

Perceived EV adoption barriers of households of different income groups

PERCEIVED EV ADOPTION BARRIERS AMONG DIFFERENT HOUSEHOLDS IN
UTRECHT, FOCUSING ON TRANSPORT JUSTICE



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1. Abstract

This study examines Transport Justice by analyzing perceived barriers to electric vehicle (EV) adoption across diverse household compositions and income levels. The research evaluates the fairness of the EV transition by exploring differences in perceived barriers among low, middle, and high-income households. Interviews with various households unveil discrepancies in experiences and barriers to adopting EVs. Applying Transport Justice, which includes distributive, recognition, and procedural justice, helps analyze the differences in perceived barriers. Understanding the relationship between perceived barriers and justice pillars reveals potential injustices within the context of Transport Justice.

The findings reveal that financial barriers to EV adoption are particularly prominent for low- and middle-income households. Barriers like battery replacement concerns and limited charging facilities are identified across all income groups. However, a closer examination indicates that low- and middle-income groups face more specific issues related to these barriers, such as lacking access to charging facilities in their neighborhoods. These unique challenges for low- and middle-income groups suggest distributive- and recognition injustice for these groups.

Additionally, the study indicates that all income groups are not adequately involved in the EV transition process, underscoring the importance of active participation from all income groups for equitable outcomes. Concerns raised by participants about government plans to reduce financial EV incentives are also highlighted. Ensuring procedural justice is crucial for addressing resistance and fostering equity. The recommendation of income-based subsidies is suggested to enhance inclusivity.

While the research emphasizes disparities among income levels, no definitive conclusions can be drawn regarding the influence of household composition and coordination on EV adoption decision-making. Further investigation into the impact of household composition and coordination on EV adoption is recommended.

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2. Introduction

Globally, cities face an increase in motorized vehicles, leading to high accident rates, traffic congestion, air pollution, and noise (Gössling, 2016). Moreover, road transport accounts for the majority of CO₂ emissions within the transport sector (Chakraborty et al., 2022; Kim et al., 2015). In 2016, the European Union signed the Paris Climate Agreement. This agreement aims to limit global warming to well below 2 degrees Celsius (*Klimaatbeleid*, 2023). Bringing the transport sector in line with the objectives of the Paris Agreement represents a major societal challenge (Schwanen, 2021). Reducing the use of fossil fuels, such as coal and oil, is crucial to mitigating climate change. Decreasing fossil fuel use reduces pollution and improves local health (Finley-Brook & Holloman, 2016). The majority of greenhouse gas emissions from the transport sector occur in urban areas, leading to a significant focus on transitioning to electric mobility (EM) in these urban settings (Schwanen, 2021). EVs are widely recognized as an environmentally friendly form of transport that can improve the sustainability of road transport and reduce local air pollution and traffic noise (Kim et al., 2015). EVs do not produce direct emissions themselves, but whether they are truly environmentally friendly or not depends on the source of electricity they rely on. Using renewable energy sources like solar, wind, or hydropower to charge EV batteries, instead of energy generated by fossil fuels, enables significant emission reduction (Adhikari et al., 2020).

Multiple studies have emphasized the growing importance of EVs in transportation policies of both national and local governments to address environmental issues (Adhikari et al., 2020; Chakraborty et al., 2022; Davis, 2019; He et al., 2022; Kim et al., 2015; Rudolph, 2016). Policymakers worldwide have introduced incentives to encourage EV adoption, aiming to promote the expansion of EV markets. These incentives include financial incentives, such as subsidies, and non-financial incentives, such as regulatory measures, the development of charging infrastructure, and awareness campaigns (Caulfield et al., 2022). In addition to government support, factors like consumer perceptions, travel behavior, high EV prices, limited driving range, charging time, and environmental concerns also influence EV acceptance (Adhikari et al., 2020). Furthermore, national governments, particularly in Europe, are increasingly implementing policies to phase out internal combustion engine vehicles (ICEVs) and establish low or zero-emission zones (Schwanen, 2021).

The transition to EVs has the potential to combat climate change, but equity concerns persist (Sovacool et al., 2019). Some policies may inadvertently exacerbate inequality, particularly impacting marginalized and vulnerable populations, like low-income groups (Finley-Brook & Holloman, 2016; Ku et al., 2021; Sovacool et al., 2019). Disadvantaged communities are disproportionately affected by environmental and transportation injustices (Khan et al., 2022). Barriers can hinder low-income consumers, favoring high-income groups in the adoption of EVs (Caulfield et al., 2022; Khan et al., 2022). Thus, EV policies have implications for social justice and energy equality (Sun et al., 2023). Ensuring fair access to EVs, with well-distributed and accessible charging infrastructure, is crucial for achieving both economic carbon neutrality and fairness in environmental policies and resources (Khan et al., 2022). In addition to income groups facing barriers to EV adoption, the decision to adopt an EV can vary among different income groups and households. Moreover, choosing a vehicle within the household is often a collective decision rather than an individual one (Guan & Wang, 2019a).

In Utrecht, the promotion of EM, particularly EVs, is encouraged, while the use of ICEVs is discouraged (*Elektrisch Vervoer*, n.d.). The main focus of this research is to comprehend the variations in perceived barriers among different households when adopting EVs and to investigate the Transport Justice implications of these barriers. The analysis takes into account the composition of households and the income level of the household concerning the perceived barriers to EV adoption. By assessing the equity implications of these barriers in the theoretical framework of Transport Justice, the study

aims to present the challenges different income groups face in adopting an EV. The research question follows:

‘How do households of different income groups experience barriers to EV adoption, and how are these barriers related to Transport Justice?’

The sub-questions are:

- What barriers do households from different income groups experience when considering EV adoption?
- How do these perceived barriers differ among the different income households?
- What are the perceptions of households regarding the equity of existing EV measures?
- How can existing EV measures be redesigned to ensure equity across all income groups, as perceived by households?
- How do household choices on EV adoption relate to the justice dimensions of transport?

2.1 Scientific relevance

A growing and vast amount of research addresses the transition to EVs. Current research on EVs predominantly centers on studying people's attitudes toward EVs and focusing on the adoption of EVs. (Barbarossa et al., 2017; Haustein & Jensen, 2018; Krishna, 2021; Shetty et al., 2020; Vassileva & Campillo, 2017). Research on individuals' attitudes toward EVs and the adoption of EVs primarily adopts a quantitative approach (Barbarossa et al., 2017; Giansoldati et al., 2020; Haustein & Jensen, 2018; Moeletsi, 2021; Shetty et al., 2020; Vassileva & Campillo, 2017). It emerges that high purchase costs (Giansoldati et al., 2020; Moeletsi, 2021) and driving range (Franke et al., 2012) are substantial barriers to the transition to EVs. The different kinds of barriers are further explained in the theoretical framework.

Other research focuses more on EVs' use, economic benefits, and annual mileage, often compared to ICEVs (Burlig et al., 2021; Chakraborty et al., 2022; Davis, 2019). Furthermore, there is existing research that considers income when studying EV purchases (Maat & Timmermans, 2009; Sovacool et al., 2019). Maat and Timmermans (2009) focus on the decision-making surrounding the use of the car for commuting, taking into account the interdependencies between household partners. Specifically, it distinguishes between single-earner and dual-earner households. Sovacool et al. (2019) focus on the link between decarbonization, innovation, and the affordability of various household energy services. It aims to explore how emerging low-carbon innovations on a household scale can help promote or hinder energy justice goals.

This study diverges by focusing on the household equity challenges associated with EV adoption from a justice perspective. By considering Transport Justice and assessing the fairness of EV measures, this study aims to provide insights into the barriers faced by different income groups in EV adoption. This study adopts a qualitative approach to investigate the collective decision-making process among households during the EV transition. This distinction is important because transport choices within a household are often made jointly and coordinated (Guan & Wang, 2019a). Existing literature does not provide insight into the influence of households on EV adoption, as all studies focus on the individual perspective. In addition, the existing literature does not address household barriers related to EV adoption in terms of Transport Justice. This study is scientifically relevant as it addresses a gap in the literature by examining the adoption of EVs while considering factors of income and equity from a qualitative approach that focuses on household decision-making.

2.2 Social relevance

The literature indicates that certain groups are systematically excluded from the benefits of transport policies (Lucas, 2012). Examining transport equity offers insights into the positive and negative effects of transport policies on different income groups (Oswald Beiler & Mohammed, 2016). Lucas (2006) emphasizes the importance of local transport planning and the need for decision-makers to be well-informed about areas with inadequate accessibility and barriers faced by residents. Additionally, Schwanen (2021) emphasizes the inadequate focus on equity during the shift to low-carbon urban mobility, stressing its importance in avoiding resistance from specific population groups and accelerating the transition. Promoting equity in transport policies is essential to ensure inclusive EV adoption and mitigate resistance from specific population groups.

Additionally, the inability of different income groups to adopt an EV can have implications for Transport Justice. Transportation is crucial in addressing equality issues, enabling access to work, education, and essential services while promoting community development and reducing crime (Lucas, 2006). However, insufficient transport can lead to transport-related social exclusion, restricting people's participation in economic, political, and social life (Gössling, 2016; Lucas, 2019). Transport-related social exclusion, results in limited access to opportunities, services, and social networks, contributing to inequality (Lucas, 2012). When governments establish EVs as the norm and enforce EV-related policies, the inability of households to adopt EVs can have implications for various aspects of equality.

This study examines the barriers experienced by households from different income groups in the process of adopting EVs. By incorporating Transport Justice principles, the study aims to identify variations in these barriers among income groups. The insights gained will be valuable for policymakers, providing a deeper understanding of the challenges faced by different households when considering EV adoption. This knowledge can assist policymakers in developing effective and equitable transport policies that address the identified barriers.

3. Theoretical framework

3.1 Transport Justice

The EM transition highlights the importance of energy justice, which addresses the equitable distribution of green energy (Sun et al., 2023). The aim is to identify disadvantaged groups and redress unfairness (Jenkins et al., 2016). Access to green energy can positively impact social justice by enhancing affordability and accessibility, contributing to a cleaner and fairer way of life (Sovacool et al., 2019). Given that low-income individuals generally allocate a larger proportion of their income to energy expenses, access to affordable green energy has the potential to reduce this inequality (Sun et al., 2023). However, the adoption of green energy may exacerbate energy equity issues, as benefits from renewables can be unevenly distributed (Sovacool et al., 2019), favoring wealthier households (Finley-Brook & Holloman, 2016). Renewable energy benefits include solar panels and energy efficiency upgrades that lead to energy cost savings (Finley-Brook & Holloman, 2016).

