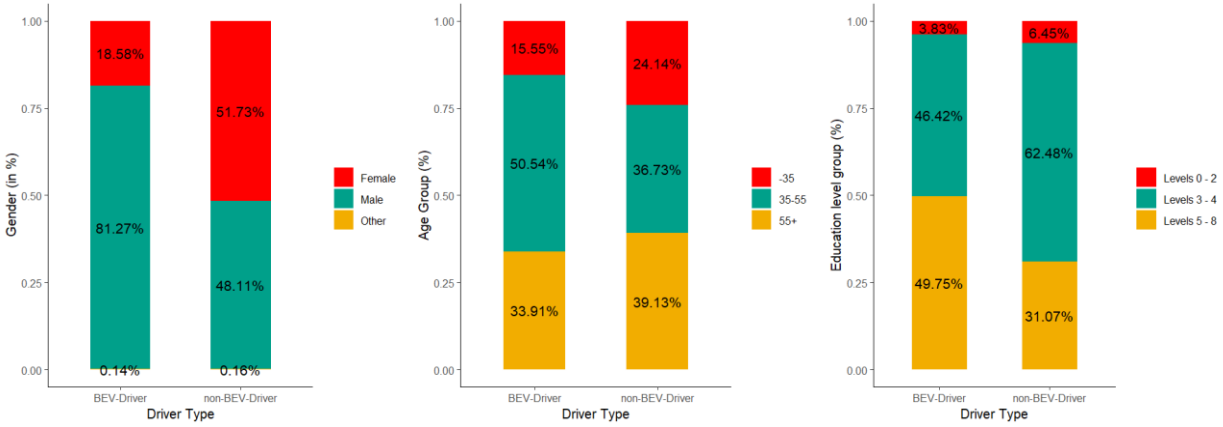

Figure 1: Gender distribution, Age Group distribution and Education level distribution of drivers (EU)

Accommodation

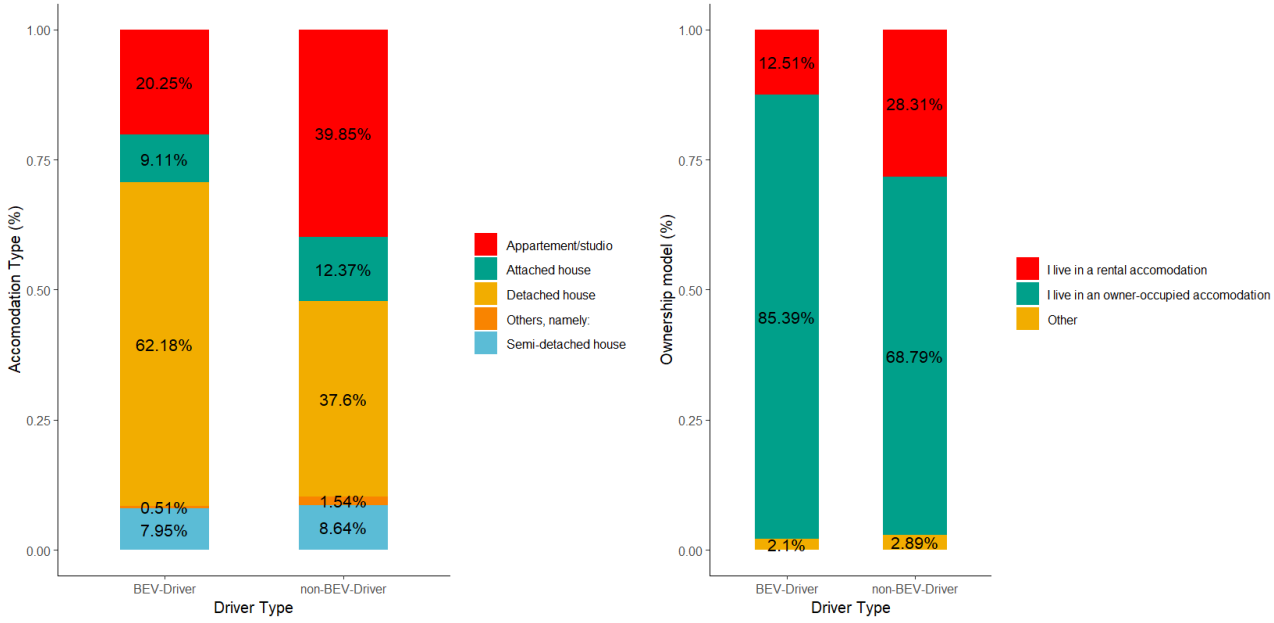

Figure 2: Accommodation type and ownership model of the respondents (EU)

Ownership of renewable energy devices at home

Fig. 3. illustrates the distribution of renewable energy device ownership among respondents, stratified by drivers of BEVs and non-BEV drivers. The results indicate that BEV drivers are more likely to own REDs than non-BEV drivers. Specifically, 52.21% of BEV drivers own solar panels, while only a minority (19.07%) of non-BEV drivers have them. Additionally, approximately one-third of BEV drivers own a heat pump, whereas the prevalence among non-BEV drivers is lower (16.35%). Home battery ownership is also shown to be twice as common among BEV drivers (12.94%), although it remains relatively uncommon overall (6.39% for non-BEV drivers). These findings suggest an association between the adoption of BEVs and the ownership of REDs, which supports existing literature [9].

