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Car Commuters' Requirements for Using Light Electric Vehicles (LEV)

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ABSTRACT

Light Electric Vehicles (LEV) have the potential to provide a sustainable mobility solution for daily commuting. LEV encompass a diverse range, from e-bikes to microcars, altogether offering energy-efficient options compared to traditional cars. Despite their environmental benefits, LEV are not much established yet. The work reported here aimed to identify user requirements and perceived use barriers of LEV regarding the use case of daily commuting with individuals who habitually use a car for this purpose. The study involved an online survey (n = 51) and an online user workshop (n = 8). The results of the survey indicate that requirements arising from typical characteristics of the commuting route are met by various LEV classes. However, looking at further user wishes that were widely expressed in the sample, such as protection against adverse weather conditions, LEV models that have a cabin appear more likely to meet the requirements. The workshop further highlighted a preference for more "car-like" LEV. Interestingly, the use phase of getting started with LEV evoked more controversy than the phase of use itself, and the "E" aspect within "LEV" (electric drive) clearly dominated the discussion, compared to the "L" aspect (small and lightweight construction). Though the discussion implied that the status quo with the car acts as a strong anchor in the users' appraisal of the LEV, participants expressed an openness to LEV, given that charging facilities are accessible and cost considerations are addressed. Users are open to adopting LEV, provided that the pricing is competitive and reflects the perceived trade-offs in vehicle features. This research sheds light on user perspectives, emphasizing the importance of addressing barriers to enhance the integration of LEV into daily commuting practices.

Keywords: User requirements, Use barriers, User-centered design, Systems engineering

INTRODUCTION

Light electric vehicles (LEV) are a heterogenous group of vehicles including 2-, 3- and 4-wheelers that range from e-bikes to so-called microcars. In the EU, they are subsumed in the vehicle classes L1e to L7e in accordance with Directive (EU) 168/2013. Compared to standard passenger cars, even the larger models among them consume significantly less energy in operation and production. Therefore, LEV could become a building block towards more sustainable mobility. However, in daily use, they are not much established yet (Ewert et al., 2020).

In the project *VMo4Orte* (*Connected Mobility for Livable Places*), we aim to identify use barriers and develop ideas to overcome them, together with users, in a number of private and commercial mobility use cases. In the current case, we studied user requirements for using a LEV on the way to work, with people who habitually take the car for this purpose.

BACKGROUND AND RESEARCH AIMS

In addition to existing research that has focused on the theoretical replaceability of cars by LEV on everyday journeys (Ehrenberger et al., 2022; Ewert et al., 2020; Gebhardt et al., 2023) or the perception of technological niches for LEV by consumers (Hyvönen et al., 2016), we aimed to do an analysis with a strong focus on perceived practicability and usability issues of LEV for specific use cases that make up a large share of everyday mobility for which currently cars are used. According to Nobis & Kuhnimhof (2018), 22% of the trips done in the mode of motorized private transport, accounting for 26% of person kilometers, pertain to commuting. Therefore, we chose this use case as one of four cases to study in the project. Our work concerning the other three use cases (private mobility: leisure trips; commercial mobility: home care, municipal services such as city cleaning) will be reported elsewhere.

The aims of our research were (1) to work out requirements arising from basic transportation needs of the commuting trips, such as the vehicle's required range, speed, and capacity for carrying passengers and luggage or other equipment, (2) to determine requirements arising from additional user needs as, e.g., comfort and safety on the commuting trip, and (3) to identify use barriers that would have to be removed from a potential user's point of view for LEV to become a serious alternative to using a car. The scope of design dimensions of interest included all aspects of vehicle design as well as context factors such as charging infrastructure, availability, or service and maintenance.

METHODS

User Survey

The survey was conceived to collect information on basic requirements arising from characteristics of the commuting trips as well as from additional user needs.