Governments view EVs as a sustainable alternative to ICEVs (Kim et al., 2015). EVs are generally more expensive to purchase than ICEVs, but involve less cost per kilometer (Chakraborty et al., 2022; Davis, 2019). Therefore, the EV can also be a sustainable and cost-saving form of transport for households, as it uses electricity instead of petrol. In addition, research by Anastasiadou and Gavanas (2022) shows that households are more likely to switch to EV adoption when the purchase is combined with a solar power system. This suggests that policies that encourage this bundling may promote EV adoption in general. However, as with Energy Justice, the EV transition needs to address equity about

the possibility of EV adoption by different income groups. Transport Justice research aims to provide insight into the barriers to EV adoption for diverse income groups, addressing issues of accessibility and equity in the EV transition.

Transport Justice focuses on population groups at risk of transport-related social exclusion due to inadequate access to transportation (Karner et al., 2020). In this study, Transport Justice is used to analyze the barriers to household EV adoption. Transport Justice of the EV transition is investigated by examining three components of justice, namely distributive justice, recognition justice, and procedural justice (Pereira et al., n.d.; Schwanen, 2021; Verlinghieri & Schwanen, 2020). These dimensions of justice are used to delve deeper into the causes of possible injustice in transport. If injustice is suspected in one or more of these justice dimensions, possible solutions to make the situation more equitable can be explored.

The perceived barriers are linked to a dimension of justice, with improvements within this dimension then considered to make Transport Justice more equitable if necessary. Potential barriers to EV adoption, are categorized into five types of barriers: financial, infrastructural, technical, social barriers and tempo-spatial barriers. This categorization is based on the research of Adhikari et al. (2020). The tempo-spatial constraints were included as influencing factors on household EV adoption, this includes the coordination of household members in making transport decisions (Guan & Wang, 2019a, 2019b; Ho & Mulley, 2015; Hu et al., 2023; Maat & Timmermans, 2009). This categorization is chosen because it gives a clear organization of the EV barriers into distinct main themes, providing a comprehensive classification of all potential perceived barriers.

3.1.1 Distributive Justice

Distributive justice examines the distribution of costs and opportunities across society, regardless of demographic characteristics, identifying potential injustices (Finley-Brook & Holloman, 2016; Jenkins et al., 2016; Karner et al., 2020; Sovacool et al., 2019; Sun et al., 2023). In the context of EV adoption, distributive justice involves identifying barriers, such as equity of infrastructure location and access to energy services society (Jenkins et al., 2016). The barriers related to distributive justice in EV adoption include financial and infrastructural barriers (Adhikari et al., 2020), as they involve the distribution of costs and benefits of EV policies.

3.1.2 Recognition Justice

Recognition Justice policies seek to comprehend the effects of policies on marginalized households and address potential overlooking or misrepresentation in society (Finley-Brook & Holloman, 2016; Jenkins et al., 2016; Sovacool et al., 2019). By acknowledging diverse perspectives rooted in social, cultural, ethnic, racial, and gender differences, recognition justice aims to prevent misrecognition and demeaning attitudes, emphasizing fair representation and equal political rights for all individuals (Jenkins et al., 2016). The barriers related to recognition justice include technical, social (Adhikari et al., 2020), and tempo-spatial constraints, as they involve the perspectives of households regarding EV adoption. Technical and social barriers include the preferences and knowledge of households about EV characteristics and measures. Tempo-spatial constraints include the coordination of household members in making transport decisions.

3.1.3 Procedural Justice

Procedural Justice aims to promote equity in EV policies through inclusive procedures, emphasizing access to decision-making processes (Finley-Brook & Holloman, 2016; Jenkins et al., 2016; Sun et al., 2023). This is achieved by mobilizing local knowledge, improving information, and enhancing institutional representation (Jenkins et al., 2016). The goal of procedural justice is to ensure fair procedures that include all stakeholders, representing and respecting their interests (Jenkins et al.,

2016; Sovacool et al., 2019). Good procedural decision-making can also yield significant gains on the other two pillars (Finley-Brook & Holloman, 2016). Encouraging the participation of low-income households in decision-making can promote greater equity in transport and EV policies, as their perspectives can be taken into account. The absence of participation of low-income households can hinder effective EV adoption measures, as their perspectives are not taken into account, possibly leading to unequal outcomes (Adhikari et al., 2020). This involves the ability of households to participate in the EV transition process. EV barriers can be minimized when every income group is represented in the EV transition process.

3.2 Household decision-making and barriers when adopting an EV

3.2.1 Financial barriers

According to Guan and Wang (2019a), car ownership is positively related to household income and size. Sovacool et al. (2019) add that access to cars, travel distances, and income are correlated, with higher-income households using cars more often, traveling longer distances, and having greater opportunities to buy new cars. EV adoption is likely to be higher among consumers with higher incomes and education levels, particularly in affluent urban areas where there is greater support for environmental policies (Anastasiadou & Gavanas, 2022; Henderson, 2020; Sovacool et al., 2019).

High-income groups take the lead in EV adoption and benefit the most from EV subsidies and privileges (Bauer et al., 2021; Henderson, 2020). In contrast, lower-income households tend to purchase cheaper and less efficient vehicle models, which benefits them less (Sovacool et al., 2019). The high purchase price is a barrier to the adoption of EVs, as they are significantly more expensive compared to ICEVs (Caulfield et al., 2022). The high purchase price, mainly related to the high cost of the battery, is according to Anastasiadou and Gavanas (2022), the main financial barrier to EV adoption. The current subsidy program primarily benefits higher-income households who can afford EVs at full price, while low-income individuals face challenges in affording them. Policymakers can help by offering subsidized interest rate credit mechanisms. However, the lack of a robust credit system also hinders EV adoption (Adhikari et al., 2020). To ensure accessibility for all income groups, the subsidy program could be better designed, possibly by basing subsidies on income levels (Caulfield et al., 2022). In addition, the risk that the price of a vehicle will fall in the future (the vehicle someone purchases today may be discounted in the future) may negatively impact consumers' choices regarding EVs (Anastasiadou & Gavanas, 2022).

A study on EV adoption in disadvantaged communities in California indicates that the adoption of used EVs is slightly higher than that of new EVs. This suggests that adoption rates in disadvantaged communities may rise as used EV prices continue to decline (Canepa et al., 2019). This means that households who choose used cars place greater importance on the price (Liao et al., 2017). Nevertheless, there are also barriers to the adoption of used EVs. Some used EVs may be approaching the end of their battery life, necessitating battery replacement shortly. The fear of a potentially defective battery can be perceived as a significant risk (Canepa et al., 2019). This financial consideration can discourage households from adopting an EV (Adhikari et al., 2020).

The cost of an EV increases when someone wants to install a home charging station (Caulfield et al., 2022), which is the most commonly used charging location. Home charging offers the lowest cost and convenience and increases the likelihood of long-term EV ownership (Chakraborty et al., 2022). Electricity charging costs are significant barriers to the adoption of EVs. The comparison of operating costs between EVs and ICEVs strongly depends on electricity rates and gasoline prices (Anastasiadou & Gavanas, 2022). EVs are expected to be purchased by households with home charging options. Potential buyers without home charging capability are held back by higher public charging tariffs (Scorrano et al., 2020). However, when free workplace charging or discounted public charging is

offered, this can be more cost-effective than charging at home (Chakraborty et al., 2022). In this way, the degree of use of workplace charging and public charging may also affect the cost of driving an EV and therefore influence the annual kilometers driven (Chakraborty et al., 2022). Since EVs depend on electrical energy for operation, increased electricity costs can discourage the adoption of EVs (Adhikari et al., 2020). However, High-income households attach less importance to fuel costs (Liao et al., 2017).

3.2.2 Infrastructural barriers

The limited availability of charging stations is a significant barrier for potential EV adopters (Adhikari et al., 2020; Anastasiadou & Gavanas, 2022; Karlsson, 2017), discouraging EV adoption (Adhikari et al., 2020). Concerns about the availability of charging infrastructure during long trips are major determinants of EV adoption (Anastasiadou & Gavanas, 2022). EV users must plan trips based on charging station availability (Chakraborty et al., 2022). There is an unequal distribution of charging infrastructure, with more in high-income areas and less in low-income areas (Caulfield et al., 2022). The inequity of charging distribution hinders EV adoption in low-income households, favoring high-income households (Khan et al., 2022). Additionally, areas with more EV charging points tend to have higher levels of car ownership, suggesting that EVs may serve as the second car in the household (Caulfield et al., 2022).

The availability of home charging has a substantial impact on the decision to adopt an EV (Canepa et al., 2019; Chakraborty et al., 2022; Scorrano et al., 2020). Without access to charging at or near their residence, consumers are unlikely to consider buying an EV (Canepa et al., 2019). However, in densely populated urban areas, buildings often lack private parking spaces, leaving residents dependent on limited street parking. The convenience and costs of parking at the destination and home influence car trips. Challenges in parking, such as the absence of a guaranteed home parking spot, lead households to choose alternative transportation modes, resulting in fewer car trips (Guo, 2013). The second most significant location for consumers is charging infrastructure at their workplace, as it offers convenient charging during working hours (Canepa et al., 2019). Another EV barrier is the scarcity of repair and maintenance workshops for EVs, which may leave consumers dissatisfied with the limited support available (Adhikari et al., 2020; Anastasiadou & Gavanas, 2022).

3.2.3 Technical barriers

The lack of evidence on reliability and performance is cited as a technical barrier to EV adoption, as people may have reservations about the technological performance of EVs due to their relative novelty (Adhikari et al., 2020). Uncertainty about technical progress negatively affects the decision-making of EV adoption (Liao et al., 2017). People with higher incomes and higher levels of education tend to adopt EVs more often, possibly due to their greater acceptance of new technologies (Canepa et al., 2019).

The research of Broadbent et al. (2021) investigates the role of media on EV consumer perceptions and awareness of EV measures. This research shows that early adopters of EVs were willing to pay extra to express their environmentally conscious values and attached less importance to a perfect market. In contrast, consumers who follow later value the purchase price more and are more concerned about the battery. These users want to wait until there is a fully developed EV market with a nationwide fast-charging infrastructure network. Innovation and ease of use of EVs play a crucial role here. These consumers need more convincing to make the switch to EVs than the early adopters. The willingness to buy EVs is related to consumers' attitudes towards these vehicles.

