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RESEARCH ARTICLE

Electric charging infrastructure and gender equality: An overview for USER-CHI (H2020 project)

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Katharina Csillak, Sophie Kamenz

Mobility Department, Institute for Climate Protection, Energy and Mobility (IKEM), Berlin, 10179, Germany

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Abstract

>**Background:** The paper investigates aspects of gender equality in the implementation process of charging infrastructure with the innovative solutions for "USER centric Charging Infrastructure project" (short: USER-CHI) as reference. The USER-CHI project offers possible solutions for user-friendly e-Mobility surrounding the Mediterranean and Scandinavian Trans European Network corridors. In this regard of providing user-friendly solutions, the need for further information to recognize gender bias in the implementation process arose. **Methods:** Therefore, the paper combines insights from the project's product development and a literature review results of gender bias in infrastructure and mobility planning. It aims at providing knowledge about gender-specific and diverse user needs which then can be incorporated into the design of charging infrastructure.

Results: The term "gender bias" is commonly understood as opinionated actions or ideas as said by the gender-grounded receptivity that women are not associated to men in status and rights. Projects in the realm of electrification of mobility and its infrastructures lack in diversity sensitivity. This paper addresses these gaps by evaluating existing datasets from the User Chi project and identifying gender bias in literature research of the mobility and transport field. **Conclusions:** The authors conclude that more diverse approaches are needed. Due to the limitations of the available dataset, the authors apply a differentiation between male and female usage patterns and needs in mobility solutions as a starting point. Therefore, the recommendations made in this paper focus on the accessibility of electric mobility and charging infrastructure for women while setting the goal to establish a more diverse (respectively gender neutral) access to this type of mobility.

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1. **Angela Carboni**, Politecnico di Torino, Turin, Italy
2. **Katie J Parnell**, University of Southampton, Southampton, UK
3. **Paula Carroll**, University College Dublin, Dublin, Ireland

Any reports and responses or comments on the article can be found at the end of the article.

Keywords
electromobility, charging infrastructure, gender, gender equality, gender bias, H2020, USER-CHI, sustainability, transport, mobility

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Corresponding author: Katharina Csillak (Katharina.Csillak@ikem.de)

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Plain language summary

The paper investigates the equality of men and women in connection with the implementation process of charging infrastructure. The User-Chi project is a reference to this research topic. The User-Chi project creates solutions for user-friendly e-mobility in the area surrounding the Mediterranean and Scandinavian Trans European Network corridors. During this creation process, it became necessary to learn more about the equality between men and women in connection to the charging infrastructure. The paper seeks to offer a summary about specific differences in user needs between men and women and how this knowledge can be integrated into the design of charging infrastructure. When thinking about the equality and inequality of men and women especially in infrastructure, the current system of electric mobility is not ideal for women. The paper offers recommendations that make it easier for women to access electric mobility.

List of abbreviations

CLICK	Charging infrastructure Location concept development kit
ECI	Electric Charging Infrastructure
EU	European Union
EU strategy	EU Gender Equality Strategy 2020–2025
INDUCAR	Inductive Charging for e-CARs
INSOC	Integrated Solar DC Charging
TEN-T Network	Mediterranean and Scandinavian Trans European
USER-CHI Infrastructure	Innovative solutions for USER centric Charging

Motivation and scope

The current Gender Equality Strategy 2020–2025 of the European Union (EU) states that gender equality is a "fundamental right".[1] But despite these significant advances over the past few decades, the EU strategy also points to slow progress.[2] A deeper view of this topic in mobility planning is therefore necessary.[3] This paper investigates aspects of gender[4] equality in the implementation process of charging infrastructure with the USER-CHI project as reference. The USER-CHI (Innovative solutions for USER centric Charging Infrastructure) project co-creates smart solutions around the Mediterranean and Scandinavian Trans European Network (TEN-T) corridor (see Figure 1). The project is funded by European Union's Horizon 2020 research and innovation programme and aims to promote and expand the e-mobility market. During the

[1] European Commission: A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 1.

[2] European Commission: A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 2.

[3] cf. Civitas (2016); *Smart choices for cities Gender equality and mobility: mind the gap!*; Policy Note; https://civitas.eu/sites/default/files/civ_pol-an2_m_web.pdf last accessed on 6 July 2022.

[4] The authors would like to underline here the difference between the terms *gender* and *sex*. The term gender refers to "the socially constructed roles, behaviours and identities of female, male and gender-diverse people" whereas sex refers to "a set of biological attributes in humans [..] that are associated with physical [..] features" (Heidari *et al*. (2016): Sex and Gender Equity in Research: rationale for the SAGER guidelines and recommended use; Research Integrity and Peer Review (2016) 1:2; DOI 10.1186/s41073-016-0007-6, p.1). The definition has been considered in this paper and the term gender has been used deliberately.

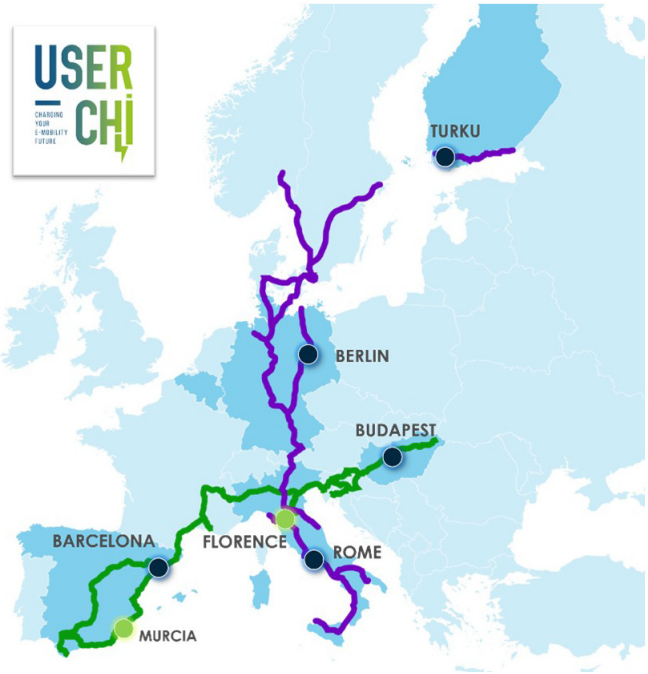

Figure 1. The project cities along the TEN-T corridor. Source: USER-CHI Project.

project, different products are developed and tested, which seek to increase the user's acceptance and accessibility of charging infrastructure. The testing sites are located in the Metropolitan Area of Barcelona (ES), Berlin (DE), Budapest (HU), Rome (IT) and Turku (FI).[5] The tested products are subsequently evaluated and improved in an exchange process organized as site visits and regular meetings for the so called *fellow cities,* which in return may benefit from the innovative products to improve their respective e-mobility plans.[6] Looking beyond the results from the demonstration sites in the mentioned project countries, User-Chi paves the way for user-friendly e-mobility solutions that could be replicated in other locations across Europe.