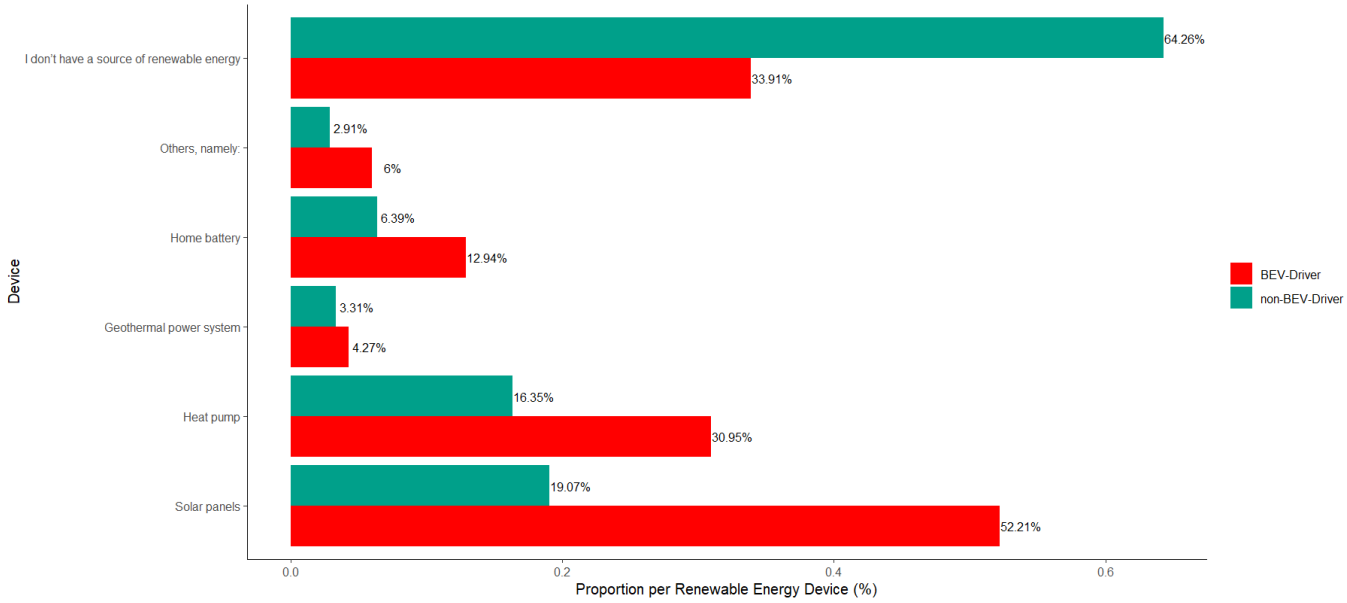

Figure 3: Ownership of renewable energy devices at home of drivers (EU)

Summary

In general, the most common European BEV driver is a middle-aged highly educated male who has a higher than average income, lives in a detached house that he owns and which is equipped with renewable energy devices.

3.3 Mobility behaviour of the European driver

Driver kilometres

Table 2 depicts the mean driven kilometres per driver type. On average, the respondents categorized as BEV drivers drove 19915.04 km a year, compared to 13066.58 for non-BEV drivers in our sample. The difference in means in statistically significant ($t^* = 658.94, p = 0$).

Table 2: Driven kilometres per driver type (EU)

Driver type	Mean	Standard Deviation
BEV-Driver	19915.04	384.7961
non-BEV-Driver	13066.58	96.9388

Factory Range, achieved range and range satisfaction

Table 3 depicts the indicated factory ranges (the range as advertised by the manufacturer) of the BEVs in the sample. The largest group (29.05%) has a factory range between 401 and 500 km, followed by the group of range 301 to 400 km (23.17%). The average factory range in 2021 was 349 km [10], which seems plausible with the data of our survey. In most cases however, and as described by Fig. 4., the factory range is not attained for the majority of the respondents. Indeed, 26.16% report having a real-life range of 10 to 20% less than the factory range. When asked about their satisfaction of the achieved range, 50.32% indicated that it is usually enough and 36.27% indicated that their achieved range is always enough. This supports existing literature about range anxiety, i.e. the fear of lack of range or running out of battery power, being a barrier for BEV adoption while research invalidates it as an issue for BEV drivers [11][12].