The limited availability of EV models is a technical barrier to adoption, as a broader range of options could appeal to a wider segment of users and encourage EV adoption (Adhikari et al., 2020; Liao et

al., 2017). Some potential buyers may dislike specific brands or prefer more options to choose from. Consumer preferences over time may vary due to people entering the EV market at different times, resulting in different preference profiles (Liao et al., 2017). Moreover, the limited availability of EV models can create the perception that the EV market is not yet mature, negatively influencing people's perception of the EV market (Liao et al., 2017).

In addition, limited EV range is a significant technical barrier, causing range anxiety concerns, especially for users with longer daily commutes (Adhikari et al., 2020; Davis, 2019). This limitation can lead to transport-related social exclusion (Lucas, 2019), particularly for those living in remote areas with longer distances to travel for essential activities (Sovacool et al., 2019). Households with multiple cars are less worried about the range, as they can use their second car, an ICEV, for longer trips (Davis, 2019; Karlsson, 2017; Liao et al., 2017). This makes households with multiple cars potential buyers of EVs (Karlsson, 2017). Two-income households are more likely to own multiple cars due to greater need and affordability (Maat & Timmermans, 2009). In addition, charging time is mentioned as a barrier to EV adoption, however, this does not play a role for people who can charge at home, as these people often charge at night (Anastasiadou & Gavanas, 2022).

3.2.4 Social barriers

Barriers to EV adoption include the lack of knowledge about EVs, with potential users being unaware of benefits such as financial incentives, charging infrastructure availability, and potential fuel savings (Adhikari et al., 2020). Potential EV users may also have concerns about the broader environmental implications of EVs, encompassing more distant factors such as battery production, power generation, and battery disposal (Henderson, 2020). Additionally, a limited understanding of EV product quality, misinformation, and misconceptions about performance, reliability, and range capacity can lead to hesitancy in adopting EVs (Adhikari et al., 2020).

EV policies consist of financial measures such as purchase subsidies, tax breaks, and lower electricity tariffs, as well as non-financial incentives such as charging infrastructure and environmental benefits. These policies, together with technological advances such as increased battery capacity, contribute to the acceptance of EVs (Anastasiadou & Gavanas, 2022). Nevertheless, a lack of information on both EV policies and the characteristics of EVs is a barrier to acceptance (Anastasiadou & Gavanas, 2022; Broadbent et al., 2021). Consumers' behavior regarding information about the benefits of EVs and the risks involved in accepting new technology plays a crucial role. Consumer confidence in EVs depends on their level of knowledge about EVs, such as information on environmental impacts, operational and maintenance costs, and vehicle characteristics such as speed, ease of use, energy efficiency, charging time, and range (Anastasiadou & Gavanas, 2022).

The absence of awareness-raising campaigns about EVs affects potential users' perceptions. Educational programs, advertisements, media communications, and government campaigns all play a significant role in reducing consumer hesitancy in adopting EVs (Adhikari et al., 2020; Anastasiadou & Gavanas, 2022). Media is the most consulted source for consumers to research vehicles, regardless of their attitude toward EVs (Broadbent et al., 2021). These awareness campaigns can familiarize households with this new technology. In short, clear policy guidelines, financial incentives, awareness campaigns, and investment in infrastructure are essential for promoting EV adoption (Anastasiadou & Gavanas, 2022). EV owners are much more aware of EV policies than ICEV owners. Similarly, it appears that people with increased awareness of EV incentives are more likely to buy an EV. In other words, the amount of research a consumer does correlates with their level of policy awareness and the likelihood of buying an EV. In addition, there is greater resistance to EVs among consumers who are less familiar with available EV incentives (Broadbent et al., 2021). The absence of this is a barrier to EV adoption.

3.2.5 Tempo-spatial constrains

According to Guan and Wang (2019b) and Ho and Mulley (2015), household context plays a role in travel arrangements, such as having children, age, income, number of vehicles, number of parking permit holders, and number of people working. Tempo-spatial constraints in EV adoption involve the coordination of household members' activities when making travel decisions, as they depend on each other for shared vehicles and tasks (Guan & Wang, 2019a, 2019b; Ho & Mulley, 2015; Hu et al., 2023; Maat & Timmermans, 2009). For example, households with two working partners need to coordinate car use more than single-earner households (Guan & Wang, 2019a; Maat & Timmermans, 2009). Commuting distance also plays a role, as individuals with longer commutes are more likely to prioritize car use (Guan & Wang, 2019b). Different population groups experience scheduling, multitasking, and multiple responsibilities in various ways (Lucas, 2012). Household capabilities are determined by the coordination of daily activities among members can influence the final joint choice to purchase a vehicle (Guan & Wang, 2019a). Household choices reflect the preferences, needs, and attitudes of all members, ultimately influencing EV adoption.

4. Research methods

4.1 Research design

This research aims to provide insights into the barriers experienced by different income groups regarding the adoption of EVs in Utrecht. The objective is to uncover differences in barriers among various income groups and household compositions. Studying different households concerning EV adoption is crucial due to policies potentially increasing inequality. Understanding and addressing these disparities is essential for achieving a more equitable and inclusive transition to EV adoption.

To map out these barriers, qualitative research in the form of interviews is done in the current study. Qualitative research is a method that allows for an exploration of the underlying reasons behind participants' choices and experiences. Qualitative research interviews are used to understand participants' experiences, feelings, and social context (Fossey et al., 2002). Through interviews, participants can express their experiences and opinions about the EV transition. The interviews were designed by the Utrecht team and other project partners within the Inclusive Transition to Electric Mobility project (ITEM) framework as part of a broader study on the inclusive transition to EVs in the European context. This interview format was also utilized in studies on EV transition in other European cities.

The interviews are semi-structured, utilizing an interview guide while maintaining flexibility in the questioning approach (Fossey et al., 2002). The interview consists of 14 questions, divided into four sections: Introduction, Travel profile, Experience with transition to and using EM, and EM-transition and social inclusion (see Appendix D). The "Introduction" examines the participants' experiences with EVs and their understanding of the EV transition development in Utrecht. The "Travel profile" delves into the participants' movements and reasons behind their chosen modes of transportation, including the travel challenges they encounter. The section on "Experience with transition to and using EM" explores the reasoning behind why participants do or do not use EVs, their awareness of EV policy measures, and whether they feel like these measures are tailored to their households. Lastly, the section on "EM-transition and social inclusion" discusses the fairness of policy measures, their influence on EV policy, and the extent to which participants feel recognized by the government.

4.2 Recruitment of the interviews

The recruitment of participants and the interviews conducted were entrusted to the professional research institute Markteffect. As an independent research institute, Markteffect utilized its qualitative research panel to reach the targeted audience. Panel members were carefully selected by Markteffect using a screening questionnaire to check if they met the criteria for the research. Afterward, Markteffect contacted the selected participants to schedule a suitable time for conducting the interviews. However, participants always had the choice to decline or withdraw from participating in the interviews.

This study's target audience consists of both ICEV and EV owners from various income groups, with and without children, residing in and around Utrecht. This study included car users only, as the ITEM project focuses on the transition from non-EM to EM in urban areas (*Inclusive Transition to Electric Mobility*, n.d.). Considering the aspect of children, the study aims to examine the influence of having children on EV adoption. Participants were divided into three income groups: low, middle, and high-income. Low-income groups earned up to 3,400 euros per month, middle-income groups earned between 3,400 and 5,700 euros per month, and high-income groups earned at least 5,700 euros per month. The division of participants is presented in Table 1.

Table 1: Distribution of the participants

Participant	Gender	Age	Income group	Household composition	Type of car ownership
1	Female	23	Middle	Single without children	ICEV
2	Male	41	Middle	Living together without children	ICEV
3	Male	54	Low	Single without children	ICEV
4	Male	40	High	Living together with children	EV
5	Female	50	Middle	Living together without children	EV
6	Male	46	Middle	Living together with children	ICEV
7	Male	60	Middle	Living together without children	EV
8	Female	39	Middle	Single with children	ICEV
9	Male	38	High	Living together without children	EV lease
10	Female	32	High	Living together with children	EV lease
11	Female	76	Low	Single without children	ICEV
12	Female	58	Low	Single without children	ICEV
13	Male	61	Low	Single without children	ICEV
14	Female	45	High	Living together with children	ICEV & EV
15	Male	43	High	Living together with children	ICEV & EV lease
16	Female	40	Middle	Living together with children	ICEV
17	Female	49	Low	Single with children	ICEV
18	Female	34	Low	Single with children	ICEV
19	Female	56	Low	Single with children	ICEV
20	Female	37	Low	Single with children	EV lease
21	Male	46	Low	Living apart together (LAT) relationship without children	ICEV
22	Male	41	Middle	LAT relationship without children	EV lease
23	Female	66	Low	Single without children	ICEV
24	Male	23	Low	Living with parents	ICEV & diesel vehicle
25	Male	36	Middle	Single without children	EV lease

Before conducting the interviews, a preliminary interview pilot was performed with three individuals to identify any issues and make necessary improvements. Unclear questions were then adjusted. This was done by the author and another MSc student within the Utrecht team. Markteffect conducted the interviews. The interviews were conducted online with 25 participants. Each interview lasted for approximately one hour. Participants received fifty euros as compensation for their participation. Granting financial incentives for participation in research raises ethical concerns. On one hand, financial incentives encourage more people to participate in research. Proponents argue that it is a fair recognition of people's contribution to research results. On the other hand, there is a risk that participants participate only because of the financial reward, which may compromise the integrity of the research. Offering financial incentives may result in the disproportionate involvement of individuals with lower incomes. This leads to a decrease in the diversity of the participant group (Zutlevics, 2016).

The interviews were recorded for transcription purposes. Markteffect processed the interviews anonymously to ensure participants felt free to share their thoughts without concern for anonymity. The research was conducted following the ethical requirements of the Faculty of Geosciences.

4.3 Data analysis

To analyze the data, the transcripts were coded using a mixed methods approach. The coding process was done collaboratively with two researchers within the Utrecht team, one of whom is the author. Creating a codebook contributes to the validity of the study, allowing transferability to another context. Initially, a codebook was developed based on concepts from the theoretical framework on EV adoption of both researchers, such as Transport Justice and its three dimensions. Later on, the codebook was further refined and expanded based on the insights gained from the interviews (see Appendix E). The coding process was conducted using the software Nvivo.

5. Results

The results are categorized based on key observations from the interviews following the sub-questions. First, the extent to which households of different income levels experience certain barriers when adopting an EV is discussed. It examines whether there are significant differences in perceived barriers and which barriers play the biggest role in EV adoption. The perceived EV adoption barriers faced by both ICEV and EV users are discussed without differentiation because these barriers collectively impact the potential adoption of EVs by future users. Second, how people with different income levels perceive the equity of EV measures will be discussed. Finally, the results show how the (in)fairness effects of these measures impact EV adoption, and the potential improvements mentioned by participants aim to better promote the distribution of EV adoption among different income groups.

