Energy Research & Social Science 130 (2025) 104449

Contents lists available at ScienceDirect

Energy Research & Social Science

journal homepage: www.elsevier.com/locate/erss

Original research article

Just transition to electric vehicles in disadvantaged communities: Integrating transportation, energy, environmental, and climate justice

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ARTICLE INFO

Keywords:
Equity
Transportation poverty
Energy poverty
Vehicle-to-home
Vehicle-to-grid
Theoretical framework

ABSTRACT

Electric vehicle (EV) adoption rates are disproportionately lower in low-income and ethnically minority communities, which may perpetuate injustices when electrifying the transportation system. Existing justice frameworks take siloed views of justice considerations in the transition to EVs, with connections between transportation, energy, and climate justice having been understudied. We developed and applied the novel Just Transition to Electric Vehicles (JTEV) framework, integrating justice considerations in the above domains. We conducted semi-structured interviews in four languages with 45 residents of underserved neighborhoods of Columbus, Ohio (USA) to investigate how EV adoption intersects with energy poverty, transportation poverty, and climate and environmental injustices. The interviews reveal five main justice themes for transportation, energy, climate, environment, and EV adoption and sub-themes of solar equity gap (under the energy justice theme), and five EV adoption subthemes: barriers to EV adoption, affordable energy support, perceived health and air quality benefits, climate benefits, and economic benefits. We showed how intertwined disadvantages perpetuate or exacerbate distributive, recognition, restorative, and procedural injustices in the EV transition. These findings are important for addressing the vicious cycle of injustices that hinder the capabilities of disadvantaged communities when designing policies for a just EV transition.

1. Introduction

As the transportation sector is the largest contributor to U.S. greenhouse gas emissions and a major driver of climate change [1], many cities have committed to achieving net-zero transportation carbon emissions by 2050, including strategies to transition from internal combustion engine vehicles (ICEVs, i.e., gasoline, diesel, compressed natural gas) to electric vehicles (EVs) [2]. In addition to the reductions in tailpipe CO_2 emissions [3,4], EVs may provide several other benefits. Financially, EV adopters may benefit from tax incentives, lower operational costs, and a lower percentage of household income spent on transportation [5]. From a human health standpoint, EVs emit lower levels of fine particulate matter (i.e., $PM_{2.5}$), which is known to be harmful to human health and increases risks for respiratory, cardiovascular, and neurological diseases [6,7]. The disparities in EV adoption rates across socio-economic groups lead to substantial disparities in the benefits of EVs across those communities.

Existing adopters of EVs tend to be educated, middle-aged with mid-to-high household income, homeowners, and able to install charging infrastructure at home [8], whereas adoption of EVs by those in low-income, marginalized, and/or underserved – hereafter referred to as "disadvantaged" – communities and communities of color is lacking [9]. This disparity is due to higher purchase prices for EVs [9], lack of access to home and public charging [10], and energy poverty – the inability to afford the energy for necessary household activities (e.g., heating, cooling) [11]. Being able to afford energy for charging is increasingly vital for EV adoption to meet transportation needs for access to life opportunities (e.g., employment, education, healthcare) [12]. In addition, transportation energy use is unequally stratified: the top 10 % and 20 % of consumers, respectively, account for 29.9 % and 47.5 % of primary energy consumption for transportation, while the bottom 50 % are responsible for only 20.4 % of primary energy use [13].

The unequal distribution of EV charging infrastructure and disinvestment of power grid facilities in disadvantaged neighborhoods, or the

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https://doi.org/10.1016/j.erss.2025.104449
Received 12 June 2025; Received in revised form 3 October 2025; Accepted 7 November 2025
Available online 17 November 2025

lack thereof, may exacerbate energy and transportation poverty, i.e., the lack of affordability and accessibility to energy and transportation services [11,14]. Without an increased capacity of the grid, electricity bills are increasing due to higher electricity demand from EVs throughout the regional energy system, which may stretch the budgets of low-income households and further prevent them from enjoying the financial benefits of EVs [15]. For example, nearly 25 % of households in the U.S. state of Ohio were unable to pay their energy bills in 2024 [16]. Further, EV owners in disadvantaged communities might not be able to charge them at home and thus rely on public charging infrastructure, which is lacking in disadvantaged communities, costlier to charge than at-home infrastructure, and can exacerbate disparities in EV adoption [17]. Disparities by socioeconomic context could even be starker in the context of nascent EV technologies such as solar-powered EVs and EVs with bidirectional charging features such as vehicle-to-grid (V2G) and vehicle-to-home (V2H). These technologies require costlier upfront investments to purchase the vehicles and install bi-directional charging infrastructure, but they could also provide more benefits, such as powering homes during outages [18], or can be sold to the electricity grid for a net profit with arbitrage [19].

Moreover, disadvantaged communities are more likely to experience energy-inefficient and substandard housing, older electricity distribution systems, and power outages during extreme weather [20,21]. Inefficient home energy systems increase energy bills, whereas unreliable grids are difficult to count on for charging EVs at home. Weather-induced power outages – which are increasing with climate change – may deter EV adoption in disadvantaged communities and hinder the success of climate policies [22].

Most studies of EV adoption focus on early adopters who are often affluent and technologically savvy [9,23–26]. Since principles of justice focus on improving conditions for the least well-off [27], issues of sample representativeness in prior work challenge understanding the barriers to EV transition in the context of disadvantaged communities. The transition to EVs intersects with considerations of transportation, energy, environment, and climate change, as well as issues of justice throughout these dimensions. Yet an integrated framework for this transition is lacking, and thus the systemic transportation and energy challenges that arise in transportation decarbonization are underappreciated.

Prior work tends to take siloed views of distinct justice concerns in transportation (i.e., socioeconomic and ethnic disparities in EV adoption) [25,26,28], energy (i.e., double energy vulnerability) [14,29,30], environment (i.e., disparities in health and air quality benefits associated with EV adoption) [7,31,32], and climate (i.e., disparities in the environmental footprint of EVs vs ICEVs) [33–35] domains in relation to EV adoption. Existing justice frameworks also lack a bottom-up perspective that characterizes lived experiences with injustices and experiences of capability deprivation [36–38]. In addition, conventional justice concepts rely on objective metrics and top-down identification of what constitutes injustice and, therefore, little is known of how people view and interpret transportation, energy, environmental, and climate injustices [39,40]. Such theoretical approaches may sustain and reproduce injustices.

We thus develop and apply the Just Transition to Electric Vehicles (JTEV) framework that aims to address the lack of integration and limitations of existing justice frameworks. In this JTEV framework, the *Capability Approach* [41,42] is the underlying theory, whereas the *distributive, procedural, recognition, and restorative tenets of justice* enable capabilities for a just transition to EVs. We apply this framework on 45 semi-structured interviews with residents of Columbus, Ohio (USA), most of whom live in disadvantaged neighborhoods, to understand: (1) their needs and experiences of transportation, energy, environmental outcomes, and climate change, and (2) their perceptions of, and barriers to, EV adoption as a result of these lived experiences. We use a reflexive thematic analysis to identify overarching themes of injustices in the EV transition and integrate those concerns across transportation, energy, environment, and climate dimensions.

By developing and implementing the JTEV framework, this work addresses several gaps in knowledge: (a) focusing on disadvantaged communities who face systemic barriers to EV adoption, rather than early adopters of EVs in higher-income groups; (b) advancing understanding of how EV transition intersects with the experience of transportation poverty, energy poverty, and climate change; and (c) addressing top-down biases of popular justice tenets by investigating how disadvantaged communities are affected by the deployment of EVs from the capability perspective. The findings from this study will help address systemic barriers that perpetuate existing injustices when designing policies for a just EV transition.

2. Theoretical framework

In the context of EV adoption, the conditions and processes in which disadvantaged communities are situated suggest several pertinent domains for a just transition:

- *Transportation justice*: focuses on disparities in the distribution of primary social goods (i.e., accessibility to opportunities, adoption of EVs, etc.) with an emphasis on transportation equity [9,24].
- *Energy justice*: focuses on the distributive impacts of energy production, energy infrastructure (e.g., grid, chargers), and residential energy demand for mobility [43,44].
- *Climate justice*: focuses on the unfair distribution of costs and burdens of climate change [45].
- *Environmental justice*: focuses on the unequal distribution of environmental burdens and benefits for different socio-economic groups [46,47].

Achieving justice in these domains requires a top-down process of just transition that collectively considers the four justice tenets: (1) *distributive justice* - the distribution of benefits and burdens, such as concerns associated with the distribution of environmental, public health, and economic well-being outcomes in EV transition; (2) *recognition justice* - the recognition of who is affected and the rights of different groups based on variations in capabilities to adopt EVs; (3) *procedural justice* - the inclusion and participation of interested parties and disadvantaged communities in decision-making processes; and (4) *restorative justice* - the recognition and rectification of past injustices [28,46–48], such as identifying and removing barriers to EV adoption in the transportation and energy systems.