Table 3: Factory range (according to manufacturer) (EU)

Range	*Frequency*	*Proportion*	*%*
201 – 300 km	278	0.2206	22.06%
301 – 400 km	292	0.2317	23.17%
401 – 500 km	366	0.2905	29.05%
501 – 600 km	133	0.1056	10.56%
601 – 700 km	26	0.0206	2.06%
I don't know	6	0.0048	0.48%
More than 700 km	11	0.0087	0.87%
Until 200 km	148	0.1175	

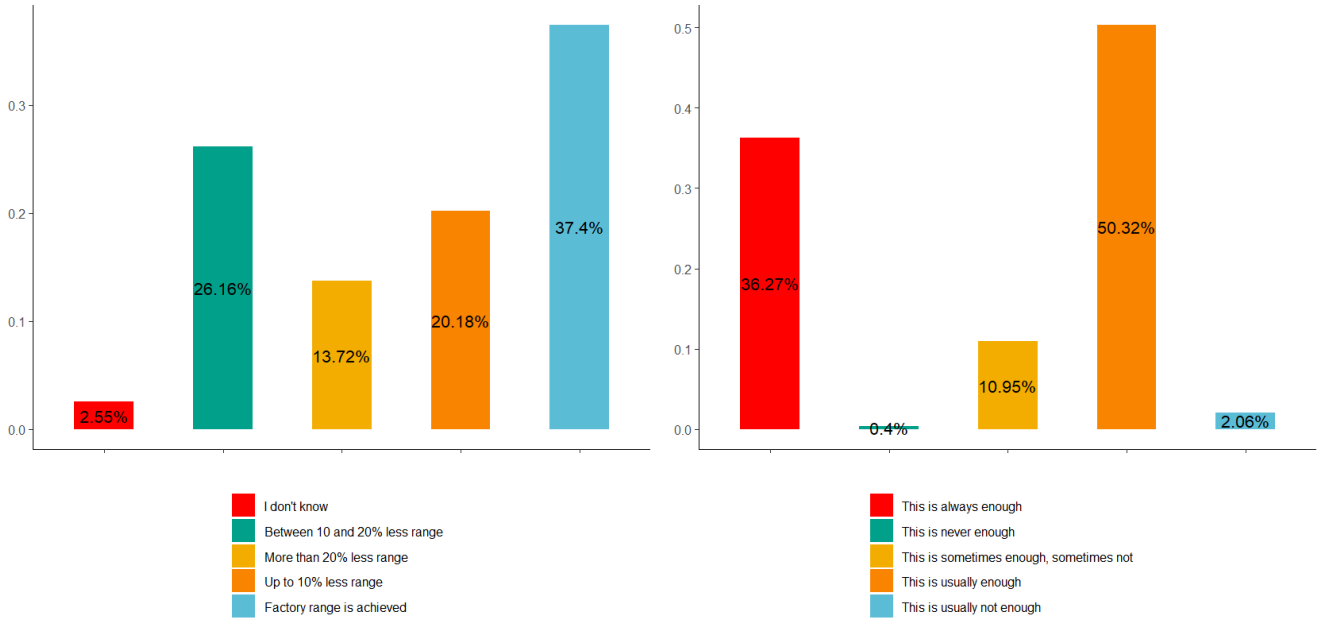

Figure 4: Achieved range and satisfaction of experienced range (EU)

3.4 Charging behaviour of the European driver

Recharging characteristics

Availability and efficiency of recharging infrastructure and systems is a key topic within BEV adoption research. Concerns about congestion at public recharging stations arise when the infrastructure

deployment is outpaced by the BEV adoption growth [13]. BEV drivers were asked to rank the most important recharging characteristics, with number 1 being the most important one and 9 the least important characteristic. Results are displayed in Table 4. The most important characteristic is the recharging speed. Pricing and payment related characteristics are highly ranked as well, taking the 2nd, 3rd, 5th and 6th spot.

Table 4: Ranking of important recharging characteristics (EU)

Recharging Characteristic	*Rank*
Recharging speed / power output of the recharging point, so I can get the quickest possible recharge	1
Easy access and payment via my recharging subscription (pass/app)	2
Possibility to pay per kWh only (instead of per minute or per session)	3
Short/no waiting time to access the recharging point, to avoid queuing	4
Clear and transparent price information, so I know how much I will be charged for my recharging session	5
Convenient on the spot payment options (eg. Debit/ credit card)	6
Possibility to do something else while your car recharges/amenities on site (food, coffee, toilets, etc)	7
Integrated cable, thanks to which you don't need to get the cable out of the trunk	8
Other	9

Waiting time at recharging stations

BEV driving respondents were asked how long they have waited (at most) at a public recharging station. The aggregated data, displayed in Fig. 5., suggests that 63.34% of the BEV drivers in our sample have had to wait to a certain extent at some point at a public recharging station. 24.66% have had to wait 15 minutes or less, 19.16% waited between 15 and 30 minutes. A non-negligeable share of the respondents, 19.52%, have had to wait more than 30 minutes. High waiting times have an effect on total cost (late arrivals, overtime wages, etc.) and routing decisions of drivers [14].