5.1 Financial barriers

Financial EV barriers can impact households' decisions regarding the adoption of EVs due to affordability concerns. Several aspects of financial barriers to EV adoption are considered, namely initial purchase price, alternative financial considerations, and operational costs. The operational costs consist of maintenance costs, possible battery replacement, and charging costs. See Table 2 for an overview of the perceived financial barriers of income groups and household types.

5.1.1 Initial purchase price

Initial purchase price of new EVs

The most frequently mentioned barrier is the initial purchase price of an EV, both for a newly bought and a used EV. All three income groups state there is a lack of equal access among income groups to purchase an EV. High-income participants, and one low-income participant, expressed state that low-income households are not able to purchase an EV. This low-income participant states that they earn above average and that's why they have the resources to drive an EV. Low- and middle-income participants state that the initial purchase price is too expensive for themselves.

A reason cited by all income groups for unequal access to the purchase of an EV is the perceived unfair distribution of subsidies. High-income participants state that low-income households don't have access to EV subsidies, and low- and middle-income participants state that they don't have access to EV subsidies and therefore can't purchase an EV. There is no noticeable difference between different types of households and their views on the purchase price of an EV.

Well, it's actually not that fair, because those assessment values of those cars are expensive and not something you can change. So the lower end of society is not really served by someone who has a low-paying job, who can't buy a €12,000 car. That can't, you see, that's a bit unfair (middle income, ICEV-owner, household consists of a couple without children).

A difference between the low- and middle-income participants is that the low-income participants state feeling like they are not taken seriously in the EV transition. This group states that the government only focuses on the involvement of middle- and high-income groups in the EV transition. Furthermore, low-income participants state that subsidies exclusively benefit early adopters of EVs and anticipate that these incentives will diminish as EVs become more widely available, placing late adopters at a disadvantage compared to early adopters.

But you mentioned that financially, is it still a hindrance?

Yes, because I am in a bad financial position or worse, yes, that's below average, then buying an electric car, even with subsidies or whatever is possible, is not at all doable now (low-income, ICEV owner, the household consists of one person).

It seems that both high-income and lower-income households believe that only low-income households are not eligible for EV subsidies and cannot afford an EV. Even though, middle-income participants also state not being able to qualify for EV subsidies and purchase an EV because of their financial situation.

Initial purchase price of used EVs

Low- and middle-income participants also express that alternatives, like used EVs and leased EVs, are too expensive for themselves and others in similar or worse financial situations, even with the subsidies to purchase a used EV. A middle-income participant even states having a used EV, but still thinks it is too expensive for them. There is no noticeable difference between different types of households and their views on the purchase price of a used EV.

In addition Low- and high-income participants state that a used EV is a risky purchase, because of the decreasing value of EVs. Participants state that a used EV is often considered costly due to its novelty, resulting in a high initial purchase price. As EVs become more commonplace, the price is expected to decrease, leading to an increase in the availability of used EVs in the market. Participants would be interested in adopting an EV if EVs were more affordable.

I'm disappointed that I don't have the money to purchase an electric vehicle myself. That was kind of the consideration when we were buying a new car, but I actually would have liked to buy an electric vehicle (middle income, ICEV-owner, household consists of a couple without children).

5.1.2 Alternative financial considerations

Still having a good ICEV

Low- and middle-income participants state having alternative financial considerations than adopting an EV. Low- and middle-income participants state that they still have a good working ICEV. They don't want to replace a good working car when it's not necessary.

I don't think so. I hope this car lasts for a few more years (low-income, ICEV-owner, household consisting of one person).

Home purchase

In addition, a middle-income participant states that investing in a house is more important than buying an EV. They are unwilling to invest in two significant expenses and prefer not to allocate their funds toward items that rapidly lose value.

So then I think, I better invest my money somewhere else than at that moment in an electric car that will also have less value in five years (middle-income, ICEV-owner, households consisting of one person).

High-income participants don't state alternative financial considerations being a barrier to EV adoption. Having alternative financial considerations was mentioned by single people without children, and once by a participant who lives together with a partner and has children.

5.1.3 Operational costs

General maintenance costs

Low-income participants state that EV maintenance costs are relatively higher for low-income households, as these households have fewer financial resources to maintain an EV. General maintenance costs are only mentioned by participants who are single, with and without kids. The maintenance costs include the possibility of needing to replace a faulty battery as well as the expenses related to regular inspections. In addition, low-income participants state their inability to repair a broken EV easily (themselves). They are dependent on EV garages, which is more costly than repairing a car themselves or going to an ICEV garage. A low-income participant also states that the expense of inspections of EVs is too costly due to their limited income.

Battery replacement

Participants of all income groups state having concerns with the life expectation of an EV battery. There was no noticeable difference between household types. A low-income participant even states that the technological advancement of EV batteries is a reason to wait to purchase an EV. They state it would be wiser to hold off on the purchase of EVs, because EV technology is advancing quickly, resulting in more advanced batteries. Participants state that the additional costs associated with a battery replacement would be too expensive for them to afford. A participant stated that a used EV is not within reach financially, primarily because of the costs associated with replacing the battery when required.

Yes, that is a matter of waiting until enough used cars are on the market. But then, you are tied to a very expensive battery pack, which probably needs to be replaced. I've got the feeling that it will never become accessible, electric cars, for people with a below-average income.

And then you say that the battery has to be replaced if it's second-hand.

Yes, probably by the time those cars become affordable to buy, second-hand, they will be so old that their batteries need replacement, so then buying cheap becomes paying dearly, as you would have to deal with the expensive battery replacement on top of it (low income, ICEV owner, the household consists of one person).

This participant has little confidence that EVs will ever become affordable for them. Besides the fact that low- and middle-income households state not being eligible for EV subsidies, they are also concerned that if they can afford an EV, they will not have sufficient financial resources when the battery needs to be replaced. A redistribution of EV subsidies could remove the financial barrier related to potential battery replacement.

Charging costs

Low-income participants state that a high charging price is a barrier to EV adoption, they want to know the cost of a full battery compared to a tank of petrol. Participants who state charging costs as a barrier to EV adoption include households consisting of singles with children, and a participant in LAT relationship without children. A low-income participant states about the possibility that energy prices could be a barrier to EV adoption.

It will stabilize at some point. When everything becomes electric.

So you think it will become more expensive then?

Yes, at the moment it is cheaper in my opinion, I don't know about road tax. The more the electricity demand becomes, the more expensive it becomes.

That would then stop you from driving electric?

That's a big point though (low-income, ICEV-owner, the household consists of one person).

In addition, low-income households could find themselves in a vicious cycle where their inability to utilize one sustainable innovation puts them at a disadvantage when it comes to adopting other sustainable innovations. Indicating that the inability of low-income households to have sustainable innovation, like solar panels, has effects on their electricity bill, which then influences their decision-making in adopting an EV, because of high charging prices. Underscoring the importance of involving lower-income groups in the sustainable transition and the EV transition to prevent further inequality.

But there are also often lower-income people who live alone in very poorly insulated houses. So, they are already paying much more. Then you find yourself in a cycle. And if you're paying a lot, you're left with very little. Then you can't save. You can't install solar panels, you can't insulate. You just find yourself in a vicious cycle. So, it is indeed unfair in that situation (high-income, ICEV-owner and private lease EV, household with children).

Table 2: Perceived financial barriers of households

Financial barriers		Income groups and household composition
Initial purchase price	New EV	<p>High, and one low-income, participants state that an EV is too expensive for low-income households. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> High- and low-income participants state that Low-income households have less access to EV subsidies than other income groups.
	Used EV	<p>Low and middle-income participants state that an EV is too expensive for them. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> Low- and middle-income participants state having no access to EV subsidies. Low-income participants state that the government only focuses on the involvement of middle- and high-income groups.

		<ul style="list-style-type: none"> • Low- and middle-income participants state having no access to subsidies for used EVs. • Low- and middle-income participants state a used EV is too expensive, because of its novelty. <p>Low- and high-income participants state that a used EV is a risky purchase, because of the decreasing value.</p>
Alternative financial considerations	Still having a good ICEV	Low- and middle-income participants state still having a good ICEV. This is stated by households consisting of singles without children, and once by a participant who lives together with a partner and has children.
	Home purchase	A middle-income participant states that they would rather invest in a house than an EV. This is stated by a household consisting of a single person with no children.
Operational costs	General maintenance costs	<p>Low-income participants state that the maintenance costs are relatively higher for low-income households, as these households have fewer financial resources to maintain an EV. This is stated by households consisting of singles without children.</p> <p>Low-income participants state their inability to repair a broken EV easily (themselves); there is dependence on an EV garage, which makes a repair more expensive. This is stated by households consisting of singles with children.</p> <p>A low-income participant states that the expense of inspections of EVs is too costly due to their limited income. This is stated by a household consisting of a single without children.</p>
	Battery replacement	<p>Participants of all income groups have concerns about the life expectancy of an EV battery in general and have concerns about the life expectancy of specific a used EV battery. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • Low- and middle-income participants state having to replace a battery is a concern because of the expense. • A low-income participant states that the technological advancement of EV batteries is a reason to wait to purchase an EV.
	Charging costs	Low-income participants state that a high charging price is a barrier to EV adoption. This is stated by

		households consisting of singles with children and a person in a LAT relationship without children.
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5.2 EV utilization barriers

EV utilization barriers can impact households' decisions regarding the adoption of EVs due to convenience concerns. Several aspects of EV utilization barriers to EV adoption are considered, namely familiarity with EV use, driving range, charging facilities, and tempo-spatial constraints. The charging facilities consist of public charging and home charging. See Table 3 for an overview of the perceived EV utilization barriers of income groups and household types.

5.2.1 Familiarity with EV use

Low- and middle-income participants express reservations about transitioning to an EV due to their unfamiliarity with EV usage. They primarily mention the need to adapt to using a different type of vehicle than an ICEV. This includes concerns about understanding how an EV drives, the driving range, and charging aspects, such as the time required for an EV to charge. Participants state their willingness to wait because of the novelty of EVs. They want to familiarise themselves with the use of EVs first before considering using one themselves. One specific aspect discussed as something they need to get used to is charging an EV, because of the driving range. Both participants have children, but one is living together with a partner, and the other one is single.