Present justice frameworks have relied on these tenets of justice. However, most of them have universalist normative assumptions that can prejudice disadvantaged communities. That is, these tenets consider the aggregated justice outcomes of the entire population but not the disaggregated outcomes by different population segments [46]. These tenets also focus on the inequitable *outcomes* rather than the *processes* that lead to those outcomes, such as the intersection with one's lived experiences. For example, the experience of transportation and energy poverty, insufficient education, medical debt due to chronic conditions, physical exclusion (e.g., charging desert), and perceptual exclusion (e.g., perception of safety and trust in technology) may perpetuate existing injustices and create new inequitable outcomes in the EV transition [49]. As a result, embedding only the tenets in top-down policy approaches can omit various vulnerabilities and limit the applicability of these tenets [36]. There is thus a need to assess injustices in the EV transition by simultaneously examining the four tenets *and* their enabled residents' capabilities for adopting EVs.

The Capability Approach to social justice [41,42] has been used in some prior studies involving transportation justice to evaluate opportunities [50,51], and the bottom-up perspective highlights that inequities in EV adoption result from systemic injustices in transportation and energy systems. From a capability deprivation perspective, injustices manifest as the lack of access to and unaffordability of EVs. In

other words, people differ in their capabilities to adopt EVs as well as their inability to benefit from the EV transition. The Capabilities Approach to social justice is suited to account for the diversity of EV adopters and identify sources of the inability to adopt EVs. It offers a foundation for the comprehensive equity evaluation of the opportunities that people have because of their personal and environmental circumstances, and it considers how EV adoption affects disadvantaged communities and what these communities can do or become because of EV adoption [40].

Combining the bottom-up Capability Approach with the top-down four tenets of justice (1) addresses the critiques of universalist normative assumptions and avoids the dominant paradigm of Rawlsian viewpoints that "take little note of the diversity of human beings" [52] in transportation research and practice; and (2) considers the multidimensional aspects of poverty – which are central to the Capability Approach – where affordability may not be the only reason why EVs are not adopted by those in disadvantaged communities. In the transition from ICEVs to EVs, being able to adopt an EV (functioning) is ethically significant, and injustice can be found in the limitation of capabilities of doing so.

In this study, we embedded the Capability Approach in the context of the EV transition. We interpreted and adapted Nussbaum's central capabilities relevant to the transportation and energy context as follows (Table 1):

We develop the Just Transition to Electric Vehicle (JTEV) framework that incorporates these bottom-up (capabilities) and top-down (tenets of justice) approaches of justice considerations to conceptualize the just transition to EVs that involves transportation, environmental, energy, and climate justice. Fig. 1 illustrates that a just transition to EVs is the outcome of the interaction between tenets of justice and central capabilities.

According to this framework, the inequitable distribution of burdens in transportation, energy, climate, and environmental domains deprives the central capabilities that are necessary for the EV transition. This *distributive injustice* can be sustained, reproduced, or remedied by underlying personal, environmental, and policy conditions that influence an individual's capability to adopt EVs. Without *recognition justice*, these conditions act as constraints on capabilities, perpetuate the inequitable outcomes, and create new inequities in the application of *restorative justice* to redistribute the perceived benefits of EVs. The participation of capability-deprived individuals/communities in the energy transition programs is a matter of *procedural justice*. By contrast, *recognition justice* enhances capabilities and leads to equitable outcomes. In other words, enabling capabilities for EV transition requires combined distributive, recognition, restorative, and procedural justice. Consequently, the interaction of tenets of justice (i.e., top-down evaluations) and capabilities (i.e., bottom-up evaluations) leads to equitable outcomes in transportation, energy, climate, and environment domains, and, therefore, a just transition to EVs.

We mapped the justice tenets and capabilities in the JTEV framework to different domains (i.e., transportation, energy, climate change, energy, and the environment) in the EV transition context in Table 2. The justice domains may have overlaps; for example, a household may simultaneously experience transportation and energy poverty – be close to a major road, be exposed to climate burdens (e.g., heat waves), rely on polluting ICEVs, and encounter barriers to adopting an EV. The justice tenets are also interrelated: the inequitable distribution (i.e., *distributive injustice*) of transportation, energy, climate, and environmental burdens is often perpetuated or exacerbated by social, environmental, and personal disadvantages (i.e., *recognition injustice*), failure to tailor investments to unique local needs for transportation and energy services to redress root causes of inequities (i.e., *restorative injustice*), and lack of participation in EV transition process (i.e., *procedural injustice*).

3. Materials and methods

3.1. Study design

We conducted semi-structured interviews with 45 residents of the Columbus metropolitan area, Ohio (USA) from February to May 2024. We deliberately oversampled individuals from low-income, racial minority, and immigrant/refugee backgrounds. To recruit participants, we displayed flyers with QR codes and links to a recruitment survey on Qualtrics at community gatherings. We also separately contacted neighborhood associations in disadvantaged neighborhoods to recruit interviewees. The interviews lasted 25–120 min, with 20 interviews conducted in person and 25 interviews conducted over Zoom, in four languages (i.e., English, Spanish, Nepali, and Somali) and translated into English for analysis. Each interview includes the sociodemographic background of the interviewees, their experiences of transportation services, energy services, climate change, perception of EVs, and other topics. Each interviewee received a $25 VISA gift card.

We applied the JTEV framework to these interviews, where Columbus serves as an example, representative application for several reasons. First, similar to many U.S. cities, Columbus has a history of segregation due to the construction of interstate highways in predominantly Black neighborhoods that are less walkable transit deserts today [53]. Second, Columbus is home to a substantial number of recent refugees and immigrants from multiple countries [54]. Third, there have been recent efforts to increase EV adoption through consumer education campaigns and deploy charging facilities under the National Electric Vehicle Infrastructure Formula program [55]. Fourth, Columbus serves as an ideal case study in EV transition that is neither a leading EV market nor a laggard. Finally, the university has a major presence in Columbus, and we understand the history and local conditions, which facilitated engagement and rapport-building within the local community.

Table 1
List of capabilities for just transition to EVs.

Our proposed capabilities	Capabilities in the EV transition context	Equivalent capabilities as defined by Nussbaum [41]
Essential life services	The ability to take advantage of the transportation and energy systems to conduct daily activities, such as accessing work, health care, food, and maintaining social connections.	*Life*: being able to maintain average life expectancy. *Bodily health*: Being able to live a healthy life. *Practical reason*: Being able to make choices for a better life. *Affiliation*: Being able to interact socially.
Political capital and sustainable infrastructure	The ability to advocate for and access safe and sustainable transportation and energy; to access information in order to make informed choices; and to participate in local planning and policies.	*Bodily integrity*: Being able to move freely and safely. *Senses, imagination, and thought*: Being able to make informed choices through reasoning. *Control over political environment*: Being able to participate in planning and policies. *Control over material environment*: Being able to maintain material properties and access economic opportunities.
Healthy living environment	The ability to enjoy a healthy living environment that is free from traffic-related hazards such as crashes and air and noise pollution.	*Emotions*: Being able to act on worries as a result of adverse impacts. *Life*: being able to maintain average life expectancy. *Bodily integrity*: Being able to move freely and safely.

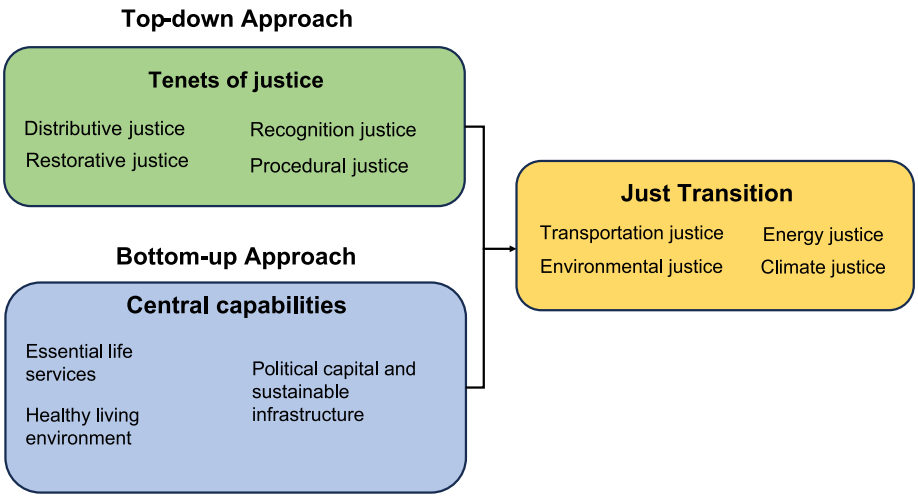

Fig. 1. The Just Transition to Electric Vehicles (JTEV) framework.