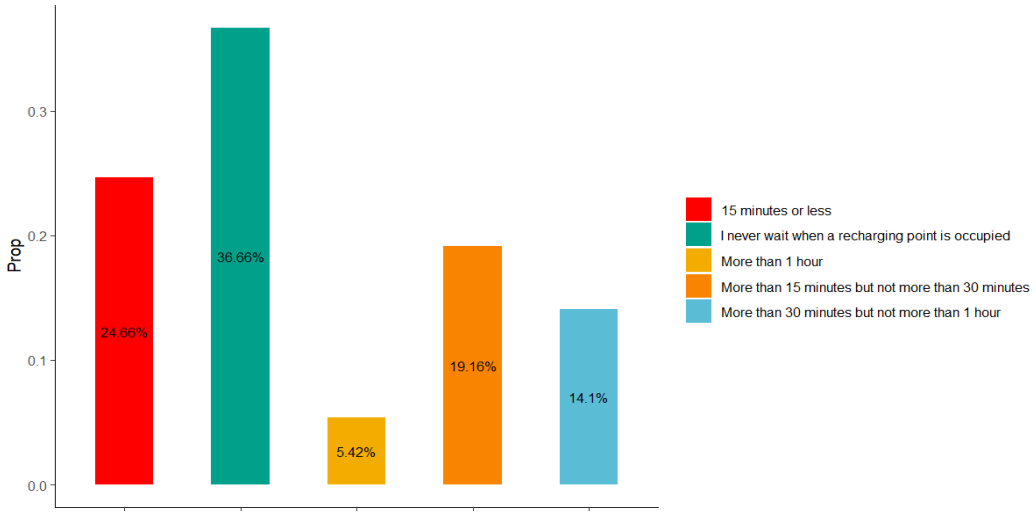

Figure 5: Highest indicated waiting times at Public Recharging Stations (EU)

Charging locations and parking availability

Respondents were asked to indicate for each possible recharging location how often they recharge at that specific location (Fig. 6.). The least popular recharging locations were the recharging station at the workplace, with 59.87% of respondents indicating “never”, and the normal household socket at home, with 50.76% of respondents indicating “never”. For daily and weekly recharging the private recharging station at home appears to be the most common choice, with 18.66% respondents recharging daily and 29.21% recharging multiple times a week. On the other hand, public fast rechargers, public recharging stations (on street/public parking) and semi-public recharging stations appear to be more common for opportunity charging [15]. We notice higher rates of respondents recharging at those locations a couples of times a month or less than once a month and lower rates of daily and weekly charging.

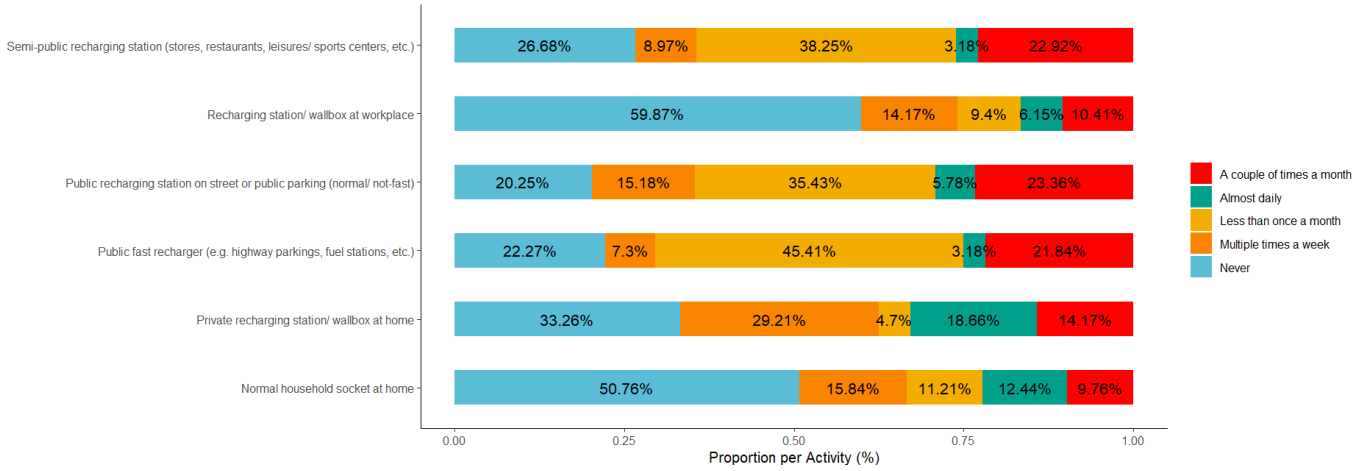

Figure 6: Frequency of use of different charging locations (EU)

As Fig. 6. illustrates, the BEV drivers who charge daily or multiple times a week tend to do so most often at home. In order to do this, a private parking spot is often required to be able to install private recharging stations. Fig. 7., where the parking options of respondents per driver type are displayed, indicates that 75.72% of BEV drivers have their own private parking, while 60.49% of non-BEV drivers have a private parking space. This confirms existing literature [5].

