

Mapping the Potential of e-Micromobility Vehicles for Sustainable Urban Development – the Case of Győr, Hungary

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Can the advancement of electromobility (e-mobility) be the key to achieving sustainable development and transportation in urban areas? While electric vehicles typically produce less environmental impact compared to conventional cars—such as reduced noise and air pollution—they still generate various externalities, including congestion costs, accidents, and adverse effects on landscapes and public spaces. In contrast, light e-micro mobility vehicles, particularly e-scooters, have emerged as a new transportation alternative in many cities worldwide and appear to facilitate a shift towards more sustainable modes of transport due to their advantages. However, e-micromobility can only contribute to sustainable urban development if careful planning and development are implemented. This study explores the history, current status, and future potential of e-micro mobility advancements. As part of the primary research, we assessed the socio-economic profiles and usage behaviors of e-micro mobility users in Győr, Hungary. We also examined the share of e-micro mobility users in the modal split, their travel patterns, and their needs and desires. The findings indicated that e-micro mobility vehicles primarily substitute walking and public transport, with fewer trips being made by private cars. Ultimately, the study concluded that a shift from car usage to e-micro mobility is achievable, provided there are suitable policy frameworks and sustainable urban and transportation development strategies in place.

1. Introduction

Transport remains one of the most challenging areas for public policy, especially in managing adverse effects caused by individual motorized transport, such as traffic congestion, accidents, and environmental pollution. Micro mobility, as well as shared micro-mobility, as a new alternative to transporting, holds great promise in ensuring sustainable urban mobility and reducing the external effects of traditional motorized transport modes. Financial markets also see micro-mobility as a growth sector. According to business expectations, e-scooters will become essential modes of transportation in cities. According to The Boston Consulting Group, the global market value of e-scooters could reach 40-50 billion USD by 2025. Key future markets include Europe and the U.S. This includes rental systems and the growth of privately owned e-scooters (Gössling, 2020). In recent years, in addition to self-owned micro-mobility devices, the rapid advance of shared micro-mobility has also been experienced worldwide and in Hungarian cities, with devices such as electric bicycles, electric scooters, and electric mopeds. The wide availability of such a wide range of new mobility services in combination with traditional transport (e.g., public transport) also creates a complex mobility environment, and together it offers a huge opportunity, especially if the focus is on the multimodal optimization of the transport system instead of a simple modal approach (Mobilissimus Ltd., 2020). However, electric scooters combined with public transport can only be competitive in the long term if they receive political support to encourage their use (McQueen and Clifton, 2022). At the same time, creating a regulatory environment for micro-mobility that is acceptable and safe for all road users poses severe challenges to planners and decision-makers everywhere.

2. Theory

According to Khorasani-Zavareh (2015), e-micromobility can be defined as the transportation of people with devices and vehicles where the weight of the vehicle is no more than 350 kg, the speed is no more than 45 km/h, while the kinetic energy of the vehicle is no more than 27 kJ, within it. Shared mobility can be defined as a travel

alternative that separates the "right of use" from the "ownership" of a vehicle (Hiba and Dulebla, 2023). The Safe Micromobility Report, prepared in 2020, examined the conditions for safe micro-mobility, the legal requirements, and the possibilities of developing the necessary transport infrastructure (ITF, 2020). Hungary also prepared the Jedlik Anyos Plan to spread electric mobility and the Jedlik Anyos Plan 2.0. The original Jedlik Anyos Plan, introduced in 2016, laid the groundwork for the development of electric mobility in Hungary, focusing primarily on the expansion of charging infrastructure and promoting the adoption of electric vehicles. It aimed at creating a basic framework for e-mobility. In contrast, Jedlik Anyos Plan 2.0, launched in 2020, extends the original plan's efforts by incorporating more comprehensive measures and strategic goals. It emphasizes a broader integration of electric mobility into the transport system, taking into account the entire urban mobility ecosystem. This includes promoting the use of light electric vehicles like e-scooters and bicycles, enhancing public transport, and supporting innovations in sustainable transportation. Overall, Jedlik Anyos Plan 2.0 represents a more holistic and integrated approach to e-mobility, reflecting advancements in technology and addressing the evolving needs of sustainable urban transportation (Jedlik Anyos Action Plan, 2015).