Table 2
Mapping the four tenets of justice to domains of electric vehicle transition.

	Transportation justice	Energy justice	Climate justice	Environmental justice
Distributive justice	Transportation burden and coping mechanisms (i.e., forgoing travel) as barriers to EV adoption	Energy burden and coping mechanisms (i.e., forgoing heating/cooling) as barriers to EV adoption	Weather-induced outages and climate impacts at the household and neighborhood levels as barriers to EV adoption	Disproportionate environmental burdens on disadvantaged communities (e.g., health burdens from traffic-related emissions) as barriers to EV adoption
Recognition justice	Socio-spatial constraints affecting capability for affording EVs to meet travel needs	Socio-spatial constraints affecting capability for energy services to meet mobility energy needs	Climate change concerns enhancing healthy living environment capability for EV adoption	Traffic-related pollution constraining capability for essential life services; Concerns enhancing healthy living environment capability for EV adoption
Restorative justice	Equitable redistribution of vehicle operating and purchase cost	Equitable redistribution of energy benefits of EVs	Reallocating investment for climate resilience/mitigation	Assistance for healthcare and air quality improvement
Procedural justice	Participating in EV transition programs and associated policies (e.g., siting of charging stations, electricity tariff designs, incentive structure) Capability for acquiring EV-related information.			

3.2. Socio-spatial disadvantage of interviewees

We used the Climate and Economic Justice Screening Tool [56] to identify disadvantaged communities based on indicators for transportation, energy, climate, and environmental burdens. For example, census tracts that are at or above the 90th percentile thresholds for these burdens and 65th percentile for low-income are recognized as disadvantaged in the tool. Generally, the higher the percentile, the higher the burden, with percentile values assigned at the lower 65th percentile for those in lower-income groups.

The interviewees live within 500 m of major roads with high average annual daily traffic (Fig. 2A); spend high average cost and time on transportation relative to all other tracts (Fig. 2B); spend at least 6 % of their income on energy bills (Fig. 2C); and are susceptible to the adverse impacts of natural hazards including heat waves, cold waves, winter weather and wildfires (Fig. 2D). That is, the interviewees (A) live close to traffic, (B) encounter significant travel barriers, (C) live in areas with high energy burdens, and (D) are vulnerable to climate change impacts.

Of the 45 interviewees, 22 had income below or close to the median household income in the county ($58,575), 16 were slightly higher, and 7 were substantially higher. Twenty-three respondents (51 %) lived in multifamily housing, and 26 (58 %) were renters (Table 3).

3.3. Analysis

We used an exploratory qualitative approach to coding the transcripts, which was guided by the JTEV framework, and analyzed the interviews using reflexive thematic analysis. Before coding, we expected that codes would map onto justice considerations for transportation, energy, climate change, environment, and electric vehicle adoption.

We contextualized emergent codes, sub-themes, and themes based on prior themes from the literature on transportation justice, environmental justice, energy justice, climate justice, and EV adoption. We followed an iterative approach to code the interviews by identifying 73 codes and grouping them under 6 sub-themes and then 5 central themes. To manage the redundant codes, the broad justice considerations for the themes provided an overview while we iteratively analyzed the detailed lower-order codes to collapse disparate codes that lacked enough data to support them into distinct injustices across transportation, energy, climate, and EV adoption [59]. We identified 90 % of the codes after ten interviews (Fig. 3), consistent with previous studies in the EV transition context [60]. The remaining 35 interviews served an important function in validating the initial codes and reinforcing evidence of the injustices embedded in the transition to EVs.

The coder and main analyst is a Black male researcher whose identity and lived experiences in East Africa influence the interpretation of experiences with disadvantages in transportation, energy, environment, and climate domains in relation to EV transition. The identity of the coder enables them to probe and interpret the intersectionality of those lived experiences in ways other researchers might not do. In addition, the other co-authors with different genders and immigration backgrounds interpreted the code and discussed the results, which may affect the results.

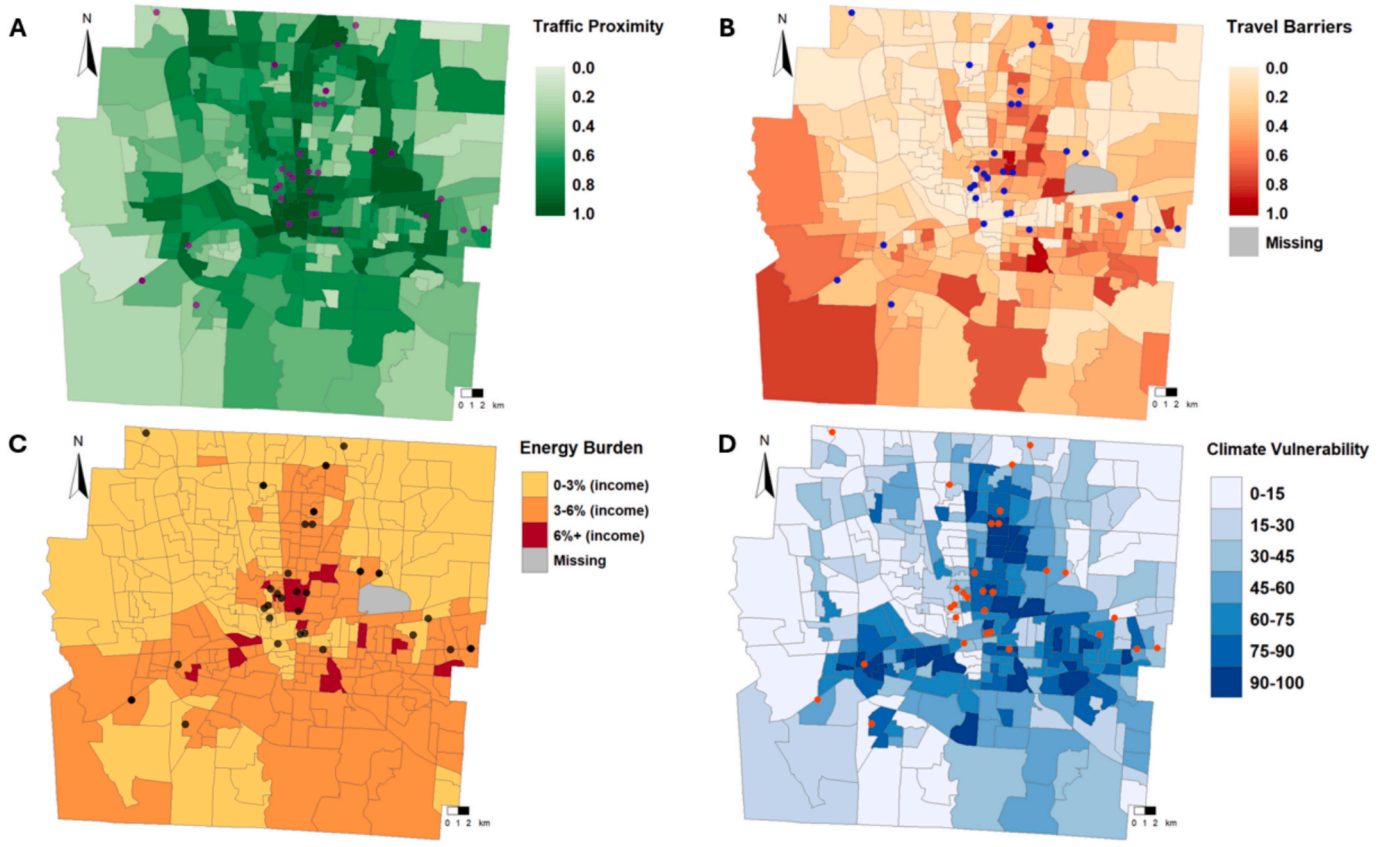

Fig. 2. Interviewee residential locations in Franklin County, Ohio (USA) by the nearest street location ($n = 45$). A - Traffic proximity and volume (percentile). B - Average relative cost and time spent on transportation relative to all other tracts. C - percentage of household income spent on energy. D - susceptibility to disasters from natural or human-caused disasters and disease outbreaks. Data sources: Climate and Economic Justice Screening Tool (Panels A and B) [56], U.S. Department of Energy (C) [57], and U.S. Climate Resilience Toolkit (D) [58].