In this regard, the need for further information to recognise gender bias throughout the implementation process arose between several city partners. According to their concerns, there is a gap that must be filled in gender bias when planning and implementing the charging infrastructure for a user-friendly e-mobility.[7,8]

Addressing this need, the paper combines insights from the project's product development and a literature review on documented differences in society as well as presumable effects of this gender bias transferred in infrastructure and mobility planning. It aims at providing knowledge about gender-specific differences in user needs which then can be incorporated into the design of charging infrastructure. According to the authors' understanding, the discussion on gender equality encompasses all genders. However, due to the limitations of available datasets, literature and state of research[9–11] the authors focus on differing patterns between male and female users only.

To this aim, the paper is structured as follows: the methodological approach is presented first, followed by a section discussing the state of the art regarding of the gender bias in literature as well as in project practices in the mobility and transport sector effect on future developments Finally, conclusions are drawn from the analysis and solution mechanisms are offered, which find their way into the USER-CHI project in a specific and practical way.

Methods

Study design

The paper intends to provide an overview on gender bias in literature and the mobility projects as well as to enable approaches which help to design an inclusive planning and implementation process for the full-scale expansion of the electric charging infrastructure (ECI). Therefore, a dual approach is applied: First, extensive literature research and meta-analysis of data to a large extent provided by USER-CHI partner IBV were conducted in order to find evidence concerning the existence of a gender bias in mobility. As previously stated, the presumable effects of gender bias in literature and differences in the meta-analysis of the project data set were transferred in the field of infrastructure and mobility planning, due to the limitations of available research. To address this research gap, the review gives implications of gender biases in infrastructure planning. Subsequently as a second step, conclusions were drawn from the results of the research and analysis which were then directly applied to the currently developed products of the USER-CHI project, intended to provide recommendations to overcome this bias.

Data collection

This study used data of results from D.1.1: User requirements for USER-CHI solutions[12]. This report presents the work performed by USER-CHI consortium members from February 2020 to October 2020, to define the users' needs and expectations related to project products. The data set used for this paper was collected with a mix-method approach by one partner of the consortium (IBV) during this time. IBV used for the end user insights the qualitative method of field diaries[13]. These field diaries are an open questionnaire that can be answered online by end users of electric charging infrastructure in the cities of the project consortium. Each city was asked to contact a total number of 15 end users with different profiles (long range user professional, low range user private, LEV user and long-range user). IBV used two standardized online questionnaires as the quantitative method[14] to generate their data set. The maximum number of questions was limited to 50 questions per questionnaire. To reach enough required participants in the selected six countries[15], IBV used the SurveyMonkey database. The database includes options to select users who meet specific requirements. In total, the questionnaire almost always achieved a sample size objective of 100 users per city for every user profile, summing up a total number of 1,800 participants[16]. The data set was then made available to the researchers.

[5] User Chi press release: USER-CHI peer learning programme is open – become a Berlin fellow city!, August 2021, https://www.userchi.eu/news/user-chi-peer-learning-programme-is-open-become-a-berlin-fellow-city/, last accessed on 21 September 2022.

[6] User Chi press release: USER-CHI peer learning programme is open – become a Berlin fellow city!, August 2021, https://www.userchi.eu/news/user-chi-peer-learning-programme-is-open-become-a-berlin-fellow-city/, last accessed on 21 September 2022.

[7] Internal protocol of the 4th Consortium Meeting in Valencia, March 2022.

[8] *Written Summary* of USER-CHI internal Webinar „Diversity in transport", 07.05.2020, online.

[9] cf. Civitas (2016); *Smart choices for cities Gender equality and mobility: mind the gap!*; Policy Note; https://civitas.eu/sites/default/files/civ_pol-an2_m_web.pdf last accessed on 6 July 2022.

[10] cf. European Parliament, Directorate-General for Internal Policies of the Union; Sansonetti, Silvia; Davern, Eamonn (2021): *Women and transport*; p. 15; https://data.europa.eu/doi/10.2861/70855 last accessed 27 July 2021.

[11] *Written Summary* of USER-CHI internal Webinar „Diversity in transport", 07.05.2020, online.

[12] Available at: https://zenodo.org/record/6920360#.Y3udC32ZOUk.

[13] D.1.1: User requirements for USER-CHI solutions, p.21f

[14] D.1.1: User requirements for USER-CHI solutions, p.23f

[15] Italy, Spain, Finland, Hungary, Germany, Norway

[16] Detailed number of participants per user profile and country: D.1.1: User requirements for USER-CHI solutions, p.23, Table 4.

Literature review

The literature research follows these preconditions: the initial research period started in June 2022 and lasted till August 2022. It was conducted as a keyword search in title, abstract and full text using key words as "gender equality", "gender discrimination" and "gender bias" in connection with "road infrastructure", "mobility sector" and "e-mobility". The databases used include established literature databases such as google scholar, academia.edu, sciencedirect.com and researchgate.net and focused geographically on scientific papers from Europe and Northern America. The main focus of the literature overview is to define and describe gender bias in e-mobility, focusing especially on the charging infrastructure. In conclusion to this procedure, the authors analysed a total of forty sources. In kind of a pioneer position, the literature overviews referred to gender in overall mobility and infrastructure to give a first overview of an underrated topic.

Analysis

The literature overview regarding gender bias in mobility was followed by a meta-analysis of data. The data taken into account encompass results of USER-CHI partner IBV's survey about user requirements for charging infrastructure, as well as data from statistical offices such as Eurostat[17]. In a second step, conclusions from the research were identified and collected. according to the following, newly formed key factors: mobility patterns, financial aspects and security aspects. Under these key factors, identified aspects of gender bias in charging infrastructure were concluded. Parallel to that, the products still being developed in the USER-CHI project were taken into consideration in order to identify eligible products to link the specific theoretical conclusions directly with the practical tools. Within this step, the authors won't reproduce stereotypes. There are gender differences in mode choice, and it can be proved that these are linked to several structural gender inequalities in society (see chapter Foundations: Aspects of gender (in)equality and linkage to transport infrastructure). The link to practical tools and products of USER-CHI tries to do a first step in breaking existing structures instead of reproducing. In summary, bridging literature research results and data analysis with the USER-CHI products will allow recommendations for more diversity in design choices of charging infrastructure, thus contributing to the goal of an inclusively user-centric charging infrastructure landscape in Europe.