5.2.2 Driving range

Participants from all income groups state the driving range of an EV is a barrier to EV adoption. There was no noticeable difference between household types. Participants mention different reasons why the driving range is a concern for them. Participants of all income groups simply state that the range is not sufficient and they don't want to charge often. They aim to charge less often and therefore be able to travel longer distances. Middle-income participants do state that they would adopt an EV if the driving range is improved in the future. In addition, low- and middle-income participants state reluctance to having to make a plan in advance, and having to think about how far they will drive and where they will have to load. Low- and middle-income participants express fear of getting stranded on the highway, because of a not-charged EV.

See, if you run out of fuel halfway, you can grab a jerrycan and get some fuel. But how do you do that with an electric car? You'd be stuck. Nobody comes around with a charger (low-income, ICEV-owner, household consisting of one person).

In addition, participants from all income groups state that they don't want to use an EV for vacation. They give the reason that they either don't want to travel longer by having to stop frequently to recharge, or they are concerned about the lack of sufficient charging points abroad.

5.2.3 Charging facilities

Public charging

The availability of charging facilities is a frequently mentioned barrier. Participants from all income groups state that there aren't enough charging stations, and they express a reluctance to have to search for a charging station. There was no noticeable difference between household types.

So, if you want an electric car, you have to search for a charging station? Then it's definitely searching for a charging station, yes. And it's often the case that the parking spots with charging stations are already occupied by other cars. That's also not conducive to people thinking about buying an electric car (middle-income, private lease EV, household consisting of one person).

Low- and middle-income participants state that there are specifically not enough charging poles in their neighborhood. There is an inadequate number of charging poles compared to the number of EVs present. Furthermore, middle-income participants express frustration that EV owners occupy EV parking spaces for too long. They fear that they will face parking problems when they own EVs themselves. In addition, participants of all income groups state having concerns about the availability of charging stations abroad, mainly concerning vacations. This is stated mainly by households consisting of partners with children, and one single without children.

Home charging

Participants of all income groups state that the inability to charge at home is a disadvantage for EV adoption. There was no noticeable difference between household types. Their preference is to have the convenience of charging at home, and if this option is unavailable, they feel displeased. A participant highlighted the difficulties associated with the absence of home charging.

Why I might have less of a chance than other people? I live in a flat on the eighth floor. People who live in a terraced house, or at least downstairs, can just get a connection at home to charge the car. That doesn't happen with me, so that would be a disadvantage when I have less chance as my neighbor who lives in a terraced house (low-income, ICEV-owner, households consisting of one person).

The participants don't delve into the possibility of being able to charge an EV at their workplace, suggesting that workplace charging is not considered significant for EV adoption among these participants.

5.2.6 Tempo-spatial constraints

The tempo-spatial constraints were not thoroughly addressed. Participants gave limited insight into the coordination of arrangements between family members when making transport choices. While some participants mentioned their travel arrangements related to children and household chores, they did not elaborate on how these factors influence EV adoption. This suggests that daily travel heavily depends on cars, but also that time constraints within a household don't substantially influence EV adoption. The choice of a specific vehicle, like adopting an EV, isn't influenced by household time constraints. Thus, tempo-spatial constraints are excluded from the chapter's summary table.

Additionally, the question arises whether households with children feel that their situation is acknowledged in the EV transition process. A participant notes that households with children aren't adequately considered in this process, indicating the need for more recognition for households with children in the EV transition process.

I'm sure they will think about that. But we don't necessarily notice anything about it. I also have no idea how that works within a municipality and in what way they try to do that. But I don't have the feeling that this is then very actively thought about. In any case, I don't notice anything about it (high-income, private lease EV-owner, household with children).

Table 3: Perceived EV use barriers of households

EV utilization barriers	Income groups and household composition
Familiarity with EV use	Low- and middle-income participants state the need to get used to an EV compared to an ICEV. This is stated by

		<p>households consisting of a single, and partners, with children.</p> <ul style="list-style-type: none"> • Low- and middle-income participants note the importance of the novelty of an EV diminishing first. • A middle-income participant states not know the charging time of an EV and the driving range
Driving range		<p>Participants of all income groups state the driving range of an EV to be a concern. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • Participants of all income groups state that the range is not sufficient and they do not want to charge frequently. • Low- and middle-income participants state reluctance to plan a trip. • Participants of all income groups state that they don't want to use an EV for vacation. • Low- and middle-income participants express fear of getting stranded on the highway.
Charging facilities	Public charging	<p>Participants of all income groups state that there are not enough charging stations. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • Low- and middle-income participants state that there are specifically not enough charging points in their neighborhood. • Middle-income participants state that the charging poles are always occupied. <p>Participants of all income groups state having concerns about the availability of charging stations abroad. This is stated mainly by households consisting of partners with children, and one single without children.</p>
	Home charging	<p>Participants of all income groups state that the inability to charge at home is a barrier to EV adoption. There was no noticeable difference between household types.</p>

5.3 Sustainability barrier

The sustainability of the lifespan of EVs can influence household decisions regarding EV adoption due to battery manufacturing and dismantling processes. This barrier doesn't align with any other chapter because it pertains to the sustainability impact of EVs, which is interconnected with the broader global disadvantages of the EV transition. See Table 4 for an overview of the perceived EV sustainability barriers of income groups and household types.

5.3.1 Sustainability of the lifespan of EVs

Participants from all income groups question the extent to which EVs are truly sustainable. There was no noticeable difference between household types. They express concerns about both the production of batteries and what happens to the batteries when they are no longer functional. There is no difference noticeable between the income groups and their sustainability concerns. Additionally, a low-income participant also wonders whether the electricity used to charge EVs is generated

sustainably. A participant even suggests that using an EV is as environmentally impactful as using an ICEV.

Ultimately, it comes down to the same thing whether you drive a petrol or diesel car. And as I just mentioned, the production of those batteries is hugely environmentally harmful and polluting. So, whether you drive electric, petrol, or diesel, it makes no difference. Okay. So, that's also a big question (middle-income, private lease EV-owner, household consisting of one person).

Table 4: Perceived EV sustainability barriers of households

Sustainability of the lifespan of EVs	<p>Participants of all income groups express concerns about both the production of batteries and what happens to the batteries when they are no longer functional. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • A low-income participant also wonders whether the electricity used to charge EVs is generated sustainably.
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5.4 Impact of EV measures on EV adoption

EV measures can impact households’ decisions regarding the adoption of EVs due to awareness and affordability concerns. Several aspects of EV measures are considered, namely awareness of EV measures, transport-related social exclusion through EV measures, participation in the EV transition, downsizing the financial EV incentives in the future, and ideas for improvement of more equitable EV subsidies. Participation in the EV transition consists of the imposition of EV measures, the importance, and the opportunity for participants to participate. See Table 5 for an overview of the perceived EV measures barriers of income groups and household types.

5.4.1 Awareness of EV measures

Participants of all income groups state that they lack sufficient information about EV measures, noting they are only partially familiar with them. There was no noticeable difference between household types. Being insufficiently informed is perceived as a barrier to participation in the EV transition. Therefore, being uninformed is considered unfair, as households with more information are more inclined to make use of EV measures.

Yes, I feel like citizens are not well informed about these [EV] measures. So, you could say, or I would say, that it hasn't been entirely fair. Just like I said, it is a bit more like a coercive measure. That's how it comes across to me, a bit coercive. Yes. Yes, I personally think that's unfair (middle-income, private lease EV, household consisting of one person).

Participants state that they are insufficiently informed about EV measures, because of a lack of information from the government and a lack of policy understanding. Low- and middle-income participants state that the government doesn’t provide enough information about the EV measures. A middle-income participant states that the information provided by the municipality does not reach all socio-economic groups effectively. The government could provide more information through media channels or should give information where you can get more information about EV measures. A low-income participant states that households interested in adopting an EV have to find out the details themselves or rely on information from their garage.

Some participants state never actively sought information about EV measures. Participants of all income groups state that they have not delved into the EV policies and, therefore, don't know the details of what it entails.

No, I don't know those [EV incentives]. I do know that the government uses incentives and that there are indeed some benefits. In terms of tax, in terms of additional taxes and things like that. I've never really looked into it (middle-income, ICEV-owner, household with children).

5.4.2 Transport-related social exclusion through EV measures

Participants from all income groups state that it is particularly challenging for low-income individuals to participate in the EV transition. This is stated mainly by partners with children and one single without children. Low-income participants are concerned about their ability to purchase an EV in the near future, especially as the novelty of EV technology keeps prices relatively high. Participants with lower incomes express concerns that if the government continues with initiatives that promote electric driving as the norm, they fear that they may be left without a car.

There are still so many cars that run on petrol. In seven years, I don't think everyone will have one of these [EVs]. This car, or whatever. And then there will be so many people thinking, yeah, well, where am I going to get the money to buy a car like this? And so do I. And then what do you do? Okay, then you say, this car can't be driven. Then you take this car to the scrap yard, but then you don't have a car. And how can you go on (low-income, ICEV-owner, household with children)?

They stress that current EV subsidies are insufficient for low-income earners, along with the exclusion of ICEVs in certain places. If ICEVs are completely excluded and the purchase cost of EVs remains unaffordable, especially for those on lower incomes, it could mean that this group no longer has access to cars. The inability to have access to EVs makes it difficult for low-income groups to reach certain daily activities with a car.

Who do you think is not benefiting from these measures? Well, those who can't afford it. Because it's not quite as simple as it seems. In the end, of course, we all benefit in terms of the environment. So I think it's important to have mentioned that. But if it's purely about mobility. And at some point, you can only go to a certain place with an electric, or at least a low-emission vehicle. Then it's mainly the people who can't afford that, who are disadvantaged (middle-income, EV-owner, household with two partners).

Using public transport as an alternative to car use isn't an option for participants. They state that public transport is too expensive and lacks flexibility. The lack of flexibility is linked to both the long travel time compared to cars and the inadequate supply of public transport. The inability of low-income groups to use a car may lead to transport-related social exclusion of this group. Concerns exist that transport-related social exclusion may contribute to increased inequality across various aspects of society. This is because low-income households are less able to participate in the EV transition, and due to the exclusion of ICEVs in certain areas, they may encounter more challenges accessing health care, education, or employment opportunities. This could create more inequality between income groups, and it could potentially cost the government more money through the reduced mobility of low-income households.

The moment you start setting a precedent where you start forcing people to do things like that, then you are going to put people in such a position that they are therefore going to become less mobile. These are often the households that already don't have very much to do.

Those will have higher indebtedness, so the social burden is going to be even greater (high-income, EV owner and business EV lease, household consisting of couple without children).