3. Method

The methodology used in this report follows a two-step analysis process. The first step involved defining the relevant regulatory framework for micromobility vehicles, with a particular focus on Hungary's legal and enforcement frameworks, drawing upon European Union regulations (EUROPA, 2013) and international practices to contextualize micromobility vehicle categories. In the second phase, the study assessed the habits, needs, and preferences of electric scooter users in Győr by conducting multiple surveys at different time points. Specifically, data were collected through a questionnaire survey administered to 73 participants between September and November 2022, exploring their traffic habits, user experiences, and opinions on local transport infrastructure regarding electric scooters. The survey consisted of demographic questions, usage preferences, and evaluations of transport facilities using a Likert scale. Additionally, another online survey was conducted in October 2023 to gather user experiences related to a newly implemented e-scooter-sharing system, focusing on user demographics and perceived infrastructure quality. While both surveys were not statistically representative, their findings provided valuable insights into user behavior and infrastructure development needs, contributing to a broader understanding of electric micromobility in Győr.

3.1 Legislative Framework

Regulation No. 168/2013 of the European Union (EUROPA, 2013) is essential for categorizing micromobility vehicles (European Parliament, 2013). It defines category L vehicles (light motor vehicles) as a standard for member states, covering two-, three-, and four-wheel vehicles. The regulation establishes criteria for categorization, such as power, speed, and dimensions, ensuring uniform regulation. Within the L1e category, various micromobility vehicles are included:

- L1e Motorized Bicycle: Maximum speed of 25 km/h with auxiliary drive, useful power between 250 and 1000 W, encompassing low-power electric bicycles.
- L1e-B Two-Wheeled Moped: A two-wheeled vehicle with a design speed exceeding 25 km/h, up to 45 km/h, and net power of up to 4000 W, which includes pedelecs, though most speed-pedelecs have 500-750 W.

In the U.S., electric bicycles and e-scooters are mainly regulated at the state level, distinguishing them from mopeds and motor vehicles. New legislation aims to allow light electric vehicles to use bike lanes and specify which can be operated without a driver's license or registration.

In Asia (e.g., China, Singapore, and South Korea), electric bicycles must have working pedals, with a maximum speed of 25 km/h, a weight limit of 55 kg, and engine power maxed at 400 W. Singapore has a new category for "personal mobility devices," separating them from cars and bicycles. In Korea, all motorized vehicles are classified as motor vehicles without specific categories. In Latin America, such as Mexico City, micromobility vehicles are classified by speed, with those under 30 km/h deemed non-motorized and those over classified as motorized (ITF, 2020).

3.2 Legislative framework of Hungary

The Hungarian Road Traffic Rules do not currently define the traffic rules for e-scooters, nor does it mention electric scooters or other micromobility devices (segway, one-wheel) among road vehicles (KPM-BM Decree, 1975). According to the current Hungarian road traffic rules, a moped is a two-wheeled vehicle classified under separate legislation in vehicle category L1e. Other micro-mobility vehicles remained outside the L1e category, the most significant of which are:

- Human-powered vehicles, such as bicycles and roller skates.

- Pedelecs, bicycles equipped with pedal assistance up to 25 km/h and an electric auxiliary motor for a motor with a continuous nominal power of up to 250 W.
- Self-balancing and non-seated vehicles (i.e. scooters).

The Road Traffic Rules amendment, which includes the National Accident Prevention Committee's comments, was expected to be adopted in the first half of 2023, but it has not been modified yet.