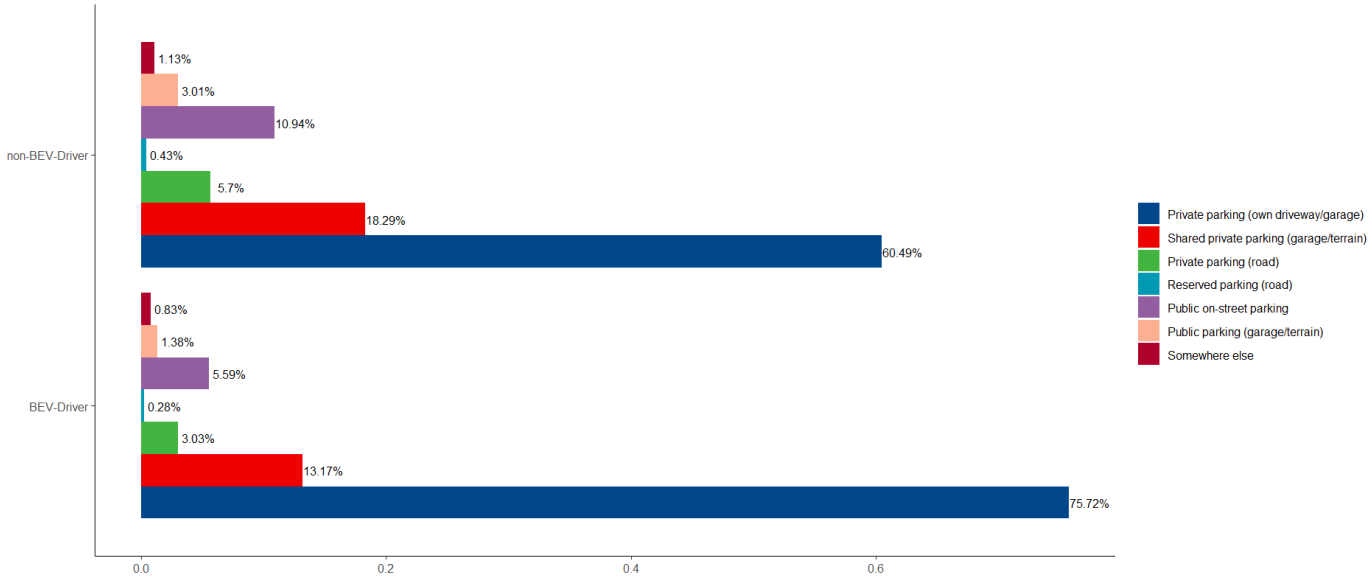

Figure 7: Parking availability per driver type (EU)

3.5 Attitudes and motivations of the European driver

Convincing arguments for the purchase of a BEV

The attitudes and motivations of European consumers towards BEVs assessed in different ways in the survey. Non-BEV drivers were asked which arguments would convince them to purchase a BEV in the future and had to choose between 12 arguments. The 5 most selected arguments are displayed in Fig. 8.. The most common argument is to get a sufficiently high purchase subsidy. This supports existing literature, where price is considered to be the greatest barrier for BEV adoption [12]. Indeed, consumers value more the upfront cost than the long term savings associated with EV ownership [16]. The second most commonly selected argument is having a sufficient driving range, which supports previous research as well [17].

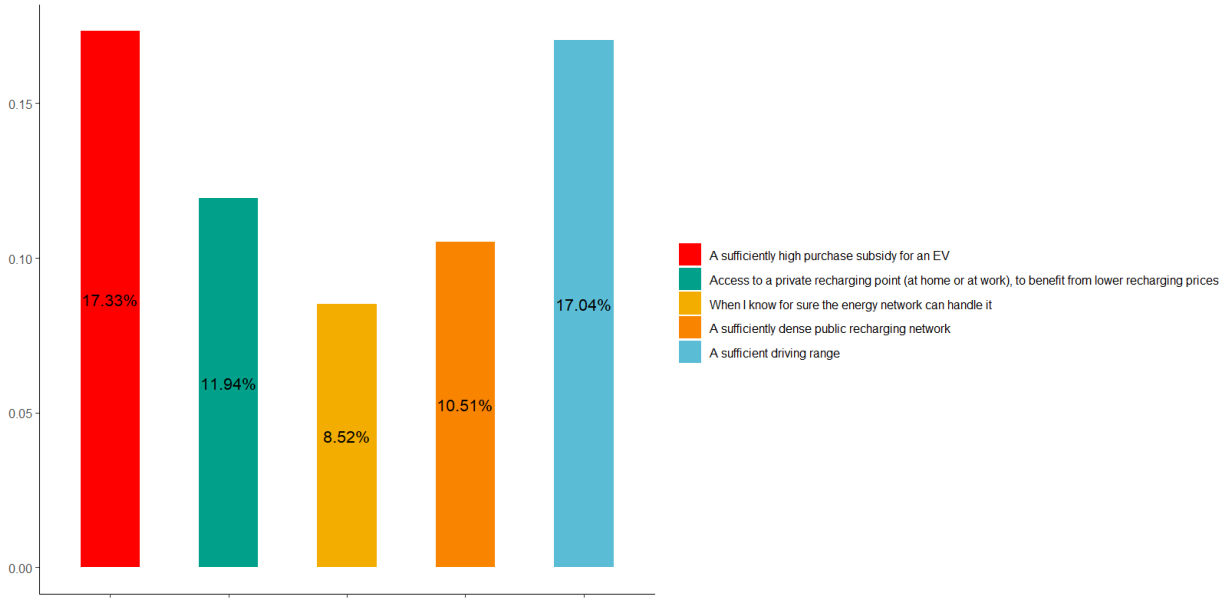

Figure 8: Frequency of indicated convincing arguments to buy a BEV (by non-BEV drivers) (EU)

To which extent is a BEV something for you?

