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Exploring the Uncharted: Understanding Light Electric Vehicle Mobility Patterns, User Characteristics, and Acceptance

Sophie Isabel Nägele [1,*], Marius Wecker [2] and Laura Gebhardt [1]

[1] German Aerospace Center e.V., Institute of Transport Research, Rudower Chausse 7, 12489 Berlin, Germany; laura.gebhardt@dlr.de
[2] Institute of Geosciences and Geography, Martin-Luther-University Halle-Wittenberg, Von-Seckendorff-Platz 4, 06120 Halle (Saale), Germany
* Correspondence: sophie.naegele@dlr.de; Tel.: +49-030-67055-8053

Abstract

Light Electric Vehicles (LEVs) offer a promising response to environmental and urban mobility challenges. This study is among the first to exploratorily examine their use, user characteristics, and owner evaluations. A qualitative pre-study with four LEV owners was conducted and informed a subsequent quantitative phase involving 23 owners. Over two weeks, participants recorded all LEV trips using GPS tracking and completed two questionnaires. Findings show that LEVs are regularly used for commuting, shopping, and work-related trips. Notably, many users live outside urban centers, indicating strong potential for short-distance travel in rural and small-town contexts for our sample. This challenges the view of LEVs as primarily urban or recreational vehicles. Within our sample, usage patterns were diverse, indicating that even among early adopters there is no single typical usage profile. While cars were perceived as slightly safer, no participant reported feeling unsafe in their LEV. User satisfaction was high: 24 of 27 respondents would choose the same vehicle again. Overall, LEVs emerge as a versatile and satisfying mobility option, relevant beyond city limits. Given their wide range of uses and positive user feedback, LEVs should be more strongly considered in transport policy to promote more sustainable and needs-based mobility.

Keywords: LEVs; light electric vehicles; mobility innovation; user perspective; sustainable mode of transport; acceptances

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1. Introduction

Following the decades of dominance by the combustion engine in passenger vehicles, the automotive industry is undergoing a profound transformation. The European Union's decisive mandate to ban new petrol- and diesel-fueled vehicles from 2035 [1] has accelerated this shift, compelling even established automotive manufacturers to substantially expand their electric vehicle portfolios.

The advantages of electrification are multifaceted. Electric passenger vehicles present a promising pathway to mitigate global carbon emissions, particularly when charged by renewable energy sources [2]. Beyond carbon emissions' reduction, electric vehicles offer further environmental benefits, including improved air quality through the elimination of fine particulate emissions from combustion engines and a substantial reduction in noise pollution [3]. However, contemporary automotive design, including electric vehicles, continues to present challenges: On the one hand, the size of vehicles affects climate change indirectly with the amount of used materials and efficiency effects due to their weight [4]. On the other hand, vehicle size has sparked an important debate about how space is used in cities. The rising prevalence of sport utility vehicles (SUVs) as a standard vehicle type has intensified public critique. In some cases, this prompted planning interventions aimed at reducing air pollution and promoting sustainable urban mobility, like banning SUVs or increasing parking costs immensely in Paris [5].

Light Electric Vehicles (LEVs) emerge as an innovative solution to these urban mobility challenges [6]. Currently, LEVs are still in a niche and the user base is relatively small. However, LEVs provide users with a transportation option that delivers more comfort than bicycles or scooters and higher energy efficiency, while avoiding the excessive capacity and high costs of standard passenger vehicles [7,8]. As such, they are a promising technological innovation and represent different vehicle categories as e-scooters or e-bikes. Importantly, in the present paper, we focus on three- and four-wheeled LEVs of the categories L5e–L7e [9].

1.1. Background

Despite the diverse range of LEVs available, spanning from single-occupant personal vehicles to larger commercial models, empirical research remains limited, especially for three- and four-wheeled LEVs. What has been researched, up until now, highlights both the potential and the persistent barriers that keep LEVs in niche markets. On the one hand, research has revealed a great potential of LEVs in substituting car trips with resulting emission savings [8,10,11]. Furthermore, Ewert et al. (2021) [12] emphasize, through expert interviews and policy analysis, the unique spatial advantages of these vehicles, e.g., their small footprint can reduce parking demand and enable the reallocation of urban space to pedestrians and cyclists. On the other hand, the same study points out systemic challenges, like strict homologation rules, top speed limitations, and driving range constraints that confine LEVs to very specific urban contexts [12].

Concerning technical considerations, some innovations can be reported, like the BICAR (however, of the L2e-category), which combines lightweight construction, integrated solar panels, swappable batteries, and user-centered ergonomics [13]. Another study's findings echo those of the BICAR study in highlighting that technical design choices (e.g., low weight, compact dimensions) directly translate into operational benefits like reduced congestion and better utilization of parking infrastructure [14]. One of the very few projects which investigates LEVs of the L5–L7 categories is the GIANTS project (Green Intelligent Affordable New Transport Solutions), which aims to design frugal, lightweight electric vehicles tailored for both advanced and emerging urban markets [15]. The project shows that stakeholder acceptance of frugal LEVs hinges on practical adaptability, safety, manageable costs, and supportive infrastructure policies, while highlighting that design appeal and modularity open specific market niches, like service and vending applications. However, another study found that when comparing driving comfort (in terms of vibration), currently LEVs perform worse compared to smaller cars (like the Smart Fortwo) [16]. Thus, promisingly, a design paper shows how relatively small engineering changes, in this case, a steering mechanism redesign in a three-wheeled EV, can significantly enhance safety and maneuverability, which are critical factors for niche market adoption [17].

At the practical application level, Ewert et al. (2021) [12] investigate LEVs in commercial urban logistics. Their mixed-methods approach reveals a striking gap: while about half the surveyed firms were unaware of LEVs like the Twizy Cargo or Microlino, those who did know them, and a smaller group who piloted them, saw clear benefits, including maneuverability, reduced operating costs, and lower emissions [18]. The study concludes that awareness and targeted demonstration projects could unlock wider commercial use, particularly in last-mile deliveries. Similarly, a large-scale survey (N = 4090) across four European countries revealed that users, compared to non-users, rate LEVs significantly higher across four advantage clusters: comfort, practicality, accessibility, and safety [19]. Notably, the study shows that interested non-users have perceptions closer to current users than to disinterested non-users, indicating that familiarity and exposure play a crucial role in overcoming skepticism. In another use case, LEV-sharing, a study showed that it is important to involve diverse user roles, including users, non-users, and organizational decision-makers, to co-create and refine LEV sharing services [20]. Lastly, public acceptance of electrified L-category vehicles is strongly driven by perceived utility, especially convenience and cost-effectiveness [21]. This study also shows that demographics (age, urbanicity) significantly influence acceptance, while concerns about safety and limited speed and range remain adoption barriers. Lastly, usage patterns differ between urban commuting and leisure, energy consumption varies with driving style and trip type, and users appreciate real-time feedback like energy use metrics [22].

In addition, while existing research has addressed some relevant research questions about LEVs, like the potential of LEVs to substitute car trips and the resulting emission savings [8,10,11], or user adaptation to LEVs in carsharing scenarios [20], a significant knowledge gap concerning individuals who have already implemented LEV usage in their daily routines persists. This seems especially interesting, as research has shown that those who are familiar with LEVs evaluate them more positive, compared to non-users [19]. Although studies have examined the perspectives of users and interested non-users regarding the advantages of these vehicles, these investigations have been limited to E-Scooters [23] or e-bikes, and electric two-wheelers [19].