3.3 User experience

Unfortunately, to date, no representative survey has been conducted in the city of Győr or Hungary that would have examined micromobility devices or the role played by electric scooters in the modal split, even though the ratio of electric scooter use in the city seems to be increasing rapidly. It would adequately present its competitiveness compared to other transportation—and infrastructure development needs. An additional question arises: Which means of transport do electric scooters distract road users from? In an international study conducted in 2021 (Wanga et al., 2021), the researchers examined the division of labor in transport in twenty-seven large cities. The study analyzes what mode of transport the current community of electric scooter users would have chosen if the electric scooter had not been available to them. In most surveyed settlements, the most significant proportion of respondents replaced walking, followed by taxis and community electric scooters (Figure 1).

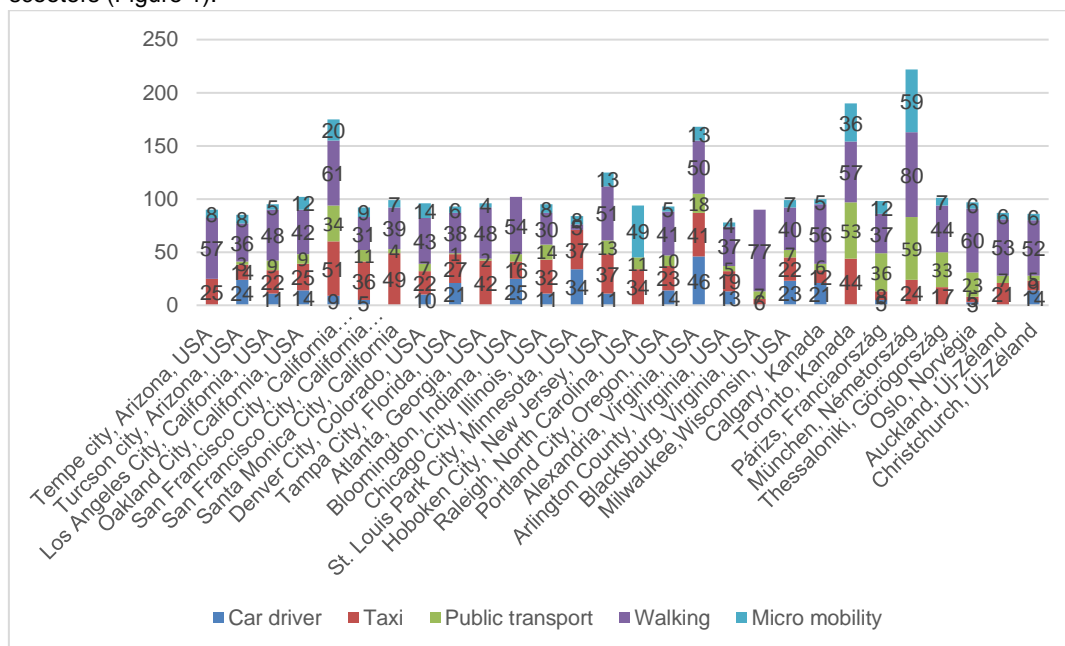


Figure 1: Substitution of modes of transport with community e-rollers (%) (Wanga et al., 2021)

3.4 Transport habits of electric scooter users and their transport infrastructure development needs

Between September and November 2022, a survey of Győr's population evaluated traffic habits, public acceptance of electric scooters, and user needs (Szakonyi and Baksa, 2023). A total of 73 individuals participated, with 64.4 % male and 35.6 % female. Most respondents (45.2 %) were aged 20-30, and 43.8 % were 30-50. Despite the sample size being less than 1 % of Győr's population, the findings indicate that 49.3 % of respondents reported having used an electric scooter, reflecting key user concerns and development needs for electric scooter usage. Significantly, 72.2 % of respondents indicated they would use an electric scooter if safe conditions were provided. The survey also explored potential usage purposes, revealing that 63 % would use scooters for commuting to work or school, 48 % for leisure, and 49 % for administrative tasks, while only 26 % would use them for shopping. Key insights emerged regarding safety, as 31.6 % expressed concerns about Győr's transport infrastructure for electric micromobility devices. Respondents evaluated transport facilities using a Likert scale. Results showed that 38 % deemed separated bicycle paths most suitable for e-scooters, while sidewalks were regarded as the least acceptable. Overall, the survey provides valuable insights into user preferences and highlights critical infrastructure needs for promoting the safe use of electric scooters in Győr (Figure 2).