Non-BEV drivers were asked whether a BEV is something for them. Table 5 displays the results. Less than half of them indicate that a BEV is something for them, with only 17.72% indicating that a BEV is definitely something them, and 26.42% indicating that is something for them. The largest group is neutral however, with 27.27% of the respondents taking this stance. Previous academic research [18] suggests that first-hand experience with BEVs is a crucial factor to transition from scepticism to support of BEVs.

Table 5: Responses to "To which extent is a BEV something for you?" by non-BEV drivers (EU)

Extent	Frequency	Proportion
Definitely not for me	2283	12.66%
Definitely something for me	3197	17.72%
Neutral	4919	27.27%
Not for me	2874	15.93%
Something for me	4766	26.42%

General attitude towards BEV

The respondents were asked how they felt about BEVs, on a scale from resolute negativity to resolute positivity. There is a clear difference between the two groups (Fig. 9.). The BEV drivers are overwhelmingly positive about BEVs, with 72.38% being very positive, 20.90% being positive and less than 1% indicating a negative feeling towards the vehicles. The feelings in the non-BEV driving group are more divided, with the largest group being neutral (21.88%). This is in line with the previous research, where it has been found that many of the advantages of driving a BEV (lower operational costs, ease of driving, etc.) only become clear to the consumer when they drive one themselves or have previously experienced it [19][20].

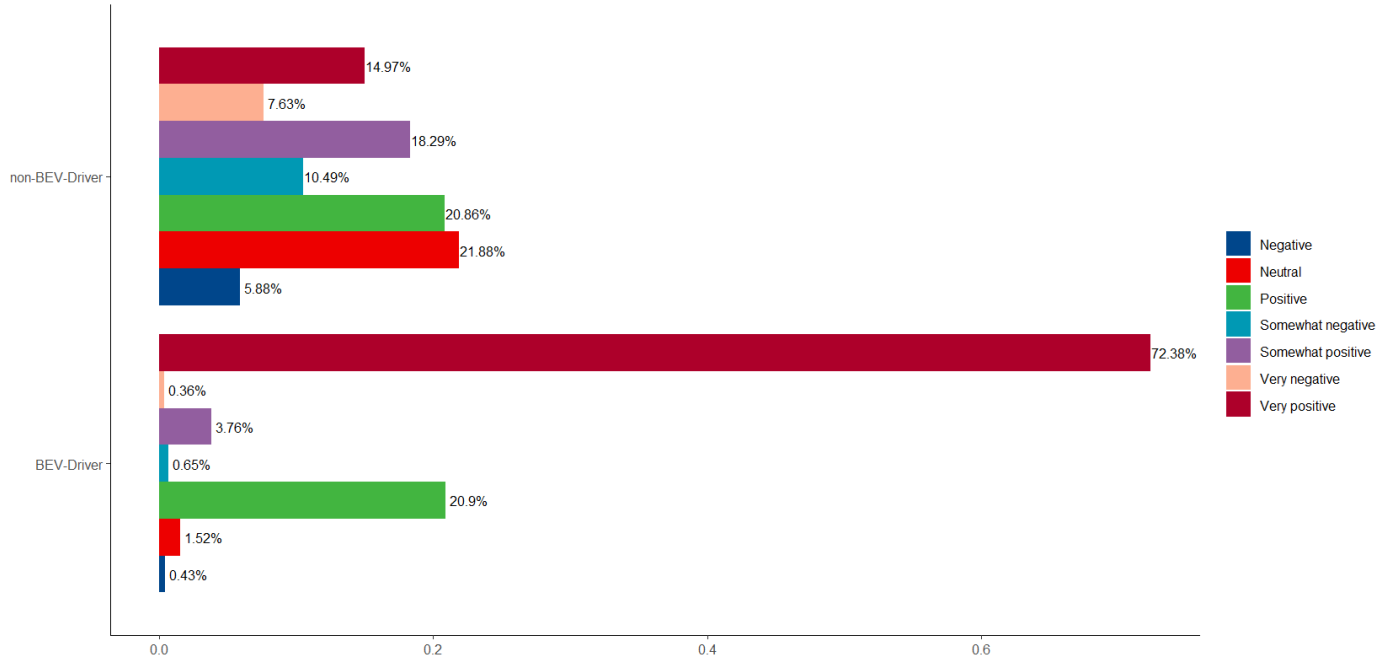

Figure 9: General attitude towards BEVs per driver type (EU)

Barriers for adoption

Respondents had to choose 3 out of a list of 25 arguments against adopting a BEV. The most common barrier for adoption of BEVs indicated by the respondents is that the cars are too expensive (26.1%) (see Fig. 10.). The 2nd, 3rd and 5th most common barriers are all related to the potential lack of effective charging infrastructure or the inaccessibility of private recharging solutions. Both the lack of recharging infrastructure as a fundamental barrier for BEV adoption [21] and the preference for accessible private charging [22] are supported by previous research. The 4th most common barrier is the supposedly insufficient driving range. Even though most trips are comfortably covered by the range offered by BEVs today, consumers worry about longer trips despite their infrequency [23].