It was divided into several parallel questionnaire sections, to which the participants were assigned by filter questions for different use cases, and consisted of a total of 36 items. Nine items related directly to characteristics of the commuting route, another 17 asked for requirements towards LEV, and 11 were demographic questions. The questions can be further grouped in the categories of informed consent and introduction, predominant context of current car use (commuting or leisure trips; this item was used as a filter, and the following items were only displayed to respondents who mainly used the car for commuting), characteristics of the car used so far (make and model, ownership), attitudes towards using a car for commuting (advantages and disadvantages, alternatives), characteristics of the commuting route (typical length, duration, number of passengers, transported objects), general requirements for a vehicle to use for commuting (e.g. maximum accepted duration of travel, weather protection, highway use), individual characteristics (e.g. age, gender, personal technological innovativeness), and experience with using different classes of LEV.

The questionnaire was provided online in the SoSciSurvey environment (Leiner, 2019). The participants were mainly recruited via the DLR Institute of Transportation Systems participant pool (SONA Systems, n.d.). In addition, the study link was distributed on social networks and via posters placed in local supermarkets.

User Workshop

The workshop was held online on two consecutive days in sessions of three and 2.5 hours duration, respectively, using the Skype for Business conferencing software (2015) and the Conceptboard online whiteboard tool (2021). Participants were recruited through the DLR participant pool and personal networks of the authors. The first day included an introduction to the scope and aims of the workshop, getting to know each other, a presentation of a selection of collected data from the survey, an introduction to different LEV classes, and the exploration of the suitability of different LEV classes for one's own commuting route. The second day involved working out barriers to usage along the individual commuting route (e. g. charging at the workplace) and across three different phases of use (entry into use, use itself, and maintenance/ servicing).

RESULTS

Survey

Sample Characteristics

The survey was completed by 51 participants, aged 21 to 66 years (M = 35.8, SD = 11.6). Of those who reported their gender, more respondents were male (37.7%) than female (26.0%; no response: 36.4%). Most respondents (31.4%) reported living in a large city (100,000–1 million inhabitants), followed by 13.7% living in a village (less than 1,000 inhabitants), 11.8% in a country town (1,000–5,000 inhabitants), 5.9% in a small town (5,000–20,000 inhabitants) and 2.0% in a medium-sized town (20,000–100,000 inhabitants). A further 35.3% did not provide an answer. A majority of participants (65.7%) had no prior experience with LEV. Among those with previous experience, 25.7% had familiarity with a two-wheeled moped or pedelec (L1e), while 5.7% had experience with a heavy four-wheeled LEV (L7e), and 2.9% had experience with a three-wheeled moped (L2e). Among those with prior experience, only two individuals owned a LEV. These vehicles were two-wheeled mopeds in both instances.

Commuting Trips

The mean commute distance was 24.9 km (SD = 22.2, max = 100). For assessing the trip duration, the questionnaire contained three items: In addition to the typical duration, respondents were also asked to report a minimum and maximum duration for their personal commute. Table 1 shows the descriptive statistics of these three duration measures for the sample. The mean typical duration was 25.6 minutes (SD = 12.6). In the majority, participants' currently used car was powered by a gasoline engine (69.4%), while 19.4% used a car with a diesel engine, and 11.1% a vehicle with a solely electric drive. The majority indicated using a vehicle that belonged to them personally (66.7%), while 27.8% relied on a family member's vehicle. A minor share of 2.8% reported using a vehicle provided by their employer.

Table 1. Descriptive statistics of the reported minimum, typical and maximum duration of commuting routes in the survey sample (in minutes).

Commuting duration	Min	M	Max	SD
Minimum duration	6	21.3	55	11.7
Typical duration	8	25.6	60	12.6
Maximum duration	8	47.9	300	50.2

Additional Requirements for Commuting

Concerning additional user needs, the questionnaire included items on desired protection from weather and other potentially unpleasant external influences. Most of the respondents reported to demand protection against precipitation (93%) and cold (90%). Many also wished to be protected from headwind (54%), heat (58 %), and sun (39%). Other factors mentioned included protection against accidents, infection with diseases, and noise.