1.2. Research Questions

Accordingly, the present study addresses this research gap by investigating a sample of LEV owners. Our primary objective is to illuminate the modalities of LEV utilization by comprehensively examining user characteristics and usage patterns in order to contribute to the understanding of this innovative mobility solution. To do so, we investigated the following research questions:

1. How are LEVs used?
2. What is the demographic profile of LEV owners?
3. What attitudinal profiles characterize LEV owners and potentially influence their decision to purchase a LEV?
4. How do LEV owners evaluate their LEV?
5. Which were the main purchase reasons of the LEV owners?
6. How do LEV owners evaluate the safety and security aspects of LEV usage?

2. Materials and Methods

To answer the research questions, we applied a mixed-methods approach. Due to the scarce empirical knowledge, we first conducted a pre-study with four semi-structured qualitative interviews with a subset of LEV owners to gain deeper insights into their motivations, experiences, and potential usage challenges. Second, with a sample of 23 LEV owners, we gathered aggregated GPS tracking data from participants' smartphones over a two-week period to capture usage patterns and travel behaviors. Third, two comprehensive questionnaires were given to the second sample, which collected demographic information, attitudes toward LEVs, and self-reported usage patterns. This triangulated methodology allowed us to develop a nuanced understanding of how LEVs are integrated into everyday mobility practices. For the data analysis, all three data sources were examined in relation to one another, meaning that GPS tracks were compared with participants' statements and evaluations regarding identifiable patterns in the tracking data.

2.1. Qualitative Pre-Study: Interviews

2.1.1. Sample: Interviews

Four LEV owners were recruited and participated in the interviews between 25 July and 12 August 2022. The participants were between 32 and 59 years old, and all participants were male. Participant 1 (P1) has owned a Renault Twizy (80 km/h max. speed) since 2013. P2 has also owned a Renault Twizy (85 km/h max. speed) since 2022. P3 is set to receive a Twike 5 (85 km/h max. speed) in the new year, and P4 has owned a Renault Twizy (80 km/h max. speed) since 2018. In the following section, the four participants will be referred to as P1–P4.

2.1.2. Procedure: Interviews

Four semi-structured qualitative interviews were conducted. Participants were recruited online, and the interviews were conducted via video call. During the interviews, the key content of the discussions was documented via protocol. The data were subsequently qualitatively deductive–inductive analyzed [24]. The interviews were necessary because existing empirical research on the topic is so scarce that designing the quantitative survey in an evidence-based manner would not have been feasible. The qualitative preliminary study provided the necessary foundation for this process.

At the beginning of each interview, participants were informed about data processing procedures. The interview followed a sequential protocol:

1. Initial Context: which LEV-model and when acquired.
2. Purchase Motivation: e.g., environmental friendliness or technical interest.
3. Model Selection Rationale: e.g., size or price.
4. User Experience: safety, speed, comfort, transport capabilities, accompaniment options, and charging infrastructure.
5. Usage Patterns: trip length, road type, and trip purpose.
6. Mobility Behavior Changes: e.g., the LEV as substitution of which vehicle.
7. Desired Improvements: infrastructure, financial aspects, and vehicle specifications.
8. Charging Habits: e.g., at home or at work.
9. Repurchase Considerations: e.g., the same or another model.

2.2. Main Study: GPS Data Tracking

2.2.1. Sample: GPS Data Tracking

The participants were recruited through various social media channels, blogs, newsletters, and LEV manufacturers who shared the survey with their customers. A total of 32 individuals expressed interest in participating, while 23 completed the study. The participants were on average, $M = 52.48$ years old ($SD = 9.12$ years), and 17.9% were female, with the remaining greater share being male.

2.2.2. Procedure: GPS Data Tracking

Mobility data were collected during a 2-week period via GPS tracking using the MovingLab App (https://movinglab.dlr.de/), accessed on 12 August 2022 an app developed by the German Aerospace Center (DLR). Once installed on a participant's smartphone, the App tracks the user's trips while applying segmentation algorithms to decompose complete trips into distinct trip segments (legs). This is conducted by analysis of the phone's sensors, geolocation and time information, relying on a multimodal approach to fuse smartphone sensor data with geospatial coordinates and temporal variables. The passive data collection system operates autonomously once activated, requiring no active user input during travel episodes. Following trip completion, participants were prompted to validate the algorithmic classification of transportation modes and to verify the temporal boundaries between trip segments, allowing for post-hoc verification of the automated modal detection system.

During the data collection period from 5 November 2022 to 22 December 2022, the participants were asked to track solely their trips with the LEV. If a trip was covered by various modes of transport, the participants could assign different modes and purposes to each leg. Only the legs conducted by LEV were considered for the analysis. Trip purpose was not indicated on trip level but on leg level, since one trip can contain various purposes.

In total, 23 persons tracked during the survey period, resulting in a total of 309 trips divided into 434 legs. It must be taken into account that not all trips were likely recorded, as participants had to manually activate the tracking each time they used their LEV, which reflects a common issue in user-dependent data collection.

2.2.3. Data Processing: GPS Data Tracking

During data preparation, some data inconsistencies were identified that likely stemmed from tracking errors or user input mistakes. Two primary data validation strategies were implemented to address these inconsistencies.

First, the technical specifications of the LEVs used indicate a maximum range of 100 km per charge, and only trips within this threshold were retained. This constraint aligned with questionnaire responses, where participants indicated their tendency to avoid trips exceeding this distance.

Second, only trips covered by LEVs were included, even though the MovingLab tracking system used a verification mechanism wherein participants manually checked all tracked trips for proper tracking (routes, time, and distance), and if the right mode of transport was automatically recognized, either confirming the initial data or correcting any errors, some trips with modes other than LEVs were tracked.

Furthermore, to ensure compatibility with established standards, the mobility data were structured according to the framework employed by "Mobilität in Deutschland" (MiD), the national travel survey of Germany conducted by the German Federal Ministry for Digital and Transport (BMDV). This standardization necessitated two methodological adjustments, as follows:

1. Individual legs were aggregated according to their corresponding trip identifiers.
2. When a leg was classified with the purpose "heading home", it was reassigned to the purpose of the preceding leg.

Legs with multiple assigned purposes were included only in calculations of overall frequency but excluded from analyses of mean or aggregate distances due to insufficient information regarding the proportional distribution of the individual purposes within these legs. Similarly, legs without any assigned purpose were omitted from the analysis.

The implementation of these validation strategies resulted in a substantial reduction of the initial dataset. Of the 1367 legs originally submitted by participants, 933 legs were excluded due to either one of the following:

1. Being covered by transport modes other than LEVs ($n = 592$);
2. Exceeding the 100 km distance threshold ($n = 3$);
3. Failed tracking of the leg distance ($n = 183$);
4. Failed giving trip purpose by the user ($n = 376$).

Meanwhile, one leg could of course fail to meet more than one condition. The filtering results in a final sample of 434 usable legs, congregating to 309 trips.

The predominant portion of excluded legs stems from the tracking application used and its underlying approach of continuously monitoring participants' mobility across the full day while capturing different transportation modes. Given this operational framework, a high attrition rate is deemed acceptable. However, what proves problematic and preventable is the failure to record/store travel distances for 183 legs by the software used, and furthermore, the absence of trip purpose data for 376 journeys, as participants did not provide this information, rendering these entries unusable for analysis.