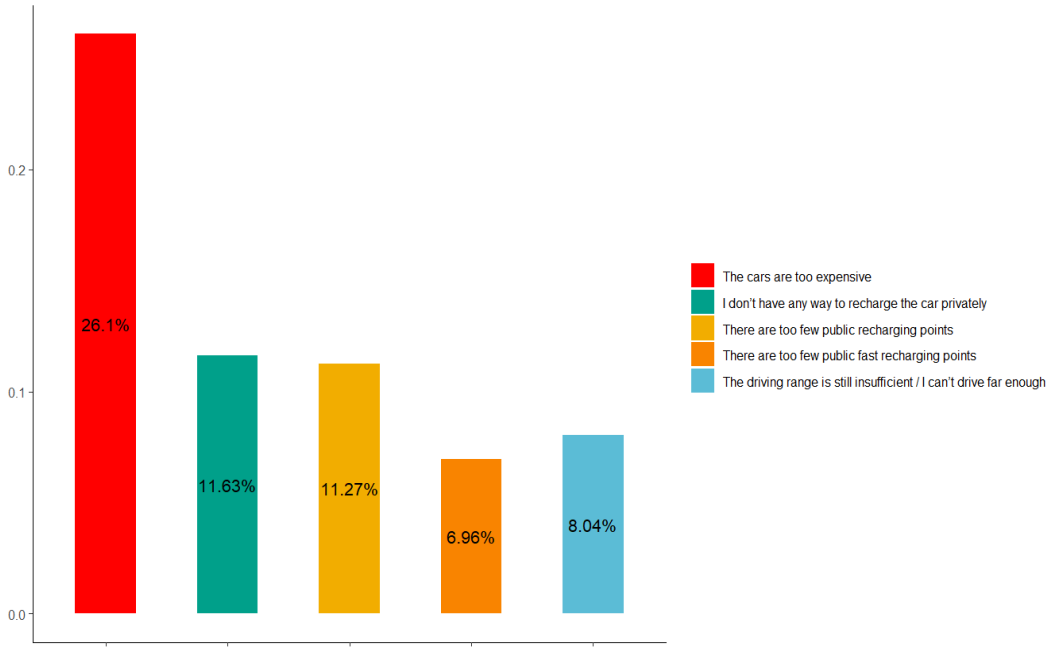

Figure 10: Barriers for adoption of BEVs (EU)

Timeframe for buying a BEV

The non-BEV drivers were asked whether they considered buying a BEV in the future, and if so, within which timeframe. The largest group, at 22.88%, would not consider a BEV as their future car. 16.38% do not know, and 13.11% consider a BEV but without a timeframe in mind. A third of the respondents would consider buying a BEV in the coming 0 to 5 years.

Table 6: Buying timeframe of non-BEV drivers to buy a BEV

Timeframe	Frequency	Proportion
After more than 10 years	89	0.49%
I don't know	2954	16.38%
No	4128	22.88%
No intention to purchase another car	1124	6.23%
Within 0-2 years	1824	10.11%
Within 2-3 years	1788	9.91%
Within 3-5 years	2065	11.45%
Within 5-10 years	1702	9.44%
Yes, but without time frame in mind	2365	13.11%

4 Future research

The results presented in this conference paper offer a brief overview of the data. in depth statistical analyses will be conducted in the near future.

Acknowledgments

We acknowledge AVERE and Dynata for the survey data.

References

[1] European Union (EU27) | European Alternative Fuels Observatory. (2022, September 30). europa.eu. Retrieved January 6, 2023, from https://alternative-fuels-observatory.ec.europa.eu/transport-mode/road/european-union-eu27.

[2] European Commission. (2022, October). Zero emission vehicles: first 'Fit for 55' deal will end the sale of new CO2 emitting cars in Europe by 2035 [Press release]. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_6462.

[3] Kurani, K. S., Caperello, N., TyreeHageman, J., & Davies, J. (2018b). Symbolism, signs, and accounts of electric vehicles in California. Energy Research & Social Science, 46, 345–355. https://doi.org/10.1016/j.erss.2018.08.009.

[4] Brückmann, G., Willibald, F., & Blanco, V. (2021). Battery Electric Vehicle adoption in regions without strong policies. Transportation Research Part D: Transport and Environment, 90, 102615. https://doi.org/10.1016/j.trd.2020.102615.

[5] Mukherjee, S. C., & Ryan, L. (2020). Factors influencing early battery electric vehicle adoption in Ireland. Renewable and Sustainable Energy Reviews, 118, 109504. https://doi.org/10.1016/j.rser.2019.109504.