Results

Foundations: Aspects of gender (in)equality and linkage to transport infrastructure

The current EU Gender Equality Strategy 2020–2025 (EU strategy) states that "gender equality is a core value of the EU, a fundamental right and key principle of the European Pillar of Social Rights".[18,19] But whereas promoting that significant progress has been achieved in the last decades, the EU strategy also states that "no Member State has achieved full gender equality and progress is slow".[20] This assessment addresses a potentially very broad set of impacts and topics which are well-researched, globally as well as on the EU level. The key objectives[21] of the EU strategy respond to the main documented inequalities and their direct and indirect impacts:

- Gender-based violence: According to a 2014 report based on interviews with 42,000 women across the 28 Member States of the EU, one in three women (33%) had experienced physical and/or sexual violence since she was 15 years old.[22,23]
- Gender stereotypes: Stereotypical expectations based on fixed norms for women and men, girls and boys that strongly contribute to the gender pay gap.[24]
- Gender gaps in the labour market, inequal participation across different sectors of the economy: More women than men work in low-paid jobs and sectors, and in lower positions.[25] With regard to the all-over employment rates, although a new record low of the gender employment gap was reached in 2021 when it dropped below 11 percentage points, the proportion of working-age men in employment still considerably exceeds that of women.[26]
- Gender pay and pension gaps: On average, women still earn less than men; lifetime cumulative gender

[17] Eurostat (2020): Gender Statistics; https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Gender_statistics#Labour_market last accessed on 7 July 2022./ Eurostat (2021): Part-time employment as percentage of the total employment, by sex and age (%); https://ec.europa.eu/eurostat/databrowser/view/lfsa_eppga$DV_576/default/table?lang=en last accessed on 7 July 2022./ Eurostat (2022): New passenger cars by type of electric drive; https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQR_CARPDA__custom_1251935/bookmark/table?lang=de&bookmarkId=00011c88-be32-474d-a488-f22e9847c12d last accessed on 8 August 2022.

[18] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 1.

[19] The referenced term "gender" encompasses the socially constructed roles, behaviours, activities and attributes that a given society considers appropriate for women and men, see European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 1., referring to Article 3(c) of the Council of Europe Convention on preventing and combating violence against women and domestic violence.

[20] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 2.

[21] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) Objectives. https://ec.europa.eu/info/policies/justice-and-fundamental-rights/gender-equality/gender-equality-strategy_en, last accessed on 21 September,2022.

[22] FRA - European Union Agency for Fundamental Rights (2014), Violence against women: an EU-wide survey, p.3.

[23] Results of a new report, expanded by a supplementary survey to ensure comparability with the 2014 data, is expected in 2023, 33. European Commission (unknown): Ending gender-base violence; https://ec.europa.eu/info/policies/justice-and-fundamental-rights/gender-equality/gender-based-violence/ending-gender-based-violence_en, last accessed 21 September 2022.

[24] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 5.

[25] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 9.

[26] Eurostat: Statistics explained, SDG 5 - Gender equality (2022), https://ec.europa.eu/eurostat/statistics-explained/index.php?title=SDG_5_-_Gender_equality, last accessed Sept. 23, 2022.

employment and wage gaps lead to larger pension gaps, so older women are at higher risk of poverty than men.[27]

- Gender care gap: Women's decisions are often based on jobs, how they work, and whether and how they share these responsibilities with their partners. This is a particular challenge for single parents, most of whom are women, and those living in remote rural areas, who often lack supportive solutions. Women also carry a disproportionate burden of unpaid work, which accounts for a large share of economic activity.[28]

- Gender imbalances in decision-making and in politics: Despite recent progress, women's under-representation in decision-making positions in Europe's businesses and industry persists.[29] For example, out of all EU27 national members of the governments or political executives dealing with transport, 78,1% are men and 21,9% are women.[30]

In general, gender inequality can be considered as deeply rooted in the structure of many areas of western societies such as the organisation of marriage and family as well as work and the economy, politics, religion and even the language itself.[31] In order to achieve the goal of gender equality, namely ensuring the equality of men and women on all possible levels,[32] it is considered a necessity to strive for social and not individual solutions.[33] Whereas the EU strategy only so much as brushes the surface on the topic of gender-related (in)equalities in the mobility and transport sector,[34] research based on data from Finland, Norway, Sweden, Denmark, Germany, India and Singapore suggests that there are gender differences in mode choice and that these are linked to a number of structural gender differences in mode choice and that these are linked to a number of structural gender inequalities in society – such as the gender power gap (decision-making gap), gender work participation gap (gender employment gap), gender pay gap, and unpaid care work gap.[35]

Moreover, these structural differences are found to have become infrastructural ones: They influenced the design of transport systems as a whole, prioritising the individual commute, and failing to incorporate planning and design for other transport patterns and needs.[36]

Gender bias in today's transport and settlement infrastructure

In recent years, researchers in the field of general infrastructure realised peculiarities of the different genders as individual realities which are worth being included as a parameter in studies. Past planning and implementation processes of projects in these fields lack sufficient consideration of diverse transport needs. This conclusion is not a new one: As early as in the 1960s, the built-in effects of urban planning after the Athens Charta (CIAM 1933) with its promotion of the "functional city" – a city which separates the functions of dwelling, working, recreation, and transportation[37] - were criticised for their shortcomings. Thus, German psychoanalyst Mitscherlich analysed in 1971 how city planning favoured only the able-to-work-adult.[38] To his analysis, cities planned in this sense presented themselves inconsiderate to the tendencies of more women entering the workforce while inhabiting the role of mothers, lacked playgrounds for children as well as sport areas for adolescents, and in general spaces for friendships and neighbourly human behaviour.

From these early critiques, there is a continuity to more recent findings that the average city structure particularly benefits the male population of a city as most women take shorter and more frequent trips due to gender-typical distribution of responsibilities in the household.[39] To this day, the existing infrastructure and its geographical distribution can only be described as invariably unequal. The circumstance of the inequality alone is to be considered as problematic, even more so considering that general infrastructure is deemed the central driver for social advantage and disadvantage. What may create connectivity for some will on the other hand lead to the production of barriers and boundaries for others.[40]

[27] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 10.

[28] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 11.

[29] European Commission (2020): A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 13.

[30] EIGE Gender Statistics Database: Women and men in decision-making – Transport - Transport decision-making at national level, 2021, https://eige.europa.eu/gender-statistics/dgs/indicator/wmidm_tra_nat__wmid_tra_natmin/datatable, last accessed Sept. 23, 2022.

[31] cf. Lorber (2010): *Gender Inequality*; p. 6.

[32] cf. Lorber (2010): *Gender Inequality*; p. 4.

[33] Cf. Lorber (2010): *Gender Inequality*; p. 6.

[34] "More women use public transport", European Commission: A Union of Equality: Gender Equality Strategy 2020–2025, COM(2020) 152 final, p. 15.

[35] Ramboll (2021): Gender and (smart) Mobility, Green paper March 2021, p. 10, https://ramboll.com/-/media/files/rgr/documents/markets/transport/g/gender-and-mobility_report.pdf, last accessed Sept.23, 2022.

[36] Ramboll (2021): Gender and (smart) Mobility, Green paper March 2021, p. 10, https://ramboll.com/-/media/files/rgr/documents/markets/transport/g/gender-and-mobility_report.pdf, last accessed Sept.23, 2022.

[37] Poerschke, Ute (2016): "CIAM's Four-Function Dogma: On the Challenge of Mixing Something That Has Been Separated." In: Feldhusen, Sebastian; Ute Poerschke; Jürgen Weidinger (eds.): "Mixings in Architecture and Landscape Architecture." Cloud-Cuckoo-Land, International Journal of Architectural Theory, vol. 21, no. 35, www.cloud-cuckoo.net/fileadmin/issues_en/issue_35/article_poerschke.pdf (enquiry date): 197 – 210.