2.3. Main Study: Quantitative Study

2.3.1. Procedure: Quantitative Study

For the quantitative study, the same sample was used as for the GPS data tracking (see Section 2.2.1). The quantitative study was administered by the MovingLab App as well, in which it is also possible to implement questionnaires. It consisted of two surveys: the initial questionnaire was completed at the beginning of the study, while the final questionnaire was filled out 14 days later, at the end of the study period. The questionnaires' content was based on the results of the qualitative pre-study, which provided first insights into relevant questions. Accordingly, the initial questionnaire first collected demographic data from the participants, followed by information about their LEV. Next, participants were asked about their attitudes concerning their LEV, as follows:

1. Whether they would purchase an LEV again if faced with the same buying decision.
2. How satisfied they were with their LEV.
3. How they evaluated their LEV.

In the final questionnaire, participants were asked about their reasons for purchasing an LEV and their specific usage patterns. Additionally, further attitudes were assessed, including the following:

1. How risk tolerant the LEV owners perceive themselves to be.
2. Usage reasons for their LEV.
3. Which attitudinal profile LEV owners have, potentially influencing LEV purchase decision [25,26].
4. How safe they perceive their LEV to be and how helpful they consider additional safety measures for LEVs.

2.3.2. Data Processing: Quantitative Study

The questionnaire data were compiled from two different datasets: the initial questionnaire and the final questionnaire. All variables were checked for plausibility and implausible entries replaced by NAs. When participants left out information, missing values were replaced with the average of values.

3. Results

In this section, the results are presented by integrating findings from the qualitative pre-study, GPS tracking data, and the quantitative survey. This combined approach allows the data sources to complement and enrich each other [27]. We reported the median (*Med*) when the data were skewed, as this better represents the central location in those cases, and the mean (*M*) when the distribution was approximately symmetric.

3.1. How Are LEVs Used?

Based on the GPS data, exemplary, the differences between the usage patterns of a rural user (see Figure 1, the Allgäu region) and an urban user (see Figure 2, Berlin) were analyzed. The heatmaps use color intensity to indicate travel frequency, with darker shades representing areas that were traversed more frequently. In the rural context, LEV usage is concentrated along a limited number of linear routes, extending over longer distances and radiating from a central node. In contrast, the urban usage pattern is characterized by a dense and spatially dispersed heatmap, with multiple high-density zones and frequent short-range trips. This suggests more flexible and localized mobility behaviors in the urban environment. These two spatial distributions should be understood as examples and not as representative usage patterns for all urban and rural areas.

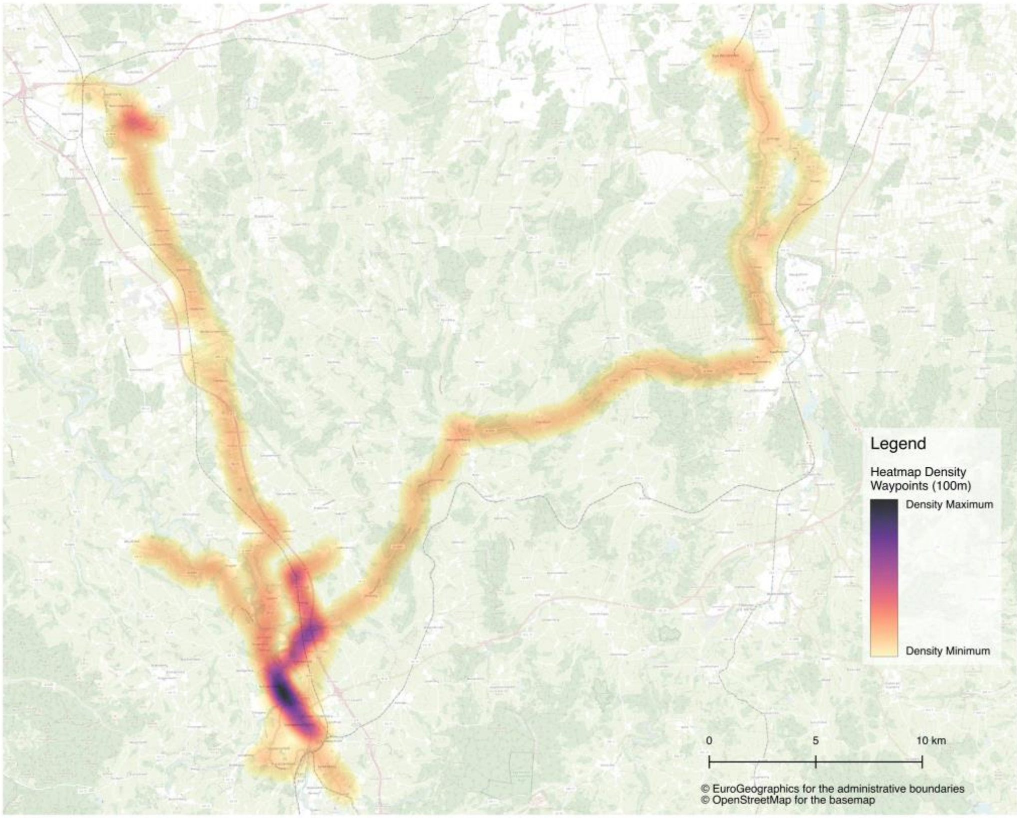

Figure 1. Heatmap of tracked trips in a rural area (Allgäu) (created by the authors).

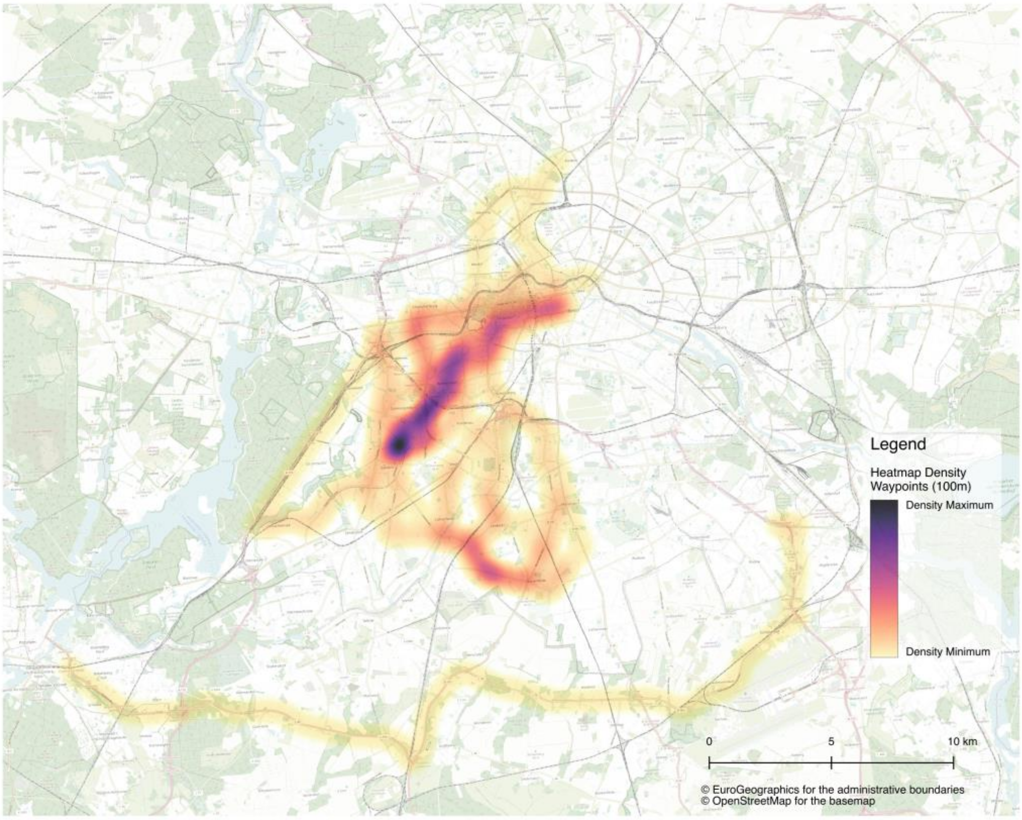

Figure 2. Heatmap of tracked trips in an urban area (Berlin) (created by the authors).