4. Findings

The 73 codes from our thematic analysis center around four main justice considerations related to the perceptions and barriers to, and lived experiences of: 1) EV adoption (*just transition to EVs*), 2) transportation services (*transportation justice*), 3) energy services (*energy justice*), and 4) climate change (*climate justice*). We also identified subthemes of 1.1) barriers to EV adoption, 1.2) affordable energy support, 1.3) economic benefits, 1.4) health and air quality benefits, and 1.5) solution to climate change under the *just transition to EVs* theme, 2.1) environmental justice under the *transportation justice* theme, and 3.1) solar equity gap under the *energy justice* theme.

4.1. Perceived barriers to and benefits of EV adoption

The perceptions of and barriers to EV adoption were centered on the disproportionate burdens of transportation, energy, and climate change for these disadvantaged communities, as well as the disparity in EV benefits, both economically and environmentally (Fig. 4).

4.1.1. Perceived barriers to EV adoption

Respondents reported a range of barriers to EV adoption that map onto *just transition to EVs* (e.g., affordability and charging desert), *energy justice* (e.g., energy burden and energy-inefficient homes), *transportation justice* (e.g., transportation burden and socio-spatial segregation), and *climate justice* (e.g., climate-related outages and negative impacts of climate change). While most interviewees viewed the lack of charging infrastructure and affordability as a major barrier, most low-income interviewees also cited issues with technical literacy, safety concerns, and power outages. From the Capability Approach perspective, the barriers to EV adoption highlight the real opportunities and constraints for EV adoption among disadvantaged communities.

4.1.1.1. Charging deserts. The majority of the interviewees indicated the lack of home chargers and nearby public charging stations as the major barriers to EV adoption. Other frequently cited concerns centered on vehicle range and charging speed. Most interviewees focused on the investment needed to install home chargers and, in many instances, mentioned that they would adopt EVs if charging infrastructure were available on a scale similar to gas stations. For example, these interviewees discussed how a lack of charging infrastructure deters them from switching to an EV.

> "*Do we have enough space to have the charging stations? I think that would probably be my biggest worry. I just know that I drive a whole lot, and I don't know how I would keep it charged, or if that's even a thing I will worry about because it keeps the charge for the day.*"
>
> (Black female, 40–50, low-income, car owner)

> "*I worry about charging, especially in the communities where I live and work right now. I don't have readily available charging stations. And so, it worries me. I don't see it accessible for me and people like me right now.*"
>
> (Black female, 45–50, low-income, car owner)

These quotes indicate perceived inaccessibility to charging infrastructure as well as misconceptions about the driving range of EVs, with many interviewees raising concerns about running out of power in the middle of the road before reaching their destination or a charging station. Disadvantaged neighborhoods indeed have low access to home, workplace, and public chargers [61]. However, the majority of vehicle trips in urban areas are within the technical range of EVs: while the EVs

Table 3
Sociodemographic characteristics of interviewees.

Category	Interviewees (n = 45)	Franklin County[a]
Gender		
Male	21 (47 %)	49.1 %
Female	23 (51 %)	50.9 %
Non-binary	1 (2 %)	N/A
Median household income		
	$58,575 (reference)	$73,795
Significantly higher	7 (16 %)	N/A
Slightly higher	16 (36 %)	N/A
About that amount	4 (9 %)	N/A
Slightly lower	4 (9 %)	Percentage below the poverty line (14.5 %)
Significantly lower	14 (31 %)	
Age		
Above 60	6 (13 %)	N/A
50–59	2 (4 %)	N/A
40–49	12 (27 %)	N/A
30–39	17 (38 %)	N/A
20–29	8 (18 %)	N/A
Car ownership		
% of households without vehicle access	9 (20 %)	7.2 %
Race/ethnicity		
White	8 (18 %)	59 %
Black	9 (20 %)	22.8 %
Hispanic	6 (13 %)	7 %
Mixed race	1 (2 %)	5 %
Nepali	11 (24 %)	N/A
Somali	10 (22 %)	N/A

[a] American Community Survey 2019–2023 5-year estimates for Franklin County, Ohio, which consists of a major part of the Columbus metropolitan area (only three interviewees live outside of Franklin County).

can go between 110 to over 300 miles on a single charge, over 73 % of all trips are less than 10 miles and over 98 % are less than 75 miles [62,63].

4.1.1.2. Unaffordable car purchases. The vast majority of interviewees cited affordability as a major issue, with many noting that EVs are more expensive to purchase than ICEVs and that many subsidies provide variable benefits based on income tax liabilities: those with higher incomes may benefit from the full incentive (e.g., $7500) and households with lower tax liabilities have proportionately less benefit [64]. Such tiered incentives can result in less ability for disadvantaged people to realize the economic benefits of EVs (e.g., lower operating and maintenance costs) and decrease their ability to adopt one. For instance, some interviewees articulated that EVs are more expensive to purchase and operate than ICEVs:

> "*It would really be difficult to switch to an EV that would cost me over $20,000 when I already have a cheaper gasoline car that satisfies all my needs.*"

(Male Somali refugee, 35–40, slightly higher than the median household income, car owner)

> "*I would be interested … if it was not more expensive than purchasing a gas car.*"

(Black female, 30–35, Slightly higher than the median household income, car owner)

Even though ICEVs have tended to be cheaper to purchase than EVs, they are more costly to operate [70]. EVs' higher energy efficiency, as well as the relative costs of electricity and gasoline, render the operating cost per mile of EVs about two-thirds cheaper than that of ICEVs. Some interviewees perceived EVs to be more expensive than ICEVs due to the limited penetration of used EVs in the market. For example:

> "*They would be more expensive than regular cars … it's like everything is expensive because there are not so many used electric vehicles on the market.*"

(White Non-binary, 20–25, low-income, non-car owner)

While this quote implies some understanding of technological

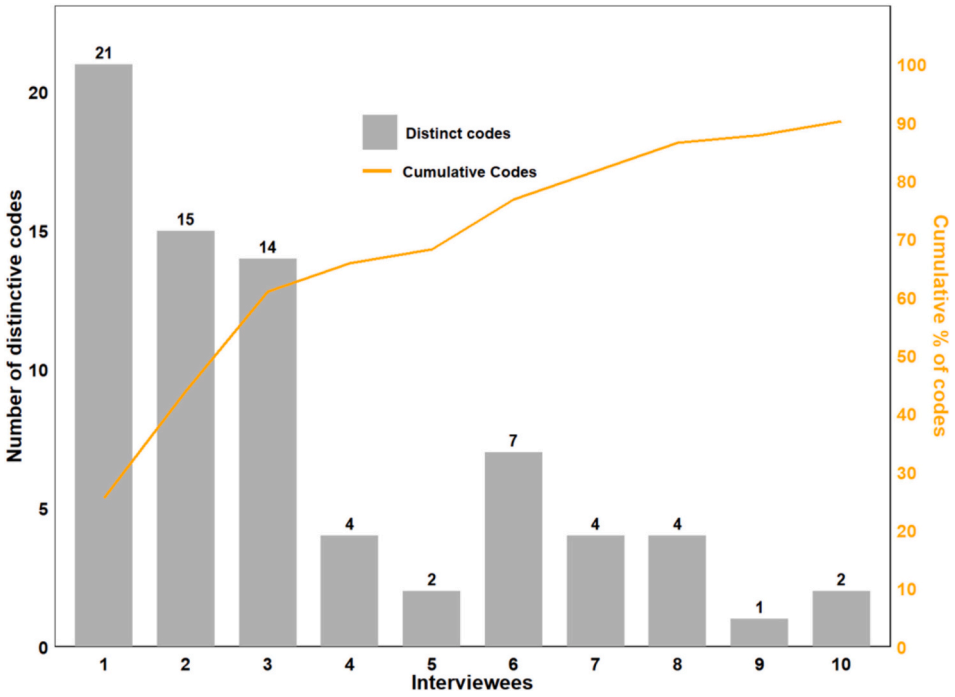

Fig. 3. Saturation of interview codes after ten interviews.