[38] Mitscherlich, Alexander (1971): Thesen zur Stadt der Zukunft, 1971, no english translation available.

[39] cf. German Federal Ministry for Digital Affairs and Transport (2017): *Result report on Mobility in Germany*; p. 52, 65; https://www.bmvi.de/SharedDocs/DE/Anlage/G/mid-ergebnisbericht.pdf?__blob=publicationFile last accessed on 18 July 2022; TTT Podcast -Gender-inclusive mobility with Ines Kawgan-Kagan and Sonal Shah (31.02.2022): *Transformative Urban Mobility Initiative*; https://www.transformative-mobility.org/news/how-to-improve-gender-disparities-in-mobility-and-urban-spaces last accessed on 25 July 2022.

[40] cf. Siemiatycki, Matti; Enright, Theresa; Valverde, Mariana (2020): *The gendered production of infrastructure*; Progress in Human Geography; Vol. 44; Sage Journals; p. 297–314 (299).

This lack of consideration of multiple variants of mobility patterns in the transport infrastructure can also be framed as an effect of gender bias. The term "gender bias" is - according to the European Institute for Gender Equality - generally understood as "prejudiced actions or thoughts based on the gender-based perception that women are not equal to men in rights and dignity".[41] Although using the wording "gender bias" or "gender inequality" which might be understood in a broader sense of the meaning and could seemingly apply to all genders, it is mostly women being disadvantaged by the phenomenon.[42] According to a definition by Health Canada (2000), "Gender Bias is the root of gender inequalities and falls into three broad problem types:

- Over-generalisation—adopting the perspective or experience of one sex and applying it to both sexes;
- Gender Insensitivity - ignoring sex and gender as important variables; and
- Double Standards - assessing the same or essentially the same situation, trait or behaviour differently on the basis of sex."[43]

However, the increased awareness of the gendered perception of infrastructure also led to the implementation of several features aiming at capturing the specific needs of the caring person. For example, one of those projects are so-called women and family car parking spaces in Germany[44] and China[45]. These parking spaces are located near stairs, elevators or exits and are furthermore well lit to take up women's needs in parking lots to be safer, easily accessible and spacious, especially when women are accompanied by older people or children.

Whilst the general infrastructure and mobility sector is able to present a noteworthy amount of research dedicated to immanent gendered parameters, there are certain areas within the overall research which fail to provide specific data concerning a potential gender bias in its conception.[46,47] This particularly involves the ECI for cars and other electric vehicles. One reason for the lack of specific data may be the only recently emerged need for a full-scale expansion of the ECI. It can be assumed that this development is related to the registration figures for electric cars, which have also only increased in some cases by leaps and bounds in recent years.[48]

The lack of recognition of female needs which is observed in the general infrastructure sector is, as shown, intertwined with the effects of gender bias in the transport sector, especially concerning female car usage and ownership. In general, women are less likely to use a car in their everyday life compared to men.[49] Furthermore, women are more likely to travel as passengers in a car than actually driving the car.[50] Regarding the issue of ownership, it is estimated that by only 70.4% women are less likely to own a car whereas 79.8% of men are considered car owners. As a consequence, this leads to the understanding that overall women are driving shorter distances and therefore have less driving experience than men.[51] The assumption is furthermore supported by the fact that women are more likely to use public transport and walk whilst the majority of men travel by car and motorcycle.[52]

The following section uses key factors to illustrate selected aspects of gender bias in the transport and mobility sector. The selection of key factors is based on the claim to prove a potential gender bias on as many diverse levels as possible. For this reason, the selection of the corresponding factors refers to those that can be transferred to the specific segment of individual electro mobility and the charging infrastructure in addition to the overarching mobility sector. Such key factors are the different mobility patterns of men and women, the differences in financial set-ups of women and their inherent security concerns.

1. Key factor: different mobility patterns. Individual mobility patterns are highly influenced by gender. Typically, men display longer and more linear travel patterns whereas women often travel shorter distances within more complex travel chains.[53] This includes women travelling during peak-off hours as well as experiencing various start and stop stages.[54] Those diverse

[41] cf. European Institute for Gender Equality; Glossary & Thesaurus; https://eige.europa.eu/thesaurus/terms/1155 last accessed on 29 August 2022.

[42] cf. Lorber, Judith (2010): *Gender Inequality – Feminist Theories and Politics*; 4th Edition; Oxford University Press; p.4.

[43] 24. Health Canada (2000): Health Canada's Gender-Based Analysis Policy, https://publications.gc.ca/collections/Collection/H34-110-2000E.pdf, last accessed on 23 September 2022.

[44] cf. Noack, Rick (2015) : *The debate over Germany's "sexist" women-only car parking space*; Washington Post; https://www.washingtonpost.com/news/worldviews/wp/2015/08/10/the-debate-over-germanys-sexist-women-only-parking-spaces/ last accessed on 20 September 2022.

[45] cf. Zhi-Chun Li, Wen-jing Liu, Xiao-Yan Wang (2022): *Women-only parking spaces, Determinants of parking space choice, investment decision, and a case study of Wuhan, China*; Transport Research Part C: Emerging Technologies; Volume 137; April 2022. https://doi.org/10.1016/j.trc.2022.103553.

[46] cf. Civitas (2016); *Smart choices for cities Gender equality and mobility: mind the gap!*; Policy Note; https://civitas.eu/sites/default/files/civ_pol-an2_m_web.pdf last accessed on 6 July 2022.

[47] cf. European Parliament, Directorate-General for Internal Policies of the Union; Sansonetti, Silvia; Davern, Eamonn (2021): *Women and transport*; p. 15; https://data.europa.eu/doi/10.2861/70855 last accessed 27 July 2021.

[48] cf. Eurostat (August 2022): *New passenger cars by type of electric drive*; https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQR_CARPDA__custom_1251935/bookmark/table?lang=de&bookmarkId=00011c88-be32-474d-a488-f22e9847c12d last accessed on 8 August 2022.

[49] cf. Soriano, Carol *et al*. (IBV) (2020): *User-Chi survey results*, p.8; womeninmobility.org/femalemobility-en last accessed on 20 September 2020.

[50] cf. Civitas: *Smart choices for cities Gender equality and mobility*; p.20.

[51] cf. Sovacool, Benjamin; Kester, Johannes *et al*. (2018): *The demographics of decarbonizing transport): The influence of gender, education, occupation, age, and household size on electric mobility preferences in the Nordic region*; Global Environmental Change; Volume 52; Table 2, Gendered differences in preferences for car ownership, electric mobility, and vehicle attributes.

[52] cf. European Parliament - Directorate General for Internal Policies (2012): *The Role of Women in the Green Economy – The issue of mobility*; p. 39; Table 4: Gender differences in Modal Split in the EU 27 (2007).