Concerning the need for transportation capacity, the majority of respondents reported to commute alone (39.2%), while 15.7% stated they were accompanied by one other person, 5.9% by two others, and 2% by three others. Items to be transported varied in size, ranging from small items (like drinks and food) to medium-sized (such as backpacks, briefcases or laptops), and larger items (e. g. walking frames, work equipment or tools).

Workshop

Sample Characteristics

Eight participants, aged between 26 and 70, took part in the workshop (M = 40, SD = 16.6). Of these, five were men and three were women. Four participants lived in a large city (100,000–1 million inhabitants), two in a village (less than 1,000 inhabitants), one in a small town (5,000–20,000 inhabitants), and one did not provide an answer. The majority of participants (n = 5) had no prior experience with a Light Electric Vehicle (LEV). Two individuals had previous experience with a two-wheeled moped, and one person also owned one.

Commuting Trips

The workshop participants' mean commute distance was 37.0 km (SD = 36.6). Table 2 shows the descriptive statistics of the three duration measures for their commutes (typical, minimum, and maximum duration).

The mean typical duration was 22.6 minutes (SD = 18.3). In the majority, participants used a vehicle powered by a gasoline engine (n = 5), one had a vehicle with a diesel engine, and one a vehicle with a solely electric drive. All participants indicated using their personal vehicle (n = 7), while one did not respond.

Table 2. Descriptive statistics of the reported minimum, typical and maximum duration of commuting routes in the workshop sample (in minutes).

Commuting duration	Min	M	Max	SD
Minimum duration	2	17.7	50	15.9
Typical duration	3	22.6	60	18.3
Maximum duration	5	37.6	90	33.5

Additional Requirements for Commuting

In addition to the workshop activity of exploring the characteristics of the individual commuting routes, participants were asked to name general requirements for a vehicle they deem suitable for daily commuting. The criteria that were mentioned can be categorized as follows (number of mentions in brackets): independence (including time independence and flexibility, n = 7), weather protection (n = 2), cost-effectiveness (n = 5), comfort (encompassing both comfort and convenience, n = 2), technical aspects (such as long range, highway-speed capability, low maintenance, high speed, and audio capability, n = 6), and overall performance (including reliability and efficiency, n = 3).

Use Barriers

Workshop participants were asked to express any uncertainties, challenges or concerns they perceived when thinking of acquiring and getting started with the use of a light electric vehicle for their daily commute. The challenges they highlighted can be categorized into the following groups: concerns about potentially high purchase costs (n = 5), uncertainty of vehicle availability (n = 2) and practicability of charging (n = 2), perceived restrictions in aesthetics (luxury, ambience, n = 3), and concerns about resale value.

The participants were also asked about any specific requirements or perceived use barriers that seemed relevant to them in the use phase of the actual commuting trip. The results can be categorized as follows: Vehicle interior features (requirement of hands-free system for phone calls, seat heating, capability to play music, n = 5), comfort (sufficient space for taller individuals, n = 1), weather resilience (functionality in sub-zero temperatures, n = 2), charging infrastructure (availability in rural areas, n = 3), potential for highway use (n = 1), and rapid charging capability (maximum 30–45 minutes, n = 1).

Finally, participants thought and discussed about how they perceived the aspect of maintenance and servicing. The challenges they envisaged can be classified into the following categories: concern about durability (durability, longevity of parts, long battery life, battery without loss of power, n = 9), sustainability (ability to repair something yourself, ability to recycle the battery, n = 4), cost (maintenance costs, upkeep costs, workshop costs, insurance costs, purchase cost of a private charging station, n = 6), technical aspects (charging time, dependence on software updates, sophistication of technology, n = 3) and availability (of a vehicle nearby, of a specialist workshop nearby, of spare parts, of competent mechanics, n = 7).