The spatial dispersion of the participants is verified by the questionnaire. There, the participants were asked in what kind of populated area they are situated. Thirteen people stated to live downtown (3 people) or in the suburbs (10 people) of major cities (>100,000 inhabitants), while 3 people stated to live in the suburbs of medium-sized cities and 0 downtown. Eleven people stated to live in small cities with 5000–20,000 inhabitants (4 participants), or in rural areas and small county municipalities of less than 5000 inhabitants (7 participants).

Regarding trip purposes, the tracking data show roughly three different clusters of trip purpose frequencies, with shopping/errands, to work, and business showing the highest count (see Figure 3). Comparably often, the LEV is used for trips serving the purpose of "to work" or "business". The second cluster in the use count with mediocre results was classified as "miscellaneous", "recreation", and "pick up sb/drop sb off". The most surprising trip purpose was picking somebody up or dropping someone off, while still seeming to be a rather secondary use case. The third cluster with the last count is the trip purpose education.

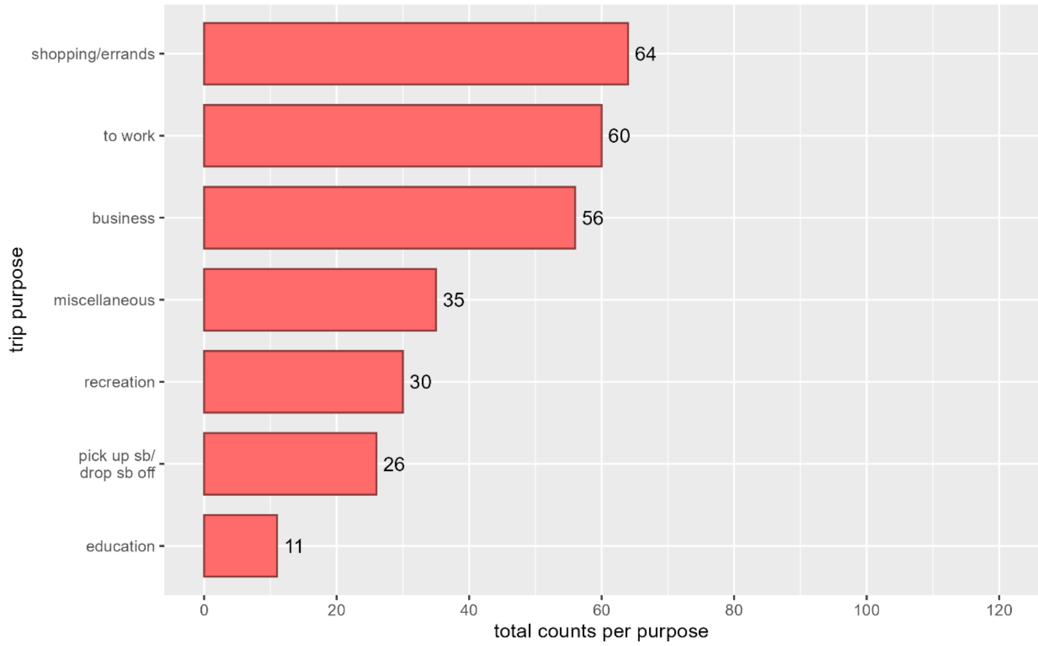

Figure 3. Aggregated count of trip purposes.

Concerning trip length, shopping-related trips exhibited the shortest median length (see Figure 4). This might indicate that in our sample, LEVs are primarily used for shorter shopping trips, making them an integral tool to fulfill daily necessities and routine purchases. Furthermore, especially business trips exhibit a larger range while still in the boundary conditions of the limited total range of LEVs. Looking at the distribution of the trips under the category "recreation" more specifically, some outliers become visible. This shows that LEVs can serve different trip purposes, while only slightly varying in trip length, with only few exceptions. Furthermore, analysis reveals that trip length distributions for nearly all trip purposes exhibit positive skewness, ranging from 0.587 (pick up sb/drop sb off) to up to 1.899 (to work). The exception is 'education' (skewness = 0.021), where the distribution is approximately symmetrical. Regarding kurtosis, only the distributions of trips under the purpose 'recreation' (kurtosis = 3.265) and 'miscellaneous' (kurtosis = 3.517) exhibit values of a normal distribution. 'Pick up sb/drop sb off' (kurtosis = 1.966) and 'education' display platykurtic distributions, while all other purposes show leptokurtic distributions (kurtosis range: 4.439–9.014).

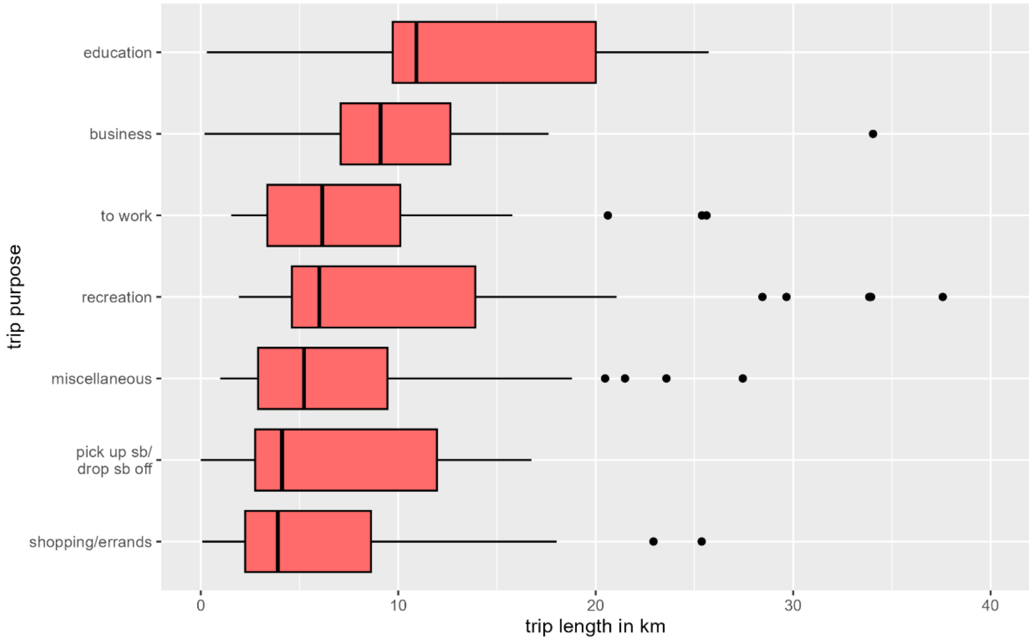

Figure 4. Boxplot of distribution of trip lengths per purpose.