Participants thus argue that this distribution of advantages and disadvantages in the EV transition is unfair, leading to distributive injustice. Implementing EV measures that specifically target low-income households, such as subsidies, can help alleviate financial barriers and promote greater equality.

5.4.3 Participation in the EV transition process

Imposition of EV measures

Low- and middle-income participants experience a sense of urgency to participate in the transition to an all-EM zero-emission zone for all personal transportation in the city center in 2030 and don't want to be forced to participate. They feel that they have insufficient influence on the EV transition and that they aren't adequately involved in the process. There was no notable difference between the household types.

Yes, I have the feeling that the citizen has not been adequately consulted in these measures. So, you could say, I would say, that it hasn't been entirely fair. Just as I'm saying, it comes across as a bit coercive then. That's how it feels to me, a bit coercive. Yes. Yes, I personally find it unfair (middle-income, EV lease owner, household consisting of one person).

Importance of participation

Low- and middle-income participants delve into the importance of the opportunity for participation in the EV transition. There was no notable difference between the household types. Participants emphasize the importance of making the EV transition a topic of discussion. They state that the government shouldn't make decisions by themselves without listening to their citizens. They believe that everyone's voice should be heard. Participants express their desire to be involved, to have the opportunity to contribute their thoughts, and to have a say in the decision-making process concerning the EV transition. Suggestions are made to encourage participation, such as instituting a referendum or using focus groups on key decisions within the EV transition.

I think that if you talk to everyone, with a wide range of different groups, you will encounter a lot of opinions. And maybe you make it [EV policy] more open for discussion. That everyone has their own opinion and is especially being heard. I think that is also an important aspect. Yes, I find that quite interesting (middle-income, ICEV-owner, household consisting of one person).

In addition, low- and middle-income participants state they don't see the value of participation in the EV transition process and express that either they lack interest in participating or believe it is best to leave it to others. However, this middle-income participant also states the importance of participation before.

Opportunity to participate

Participants of all income groups state that they perceive there is no opportunity for them to participate in the EV transition process, and express a sense of exclusion. There was no notable difference between the household types. They feel like the government holds control of the EV transition process, and as a result, they do not have the opportunity for input.

That I have influenced myself? Uhm... No, I don't think so.

No, why not?

Well, these measures are conceived and implemented. And if I disagree with that, I don't think anyone cares (low-income, ICEV-owner, household with children, single with a child).

In addition, if participants would like to participate and have a say in the EV transition, they wouldn't know how. This is mentioned among all income groups.

I don't feel that local citizens are very much considered. That they are included in such choices or questioned. Whether they don't know which way. I have never heard, so to speak. So they have no idea about my travel needs. I think. Yes, that's a bit negative. But no, I don't think so (high-income, private lease EV, household with children).

5.4.4 Downsizing financial EV incentives in the future

In 2025 the subsidy for EVs will end and EV owners have to pay road tax, like motor vehicle tax, again. Participants of all income groups state that the downsizing of the financial EV incentives has a negative effect on their decision to adopt an EV. There was no notable difference between the household types.

I know that the motor vehicle tax exemption will be discontinued. You don't pay that now if I'm correct. And you will have to encumber that in the future.

Yes, that's correct. And what do you think about it being discontinued?

Well, that's one less reason to purchase an electric vehicle. If the government wants to keep encouraging that, then they shouldn't do that, I think (middle-income, private lease EV, household consisting of one person).

However, participants of the high-income group don't specifically discuss their financial situation, but make a general statement that this could persuade people not to adopt an EV. Indicating that the downsizing of EV incentives has more effect on the middle and low-income group than it has on the high-income group.

In addition, a low-income participant states that early adopters, mainly high-income households, are the winners of the EV transition. This group could benefit from the EV measures, while lower-income groups were excluded from the EV measures. When EV adoption became more widespread, the government decided to discontinue EV incentives, leaving lower-income groups without the opportunity to take advantage of these incentives, which is seen as unfair.

It is now that people who are frontrunners can take advantage of all kinds of incentives and later when it becomes a bit more massive and an electric car also becomes more accessible to people with somewhat lower incomes then all those incentives will be phased out (low-income, ICEV-owner, household of one person).

5.4.5 Ideas for improvement financial EV incentives

Participants from all income groups and household types state that the current subsidy agreement on EV adoption is not in proportion to income. The EV subsidy where everybody gets the same amount of subsidy, after the purchase of an EV, is perceived as unequal. Low-income, and in a smaller amount middle income, households can't participate in the EV transition with the current EV subsidy, while high-income groups can purchase an EV without subsidy. This indicates that improvements can be made in distributive justice, with a greater focus on addressing different income levels.

Participants of all income groups have provided ideas for improving the accessibility of EV purchases and EV subsidies for low-income households. The most frequently stated idea, mentioned by all income groups, is to implement income-based EV subsidies. This was mentioned through mainly

households, singles, and partners, with children, and one participant who is in a LAT relationship without children.

Participants state that everyone, regardless of income group, should have the right to purchase an EV. They suggest that low-income households should receive a higher subsidy than middle-income households, and middle-income households should receive more than high-income households. In addition, low- and high participants state that eligibility for EV subsidies should not depend on the minimum amount you must spend on an EV purchase to qualify for the subsidy. There was no noticeable difference between household types.

Everyone, regardless of income, should be able to purchase an electric car with the support of the government. That's something you could do. So, it's not based on the minimum; everyone gets the opportunity. But, it should be based on income (high-income, EV-owner, household with children).

There's even a suggestion that high-income households, that can afford to purchase an EV without a subsidy, should not receive any subsidy at all.

And then you could say, equal treatment for everyone, but I don't agree with that.

Do you think that if people can afford such an expensive car, they don't need the subsidy?

No, it would be better to allocate those funds to another purpose (low-income, ICEV-owner, household consisting of one person).

Furthermore, low- and middle-income participants state that the EV subsidy should be overall higher. This is stated by households consisting of singles with and without children. For example, participants state that instead of the current subsidy, you should get half of the purchase price of an EV back. Other participants state that increased subsidies for used EVs could encourage more purchases. A participant proposed that the government could offer a subsidy for the replacement of used EV batteries, which would reduce people's reluctance to purchase a used EV.

Lastly, a middle-income participant discusses a government subsidy designed to assist young, newly employed households in purchasing an EV, especially considering their need to acquire both a house and a car. There was no noticeable difference between household types.

Table 5: Perceived EV measures barriers of households and ideas for improvement of EV measures

EV measures barriers	Income groups and household composition
Lack of awareness of EV measures	Participants of all income groups state that they are partly familiar with the EV measures. There was no noticeable difference between household types. <ul style="list-style-type: none"> • Low- and middle-income participants state that the government doesn't provide enough information about EV measures. • Low- and middle-income participants state not understand what specific EV measures entail. • Participants from all income groups state never delved into the EV measures.
Transport-related social exclusion	Participants of all income groups state having concerns about transport-related social exclusion for

		<p>disadvantaged households. This is stated mainly by partners with children and one single without children.</p> <ul style="list-style-type: none"> • Participants of all income groups state that inadequate EV measures for low-income households and the restriction of ICEVs in certain areas contribute to potential transport-related social exclusion for low-income households. • Participants of all income groups state that public transport isn't an option, because of high costs and inflexibility.
Participation in the EV transition process	Imposition of EV measures	<p>Low- and middle-income participants don't like to feel like they are forced to participate in the EV transition. There was no noticeable difference between household types.</p>
	Importance of participation in the EV process	<p>Low- and middle-income participants state the importance of participating in the EV transition process. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • Middle-income participants state instituting a referendum on key decisions within the EV transition. <p>Low- and middle-income participants state participation in the EV transition process is not important.</p>
	Possibility to participate in the EV transition process	<p>Participants of all income groups state not being able to participate in the EV transition process. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • Participants of all income groups state that they can't participate because the government is in control. • Participants of all income groups state they can't participate because they are unaware of the possibility of participating.
Downsizing financial EV incentives		<p>Participants of all income groups state the future downsizing of EV measures is a barrier to EV adoption. There was no noticeable difference between household types.</p>
Ideas for improvement financial EV incentives		<p>Participants of all income groups bring in ideas to improve the equity of EV measures.</p> <ul style="list-style-type: none"> • Participants of all income groups suggest implementing income-based EV subsidies. This is stated mainly by households consisting of partners, single, with children, and one person in a LAT relationship without children. • Low- and high participants suggest that households shouldn't have to spend a

	<p>minimum amount on an EV purchase to qualify for subsidies. There was no noticeable difference between household types.</p> <ul style="list-style-type: none"> • Low- and middle-income participants suggest that EV subsidies overall should be higher. This is stated by households consisting of singles with and without children. • A middle-income participant suggests that there should be subsidies designed to assist young, newly employed households in purchasing an EV.
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6. Discussion

In the discussion, the results of the present study are confronted with the existing literature in the field of Transport Justice. The aim is to address and answer the sub-questions of the current study. The correlation between household decisions on EV adoption and justice dimensions of transport is discussed. This chapter is divided into financial considerations, usage considerations, and participation of households in the EV transition. At the end of this chapter, there is an overview of the perceived barriers of low-, middle- and high-income groups (see Table 6).

6.1 Financial considerations when adopting an EV

6.1.1 Initial purchase price

The low-income group is explicitly cited as encountering difficulties with EVs' high initial purchase price and their exclusion from government incentives, which are only available to those with a median income or above. Low- and middle-income participants expressed concerns about the initial purchase price of new and used EVs and the lack of accessible subsidies. There was no noticeable difference between household types and statements made about the initial purchase price of an EV. This indicates that household types don't influence the perceived purchase price barrier.

Low- and middle-income participants state that the price of used EVs is still too high, because of the novelty of EVs. The literature suggested that low-income households might be more inclined to adopt a used EV as the price decreases (Canepa et al., 2019). However, the interviews revealed that the price of used EVs needs to fall further before more adoption occurs. In addition, low- and high-income participants state that a used EV is a risky purchase, because of the decreasing value. This aligns with the literature indicating that the depreciation of an EV's value can negatively impact consumers' choices regarding EVs (Anastasiadou & Gavanas, 2022).

High-income groups did not express difficulties encountering the high initial purchase price. These findings align with the literature, which suggests that higher-income households have better access to financial opportunities and EV incentives, while low-income groups face difficulties due to limited financial resources (Caulfield et al., 2022). This indicates that there is distributive injustice of EV purchase subsidies, disadvantaging low- and middle-income households.