[53] cf. Civitas: *Smart choices for cities Gender equality and mobility*; p. 20.

[54] cf. European Parliament: *Women and Transport*; page 16.

mobility patterns can be considered as gendered mobility patterns which appear to be a result of the role distribution of men and women within the labour market as well as the family.[55] A phenomenon directly interacting with this finding is the concept of mobility of care. According to this understanding, women are considered the primary care givers for the family, meaning that they are responsible for domestic chores as well as the care of dependent children, elderly relatives, and the sick.[56] Among such chores are for example grocery shopping and bringing children to school. As a result, women often undertake a smaller number of work trips compared to men, whereas they generally travel more often due to the combination of work and care trips as illustrated by statistics from several European countries focusing on the purposes of trips differentiated by gender.[57]

2. Key factor: financial aspects. Women are considered to be less likely to own or use private electric vehicles as well as car-sharing options.[58] According to the IBV survey conducted for the USER-CHI project, such a discrepancy can amount to only 27,4% of electric vehicles are owned by women in contrast to 72,6% by men.[59] Even though they are considered to be more sensible towards environmental issues.[60]

There appears to be several reasons explaining this reality. First and foremost, women tend to be subject to financial contingencies due to the existing income gap between men and women meaning that women earn less than men whilst doing the same work.[61] Currently, the gender pay gap in the European Union amounts to 14.1% which leads to women earning 86 Cents for every Euro earned by a men.[62] As a result, women are often negatively affected in their career development and labour income and therefore are less likely to be willing to pay for better transport services or access to private transport modes.[63] But not only the gender pay gap causes financial restraints for women. In 2020, 77.2% of men were employed all over Europe while the employment rate of women is only 66.2%.[64] Furthermore, women are more likely to be employed in part-time jobs as studies focusing on the 27 EU-countries as well as Switzerland, Norway and Iceland show.[65] Nearly half of all women employed in part-time jobs name "family or personal responsibilities" as the main reason keeping women for their type of employment. On the other hand only 11.7% of men are employed part-time for the same reason.[66] In addition to that, the employment catchment area that women have access to is being restricted due to the complex areas of responsibilities imposed on many women, leading to a so-called double working day as well as the mode of transportation most women use which includes primarily public transport instead of privately owned cars.[67]

Another reason which can be used to explain why women are less likely to privately own an electric vehicle is the public perception of the ownership of a car and the influence of it by reports of the media. In general, cars are displayed as a necessity for men to care for their families. It is often thereby connected to the image of a successful and powerful man driving a car that "completes" him as a person.[68] By focusing on men instead of all genders as a target group for car ownership, it may could be concluded that women could believe that the car is not essential in their reality of lives.

Finally, the financial situation of single parents, most of them being single mothers, may provide another explanation for the small number of women owning a private electric vehicle. This is due to the fact, that especially single mothers tend to have the highest risk of poverty[69] leading to the incapability to pay for certain types of mobility, especially individual transport.

3. Key factor: security aspects. In general, there are two types of risks which have to be considered when talking about security aspects concerning women in the mobility sector. One is the risk of accidents and the other is the risk of experiencing sexual harassment.[70] Women are considered to be disproportionally

[55] cf. Civitas: *Smart choices for cities Gender equality and mobility*; p. 9.

[56] cf. European Parliament: *Women and Transport*; p. 15.

[57] cf. German Federal Ministry for Digital Affairs and Transport (2017): *Result report on Mobility in Germany*; p. 64; https://www.bmvi.de/SharedDocs/DE/Anlage/G/mid-ergebnisbericht.pdf?__blob=publicationFile last accessed on 18 July 2022; UK Department of Transport (2020): *National Travel Survey*; Chart 27; https://www.gov.uk/government/statistics/national-travel-survey-2020/national-travel-survey-2020 last accessed on 18 July 2022.

[58] cf. Giménez *et al*. (2021): *D1.1 – User Requirements for USER-CHI solutions*; p.143f; https://zenodo.org/record/6920360#.YynTrC0RqgQ last accessed 20 September 2022;

[59] cf. Soriano, Carol *et al*. (IBV) (2020): *User-Chi survey results*, p.8.

[60] cf. Duchene (2011): *Gender and Transport*; International Transport Forum Discussion Papers, No. 2011/11; OECD Publishing; p. 9.

[61] cf. Eurostat (2018); *Gender overall earnings gap (GOEG)*; https://ec.europa.eu/eurostat/statistics-explained/images/8/83/Gender_overall_earnings_gap_%28GOEG%29%2C_2018_%28%25%29.png last accessed on 7 July 2022.

[62] cf. European Commission (2021): *Equal Pay? Time to close the gap!*; Fact Sheet; https://ec.europa.eu/info/sites/default/files/aid_development_cooperation_fundamental_rights/equalpayday_factsheet.pdf last accessed on 7 July 2022.

[63] cf. Civitas: *Smart choices for cities Gender equality and mobility*; p. 13.

[64] cf. Eurostat (2020): *Gender Statistics*; https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Gender_statistics#Labour_market last accessed on 7 July 2022.

[65] cf. Eurostat (2021): *Part-time employment as percentage of the total employment, by sex and age (%)*; https://ec.europa.eu/eurostat/databrowser/view/lfsa_eppga$DV_576/default/table?lang=en last accessed on 7 July 2022.

[66] cf. Civitas: *Smart choices for cities Gender equality and mobility*; p. 13.

[67] cf. Duchene: *Gender and Transport*, p. 11.

[68] cf. Ramboll (2021): *Gender and (Smart) Mobility*; Green Paper; p. 33.

[69] cf. Damaske, Sarah *et al*. (2017): *Single mother families and employment, race, and poverty in changing economic times*; Social Science Research; Volume 62; pp. 120–133 (132).

[70] cf. European Parliament: *Women and Transport*; p. 17.

affected by the design of public spaces causing them to develop avoidance strategies when going outside at night or even to stop travelling at all.[71] When analysing the risk of accidents related to the travel behaviour of a women, it is important to notice that women are often considered to be better drivers than men.[72] This assumption is derived from the hypothesis that they take fewer risks when driving. For example, young men are at a significantly higher risk for road traffic injuries as they are believed to be more likely to engage in aggressive driving behaviour. Furthermore, they are found to be more prevalent than women under the influence of alcohol and drugs.[73] In general, the predominant amount of fatal car accidents is caused by men.[74] Women on the other hand are considered to be more observant as well as attentive to other road users therefore causing fewer accidents.[75] When taking into account the risk of experiencing sexual harassment, many women have developed several protection mechanisms in order to avoid these kinds of situations. In particular, these different strategies relate to the travelling at night times as outdoor crime rates, especially concerning sexual offences, increase at nightfall.[76] Therefore, women tend to travel less at night due to their fear of violence and even due to gender roles restricting some women of leaving their home at night time.[77] Likewise, women tend to choose routes which seem to provide the highest level of safety possible, which causes them to act more carefully in general when in traffic.[78]