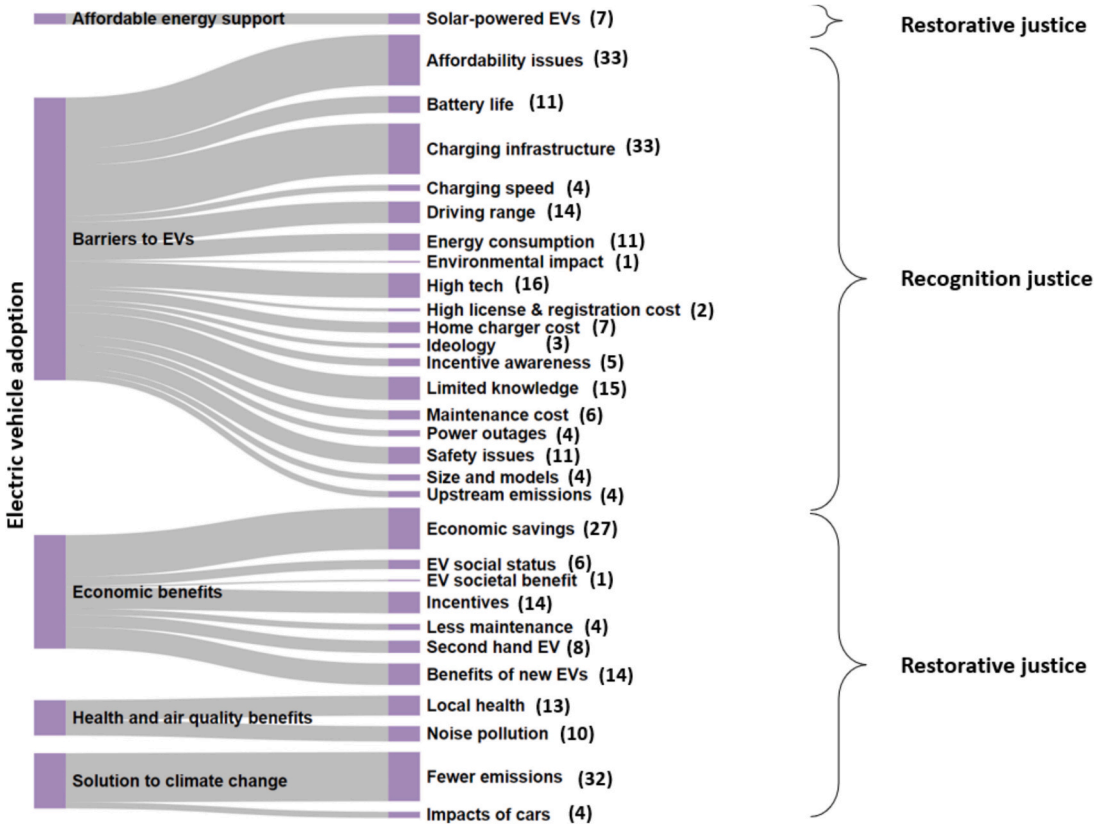

Fig. 4. Electric vehicle adoption theme and sub-themes based on tenets of justice ($n = 45$). Numbers represent the number of interviewees per code.

learning where unit costs decrease with cumulative production, it also signifies the demand for used EVs in disadvantaged communities. Indeed, evidence from California shows that individuals in disadvantaged communities are buying used EVs at a higher rate than new EVs [9]. One interviewee mentioned that he would prefer to buy a used EV over a used ICEV because he perceives it will last longer:

> "*It's actually better to buy a second-hand Tesla as opposed to buying a second-hand internal combustion engine vehicle. Maybe, I think Tesla is electric and it will not age like other cars.*"
>
> (Male Somali refugee, 25–30, low-income, car owner)

One interviewee linked affordability issues with advanced technical and design attributes of EVs such as battery size, vehicle size, and luxury interiors that are deemed unnecessary for their daily use:

> "*They're expensive because the market for them right now seems to be very large machines aiming for 300 miles range, and you know, luxury interiors. And they're huge.*"
>
> (White male, 30–40, slightly higher than median household income, car owner)

These views about cost suggest that some individuals may attribute the higher upfront purchase price of EVs to the design and performance of EVs, which is consistent with research that shows that the availability of luxury EV models on the market could be driving disparities in EV adoption [23]. Most current EV models are also marketed to wealthier customers who are environmentally conscious and/or technologically savvy, which in turn pushes up the adoption rate among this segment of the population compared to lower-income groups [9].

4.1.1.3. Higher costs for initial home setups and energy consumption. Most interviewees were concerned that adopting EVs would increase their electricity bills and thus increase their transportation cost burden. An interviewee who owns an EV perceived that EV adoption drives up household electricity consumption:

> "*So, all in our garage was $120,000 including the equipment and the chargers, including everything. We built a large garage that has a shop and it's a 3 bay and all of the things but we're in a historic district, so we had to make sure that certain finishes are done. I'm probably spending an additional $120 a month on electricity for charging purposes. It looks like our bill ranges somewhere between $200 and probably almost $400 a month, depending on whether or not it's winter or the air conditioning is on. And it has gone up since we've added an EV.*"
>
> (White female, 40–45, high-income, car owner)

Another interviewee echoed similar concerns about the electricity bill:

> "*It seems like my electric bill will just go up. So, I probably wouldn't want to add on to my electrical consumption.*"
>
> (Black male, 25–30, close to the median household income, car owner)

While we acknowledge the valid concerns about increased electricity bills, it is noteworthy that they do not reflect the concomitant decrease in expenditures on gasoline. However, in many places in the United States, gasoline bills may seem cheaper because they are for only one service (i.e., transportation). Gasoline purchases may also have more flexibility in timing than monthly electricity bills with specific due dates.

4.1.1.4. Other barriers to an EV transition. Interviewees mentioned other barriers, such as unreliable EV-related infrastructure and services (e.g., frequent power outages) that limit the reliability of using EVs. Many people also characterized EVs as high-tech products that enhance driver comfort but also require significant technical literacy and trust in the technologies. For example, the following sentiment shows a general misconception of mobility technologies, especially the integration of voice and facial solutions into EVs, which have not yet been implemented.

"*EVs are high-tech products so sometimes the facial recognition technology might misidentify you and keep you outside of your car when you need it the most. Some EVs might work with voice recognition assistants like Siri, and you can undergo surgery that can change your voice. It might fail to unlock your car because your voice is different now*."
(Male Somali refugee, 30–35, close to the median household income, car owner)

Battery degradation over the EV lifetime was another concern cited by interviewees, especially the health of batteries in bidirectional EVs such as V2G and V2H technologies. While interviewees showed interest in these bidirectional EVs for revenue potential and mitigating power outages, some of them emphasized that their mobility needs take precedence over the need to sell electricity back to the grid or to power their homes. This priority reflects a lack of awareness about bidirectional EVs in most cases and EV tax incentives in some cases. This lack of awareness suggests a deprivation of *political capital and sustainable infrastructure* capabilities that need to be addressed in future energy transitions.

4.1.2. Perceived benefits of EVs

While being hesitant to adopt an EV, the interviewees also recognized many benefits of EVs. The following environmental, economic, energy, and public health benefits from a *restorative justice* perspective could motivate local communities to adopt EVs.

4.1.2.1. Perceived environmental and climate benefits. More than half of the interviewees discussed reductions in air and noise pollution as benefits of EVs. When asked about how much reducing air pollution matters to them when buying a new car, thirteen of the 45 interviewees explicitly mentioned the positive impact of EVs on health, particularly the local health impacts. Most of these interviewees perceived a strong sense of injustice regarding their disproportionate exposure to pollution from ICEVs, which overlaps *transportation justice* considerations.

Ten interviewees agreed that EVs reduce community nuisance and noise levels, which suggests awareness by residents from disadvantaged communities who often experience the negative health and environmental impacts of the noise generated by ICEVs and may benefit from the EV transition [65]. More than 70 % of interviewees viewed EVs as an environmentally friendly alternative to ICEVs. Most interviewees focused on the environmental benefits of adopting EVs using terms such as "environmentally friendly," "saving [the] Earth," "saving the planet," and "cleaner and healthier environment." The strong focus on the environment in the responses of interviewees could indicate concerns about climate change impacts.

"*For me, it would be much better because then we wouldn't pollute the ozone layer and the air. At some point, getting rid of gasoline cars because all they do is pollute the planet.*"
(Hispanic male, 30–35, low-income, immigrant, non-car owner)

These individuals believe that the EV transition is more likely to bring air quality and health benefits:

"*They are good for pollution and health. The cleaner the air, the better the health*."
(Black male, 30–35, low-income, food delivery worker, non-car owner)

"*Columbus air quality is horrific. Aside from adding to the tree canopy and more green spaces that's the absolute best way, to improve the air quality is to reduce the number of gas-powered engines used. I mean, it's really something we need to do*."
(White female, 60–65, low-income, schoolteacher, car owner)

These comments show that the perceived health benefits could motivate EV adoption, although the evidence that EVs improve air quality, with associated improvements in health outcomes, is complicated and depends on the relative exposures throughout the lifecycles of the vehicles and the supply chains for the fuel (e.g., oil refineries vs. electricity generation facilities) [66]. The comment reflects a general misconception about the air quality in Columbus being very poor, which does not reflect the actual statistics that the air quality has been ranked good in recent years [67,68].