In addition, low- and middle-income households made the statement that they have other priorities than purchasing an EV, such as maintaining their well-functioning ICEV or buying a house. This indicates that higher-income participants do not face the same trade-offs when deciding to adopt an EV. This highlights the importance of recognizing that low- and middle-income households, due to their limited financial resources, must take into account other financial expenses before

deciding to adopt an EV. This is stated by households consisting of singles without children, and once by a participant who lives together with a partner and has children. This suggests that these households may be more inclined to consider alternative financial options rather than adopting an EV. It could indicate that households with children prioritize different considerations above financial considerations. It could also indicate that households with dual earners may have fewer financial considerations to take into account, given that they generally have more financial resources than single earners (Maat & Timmermans, 2009).

6.1.2 Maintenance costs

Low-income participants make statements about the general maintenance of EVs being too high for them. This is stated by households consisting of singles, with and without children. This suggests that singles play greater importance in the maintenance costs of EVs than other household types. This could also be attributed to the fact that single earners typically earn less money than households with dual earners (Maat & Timmermans, 2009). It is important to recognize that households with less to spend, may face greater challenges in covering maintenance costs.

Participants of all income groups have concerns about the life expectancy of new and used EV batteries. However low- and middle-income participants explicitly state having to replace a battery is a concern because of the expenses. This is in line with the literature, saying that the fear of a potentially defective battery can be perceived as a significant risk (Canepa et al., 2019), and can discourage households from adopting an EV (Adhikari et al., 2020). The literature connects potential battery replacement as a concern of used EVs, but the results indicate that this concern is mentioned both with new and used EVs. There was no noticeable difference between household types and statements made about battery replacement, indicating that household types don't influence the perceived battery replacement price barrier.

A low-income participant states that the technological advancement of EV batteries is a reason to wait to purchase an EV. This aligns with existing literature, which states that the absence of conclusive evidence regarding the reliability and performance of EVs is cited as a technical barrier to their adoption (Adhikari et al., 2020). The literature suggests that individuals with lower incomes may face more challenges with the current technical capabilities of EVs, as people with higher incomes tend to have a greater acceptance of new technologies (Canepa et al., 2019). This indicates the importance of recognizing that low-income households may be hesitant to embrace the new technology of EVs.

6.1.3 Charging costs

Low-income participants state that a high charging price is a barrier to adopting EVs for them. Participants express the desire to compare electricity rates with gasoline prices, aligning with the literature indicating that charging costs are barriers to EV adoption (Anastasiadou & Gavanas, 2022). However, the interviews don't explore the costs of charging at specific locations, such as at work, at home, or in public, which differs from the literature. The importance that low-income households attach to charging costs, could result from the fact that low-income individuals generally allocate a larger proportion of their income to energy expenses (Sun et al., 2023). This indicates the importance of recognizing that energy costs make up a relatively larger share of household expenses for low-income households. This observation aligns with the literature, which indicates that high-income households place less importance on fuel costs (Liao et al., 2017). This is stated by households consisting of singles with children and a person in a LAT relationship without children. This could also be because single earners have less to spend than double earners (Maat & Timmermans, 2009).

In addition, the literature states that the adoption of green energy may exacerbate energy equity issues, as benefits from renewables can be unevenly distributed (Sovacool et al., 2019), favoring wealthier households (Finley-Brook & Holloman, 2016). Renewable energy benefits include solar panels and energy efficiency upgrades that lead to energy cost savings (Finley-Brook & Holloman, 2016). It is important to recognize that households are more likely to switch to EV adoption when the purchase is combined with a solar power system. This suggests that policies that encourage this bundling may promote EV adoption in general (Anastasiadou & Gavanoas, 2022). However, the results did not show that conversely not having a solar power system makes people less likely to want to buy an EV, as the electricity costs would be higher than if a household could generate its electricity. Either way, this cannot be ruled out as a factor in buying an EV. The government could make subsidies for solar panels more accessible to low-income households, thus indirectly improving the distributive justice of EVs.

6.2 Utilization considerations when adopting an EV

6.2.1 Charging facilities and driving range

The unavailability of nearby charging facilities is frequently mentioned by participants of all income groups as a crucial barrier to EV adoption, in line with the literature (Adhikari et al., 2020; Karlsson, 2017). There was no noticeable difference between household types and statements made about the charging facilities of an EV. This indicates that household types don't influence the perceived charging facilities barrier. However, the results show that low- and middle-income households have more difficulty finding available charging facilities in their neighborhood. This result is consistent with the literature, which states that the distribution of EV charging infrastructure is uneven, with limited access to charging stations in lower-income areas (Khan et al., 2022).

Participants of all income groups state that the inability to charge at home is a barrier to EV adoption. This is consistent with the literature, which indicated that having charging points available at or near home is essential for consumers to seriously consider adopting an EV (Canepa et al., 2019; Chakraborty et al., 2022; Scorrano et al., 2020). Charging at home also didn't show any noticeable differences between household types and statements. The reasoning behind this could be that urban dwellers, regardless of income, often lack private parking spaces, leaving residents dependent on limited street parking (Guo, 2013). While participants do express a desire to charge their EVs at home, their motivation leans more toward convenience than financial considerations. This contrasts with the literature, which suggests that, besides convenience, charging at home is especially beneficial due to lower charging costs (Scorrano et al., 2020). The interviews don't explore the possibility of being able to charge an EV at the workplace, with low charging costs, which also differs from the literature (Chakraborty et al., 2022).

Participants of all income groups also stated that they don't want an EV for holidays, because they would have to charge it on the road. They are afraid that it might be more challenging to find charging stations abroad. This is in line with the literature, saying that during a vacation, people don't want to consider and plan their trip solely based on the availability of public charging stations for their EVs (Chakraborty et al., 2022). This is stated by households consisting of partners with children, and one single without children. This observation might imply that locating charging stations abroad is viewed as a barrier for these specific household types. No underlying relationship has been identified for this phenomenon.

Participants of all income groups state the driving range of an EV to be a concern. These fears include running out of energy during journeys and limitations for vacations. This aligns with the literature, which indicates that the limited range may cause range anxiety concerns, especially for users with longer daily commutes (Adhikari et al., 2020). There was no noticeable difference between household

types and statements made about the driving range of an EV. This indicates that household types don't influence the perceived driving range barrier.

Low- and middle-income participants explicitly mentioned their hesitation to plan trips, while high-income participants didn't mention this. Participants from these income groups also expressed concerns about the possibility of being stranded on the highway. This can be viewed as a form of distributive injustice, as higher-income households have the financial means to acquire EVs with a longer driving range, providing them with fewer limitations in planning vacations compared to middle- and low-income groups. Another possible explanation according to previous research could be that higher incomes are more likely to have a second car (Maat & Timmermans, 2009), with one of the cars being an ICEV used for longer distances, thereby reducing EV range concerns (Liao et al., 2017). This indicates the importance of recognizing that owning an EV leaves low- and middle-income households more exposed to driving distance constraints and dependent on only one car. However, this was not notable in the results of the current study.

6.2.2 Time-spatial constraints

Previous research shows that the coordination of daily activities among members can influence the final joint choice to purchase a vehicle (Guan & Wang, 2019a). However, based on the results, this is not evident as time-spatial constraints related to EV adoption were not addressed. Therefore, no conclusions can be drawn on the time-spatial constraints of households and their influence on EV adoption based on the data provided by participants. However, it has been stated that the needs of households with children are not sufficiently considered in the process of EV transition, indicating recognition injustice of this group. The inclusion of input from households with children in the EV transition process could contribute to mitigating this barrier. These findings highlight the need for more focus on household composition and time constraints in EV adoption in future research.

6.2.3 Knowledge of EV characteristics and measures

Low- and middle-income participants express reluctance to use EVs and prefer to wait for further developments. This is consistent with the literature, which suggests that people may be reluctant about the technological performance of EVs because of their relative novelty (Adhikari et al., 2020). This is stated by households with children, indicating that these households place more importance on comprehensive information about EVs than other household types. This may be attributed to the fact that the presence of children contributes to considerations in travel arrangements (Guan & Wang, 2019b; Ho & Mulley, 2015). The coordination of daily activities among household members influences travel decisions (Guan & Wang, 2019a, 2019b; Ho & Mulley, 2015; Hu et al., 2023; Maat & Timmermans, 2009), potentially impacting the collective decision to purchase a vehicle (Guan & Wang, 2019a). Having children thus involves taking into account the travel plans of more family members, and consequently, households with children may seek additional information about EVs compared to other household types, as more household members depend on the car.

Potential EV users need information about the benefits of EVs and the risks associated with accepting new technology (Anastasiadou & Gavanas, 2022). Lack of information about the features of EVs is a barrier to acceptance (Anastasiadou & Gavanas, 2022; Broadbent et al., 2021). The discrepancy in adoption rates between income groups might be attributed to higher socio-economic status individuals being more inclined to embrace new technologies earlier, while low and middle-income groups exhibit more caution due to perceived risks and limited disposable income (Canepa et al., 2019). This highlights the importance of recognizing the reluctance of low- and middle-income groups to the new technology of EVs.

In addition, participants of all income groups raised questions about the sustainability of EVs. There was no noticeable difference between household types and income levels and statements made about the sustainability of an EV. This indicates that household types don't influence the perceived sustainability barrier. They express concerns about both the production of batteries and what happens to the batteries when they are no longer functional. The literature states that sustainability barriers include, battery production, power generation, and battery disposal (Henderson, 2020), which aligns with the findings. Additionally, people wonder whether the electricity used to charge EVs is generated sustainably. Questioning the sustainability of EVs suits the behavior of late adopters. According to the literature, late adopters need more convincing to make the switch to EVs than early adopters. These users want to wait until there is a fully developed EV market (Broadbent et al., 2021).

Furthermore, participants of all income groups state that they are partly familiar with the EV measures. This aligns with the literature, which indicates that potential users may be unaware of the benefits associated with EVs, influencing their decision-making process when considering EV adoption (Adhikari et al., 2020). There was also no noticeable difference between household types and statements made about awareness of EV measures. In addition, Low- and middle-income participants state that the government doesn't provide enough information about EV measures and that they don't understand what some EV measures entail, which highlights the presence of recognition injustice. The literature suggests that there is greater resistance to EV adoption among consumers who are less familiar with available EV incentives (Broadbent et al., 2021), therefore, the lack of knowledge about EV incentives is a barrier to EV adoption. The fact that households of all income groups are only partially, and not wholly, familiar with EV measures indicates the need for more information about EV incentives.