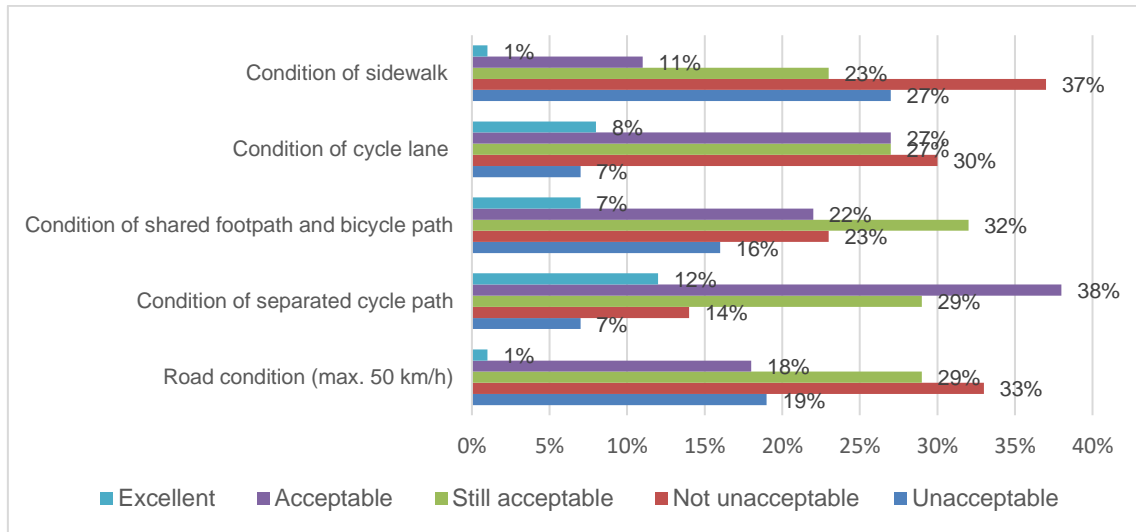


Figure 2: Public opinions on the state of the transport infrastructure regarding the use of electric scooters and other micro-mobility vehicles

While examining public opinions, we were also interested in assessing individual transport facilities regarding traffic safety. According to the respondents, separated bicycle paths are the safest (32 %). At the same time, people think that the most dangerous is to travel on the sidewalk (29 %) and public road (22 %), presumably because of the significant difference between e-roller-pedestrians and e-roller-cars due to the difference in speed and the previously presented low-quality covers. Commuting with an electric micromobility device on a shared pedestrian and bicycle path is also considered safer (40 %) than dangerous. The public perception of the bicycle lane is similar to that of the shared pedestrian and bicycle path since 40 % of the respondents also think electric scooters are safer than dangerous in this transport facility (Figure 3).