Advantages from implementing gender neutral charging infrastructure

The recognisable gender bias in the general mobility sector as well as individual electro mobility and charging infrastructure makes the system itself vulnerable to disadvantages. It is assumed that a system which is to be regarded as a one-sided system due to gender bias must also be described as an inefficient system. The reason for this is that the system at best benefits parts and at worst fractions of the entirety. In this way, it can never be fully utilised. On the same basis, the system cannot claim sustainability.[79]

Conversely, various positive outcomes can be expected in pushing back gender bias in the electromobility and charging infrastructure sector. This requires the consistent application of the principle of gender mainstreaming. In principle, it is considered as the "(re-)organisation, improvement, development and evaluation of (…) processes, so that a gender equality perspective is incorporated (…) at all levels at all stages, by the actors (…)".[80] The concept was originally defined for the area of policy making, but its essence can easily also be transferred to other areas. Thoughtful implementation of the concept in the area of individual electromobility and charging infrastructure allows for efficient use of human resources and enhancement of women and men in view of different societal roles.[81] Furthermore, it leads to better informed decisions in the planning and implementation process and therefore to a better assessment in general.[82] Ultimately, the integration of the concept of gender mainstreaming raises awareness among the broader public thereby making the topic visible and is expected to change negative attitudes.[83]

Approaches and recommendations

Due to particular needs of women, which lead to specific characteristics influencing women's mobility, electric cars do not appear to be the default solution.[84] Therefore, the recommendations made should focus on the intention to make the usage of electric mobility more accessible for women and at the same time set the goal to a gender-neutral access to this type of mobility. Jane Jacobs showed an approach for the field of urban planning that could be transferred in its basic features to the planning of the charging infrastructure of electromobility. She writes that in the attempt to create diversity, it is necessary to include a "mixture of functions" in a neighbourhood, rather than separating areas in commercial, residential, and cultural spaces.[85] This approach shall be considered as the baseline for the following recommendations.

In the following the conclusions previously drawn in this paper shall be applied to a specific project – the USER-CHI

[71] cf. Middleton, Fion(2021): *Urban planning and women's safety: a research project*; Turley; 14 October 2021; https://www.turl ey.co.uk/comment/urban-planning-and-womens-safety-research-project last accessed on 26 July 2022.

[72] cf. Duchene: *Gender and Transport*; p. 9.

[73] cf. González-Sánchez, Guadalupe; Maeso-González, Elvira *et al*. (2021): *Traffic Injury Risk Based on Mobility Patterns by Gender, Age, Mode of Transport and Type of Road*; Sustainability; p. 12.

[74] cf. Federal Statistical Office (2017): Traffic accidents; Special series 8, Number 7; p. 129.

[75] cf. Duchene: *Gender and Transport*; page 9.

[76] cf. Fotios, Steve A. *et al*. (2021): *The Effect of Lightning on Crime Counts*; Energies, 14, 4099, p. 7.

[77] cf. Zhang, Mengzhu *et al*. (2022): *Constructing women's immobility: Fear of violence and women's constricted nocturnal travel behaviou*r; Travel Behaviour and Society; Volume 26; January 2022; Fig. 3 (b) Gender differences in time of NT.

[78] cf. Bellmann, Frieda *et al*. (2020): *Women move differently*; World Economic Forum; https://www.weforum.org/agenda/2020/01/mobility-in-2020-a-female-perspective/ last accessed 20 September 2022.

[79] cf. European Institute for Gender Equality (2020): *Benefits of equality through infrastructure provision: an EU-wide survey*; Luxembourg: Publications Office of the European Union, p. 11.

[80] Council of Europe (1998): *Gender Mainstreaming, Conceptual framework, methodology and presentation of good practices. Final report of Activities of the Group of Specialists on Mainstreaming (EG-S-MS)*; Strasbourg.

[81] cf. European Institute for Gender Equality, p. 11.

[82] cf. Council of Europe: *Gender Equality Strategy: Achieving gender mainstreaming in all policies and measures*; https://rm.coe.int/168064379a last accessed on 5 September 2022.

[83] cf. Council of Europe: *Gender Equality Strategy*.

[84] cf. Bellmann *et al*.: *Women move differently*.

[85] cf. Jacobs, Jane (1961): *The Death and Life of great American Cities*.

Project – in order to illustrate and incentivise approaches aiming at including women's needs in future electromobility projects.

The USER-CHI Project focuses on the co-creation and demonstration of smart solutions around seven connecting nodes of the Mediterranean and Scandinavian-Mediterranean Trans European Network-Transport (TEN-T). Several of these solutions shall be presented in the follow-up, and at the same time approaches within the applications shall be proposed that represent a fundamental contribution to the integration of the special needs of women in the context of the development of an electronic charging infrastructure.

One USER-CHI product is the Charging infrastructure Location Concept development kit (**CLICK**[86]). This planning tool addresses mainly municipalities aiming at extending their charging infrastructure by using different data regarding the city and its districts such as demographic statistics and previous usage of electric vehicles. It is designed to provide recommendations of the position, amount, and preferable technology of future charging points in a certain area. The tool will be tested in a two staged implementation during the term of the project by the city partners. The tool will be accompanied by user support materials developed in the project, too, as well as by workshops. So far it is not clear, in which way CLICK recognises a possible gender bias in the demographic data set. Overall, there is a possibility to introduce gender equality in the planning tool, by including behavioural patterns and usage of electric vehicles in future adaptions of the algorithm. Such a planning and programming process should be designed to recognise and process gender sensitive information.

This could be achieved explicitly through the inclusion of gender-sensitive data within the four-stage CLICK application. Therein, step 3 ("feed data") and step 4 ("get recommendations") require addressees to feed gender sensitive data to the tool such as distribution of inhabitants regarding male and female or the number of families in the area. Apart from that, it can be further requested to characterise a certain neighbourhood as a socially advantaged or disadvantaged area. Finally, a variety of other criteria may be considered in order to receive recommendations as accurate as possible such as the amount of privately owned charging infrastructure; number of schools and kindergartens in the area as well as other facilities often visited by women due to phenomenon of mobility of care.

As a result, the recommendations provided should mirror the gender sensitive information by highlighting locations which either acknowledge specific security needs of women such as well-lit places for charging infrastructure as well as public places or places near entrances of buildings and residential buildings. On the other hand, women's specific rapid mobility pattern needs to be taken into account when enumerating recommendations such as fast-charging stations in front of kindergartens or schools, shops, doctors' offices and nursing homes. Furthermore, the recommendations for the location itself should adapt to the environment and its inherent conditions. An illustrative example may be to propose a collective e-bike charging station in front of park entrances or playgrounds instead of charging stations for cars to minimise traffic and thus avoid accidents and to additionally achieve a diversification of the mobility options.