Also, the usage patterns per weekday show that the LEV is an integral tool to fulfill daily necessities and private errands for our sample (see Figure 5). During the 47 day survey period, the LEV trips per person were tracked with a median of 18.5 days (*SD* = 22.87). This suggests, also based on the questionnaire answers given in the next passage, that not all trips covered by LEVs were recorded by the tracking system. The wide range of the participants' recording (range = 1–97 days) results in the high standard deviation observed in the data. The questionnaire also provides insight into how many days of the week the participants were using their LEV. In total, a large share of the participants, 19 of 23 persons, stated that they use their LEV five or more days per week. This is in line with the results of the qualitative pre-study. There, the participants stated that they use the LEV for all trip purposes within its range. However, the perceived higher comfort of car usage in some cases leads to a preference to use the car instead of the LEV. One participant of the pre-study, P1, uses the LEV for all trips except those that exceed its range, but now drives it less often due to having purchased a more comfortable EV. P2 uses the LEV for all trips, including longer distances with intermediate charging, mainly for driving children, private errands, and commuting to work. P3 plans to use the LEV for all trips in the future, while P4 uses it only within its range and prefers a second car for comfort, using it for 80% of the trips.

Additionally, nearly every one of the participants answering the initial questionnaire is in paid employment, and the peak of tracked trips on Tuesday and Wednesday indicates an integration of LEVs on labor days and therefore work-related purposes and/or purposes of private errands. Accordingly, 25 of 27 participants indicated their paid employment being their most influential mobility driver (as can also be seen in Figure 3). It should be considered though that participants may have carried out recreational activities with conventional cars or other means of transport, whose usage was not assessed in this study. Accordingly, in the survey, participants stated they would not make trips with the LEV in specific situations (longer trips, some indicating a limit between 25 and 100 km). Last but not least, the questionnaire reveals that, on average, the participants use the LEV for *M* = 6.24 km (*SD* = 2.67) with a *Med* = 5.70 km.

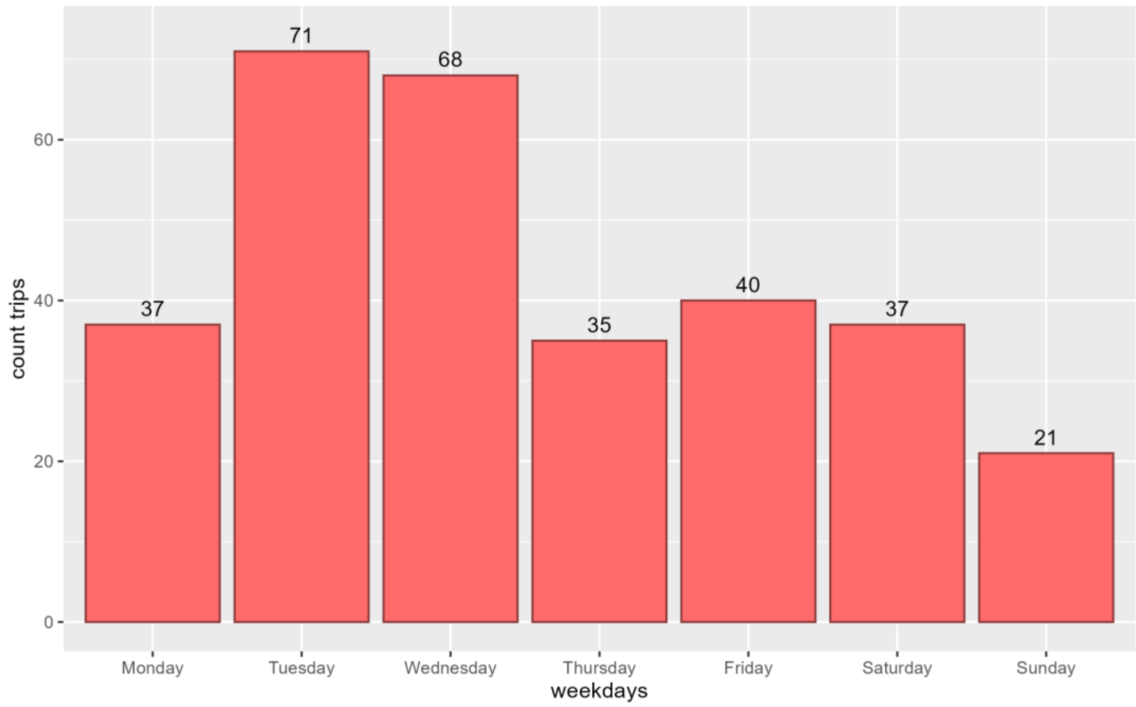

Figure 5. Trip count per weekday.

Moreover, the average daily activities of the users studied can be easily accomplished within the range of an LEV. When it comes to the issue of charging, the qualitative pre-study revealed that LEVs are primarily charged at home. The long charging time is criticized, and it is often cited as the reason why charging is primarily conducted at home. Fast-charging capability is repeatedly requested. The questionnaire supports these results (see Table 1). While charging at home is the most common habit, some of the LEV owners use charging options at other locations, such as at their workplace or in public spaces (e.g., supermarket parking lots). However, the frequency of charging in these locations is much smaller.

Table 1. Frequency of charging the LEV at different locations of the 27 participants of the quantitative survey.

Location	*n*	Never	On Single Days per Month	On Some Days per Month	Several Times per Week	Always
At home	27	3.70%	3.70%	7.41%	25.93%	59.26%
At Work	23	73.91%	4.35%	8.70%	13.04%	0.00%
Public	23	43.48%	30.43%	21.74%	4.35%	0.00%
Public rural	22	77.27%	13.64%	4.55%	4.55%	0.00%

3.2. What Is the Demographic Profile of LEV Owners?

The four participants of the qualitative pre-study were all male and between 37 and 59 years old. In the literature, LEV users are often described as resembling the classic early adopter profile: predominantly male, middle aged, well educated, and with an above-average income. Our sample is not representative, but rather the result of an intensive recruitment phase aimed at finding LEV users at all, as they remain relatively rare in Germany to date.

The participants of the quantitative study were on average M = 52.48 years (SD = 9.12 years) old, and 17.9% were female. The monthly net income of the participants' household ranged from €1500 to more than €7000, with a median between €4000 and €5000, which is slightly above the average of Germany [28]. All individuals in the sample had completed an educational qualification: the vast majority, 10 each, held either an Abitur (A-levels) or a university degree (74.07%), 3 had a secondary school certificate (11.11%), and 4 reported other forms of education or training, which is highly above the average of Germany [29]. The demographic profile of the LEV owners of the qualitative and quantitative study can be found in Table 2.

Table 2. The average demographic profile of LEV owners of the quantitative survey.

Factor	Characteristic
Gender	Mainly male
Age	Between 4 and 50 years
Income	Slightly above German average
Education	Highly above German average
Household size	Living with 1–2 others
Children	Having 1–2 children
LEV as main substitution of which mode	Most of the LEVs substitute a car (70.37%)
How often accompanied by someone else in the LEV	More than half are occasionally accompanied by someone else when driving their LEV

3.3. What Attitudinal Profiles Characterize LEV Owners and Potentially Influence Their Decision to Purchase an LEV?

Regarding the LEV owners' attitudes, the quantitative survey revealed a nuanced characteristics profile (see Table 3). Previous studies showed that electric vehicle purchase intentions are related to moral and social factors, technical feasibility, and notions of collective efficacy. As an attitudinal profile was not developed for LEV owners up until now, these results were taken into account. Therefore, morality [30], social norms [26], technical feasibility [31], and perceived collective efficacy [32] were investigated.