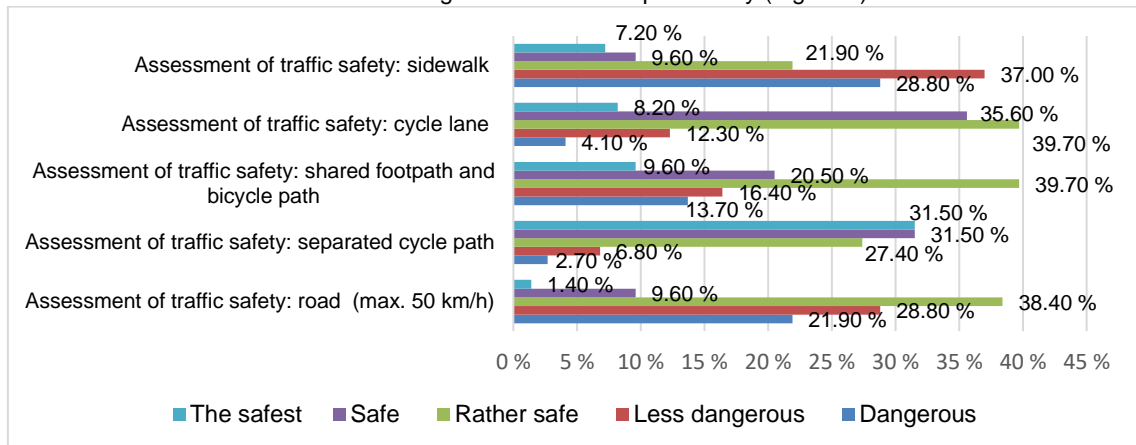


Figure 3: Public opinions on the traffic safety of the transport infrastructure regarding the use of electric scooters and other micro-mobility vehicles

3.5 Transport habits of shared electric scooter users and their transport infrastructure development needs

After Budapest, in February 2023, the TIER community e-roller sharing system was also launched in Győr, with 200 rental stations and 500 units, each with a maximum speed of 25 km/h. speed scooter, the purpose of which was to provide an environmentally friendly and emission-free micromobility service covering the entire city. The German company TIER is a dominant player in the electric vehicle market, present in 260 cities in 20 countries, including 5 Hungarian settlements (Budapest, Gödöllő, Miskolc, Siófok and Győr). Around 7,000 shared electric scooters, 170 rentable electric scooters, and nearly 2,000 shared bicycles are operating in Budapest. According to Budapest reports, the average length of trips made with TIER electric scooters for rent is between 500 m and 2.5 km, corresponding to a travel time of approximately 2 to 12 min. Micromobility devices

in Budapest are typically used on shorter road sections, supplemented by other modes of transport. Customers used the TIER-shared electric scooters for 8.5 min in 2020 and 13 min in 2021, so system usage showed an increasing trend in the capital during the examined period (Töröcsváry et al., 2022). Research conducted in other European cities also showed a similar result, where the average time of e-roller use was 12 min. In contrast, the average length of journeys was 4.5 mi, i.e. 7.2 km. In cities, most trips are made in the city center and waterfront areas during the afternoon rush hour (Foissaudet. al., 2022). Considering the above experiences, a similar development trend in community e-scooter use can also be expected in Győr.

To investigate user experience and satisfaction with the Győr TIER scooter, a questionnaire was conducted in October 2023 with 47 participants. Although the small sample size limits the generalizability of the findings, it provides valuable insights for system operators when considered alongside previous studies. This research captures specific user experiences and preferences that can inform development strategies and complement earlier findings on user habits and infrastructure needs. Such integration enables operators to better tailor their services and enhance overall e-scooter satisfaction.

Half of the respondents were young adults aged 18-25, with 67 % identifying as male and 23 % as female. In terms of occupation, 50 % were students, 41 % were employees, and 9 % were retired. Among those surveyed, 38 % used the TIER scooter regularly, 35 % had tried it, and 27 % had not yet used it. Most users (41 %) rode for leisure, while 17-22 % used it for commuting. The majority (75 %) typically traveled 2-5 km, taking about 10-12 min.

The survey also focused on user opinions regarding local transport infrastructure and traffic safety. The quality of the available infrastructure significantly impacts perceptions of the TIER e-scooter, although it is not solely dependent on the service provider. Consistent with previous findings (Szakonyi and Baksa, 2023), most respondents preferred bicycle facilities, with 60 % primarily using bicycle paths, followed by bicycle lanes and separated pedestrian and bicycle paths (Figure 4).