Another product of USER-CHI, tested in Barcelona, which clearly takes up this point is **INSOC**[87]- Integrated Solar DC Charging for Light Electric Vehicles. This charging station is designed with solar panel roof for e-bikes and e-scooters as a solution combining charging, onsite production of renewable energy and theft-proof parking. Besides being a climate-friendly solution and representing multimodal instead of solely car-based mobility options, the product also refers to transport modes being more likely used by women. This is due to the special demands women are facing in the context of the mobility of care phenomenon. Therefore, the design of the charging point itself may contribute to reach more gender equality in the electric charging infrastructure. Such an inclusive design could include measures like roofed charging points, storage areas to enable unloading shopping without any difficulties and perimeter surrounding the charging point in cases where it is located near roads in order to hinder children from running out into the street. Furthermore, it could be advantageous to provide charging stations for cargo bikes with enough space between single charging points to move around the vehicle. Additionally, the installation of an emergency button able to trigger silent and loud alarms may seem sensible to increase the feeling of security of women. The explicit location of these charging stations could follow the recommendations previously mentioned.

Especially in terms of safety, the product **INDUCAR**[88] - Inductive Charging for e-CARs – may recognise aspects increasing gender equality. The wireless charging solution will be aligned with the Machine-to-Machine communication technologies, to fully automate the identification, payment and charging operations. Therefore, it also sets an opportunity to improve the general feeling of safety in particular due to an alternative usage to cable charging. Furthermore, it could meet practical needs resulting from the previously mentioned specific needs due to women's mobility patterns and in regard to mobility of care. INDUCAR aims to be less time consuming and reversely a more time effective method than conventional charging infrastructure, that could support women.

[86] cf. User-Chi: CLICK product presentation; https://www.userchi.eu/products/click/ last accessed on 20 September 2022.

[87] cf. User-Chi: INSOC product presentation; https://www.userchi.eu/products/insoc-integrated-solar-dc-charging-for-light-electric-vehicles/ last accessed on 20 September 2022.

[88] cf. User-Chi: INDUCAR product presentation; https://www.userchi.eu/products/inducar-inductive-charging-for-e-cars/ last accessed on 20 September 2022.

Finally, the **Station of the Future Handbook**[89,90] has a high potential in combining all previously mentioned aspects in the development of the selected USER-CHI products. This handbook includes guidelines and recommendations to design the perfect user-centric charging station. The purpose is to accelerate the widespread usage of electric vehicles, encouraging users of different social groups and market segments to overcome existing acceptance barriers, and therefore providing viable business models to private stakeholders. It addresses CPOs, EMPs/MSPs and other private stakeholders of the electromobility field. On the one hand, it could raise awareness concerning the existence and specific circumstances surrounding gender inequality within the general transport infrastructure and accordingly charging infrastructure - especially the key factors listed above. On the other hand, it could provide guidance and recommendations regarding the creation of either public or private financing models for the use of charging infrastructure. Such financing structures could integrate reduced pricing systems for certain age groups given that there is an increased probability of old-age poverty among women. In addition to that, provisions for specific travel periods for example more economical tariffs during night hours to ensure safe transport to one's home or provisions concerning the means of transport including cheaper tariffs for e-bikes rather than electric vehicles could be promoted in the handbook.

Outlook

While a comprehensive scientific overview of the question of the existence of a gender bias in electric charging infrastructure cannot yet be clearly answered, it is probably recognisable that the problem of gender inequality in the field of infrastructure planning and implementation has been identified. It can be assumed that in future projects of planning and implementation of charging infrastructure projects, criteria leading to an adjustment of gender inequality will be increasingly included. It remains to be said, however, that the current approach to planning and implementing charging infrastructure projects is largely oriented towards the status quo and as a result carries the existing gender bias in the field of general infrastructure on to new fields such as charging infrastructure. The USER-CHI project could counteract the status quo of a gender bias in charging infrastructure by fully exploiting the existing potential of the individual products. According to the proposals, the topic around gender bias could be brought into the focus of development and proposed solutions could be developed that are oriented towards the concrete ideas of this paper. Future research needs to address gender and diversity issues to establish sustainable and future oriented mobility and transport infrastructures. Because of this, it is also necessary to approach the topic from a conceptualised side. Especially with regard to which concepts scientists can use to assess a non-discriminatory and diversely accessible infrastructure. Nonetheless, focussing on creating for example a system of categories to assess diversity in transport. In this way, the USER-CHI project could develop even further into a lighthouse project that serves as a blueprint for the central questions and criteria for the future planning of charging infrastructure.

Data availability

Underlying data

This study used results from D.1.1: User requirements for USER-CHI solutions by IBV and their underlying data set of their research work. The report is available at: https://zenodo.org/record/6920360#.Y3udC32ZOUk. The data set was provided by the project partner. The data set contains the results of the field diaries and the two questionnaires for end-users. The conclusions from the data sets (data set of IBV and the data sets of Eurostat [see below]) were used for the research of this paper. According to the following, newly formed key factors: mobility patterns, financial aspects and security aspects. Under these key factors, identified aspects of gender bias in charging infrastructure were concluded with support of the data sets (see chapter Gender bias in today's transport and settlement infrastructure).

The data set is not publicly available. The contact person for the data set is Juan Fernando Gimenez of IBV (juanfernando.gimenez@ibv.org). The conditions for data sharing and access to this data set need to be clarified directly with the before mentioned responsible person.

The following data was collected from Eurostat:

Eurostat (2020): Gender Statistics; https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Gender_statistics#Labour_market last accessed on 7 July 2022.

Eurostat (2021): Part-time employment as percentage of the total employment, by sex and age (%); https://ec.europa.eu/eurostat/databrowser/view/lfsa_eppga$DV_576/default/table?lang=en last accessed on 7 July 2022.

Eurostat (August 2022): New passenger cars by type of electric drive; https://ec.europa.eu/eurostat/databrowser/view/ROAD_EQR_CARPDA__custom_1251935/bookmark/table?lang=de&bookmarkId=00011c88-be32–474d-a488-f22e9847c12d last accessed on 8 August 2022.

Acknowledgements

Special thanks to Friederike Pfeifer and Dr. Alexandra Appel for their support in the revision of this paper.

[89] cf. User-Chi: Station of the Future Handbook product presentation; https://www.userchi.eu/products/station-of-the-future/ last accessed on 20 September 2022.

[90] Station of the Future Handbook, Online Version (2022); https://www.userchi.eu/wp-content/uploads/2022/12/SotF_USER-CHI_final.pdf last accessed on 14.02.2023;

Station of the Future Handbook, Webinar Presentation (2022); https://www.userchi.eu/wp-content/uploads/2022/12/20221212_USER-CHI_SotF_webinar.pdf last accessed on 14.02.2023;

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Paula Carroll
University College Dublin, Dublin, Leinster, Ireland

Summary: The authors address a very real and important research gap, the results could be transferrable not just to other European countries, but to other developed countries. I would like to see a clearer definition of gender bias (particularly in the context of transport infrastructure design), The definition in the Abstract is a bit clunky, the EIGE definition on p.7 is more useful. Otherwise, the scope of this paper is well defined.