While many interviewees appreciated the environmental benefits of EVs, when considering the purchase of a new vehicle, only four said they would consider the environment, whereas 23 mentioned that low cost and convenience take precedence. These sentiments suggest that EV adoption by those in disadvantaged communities may be driven by affordability more than other benefits.

4.1.2.2. Economic benefits. About 80 % of interviewees characterized EV adoption from the perspective of economic savings. Most mentioned that EVs have lower fuel costs than ICEVs; this awareness suggests that savings in fuel costs could be a driver in the interest in EV adoption. Some interviewees also mentioned lower maintenance costs for EVs, while many others perceived EVs as more expensive to maintain than ICEVs. In addition, some disadvantaged individuals who rely on cars for day-to-day needs viewed purchase incentives for EVs and the ability to afford second-hand EVs as an opportunity to benefit from the EV transition.

Many interviewees also discussed the economic benefits associated with selling electricity back to the grid using V2G EVs and reducing electricity bills by opting to power homes using V2H EVs. However, these interviewees did not mention how they would be paying for the electricity to charge up their vehicles before transferring electricity back to the grid or their homes. One EV owner, for example, highlighted some barriers to V2G services among EV owners.

"*… [Many] of our local power companies are not willing to do that. So, AEP* [a major electricity provider in Columbus] *is not going to let me sell back energy to them that I've produced on my own property*."
(White female, 40–45, higher than the median household income, car owner)

This challenge highlights the interconnections between transportation and energy and the need for cooperation between policymakers, planners, and utilities for EVs to be integrated into electricity grids. With respect to V2H capabilities, some interviewees embraced the benefits that such EVs can be used as power storage in underserved neighborhoods where outages are frequent and thus have the potential to address energy poverty.

4.2. Transportation justice

The perspectives frequently mentioned by the interviewees from disadvantaged communities suggest that they are not well-served by the transportation system, evident from their cost burden, coping mechanism of forgoing necessities, and exposure to traffic-related emissions (also related to *environmental justice*) (Fig. 5).

Interviewees cited transportation and mobility needs that often intersected with their ability to adopt EVs, which highlights the deprivation of capabilities. The challenges included a lack of infrastructure for non-car modes and a stark disparity in the frequency of non-essential trips as well as access to opportunities, corresponding to *political capital and sustainable infrastructure*, and *essential life services* capabilities. Of the 45 interviewees, 16 mentioned that their neighborhoods have experienced continual disinvestment from redlining legacies, such as poor transportation and energy infrastructure.

The interviewees highlighted the high poverty concentration and poor access to public services and amenities. For instance, an interviewee explained how entrenched disadvantages impede the transition to EVs:

"*We know, one of the biggest challenges is economic development. We've been subject to systemic racism in the redlining, so we didn't have access to the many opportunities that others have had … We need to increase the*

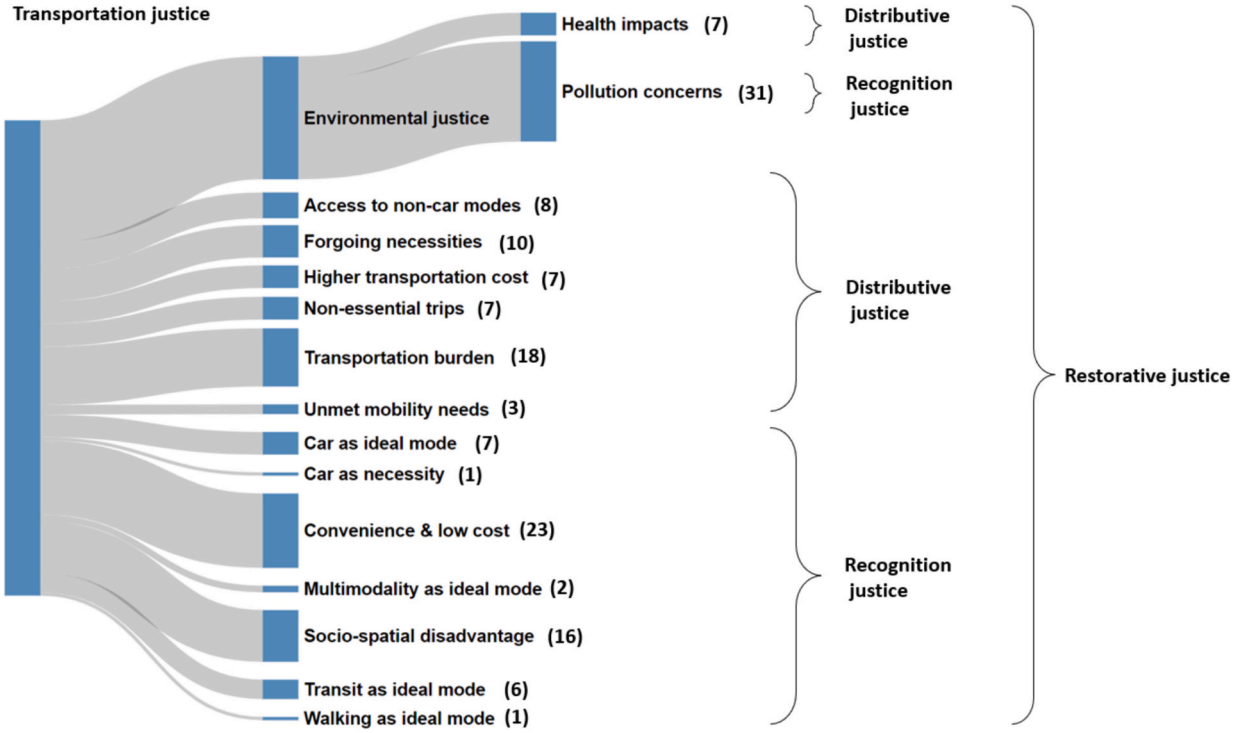

Fig. 5. Transportation justice theme codes and sub-theme for environmental justice.

number of stations for electric cars to be recharged because we don't have any in Linden [a neighborhood with predominantly low-income Black population]."
(Black female, 70–80, low-income, part-time employee, non-car owner)

Other interviewees echoed the slow pace at which infrastructure is rolled out in disadvantaged communities. One interviewee implied that the placement of EV charging stations is skewed against their community:

"*I would just say at the pace of getting the technology out there, it's not happening as fast as other areas. It's almost like a forgotten place … they had the money for the station, but I believe it went up further north.*"
(Mixed-race female, 60–65, close to median income, car owner)

The interviews highlight spatially overlapping transit deserts and charging deserts, with the former leading to the lack of access to jobs and participation in society. For those who want to avoid or reduce driving, low access to non-car modes was mentioned as a major challenge because the disinvestment in transit and bicycle infrastructure has defaulted to reliance on cars in disadvantaged communities. For disadvantaged populations who have less flexible jobs, often have less access to reliable travel modes, and are less likely to work from home [69], car ownership and use were viewed as both an ideal and a burden (i.e., with costs such as car insurance, maintenance, and fuel). Some of the interviewees also mentioned coping mechanisms, such as forgoing necessities like food, to pay for transportation services. These comments are consistent with findings from prior studies in other cities [70].

The analysis also revealed a disparity in the frequency of long-distance trips, with only seven – all in the high-income category – of the 46 interviewees mentioning that they frequently make long-distance car trips. In other words, most trips are within the city and could be done with EVs with careful planning of public chargers to fulfill residents' travel needs without range anxiety.

4.3. Environmental justice related to transportation

Many interviewees perceived that their communities are heavily polluted, with a strong sense of injustice about air pollution and its impact on their health. A majority of the interviewees (73 %) explicitly discussed their concerns about the disproportionate exposure to traffic-related air pollution. For example:

"*I can't stand when you go down the street or you're behind a car and you smell all this crap …. You know it can't be good for you. You know you can't. So, I want to live. I'm 65. My goal is to get to 120. Not only do I feel like pollution has affected my health, but again, another tragedy is that my mother I honestly believe along with quite a few people in my community died from it.*"
(Mixed-race female, 60–65, close to median income, car owner)

This view is corroborated by prior literature that shows the residents of underserved neighborhoods are more likely to be exposed to traffic and industrial pollution [71]. Some interviewees mentioned that they experienced direct negative health impacts of air pollution, including asthma, attributing the air pollution in their neighborhoods to ICEVs.