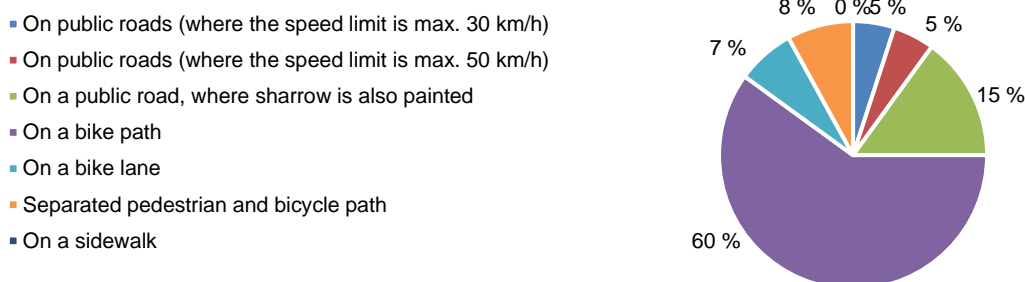


Figure 4: Which transport facility do you prefer to use with an e-roller?

Although the research results cannot be considered representative in themselves, together with the previous research and considering the experiences of another Canadian study, they formulate essential guidelines for a design that supports electric micromobility and sustainable urban development. The study, conducted in Calgary, examined 29,544 road sections and their impact on e-scooter usage. The findings were compelling, showing that sidewalks, dedicated bicycle facilities, lower speed limits, more streetlights, and trees all positively affected e-scooter use. This means that scooter riders more frequently used road sections with these characteristics. Additionally, road sections in higher-prestige residential areas and those with a higher density of commercial and service units were popular among e-scooters (Yang et al., 2022).

3.6 Findings related to the existing legal framework

The existing legislative framework in Hungary inadequately addresses electric scooters, leading to confusion and safety concerns among users, as reflected in the survey results. Respondents expressed significant safety issues and highlighted the need for better infrastructure, indicating that legal reforms are necessary to support electric scooter usage and improve conditions for users. Overall, the disconnect between current regulations and user needs underscores the urgency for updates in the legislative framework.

4. Conclusions

The increasing popularity of electric micromobility devices, particularly electric scooters, is transforming urban mobility in a significant and seemingly unstoppable manner, whether through community-sharing programs or privately owned vehicles. Unfortunately, existing environmental and transport infrastructure developments have not kept pace with the rapid technological advancements and widespread acceptance of these efficient modes of transport. In Győr, while the growth of these new transportation options is evident, the necessary infrastructure

is lacking, as current developments primarily address bicycle transport facilities that are already hampered by network deficiencies.

The results of the questionnaire survey suggest that while separated bicycle paths are viewed positively for traffic safety among electric micromobility users, they comprise only a small portion of the overall bicycle network. Conversely, shared pedestrian and bicycle paths—often perceived negatively—dominate the infrastructure in Győr. This situation highlights the urgent need for innovative approaches to developing the existing transport infrastructure to better cater to micromobility users.

To effectively promote light e-micromobility vehicles like e-scooters as a sustainable alternative to cars, urban areas must ensure that suitable cycling infrastructure and road surfaces are developed. This includes reducing traffic congestion and enhancing safety measures, facilitating a modal shift toward more sustainable transportation options. Comparing the findings from Győr with a similar study in Calgary, Canada, reveals parallels in user preferences for dedicated cycling facilities. Respondents in both studies favor separated bike paths and express safety concerns about the current infrastructure. Research from Calgary also indicates that dedicated bike lanes and lower speed limits positively influence e-scooter usage, emphasizing the need for improved infrastructure.

Overall, the study provides valuable insights into electric micromobility usage in Győr, although future research could benefit from addressing certain limitations. The sample of 73 participants offers useful insights into user behavior and perceptions, but a larger and more representative sample could enhance the findings' generalizability. While self-reported data is common in transportation research, capturing user experiences related to infrastructure and safety is crucial for understanding evolving trends. Future studies could further enrich these findings by integrating empirical data alongside user perceptions, leading to a more comprehensive evaluation. Finally, comparisons with similar studies, such as the one in Calgary, highlight not only shared challenges but also open avenues for enhancing infrastructure and policymaking to better integrate electric micromobility devices into urban transport systems.

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