It gets visible that concerning morality, many participants feel a moral obligation or personal belief that purchasing an LEV is the right action to fulfill their moral obligations. The variation, as seen in the standard deviations, however, suggests that there are diverse perspectives on moral issues related to LEVs. With regard to social norms, the results suggest that social pressure or expectations from others to purchase LEVs are less influential. This finding appears plausible, as LEVs have not yet been widely adopted by the mainstream, and therefore, strong societal influence is lacking. However, a stronger belief in receiving moral support from the social surrounding for purchasing an LEV exists, with a low standard deviation, indicating a more uniform perception of social support in these decisions. For technical feasibility, the responses indicate a general agreement with the role of LEVs in future transportation, suggesting confidence in the feasibility of LEVs. The relatively low standard deviations here are in consistent agreement regarding the technical viability of LEVs. Finally, the perceived collective efficacy responses reveal a more divided opinion. While participants generally believe in the potential for collective action to address transportation transformation and climate-friendly mobility, there is a stark contrast to the skepticism about the ability to make a difference in achieving long-term ecological mobility.

Table 3. Attitudinal LEV owners' profile concerning morality, social norms, technical feasibility, and perceived collective efficacy, with the scale being 1 = do not agree at all up to 5 = totally agree.

Factors and Items	**Responses**
Morality	
Regardless of others' behavior, my personal principles indicate that, for environmental reasons, purchasing an LEV when buying a new vehicle is the right course of action.	MW = 4.42, SD = 0.93
Driven by values I consider important, I feel a moral obligation to purchase an LEV when acquiring a new vehicle.	MW = 3.54, SD = 1.34
Due to environmental concerns, I experience a sense of guilt when selecting a non-LEV vehicle during the purchase of a new car.	MW = 3.00, SD = 1.24
Social Norms	
People who are important to me expect that I will purchase an LEV again when buying a new vehicle.	MW = 2.42, SD = 1.21
People who are important to me tell me that I should consider purchasing an LEV again when acquiring a new vehicle.	MW = 2.54, SD = 1.22
People who are important to me support me when I purchase an LEV again.	MW = 3.65, SD = 1.17
Technical feasibility	
LEVs will be an important mode of transportation in the future.	MW = 4.27, SD = 0.94
LEVs should play an important role in our transportation system.	MW = 4.42, SD = 0.93
LEVs have significant advantages over conventional cars.	MW = 4.19, SD = 1.00
Perceived collective efficacy	
I trust that we, as individuals, can contribute to the transformation of transportation.	MW = 4.00, SD = 1.12
I am confident that we will find ways to be climate-friendly in our mobility.	MW = 4.12, SD = 1.09
I do not believe that we can make a difference in achieving long-term ecological mobility.	MW = 1.81, SD = 0.79

3.4. How Do LEV Owners Evaluate Their LEV?

In the quantitative survey, the vast majority (24 participants) agrees with the statement that they are satisfied with their LEV. Two only partly agree and one person does not agree at all. In the qualitative pre-study, the LEVs were generally rated more positively than negatively. Participants highlighted that while the comfort is relatively low, it was not an issue for users. The driving experience was compared to go-kart or motorcycle riding, and all participants felt safe in their LEVs. Two recurring negative aspects were the long charging time, with a desire for fast-charging capability, and the need for the LEV to reach speeds of 100 km/h to avoid being overtaken by trucks. Additionally, the range drops significantly in winter, and more storage space would be appreciated.

The participants were asked which problems they experienced with their LEV up to now. Table 4 shows the clustered reported problems.

Table 4. Reported problems the owners had with their LEV.

Problem Cluster	Specification
No Problems	11 participants reported no problems
Uncomfortable seat	5
Replacement parts are not available	3
Limited range	3
In winter cold	3
Breaks not working properly	2
Failure of/problems with the charging unit	2
Problems with hazard warning lights	1
Incompetent LEV service centers	1
An excessively stiff suspension system	1

3.5. Purchase Reasons and Would the LEV Owners Purchase It Again?

The participants purchased their LEV since the year 2012 until today, out of a variety of reasons. The most frequently mentioned reasons were related to environmental considerations, primarily due to the energy- and resource-efficient nature of the electric driving experience offered by LEVs. Additionally, the relatively low costs of LEVs compared to other motorized modes of transport contributed to participants' purchasing decisions. This included lower costs for the purchase price and the propulsion system, as electricity is significantly cheaper than gasoline and diesel, especially when there is the option to use self-generated solar power. Furthermore, the vehicle concept itself was noted as a purchase reason. Emotional factors such as curiosity, fun, as well as the design and practicality of LEVs convinced some participants to buy an LEV as well. Compared to other small vehicles (e.g., motorcycles), the LEV was perceived as offering protection from the weather, and the independence from diesel and gasoline was viewed as an advantage. The LEV was seen as particularly suitable for solo trips and short urban commutes. Ease of use was also positively commented on, including features such as charging from a standard outlet and its small size, which simplifies parking. Some buyers also acquired it as a supplementary second vehicle. One participant even mentioned that seeing LEVs being used by others influenced their purchase. Taken together, Table 5 provides a concise overview of various purchase motives, with the first being mentioned more often, than the last, as follows:

Table 5. Purchase reasons of the participants of the quantitative and the qualitative pre-study.

Category	Aspects
Environmental Friendliness	• Energy-efficient • Electric • Resource saving • Desire to ease "green conscience"
Cost-effectiveness	• Affordable purchase price • Low fuel/energy costs • Charging with solar power
Vehicle Concept	• Appearance • Suitable for short urban trips • Drives often alone • Independence from diesel/gasoline • As an additional vehicle • Suits mobility needs

Table 5. *Cont.*

Category	Aspects
Comfort	• Weather protection (vs. motorcycle, etc.) • Fun to drive • Charging via household power outlet
Personal Motivation and Interest	• Curiosity • Interest in Electromobility • Inspired by other users • Fascination with technological innovations
Size	• Easy to park • Small dimensions

Additionally, the quantitative survey revealed that 24 of the 27 participants would purchase the same LEV again. Only two participants were unsure and one participant would not purchase the same LEV again. Three of the four participants of the qualitative pre-study would purchase the same vehicle again, reflecting a high level of overall satisfaction. P1 would purchase the same vehicle again, but would prefer the next model to possess a fast-charging capability. P2 would also buy the same model again, as he has not found another vehicle with the appropriate width. P3 would buy the same vehicle, as it now has a small tow bar for carrying out small transports. P4, however, would not buy the same model again, and would instead choose a larger model for better comfort and range.

3.6. How Do LEV Owners Evaluate Safety and Security Aspects of LEV Usage?

While no one reported feeling unsafe in their LEV, participants generally feel safer in a car than in an LEV. Six participants *feel very safe* in a car, while only three feel the same in an LEV. Fifteen participants report *feeling safe* in a car, compared to thirteen in an LEV. Two participants have mixed feelings of safety in a car, while seven report the same for LEVs. Regarding safety, participants of the qualitative pre-study consistently expressed that *they felt safe* in their LEVs. Despite the lower comfort levels, particularly in winter, none of the participants raised concerns about safety. They described the driving experience as similar to riding a go-kart or motorcycle, but none of them *felt unsafe*. This suggests that LEV owners are comfortable with the vehicle's safety features and do not perceive significant risks while driving.