4.4. Energy justice

Many disadvantaged individuals had fewer financial resources and lived in energy-inefficient homes that required more energy for heating and cooling, and many interviewees described the burden of their energy bills. For example,

"*… I would say [our energy bills account for] a good 40% of [our monthly expenses] because my gas, electricity, and water total – those three bills totaled together are close to what I pay for my house note.*"
(Black female, 70–80, low-income, part-time employee, non-car owner)

These households often develop coping mechanisms, such as forgoing necessities to pay for energy services, and relying on space heaters or baking to warm their houses in the winter:

"*I want you to know that space heaters are too inefficient because you would need multiple space heaters to keep the whole building warm.*"
(Somali female, 40–45, low-income, jobseeker, car owner)

"*I also bake to generate more heat in my home.*"
(Black male, 30–35, low-income, food delivery worker, non-car owner)

In addition, disadvantaged households continue to face systemic barriers to capitalizing on incentives for, and other financial benefits of, renewable energy infrastructure. For example, interviewees mentioned the unaffordability of converting from natural gas-based to electric-based heating and cooking systems or installing solar photovoltaic panels (Fig. 6). They are thus unable to offset energy costs and enjoy the benefit of EVs without more energy burden. Most interviewees also mentioned other barriers, such as those relating to housing (e.g., renting and not owning, lack of supporting infrastructure) and technology literacy.

4.5. Climate justice

Fig. 7 shows the six climate justice considerations that were identified: climate change concerns, lack of awareness and concern about climate change, direct and indirect impacts of climate change on low-income communities, responsibility for climate change causes, and power outages during extreme weather events under the climate justice theme. The climate justice considerations intersect with transportation and energy injustices in the EV transition; for example, weather-induced outages, aging electrical grids, and older housing stock may deter the adoption of EVs.

Most interviewees expressed concern about climate change and considered it a pressing issue, whereas a few individuals mentioned that they are not concerned or did not know about climate change. Interviewees from disadvantaged neighborhoods perceived that the lack of trees and greenspaces in their neighborhoods resulted in their neighborhoods being hotter than those in affluent (and greener) neighborhoods. Such issues suggest that extreme heat is likely to result in more electricity demand for cooling in underserved areas and those with energy-inefficient housing. These comments suggest that those who live in underserved communities may be deprived of *healthy living environment*, and *political capital and sustainable infrastructure* capabilities.

In the transportation context, while some interviewees felt a personal responsibility for the environmental implications of their ICEVs, the interviewees called for collective action to address climate change.

"*I want to buy a car that does less harm to others, and I want to avoid getting exposed to harm.*"
(Somali female, 65–70, low-income, retiree, non-car owner)

"*I think the individual effect on tackling climate is not very tangible. However, I believe collective action can drive change.*"
(Male Somali refugee, 25–30, low-income, car owner)

Some interviewees were also concerned about climate change impacts on future generations, which highlights an awareness of intergenerational justice issues with climate change. This understanding indicates that many people prioritize not only the environmental benefits that accrue to them but also those reserved for future generations.

"*I am very concerned about [climate change] … Unless we do something sooner than later I feel my grandchildren will suffer.*"
(Black female, 70–80, high income, retiree, car owner)

"*I'm extremely concerned about [climate change]. It profoundly affects my life. It terrifies me.*"
(White female, 60–65, low-income, schoolteacher, car owner)

Some interviewees attributed power outages to frequent storms induced by climate change, and these outages were articulated as another barrier, on top of other vulnerabilities, to EV adoption in (their) underserved neighborhoods.

4.6. Summary: just transition to electric vehicles

Findings reveal that the injustices embedded in the EV transition in disadvantaged communities extend beyond income and are shaped by lived experiences with wider transportation, energy, climate, and environmental disadvantages. Table 4 provides a descriptive understanding of these injustices from the perspective of disadvantaged communities, related prescriptive restorative measures, and their corresponding capabilities. The descriptive tenets of justice sum up the

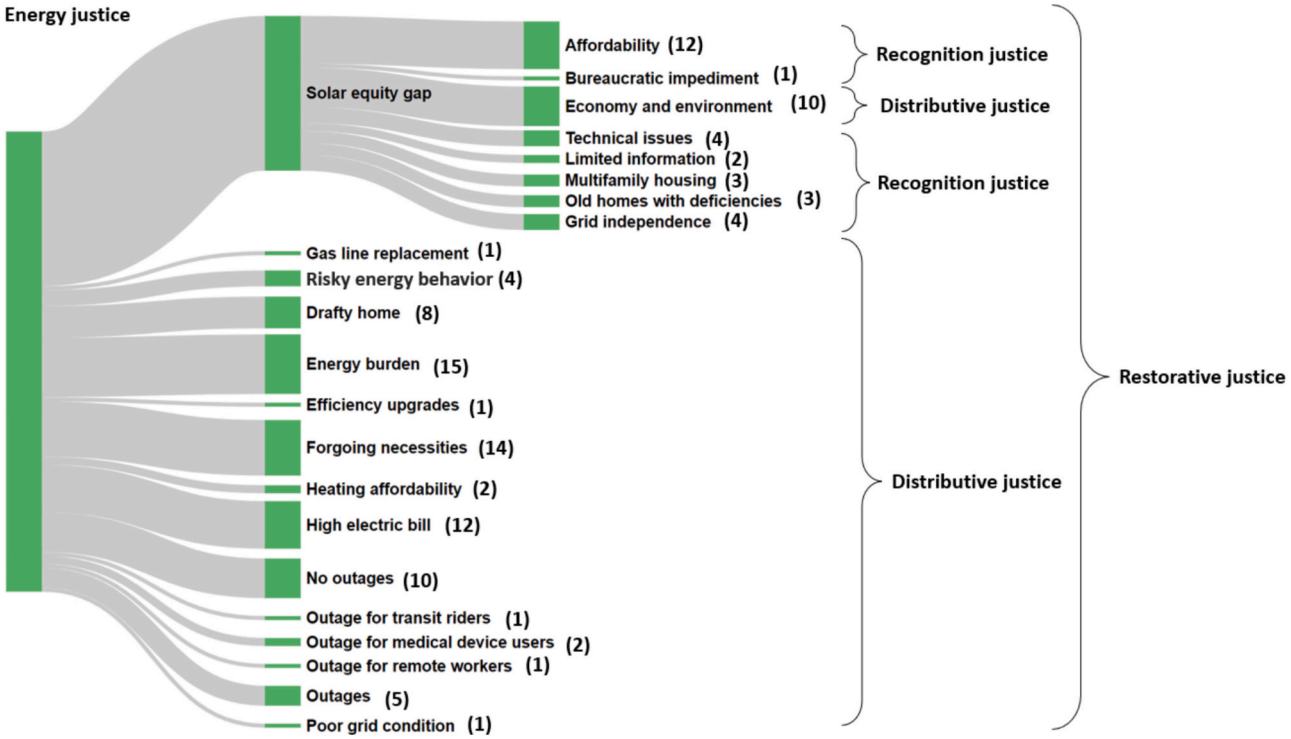

Fig. 6. Energy justice theme codes and codes for sub-theme for solar equity gap based on tenets of justice ($n = 45$).

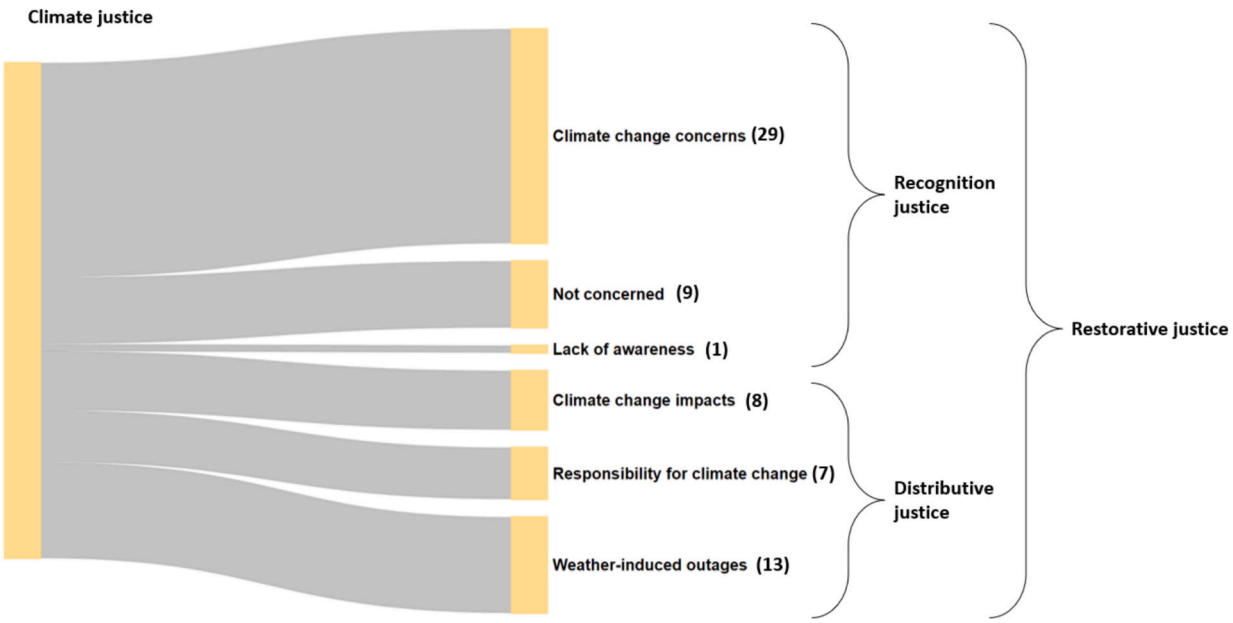

Fig. 7. Climate justice theme and codes based on tenets of justice ($n = 45$).

existing injustices based on the interview themes – the issues that need to be recognized at the top-down level – and the prescriptive tenets of justice provide potential policy and planning instruments to correct existing injustices.