[6] Dimatulac, T., & Maoh, H. (2017). The spatial distribution of hybrid electric vehicles in a sprawled mid-size Canadian city: Evidence from Windsor, Canada. Journal of Transport Geography, 60, 59–67. https://doi.org/10.1016/j.jtrangeo.2017.02.010.

[7] Bansal, P., Kockelman, K. M., & Wang, Y. (2015). Hybrid Electric Vehicle Ownership and Fuel Economy across Texas. Transportation Research Record: Journal of the Transportation Research Board, 2495(1), 53–64. https://doi.org/10.3141/2495-06.

[8] Pillai, A., Curtis, J., & Tovar Reaños, M. A. (2022). Spatial scenarios of potential electric vehicle adopters in Ireland. Case Studies on Transport Policy, 10(1), 93–104. https://doi.org/10.1016/j.cstp.2021.11.008.

[9] Gezelius, M., & Mortazavi, R. (2022). Effect of Having Solar Panels on the Probability of Owning Battery Electric Vehicle. World Electric Vehicle Journal, 13(7), 125. https://doi.org/10.3390/wevj13070125.

[10] International Energy Agency. (2022). Global EV Outlook 2022. In *iea.org*. IEA.

[11] Langbroek, J. H., Cebecauer, M., Malmsten, J., Franklin, J. P., Susilo, Y. O., & Georén, P. (2019). Electric vehicle rental and electric vehicle adoption. Research in Transportation Economics, 73, 72–82. https://doi.org/10.1016/j.retrec.2019.02.002.

[12] Adepetu, A., & Keshav, S. (2015). The relative importance of price and driving range on electric vehicle adoption: Los Angeles case study. Transportation, 44(2), 353–373. https://doi.org/10.1007/s11116-015-9641-y.

[13] J. Antoun, M. E. Kabir, R. F. Atallah and C. Assi, "A Data Driven Performance Analysis Approach for Enhancing the QoS of Public Charging Stations," in IEEE Transactions on Intelligent Transportation Systems, vol. 23, no. 8, pp. 11116-11125, Aug. 2022, doi: 10.1109/TITS.2021.3100875.

[14] Keskin, M., Laporte, G., & Çatay, B. (2019). Electric Vehicle Routing Problem with Time-Dependent Waiting Times at Recharging Stations. Computers & Operations Research, 107, 77–94. https://doi.org/10.1016/j.cor.2019.02.014.

[15] Teoh, T., Kunze, O., Teo, C., & Wong, Y. D. (2018). Decarbonisation of Urban Freight Transport Using Electric Vehicles and Opportunity Charging. Sustainability, 10(9), 3258. https://doi.org/10.3390/su10093258.

[16] Tamor, M. A., Gearhart, C., & Soto, C. A. (2013). A statistical approach to estimating acceptance of electric vehicles and electrification of personal transportation. Transportation Research Part C-Emerging Technologies, 26, 125–134. https://doi.org/10.1016/j.trc.2012.07.007.

[17] Zhou, W., Cleaver, C. J., Dunant, C. F., Allwood, J. M., & Lin, J. (2023). Cost, range anxiety and future electricity supply: A review of how today's technology trends may influence the future uptake of BEVs. Renewable & Sustainable Energy Reviews, 173, 113074. https://doi.org/10.1016/j.rser.2022.113074.

[18] Burgess, M., King, N., Harris, M., & Lewis, E. G. (2013). Electric vehicle drivers' reported interactions with the public: Driving stereotype change? Transportation Research Part F-Traffic Psychology and Behaviour, 17, 33–44. https://doi.org/10.1016/j.trf.2012.09.003.

[19] Bühler, F., Cocron, P., Neumann, I., Franke, T., & Krems, J. F. (2014). Is EV experience related to EV acceptance? Results from a German field study. Transportation Research Part F-Traffic Psychology and Behaviour, 25, 34–49. https://doi.org/10.1016/j.trf.2014.05.002.

[20] Jensen, A. A., Cherchi, E., & Mabit, S. L. (2013). On the stability of preferences and attitudes before and after experiencing an electric vehicle. Transportation Research Part D-Transport and Environment, 25, 24–32. https://doi.org/10.1016/j.trd.2013.07.006.

[21] Yang, T., Long, R., Li, W., & Rehman, S. U. (2016). Innovative Application of the Public–Private Partnership Model to the Electric Vehicle Charging Infrastructure in China. Sustainability, 8(8), 738. https://doi.org/10.3390/su8080738.

[22] Plötz, P., Schneider, U., Globisch, J., & Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. Transportation Research Part A-Policy and Practice, 67, 96–109. https://doi.org/10.1016/j.tra.2014.06.006.

[23] Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R. L., & Stannard, J. (2012). Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. Transportation Research Part A-Policy and Practice, 46(1), 140–153. https://doi.org/10.1016/j.tra.2011.09.008.

Presenter Biography

Dennis Verbist is a graduate in Business Economics from the Vrije Universiteit Brussel, where he is now active as a PhD student and teaching assistant. His main field of research revolves around the socio-economic aspects regarding the adoption of Electric Vehicles and their integration into the mobility landscape, with a particular focus on policy and energy justice related issues.