Preferred LEV Classes

Participants were asked to express what their most preferred option among the LEV classes would be for their daily commute. Five participants chose L5e (microcar, without speed limitation by regulation, 3-wheeled, to be used by up to 5 people by regulation). Of these participants, four took the chance to specify further conditions under which they would consider the vehicle suitable for them. These included that speeds of up to 130 km/h would be attainable, that the actual range would exceed 300 km, that a home charging infrastructure would be available, and that the vehicle would be suitable for highway use. Reasons for not wanting to use this class included concerns about not fitting in well of a user with great body height.

Two participants chose the L7e class (microcar, speed limitation of 90 km/h by regulation for road-use vehicles, 4-wheeled, to be used by up to 4 people by regulation). Further qualifications concerning this choice included the requirement of easily accessible charging facilities (n = 2) and traffic safety (n = 1). One person, who was already using a two-wheeler for commuting, opted for the L1e class (moped or s-pedelec, up to 45 km/h by regulation, can be used by up to two people by regulation), provided that the range would be sufficient (one-way route length was 40 km in this case, and the participant would have to use an alternative route due to the impossibility of using the motorway with L1e vehicles). Two other participants expressed willingness to use L1e vehicles during the summer or in good weather conditions, respectively. Perceived obstacles to the use of L1e vehicles were their relatively low speed and limited range. Obstacles mentioned to the use of other LEV classes were often similar and can be categorized as follows: inadequate speed (especially on rural roads), insufficient range, vehicle design issues (limited storage space, not suitable for body size), regulatory constraints (requirement for a special driving license class, other cumbersome regulations), increased accident risk, lack of comfort, and absence of weather protection in open vehicles.

DISCUSSION

In our study, that combined an online survey and an online user workshop, we aimed to identify user requirements and use barriers concerning the use of LEV for daily commuting.

The survey results showed that requirements arising from the distribution of commuting route characteristics – such as route length, typical number of passengers, transported objects – of the majority of respondents could be met by most LEV classes. However, looking at further requirements expressed in the sample, such as protection against precipitation, cold, headwind, heat, or sun, LEVs that have a cabin appear more suitable to meet user needs.

The survey results and the discussion we experienced in the user workshop suggest that the status quo of using a car for commuting acted as a strong anchor in the users' appraisal of LEV, especially in terms of the relatively high possible speed and the convenience they are used to. A majority of workshop participants chose the three-wheeled L5e class as their preferred option among the LEV classes. We assume that this result can partially be explained by a reluctance to accept a (legally prescribed) throttling of the maximum speed of a vehicle, that holds for all road-suitable LEV classes with more than two wheels except this one. In practice, most L5e class models are not faster though than, e.g., L7e class models. Moreover, the L5e class is the only one that is theoretically, i.e. by regulation, approved for up to 5 passengers – even though in practice, this capacity can hardly be achieved by any existing model, and the typical capacity is one or two passengers.

Looking at the questions and concerns raised by the workshop participants, interestingly, quite a large proportion revolved around the robustness and durability of LEV parts, especially the battery. While vehicle design and construction can take over their share in allaying these concerns by providing high quality and durable products, this alone is probably not enough. It seems sensible to address such concerns through increased communication and education measures. One promising approach could be to enable users to gain experience with LEVs, an idea that was also expressed by the workshop participants.

Despite all concerns, our participants expressed a willingness to switch to LEV or at least to replace one of two family vehicles with a LEV, provided that some basic conditions are met, one of which would be the availability, easy accessibility and high user-friendliness of charging facilities. The discussion in the workshop suggested that the participants perceived a LEV as a kind of car where you have to make small compromises in certain areas such as speed, transport capacity and comfort, but also that this would be acceptable to users as long as the perceived reduction in value would be reflected in correspondingly lower prices for purchase and use.

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