A lack of information about both EV policies and the characteristics of EVs is a barrier to acceptance (Anastasiadou & Gavanas, 2022; Broadbent et al., 2021). According to the literature, these barriers could be reduced, and potential EV adopters could be encouraged through the provision of more information about EVs. Providing information both by the government itself and the media, since media is the most common means of obtaining information about EVs (Adhikari et al., 2020; Anastasiadou & Gavanas, 2022).

6.3 Participation of households in the EV transition

6.3.1 Transport-related social exclusion

Participants of all income groups express concern for reduced mobility for low-income households due to the transition from ICEVs to EVs. This is stated by partners with children and one single without children, indicating that these households have more concerns about transport-related social exclusion than other household types. This can be explained by the impact of children on travel arrangements (Guan & Wang, 2019b; Ho & Mulley, 2015). Having children involves considering the travel plans of more family members, as more household members depend on the car. Because more family members rely on the car, coordination among family members is necessary. This may lead to greater concerns about the inability to carry out daily activities if EV adoption isn't possible.

They state that inadequate EV measures for low-income households and restrictions on ICEVs in specific areas could lead to these households being without access to a car. This potential outcome may contribute to transport-related social exclusion for those with lower incomes, aligning with findings in the literature. Insufficient transportation could limit people's involvement in economic, political, and social life (Gössling, 2016; Lucas, 2019). The absence of Transport Justice could therefore lead to transportation-related exclusion (Lucas, 2019).

Recognition and participation of the low-income group can create more equity and less resistance in the EV transition. This highlights the importance for the government to focus on increasing awareness about EV policies and allowing for greater public participation in decision-making. As the literature suggests, good procedural decision-making can lead to significant gains in distributive justice and recognition justice (Finley-Brook & Holloman, 2016). Therefore, involving individuals from the low-income group in the policy-making process can lead to more equitable policies and reduce barriers for this group to participate in the EV transition.

6.3.2 Participation in the EV transition

Low- and middle-income participants stress the importance of their participation in the EV transition process. However, participants of all income groups state not being able to participate in the EV transition process. This is partly because they feel that the government has all the power and that there is no room for participation, or that they don't know how to participate. This leaves them with no opportunity for input or involvement in the EV transition. In addition, Low- and middle-income participants expressed concerns about the enforcement of the policy. Participants expressed feeling obligated to participate in the EV transition, which they find displeasing, indicating recognition injustice. This lines with the literature, stating that the EV transition can be accelerated and resistance within certain population groups can be minimized through the implementation of more equitable EV policies (Schwanen, 2021). There was no noticeable difference between household types and statements made about unawareness of EV measures. This indicates that household types don't influence the perceived unawareness EV measures barrier.

6.3.3 Ideas of participants for improvement financial EV incentives

The literature states that current EV purchase price subsidies primarily benefit higher-income households, while low-income individuals face challenges in affording them (Adhikari et al., 2020). This is in line with the findings, that both new and used EVs are considered too expensive for low-income- and middle-income households, indicating distributive injustice. Participants of all income groups expressed dissatisfaction with the current EV subsidies and provided suggestions to make them more equitable for all income groups.

The ideas presented primarily revolve around income-based purchase price subsidies, as well as overall increases in purchase price subsidies. Participants of all income groups suggest implementing income-based EV subsidies. This is stated mainly by households consisting of partners, single, with children, and one person in a LAT relationship without children. This suggests that these household types place greater importance on income-based subsidies. Households with children face additional expenses associated with childcare, leaving them with less money available for other expenses. Financial considerations weigh more heavily on low- and middle-income households. This suggests that low- and middle-income households with children are more likely to benefit from income-based subsidies. Low- and middle-income participants suggest that EV purchase price subsidies overall should be higher. This is stated by households consisting of singles with and without children. This could be linked to the fact that single earners tend to earn less money compared to households with dual earners (Maat & Timmermans, 2009). Consequently, they may have less financial resources to adopt an EV and thus could potentially benefit from higher subsidies.

Enabling individuals with lower incomes to partake in the EV transition and experience the advantages of owning an EV contributes to a more equitable distribution. This is consistent with the literature suggesting that subsidy policies should be revised to achieve greater equity and accessibility for all income groups (Caulfield et al., 2022). In other words, revised EV subsidies, such as income-based subsidies, can reach more resources for low- and middle-income groups and thus create more distributive justice.

Despite suggestions for more equitable or even increased subsidies, incentives for EVs are set to be terminated. The future reduction in subsidies and discontinuation of beneficial arrangements were mentioned by every income group and all household types as a barrier to EV adoption. This highlights that the purchase price and operating costs of EVs have a considerable impact on all income groups, but they particularly affect low- and middle-income households. This aligns with the literature that argues that the subsidy program should not be abolished because it serves as an incentivizing mechanism for everyone to adopt an EV (Caulfield et al., 2022). This suggests that ending these EV incentives will lead to more barriers to EV adoption. However, the interviews do not suggest that ending these EV incentives will lead to a greater degree of distributive injustice, as it was previously found that low- and middle-income households are largely ineligible for these incentives.

Table 6: Perceived EV barriers of income groups

Perceived EV adoption barriers	Low-income	Middle-income	High-income
Initial purchase price	Yes	Yes	No
Alternative financial considerations	Yes	Yes	No
Maintenance costs	Yes	No	No
Battery replacement	Yes	Yes	Yes
Battery replacement costs	Yes	Yes	No
Charging costs	Yes	No	No
Familiarity with EV use	Yes	Yes	No
Driving range	Yes	Yes	Yes
Having to plan a trip	Yes	Yes	No
Charging facilities	Yes	Yes	Yes
Charging facilities in their neighborhood	Yes	Yes	No
Home charging	Yes	Yes	Yes
Sustainability of EVs	Yes	Yes	Yes
Awareness of EV measures	Yes	Yes	Yes
Government information on EV measures	Yes	Yes	No
Imposition of EV measures	Yes	Yes	No
Possibility to participate in the EV transition process	Yes	Yes	Yes
Downsizing EV measures	Yes	Yes	Yes

7. Conclusion

This research focuses on answering the question: 'How do households of different income groups experience barriers to EV adoption, and how are these barriers related to Transport Justice?'. 25 interviews with ICEV and EV owners across different income groups residing in and around Utrecht were conducted to answer the research question. The results of this study show that low-income groups in particular, followed by the middle-income group, experience barriers to adopting EVs. Recognizing the additional challenges these groups face in participating in the EV transition is crucial to promoting greater equity in transport.

The main barriers that came across were financial barriers, such as the initial purchase price, alternative financial considerations, like still having a good working ICEV and wanting to buy a house, and potential battery replacement costs. Maintenance costs and charging expenses were only noted by the low-income group. Although the importance of charging costs for this group was underscored, the interviews did not delve into the expenses associated with home charging, charging at work, and public charging rates. Financial barriers may decrease for low- and middle-income earners if their financial situation is taken more into account. All income groups state that EV purchase price subsidies are not accessible to low-income households. This is because the minimum amount required to be spent on an EV, according to the subsidy measures, is financially out of reach for lower incomes. While middle-income participants also mentioned their inability to purchase an EV due to not qualifying for purchase price subsidies. This indicates that both low- and middle-income households report experiencing distributive injustice in EV subsidy measures. Making these subsidies accessible to both low and middle incomes would likely reduce the initial purchase price as a barrier. However, this doesn't provide clarity on how it would impact the other perceived financial barriers.

Participants of all income groups expressed concerns about the challenges faced by low-income households in adopting EVs, due to factors such as not qualifying for EV purchase price subsidies and the prohibition of ICEVs in certain areas. They worry that this could leave low-income individuals without a car, leading to transport-related exclusion. To prevent this, policymakers need to focus on equity in EV policies. One possible way to make EV subsidies more equitable for all income groups, as the findings show, is to introduce income-based subsidies. While the results show the need for more equitable EV measures for all income groups, the government plans to reduce financial incentives for EV adoption. All income groups indicate that this will be a barrier to their future EV purchase. This could mean that high-income households may start facing financial barriers in adopting an EV in the future.

High-income groups, like low- and middle-income groups, experience barriers on issues such as battery replacement, range, and charging facilities. However, closer examination reveals that low- and middle-income groups experience more specific barriers, both in terms of costs and limited access to charging facilities. Participants of these income groups indicate that battery replacement is a barrier for them because of the extra costs involved. Low- and middle-income participants are more likely to be reluctant to plan a trip with an EV, than high-income participants. And, charging stations are a barrier for them because they are less likely to be found in their neighborhood. Moreover, low- and middle-income groups are less familiar with using EVs than the high-income group. These groups provide more information about EVs and prefer to wait until the market is further developed. These barriers indicate distributive and recognition injustice, as low- and middle-income households experience more barriers due to their financial situation. Recognizing that low- and middle-income households face different barriers to adopting EVs than high-income households, enables the implementation of measures to alleviate perceived adoption barriers for low- and middle-income groups.

The results also show that all income groups have limited information about EV measures, lack knowledge on how to participate in the EV transition process, and have no opportunity to participate in the EV transition process. Inadequate communication from the government and media plays a role in these barriers. Low- and middle-income groups indicate that they don't want to be forced to participate in the EV transition and that the government does not provide enough information. This indicates that low-income households should be more included in the transition process to EVs to avoid resistance to the EV transition. By engaging all income groups in the EV transition process through improved government communication and empowering residents, thereby ensuring procedural justice, significant advancements could be achieved in the other dimensions of justice, namely distributive and recognition justice. Achieving advancements in distributive justice involves ensuring equal distribution of EV purchase subsidies and charging stations among different income groups and households. Progress in recognition justice means recognizing the differences between income groups and households in the barriers they experience. Improving the three justice dimensions can enhance Transport Justice in the context of EV adoption, reducing the likelihood of transport-related social exclusion for households.

The findings of this study did not reveal time-spatial constraints and the exact differences between household types and their perceived barriers. Consequently, no conclusions can be drawn on these aspects. However, the household type that emerged most frequently in connection with financial constraints was the single-person household. An assumption was made that single individuals earn less than households with dual incomes, potentially leading to more perceived financial barriers to EV adoption. In addition, households with children are predominantly associated with concerns about transport-related exclusion. The assumption is that, due to more family members relying on the car, coordination is necessary, potentially causing increased concerns about daily activities if EV adoption is not feasible. Regardless, future research could delve deeper into the influence of household composition and coordination on EV adoption, as this aspect was not thoroughly investigated in the current study. The current study has provided a broad overview of various barriers to EVs in households, and further in-depth research on the role of the household in EV adoption would complement this. This involves asking more detailed questions during interviews specifically about the household's role, particularly concerning composition and coordination in the context of EV adoption.

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