I wondered what the colour coding in Fig 1 represents – a key would be useful. I wondered how user's acceptance and accessibility are measured, and if there was some initial assessment to provide a baseline against which any change could be benchmarked? P.9 mentions an "inefficient system". It's possible to make a better link between the conclusions if the authors make it clearer how the Charging Infrastructure is being assessed.

The data gathering methodology is well described and appropriate for the research questions. The charging infrastructure user survey sample size of 1,800 is adequate. The literature review of 40 papers at the gender/mobility nexus is also adequate, and the literature search approach is well described.

However, the Results section could be structured better. It is not clear that what follows is an analysis of the 40 sources. This section seems to contain additional content (not the 40 papers) that could be moved to the Motivation and Scope section. The thematic analysis of the papers staring on p. 7 could be summarised in a table to highlight the findings. I didn't see any analysis of the user survey in the Results section.

The set of recommendations could be better linked to the analysis of the papers. The authors say the results are used in the "USER-CHI project in a specific and practical way". However, the "Approaches and recommendations" section seems to be suggestions for how the tools/products could be adapted, rather than evidence that they were adapted to incorporate gender perspectives.

The authors conclude more diverse approaches (to charging infrastructure design) are needed. This is true, and I think the authors also mean that existing approaches should be modified to take account of the diverse needs of stakeholders. There is a need to ensure gender mainstreaming, i.e., that gender needs are included at the outset in all transport infrastructure development, the set of recommendations starting on p.9 give some useful suggestions on what future (transport infrastructure) projects should be alert to.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

Are all the source data and materials underlying the results available?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Operations Research; Clean Energy Transition; Gender Equality;

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 02 Jan 2024

Katharina Csillak

Dear Paula Caroll, thanks for your detailed review on our paper. Your remarks are useful for our overworking process. I hope to be able to work on a second version of the paper soon. Especially the aspect on the results of user survey needs to be underlined and seperate (from the literature) in a better way - I totally agree. In addition: yes, the results could be adapted by the tools, but there is no evidence that the tools are/were adapting our results. That was on purpose, because the paper was a start to give a better recognization of the topic for the product developers. The results were largely discussed in a webinar (December 2022). Unfortunately, most product developers told us, that the development their products was already finished at this time, but they try to involve the aspects in the further improvements of the products and add them to the learnings from the project for further

work. In conclusion, we hope, that the topic is getting more awareness in future and that we are able to overwork this paper or add another one with main outcomes. Thanks again and best regards, Katharina Csillak

Competing Interests: No competing interests were disclosed.

Reviewer Report 27 September 2023

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Katie J Parnell
University of Southampton, Southampton, England, UK

This paper discusses and important issue for the future of charging infrastructure and the project discussed is much needed. I enjoyed it. However, I think more clarity of the write up of the approach is required to ensure that the important message of the paper is fully delivered. I provide some specific details on these points below.

Abstract:

- It could be more clearly stated here what exactly was done within the literature review. It is not very clearly written and therefore the key aim is not as clear as it could be.
- 'Gender bias' is also typically referring to the bias in datasets which have traditionally captured more male data in the mobility domain, and therefore the data used to inform mobility and its design is biased towards males.
- You state in the plain language summary that women are disadvantaged currently within the development of charging infrastructure, this would be of interest to be included within the abstract.

Methods:

- Was a balanced male/female sample targeted in the data collections phase? How was gender accounted for in the sampling?
- Any ethical approval processes should be included.
- Scopus and Web of Science are typical databases used to obtain peer reviewed literature, why were these platforms not used?
- You state that you are interested in e-mobility charging infrastructure, why did you not include 'charging infrastructure' or 'electric mobility' within the search terms?

- More detail on the inclusion/exclusion criteria is needed. How many papers were initially identified, how many were rejected and on what grounds.
- Furthermore why was Europe and North America focused on?
- Analysis: It is not clear within this section exactly what was done and it is a little confusing. Consider the use of a figure to present the different stages of research and where the analysis of this research paper fits in.
- It is not clear how the key factors were identified, did these come from the literature review findings?

More inclusion of the gender data gap – alongside the other factors on page 7. A lack of data on females and their use and experience of systems has led to a bias towards the needs of males. Future work to overcome this should seek to have balanced and representative samples of males and female participants. Disaggregation of data on gender is also vital to ensure that potential gender differences are identified. This approach should be taken with the future gender-equity approach which is proposed and the CLICK application with the 'gender sensitive data'.

Within electric mobility, it seems that your focus is on electric vehicles. But there is growing research in the field of electric micromobility, e.g. ebikes and escooters, which considers gender equity. This is not referred to. Is this intentional? If so the scope of the area of focus should be stated early on.

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
No

Are all the source data and materials underlying the results available?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Transport researcher focusing on Gender equity, Human Factors, e-micromobility and automation.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

Author Response 02 Jan 2024

Katharina Csillak

Dear Katie Parnell, thanks for your detailed and helpful review. I totally agree on the points about the abstract and method chapter of our paper. We still need here improvement and your questions and remarks are helping us to overwork the paper. I hope to do so in near future. Thanks. I'm also sharing your opinion on the better inclusion of the gender data gap. For sure, missing data has led to a bias in the recognizing of needs in transportation. Future work on gender equality should be able to overcome this bias - we hope and stronly believe, that this will be the case with the higher number of papers recognizing and adressing this issue. We thought we outlined this clearly with our work. Nevertheless, I think we can also add some more sentences on this aspect again to unterdline this fact in a better way. Within electromobility, the project also adress ebikes and escooter. This is clearly linked in the last chapter with the product "INSOC". That is also the reason, why we didn't referred only to e-vehicles in the beginning. So yes, that was intentional. Thanks again and best regards, Katharina Csillak

Competing Interests: No competing interests were disclosed.

Reviewer Report 31 August 2023

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Angela Carboni
Department of Environment, Territory and Infrastructure Engineering (DIATI), Politecnico di Torino, Turin, Piedmont, Italy

The paper is developed in the framework of USER-CHI European project. The aim is to show the aspects of gender equality in the implementation process of charging infrastructure.

The authors claim to use the data told in a questionnaire but this is not at all enhanced in the paper and it is not at all clear to me what data were obtained and how they were used for this research.

I think the structure of the paper deserves a thoughtful revision, I think some titles are either too general or do not fully reflect the content such as "Literature review" or "Analysis".

There are two Horizon projects that have dealt precisely with gender issues in transport and mobility: DIAMOND and TINNGO. I recommend seeing the material produced to enrich some of the concepts.

The introductory part ("Foundations: ..) is a bit dispersive in reading as well as the chapter more focused on transportation and mobility, beware of repetition of concepts that make the reading chaotic.

Much appreciated and well-structured is the section on project tools and their potentials, which in my opinion is the heart of the paper and should be better emphasized.

Finally, I suggest to the authors a re-reading of the paper as some typos (User Chi instead of USER-CHI) are present as well as inappropriate truncated words (e.g. won't).

Is the work clearly and accurately presented and does it engage with the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Not applicable

Are all the source data and materials underlying the results available?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Not applicable

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Transport systems

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.