To investigate whether LEV owners are more risk tolerant compared to individuals who prefer driving a car, the risk tolerance was investigated as well. While four participants reported being hardly risk tolerant in general, nine indicated moderate risk-taking behavior, eight were somewhat risk tolerant, and two were very risk tolerant.

To enhance the perceived individual safety in LEVs, participants rated headrests, airbags, and raising the top speed of LEVs to 50 km/h as the most helpful (see Table 6). The majority also rated the anti-lock braking system (ABS) and speed limits in city centers as predominantly helpful. There were mixed opinions regarding the effectiveness of dedicated lanes for LEVs and a larger crumple zone, with both being slightly viewed as helpful. Assistance systems, such as lane-keeping systems, were considered less helpful.

Table 6. Rating of helpfulness of additional safety measures in LEVs of the 27 respondents of the quantitative survey.

Measure	Very Helpful	Helpful	Neutral	Not Helpful	Not at All Helpful	I Don't Know
Speed limits in inner cities	33.00%	18.52%	14.82%	11.11%	7.41%	0.00%
Increase in maximum speed for L6e vehicles to 50 km/h	51.85%	18.52%	7.41%	0.00%	0.00%	7.41%
Dedicated lanes for LEVs	29.63%	11.11%	14.82%	22.22%	3.70%	3.70%
Airbags	59.26%	14.82%	7.41%	3.70%	0.00%	0.00%
Driver assistance systems (e.g., lane keeping assist)	3.70%	7.41%	18.52%	29.63%	22.22%	0.00%
Anti-lock braking systems (ABSs)	29.63%	25.93%	22.22%	7.41%	0.00%	0.00%
Headrests	59.26%	25.93%	0.00%	0.00%	0.00%	0.00%
Larger crumple zones	7.41%	29.63%	44.44%	3.70%	0.00%	0.00%

4. Discussion

The present study provides a first exploratory overview of 23 LEV owners' usage patterns as well as their user characteristics, the evaluation of their LEVs, purchase reasons and satisfaction, as well as their safety and security concerns. It provides a nuanced view of LEVs and their integration into everyday mobility routines within the present sample. While it is often assumed that LEVs are primarily suitable for recreational purposes or leisure-oriented use, our data challenge this notion by highlighting their relevance for regular, workday-related trips in our sample. This underlines the potential of LEVs to serve as reliable transport solutions for short, routine-oriented travel, thereby expanding their perceived field of application. The high rate of repeat purchase intention in the present sample reflects strong overall satisfaction, even if individual needs vary (e.g., range, comfort, charging speed). This high satisfaction level reinforces the relevance of LEVs as practical tools for everyday mobility.

Interestingly, although LEVs are generally associated with urban mobility [6,7,12,20,21], our spatial analysis and participant demographics reveal a significant share of users living outside central urban areas or suburban zones. Approximately 50% of our sample does not reside in large cities, indicating that LEVs are also valued in smaller towns and rural contexts. This observation invites further exploration into LEVs as viable alternatives for short-range mobility in less densely populated regions, especially where public transport infrastructure may be limited. Previous argumentation considered lacking infrastructure and longer routes, which were considered as less attractive for LEV usage, compared to urban conditions [7,12,20]. Still, as approximately 50% of the participants live in cities, LEVs serve as an innovative solution for urban challenges, like pollution, space constraints, and energy efficiency as well [7,8].

Moreover, the demographic profile of LEV-users or -interested individuals of previous studies was quite similar to our sample [19,21,23]: mainly male, technically interested, middle aged, educated, and wealthy. Importantly, previous research has shown that user choices between combustion engines, hybrids, and EVs are shaped not only by economic factors, but also by demographic aspects like age, gender, and urban versus rural residence [32]. At present, LEVs predominantly appeal to and are visible among a relatively narrow user segment. Future efforts should aim to broaden this audience by better addressing the needs of those who are currently underserved by existing offerings. Further research is warranted to examine how younger individuals, women, and those with lower incomes might be encouraged to adopt LEVs, as these vehicles could represent a valuable and accessible mobility alternative for these groups as well.

One central aspect in our study is the seasonality of usage. The data were collected during fall and winter. These periods are typically considered less favorable for LEV use due to weather-related discomfort and, for some models, the lack of heating or other amenities. Previous research has already shown reduced usage intensity during cold and rain and high usage intensity during spring and summer [19,23]. However, the deliberate timing of the present study enabled us to test the robustness of LEV use under "worst-case" conditions. The fact that participants still used their LEVs extensively during this time demonstrates the practicality and versatility of these vehicles, even under challenging circumstances. However, this season may underrepresent fair-weather usage patterns and we are not able to show seasonal comparison. Future research should extend the tracking duration (e.g., 3–6 months) to capture usage patterns during seasonal variations.

Another key finding is the diversity of use cases and usage intensities. While some participants use their LEV sporadically, others report an annual mileage exceeding 6000 km (M = 6.24, SD = 2.67 per trip). The relatively low skewness and high standard deviation in usage patterns suggest a wide range of user types and mobility needs. Previous research assumed mainly work-related trips and short distance trips to run errands [8,13,20]. However, the data of our participants point to a spectrum of usage intensities, reflecting LEVs' flexibility in complementing other modes of transport, depending on individual needs.

The survey also surfaced a few unexpected use cases. For example, picking someone up or transporting goods were mentioned as practical LEV applications, despite the vehicle's small size. Similarly, outliers in the "recreational" trip category may reflect LEV enthusiasts using the vehicle as a central component of their leisure experience, analogous to how motorcyclists enjoy long, scenic rides. These longer trips may also indicate users experimenting with trip distances during their free time, when time constraints are less pressing. However, most users reported not undertaking trips longer than 25–100 km, supporting the assumption that LEVs are primarily used as a complement to other modes of transport (87.5%) and only serve as a complete replacement in 12.5% of cases [33].

Moreover, as previously shown in relation to users' motivations for using LEVs in sharing schemes [20] and of actual users [19,22], this study likewise highlights the importance of environmentally sustainable mobility solutions for this user group. The transition toward more sustainable mobility, such as reducing global carbon emissions and enabling the use of self-generated electricity from private solar panels, serves as an additional incentive for the LEV purchase. And above that, electric drivetrains influence purchasing decisions in favor of LEVs even independently of sustainability motives, as electricity is cheaper, even more so if self-generated power can be used [34]. However, one important aspect to consider is that many individuals remain highly skeptical about the alleged sustainability of cars, including electric vehicles [35]. In this context, LEVs could play a key role in addressing this skepticism and positioning themselves as a genuinely sustainable mode of transport. Although the growth is gradual and incremental, sales figures indicate that microcars are indeed gaining traction, with approximately 103,000 units sold annually across Europe and a significant upward trend continuing [33]. The attitudes of the LEV owners in our sample suggest that while individuals show optimism regarding personal and collective action for environmentally friendly mobility, social norms and perceived moral obligation play less of a role in their decision-making compared to factors like technical feasibility. Skepticism towards LEVs mainly comes from concerns about safety, range, comfort, weather, and social acceptance [21,23]. Accordingly, to increase interest for LEV purchase, it might be useful to concentrate on their sustainability as well as their technical feasibility, to increase perceived suitability as well as social acceptance. When seeking to derive insights from comparable innovation processes, such as the adoption of electric vehicles (EVs), recent research demonstrates that innovation and acceptance trajectories are prolonged and complex due to multifactorial influences. In the case of EVs, persistent technological challenges remain, including limitations in battery capacity and concerns about sustainability; socio-economic barriers, such as high purchase prices; societal barriers, including the need to acquire new skills and cultivate openness toward novel technologies, as well as regulatory barriers, such as the expansion of charging infrastructure and the design of subsidy schemes, play a decisive role [36]. Those aspects are and will be relevant also for LEV adoption. The study emphasizes the critical importance of political support, which will likewise be central for the diffusion of LEVs. Equally important is the understanding of user preferences and the communication of key benefits, such as sustainability, to raise awareness among potential adopters [36].

Furthermore, multi-modal mobility is an important aspect in LEV usage behavior: Although this study did not systematically assess participants' use of other vehicles, qualitative feedback suggests that some users switch to conventional cars for longer trips. Future research could enhance the understanding of how and when users switch between different modes of transport and how LEVs can be integrated into a broader, context-sensitive mobility system. Notably, LEVs have already been found to be relevant in a multimodal mobility context, e.g., as part of multimodal trip parts as well as LEV sharing as a bridge between different means of transportation [19,21,22]. Future research should explore the role of LEVs within multimodal mobility systems, their long-term integration into everyday life across diverse user groups, and their suitability for shared mobility concepts.

Lastly, while safety concerns are frequently raised in public discourse around LEVs as well as by previous studies [12,16,17,23], the findings of the present work show that participants generally felt safe in their vehicles. Although cars were perceived as offering a higher level of safety, none of the participants expressed actual feelings of unsafety while using their LEV. Instead, many described the driving experience as comparable to go-karting or motorcycling, lower in comfort but not in perceived control or security. This suggests that the LEV users of our study have adapted to their vehicles' characteristics and feel confident in navigating them, however, may also have lower safety needs altogether. It should be noted that current LEV owners do not necessarily represent an average car driver. Instead, current users appear to be a curious and engaged group of pioneers who have consciously chosen this type of vehicle. They are often motivated by environmental concerns, and bring specific expectations and assessments to this vehicle category. Furthermore, they might have higher levels of sensation seeking and thereby could be more comparable to motorcyclists, which should be investigated in the future. One participant of the FGDs even pointed out that he drives with his LEV onto the Autobahn (Highway) and still feels safe, even when being between two trucks. He did not criticize the safety aspect, but not being able to overturn the trucks, as the speed of LEVs is limited. Future research should investigate more closely how safety perception between cars and LEVs differs, and which specific aspects this difference concerns.

Although initial statistics provide some insight into accident rates [37,38], the currently available number of data points remains too limited to draw robust conclusions. Nevertheless, it can be observed that the safety systems in LEVs are presently less comprehensive than those found in conventional cars [39]. Whether this leads to a higher probability of injuries and/or accidents appears plausible, but cannot be confirmed with certainty at this point. Furthermore, investigation about e-bikes, e-scooters, and hoverboards provide worrying insights due to the high accident rates [40]. A study of the Fraunhofer institute adds an important safety dimension by examining the structural integrity and crashworthiness of lightweight LEVs [39]. Their analysis identifies vulnerabilities inherent in lighter structures and recommends design optimizations, such as advanced materials and multi-impact testing, to meet regulatory safety standards without compromising vehicle weight.

5. Limitations and Future Research

Some limitations should be considered in interpreting the findings of this study. First and foremost, the small sample size (*N* = 23 tracked LEV owners and data from 27 LEV owners) limits the generalizability of our results. Due to the currently low penetration of LEVs in society, recruiting participants was particularly challenging. Despite these efforts, the limited sample size does not allow for statistically robust conclusions. Future research should aim to include larger samples, even though recruiting within this specific user group remains difficult.

Second, our recruitment strategy relied on LEV-focused channels, which likely attracted primarily LEV enthusiasts. This self-selection bias, combined with the small sample size, may mean the findings do not fully represent the potentially broader population of LEV owners. Future studies should therefore aim to include participants beyond this core enthusiast community.

Third, the sample in this study was predominantly male (82.1%). This gender imbalance could influence reported usage patterns, perceptions of safety, and attitudes toward LEVs, further limiting generalizability. For example, gender influences safety and security perceptions and definitions [41]. As demonstrated by previous research and supported by our sample, current LEV users are predominantly male. Future research should therefore examine whether existing LEV designs adequately address gender-inclusive safety and security requirements as well as other relevant needs, an area in which many forms of transportation still fall short [42]. Furthermore, future research should strive for a more balanced gender representation and could explore potential gender differences in trip purposes (e.g., errands vs. commuting to paid work) and overall usage patterns. Interestingly, our findings suggest that the women in the sample often used LEVs only after their male partners had purchased them, highlighting possible dynamics in household adoption worth exploring further.

Fourth, the participants in our sample tended to have relatively high levels of education and income. These socioeconomic factors may affect both access to LEVs and attitudes toward their use. Future research should investigate these aspects more systematically to better understand how demographic factors shape LEV adoption and use.

Lastly, it should be further explored whether users' evaluations of LEVs depend on how they previously completed the trips they now make with an LEV. For instance, individuals who formerly cycled these routes may value the added weather protection and comfort, whereas those who previously drove conventional cars might perceive LEVs as offering reduced comfort. Such habits, prior expectations, and earlier mobility experiences should be examined in greater depth in future research. An LEV is neither a car nor a bicycle or scooter; it represents a distinct mobility innovation that must still establish its own identity in the transport landscape. However, this process cannot be fully understood without considering users' previous mobility patterns and the expectations shaped by them.

6. Conclusions

The present study challenges the perception of LEVs as primarily leisure-oriented vehicles and underscores their practicality for everyday use, even in rural or less densely populated areas for our sample. Despite being assessed under suboptimal conditions (during the colder fall and winter months), LEV users continue to rely on their LEVs for a wide range of travel purposes, including commuting, shopping, and recreational trips. The diverse usage patterns observed, along with the high level of user satisfaction, suggest that LEVs are well suited to complement other modes of transport in a multi-modal mobility system in our sample. A key contribution of this study lies in the exploration of LEV owners' purchase reasons and characteristics. Thereby, the study's results indicate that environmental and cost-related benefits, such as energy efficiency and the possibility of using solar power for charging, play a significant role in users' decisions to adopt LEVs. Furthermore, the LEV owners in our sample were mainly male, technically interested, middle aged, well educated, and wealthy. Therefore, the mixed-method approach provides in-depth qualitative insights with accurate, data-driven GPS tracking and differentiated insights from the two questionnaires. Nevertheless, the study faces certain limitations, including a relatively small sample size and a user group that is currently not fully representative of the wider population. Despite this limitation, it can be assumed that the wider population holds certain characteristics, which were also found in the present paper: LEV owners (of the category L5e–L7e) are probably mainly male, technically affine, and wealthy. Future research should therefore aim to expand the demographic scope, investigate a gender-inclusive design and safety considerations, and examine how prior mobility habits shape perceptions of LEVs. Overall, the results underscore the potential of LEVs to support more sustainable, flexible, and user-centered transport systems across diverse geographic and social contexts, thereby contributing to the broader transition toward sustainable mobility.

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