Procedural justice connects the bottom-up concerns to solutions from the top-down approach by allowing researchers and practitioners to understand the distributive and recognition (in)justice, and propose potential solutions to correct them and achieve restorative justice.

5. Discussion

5.1. Energy transition in underserved communities

This study corroborates prior evidence that shows households in the United States generally face barriers to EV adoption (e.g., financial constraints, charging deserts, and lack of awareness of existing tax incentives [9,25]), and identifies other barriers that are unique to disadvantaged communities: increased prevalence of weather-induced power outages; concerns about increased household electricity burden, battery life and safety; and limited knowledge about EV technologies, among others. These barriers reflect multidimensional deprivation of capabilities in transportation and energy services specific to disadvantaged communities, which are consistent with several past studies on the intersectionality between transportation energy poverty (i.e., double energy vulnerability), burdens from extreme weather events, and environmental health problems. These disadvantages compound on one another, and amplify constraints on disposable income and ability to afford EVs [44,72], further widening the gaps in financial benefits of EVs experienced by residents of disadvantaged communities and those from non-disadvantaged backgrounds.

Our results also show that many members of disadvantaged communities generally have positive perceptions of EVs. For example, EVs are associated with cleaner air, lower emissions, and economic savings despite the misperception of electricity cost for mobility, which may signal their support for policies that promote EVs to restore deprived capabilities. In addition, members of disadvantaged communities seem to value the economic benefits of EVs more than their environmental health and climate benefits, suggesting campaigns that highlight economic benefits and policy that remove financial burdens may be most impactful. More broadly, our results show EV transition does not occur in isolation; instead, it interacts with historical inequities built into the housing, electricity grid, transportation, and energy infrastructure in the U.S. context [28], which suggests that benefits of EV adoption could have knock-on effects that at least partially mitigate deprived capabilities for meeting needs in transportation, energy, climate, and environmental domains.

In alignment with the JTEV framework, we find deprivation of capabilities for *essential life services, political capital and sustainable infrastructure, and healthy living environment*. The deprivation of these central capabilities related to the EV transition is consistent with findings from the broader energy justice literature. Energy poverty is connected to the deprivation of multiple capabilities – including those for emotional well-being, health, mobility, housing, and recreational activities [73] – and can engender intertwined disadvantages, especially *lack of capability for political capital and sustainable infrastructure* (in the sense of inability to maintain energy-inefficient housing), which often coexists with poor capabilities for *essential life services and healthy living environment* [74]. Negative emotions, especially worry about environmental burdens, can contribute to increased pro-environmental actions in wealthier countries [75], and our thematic analysis suggests that concerns about climate and environmental burdens could thus enhance the capability for *healthy living environment* for the EV transition. Our findings also show that there are misconceptions or opinions that lack supporting evidence, such as EVs being more expensive to operate than ICEVs, high-tech products that are difficult to use and vulnerable to fire hazards.

5.2. Future research and policy recommendations

Our findings from this study highlight several promising directions for future research. More research is needed to unpack the interactive cycles of distributive (in)justice (i.e., burdens and coping strategies), recognition justices (i.e., socio-spatial disadvantages that sustain distributive injustice), and restorative justice (i.e., application of restorative justice by prioritizing disadvantaged communities) alongside procedural justice to advance a just transition to EVs. More work is also needed to test the JTEV framework with disadvantaged communities in different geographical contexts, using other methods such as focus groups and quantitative approaches. The misconceptions about EVs may affect the transition process and require the government to step up educational campaigns and local community engagements to build trust in EV technologies. Moreover, homeownership issues emerge as a critical barrier to EV transition, which suggests that investment in

Table 4
Relationships between capabilities, tenets of justice, and justice themes.

Major themes	Capabilities	Descriptive tenets of justice: Existing issues	Prescriptive tenets of justice: Potential actions
EV adoption			
Barriers to EV adoption: Charging desert and unaffordable car purchases	• *Essential life services* • *Political capital and sustainable infrastructure*	*Distributive*: inequitable distribution of charging infrastructure and income. *Recognition*: people who live in charging deserts and low-income neighborhoods are disadvantaged.	*Restorative*: siting charging stations in underserved neighborhoods and providing incentives for EV purchases that can benefit low-income people.
Barriers to EV adoption: Higher energy costs for mobility needs	• *Political capital and sustainable infrastructure*	*Distributive*: inequitable energy burden, energy infrastructure and housing. *Recognition*: people who live in multifamily housing, drafty homes, or renters.	*Restorative*: energy retrofit programs with incentives for low-income households.
Barriers to EV adoption: Others	• *Political capital and sustainable infrastructure*	*Distributive*: inequities in grid maintenance/ investment and awareness about EV technologies and incentives. *Recognition*: poor grid conditions and lower technology literacy.	*Restorative*: increasing reliability of electrical grid and outreach with EV information and financial incentives.
Benefits to EV adoption: Perceived environmental and climate benefits	• *Essential life services* • *Political capital and sustainable infrastructure* • *Healthy living environment*	*Distributive*: inequitable distribution of climate and environmental benefits. *Recognition*: disparities in burdens due to extreme weather and emissions.	*Restorative*: increasing tree canopies to mitigate heat waves in disadvantaged neighborhoods, and providing incentives and medical insurance for households in environmental justice communities that rely on electronic medical devices for their long-term health.
Benefits to EV adoption: Economic benefits	• *Political capital and sustainable infrastructure*	*Distributive*: inequities in EV incentive structures and mobility benefits. *Recognition*: transportation cost burden of owning and operating a vehicle.	*Restorative*: Transition to affordable used EVs to reduce operating (e.g., gasoline) and maintenance expenses.
Domains of justice			
Transportation justice	• *Political capital and sustainable infrastructure* • *Essential life services*	*Distributive*: disparities in access to affordable modes, coping strategies, and long-distance trips. *Recognition*: ideal modes of transportation and precedence of cost and convenience over environmental concerns.	*Restorative*: attention to affordability and ideal modes of transportation in the EV transition.
Environmental justice	• *Healthy living environment* • *Essential life services* • *Political capital and sustainable infrastructure*	*Distributive*: disparities in exposure to traffic-related pollution. *Recognition*: anxiety and worry about air pollution and longevity.	*Restorative*: Adoption of EVs to improve air quality and moving pollution sources out of disadvantaged communities.
Energy justice	• *Essential life services* • *Political capital and sustainable infrastructure*	*Distributive*: Disparities in energy cost burden, coping strategies, power outages, and access to cost-saving energy solutions such as solar panels. *Recognition*: redlining, historic disinvestment, old homes with structural deficiencies and solar energy literacy.	*Restorative*: affordable energy benefits associated with EVs with vehicle-to-home capabilities, solar energy incentives and improving access to information about solar technology.
Climate justice	• *Healthy living environment* • *Political capital and sustainable infrastructure*	*Distributive*: Disparities in impacts of climate change at neighborhood and individual level. *Recognition*: frequent weather-induced climate outages in underserved neighborhoods.	*Restorative*: equitable distribution of greenspaces to mitigate climate change impacts and renovating power grid infrastructure.

affordable public chargers could reduce the gap between single-family homeowners and multifamily housing dwellers.

While we attempted to mitigate subjectivity bias in our coding by using the JTEV framework to guide the selection of overarching themes of injustices, triangulating justice themes with the U.S. Climate and Economic Justice Screening Tool to identify the intersectionality of injustices embedded in EV transition, and employing an inductive iterative approach to interpret interview transcripts line by line to identify all possible justice codes and themes, we acknowledge some subjectivity bias in coding may be present and would thus be a potential limitation. In addition, findings from our study are generalizable to other U.S. cities that experienced segregation and structural inequities in housing, transportation, and energy infrastructure. Moreover, the lived experience with the injustices of the immigrant populations may also be similar to the experiences of those from similar backgrounds who recently relocated to the United States. However, the severity of the inequities depends on the local geographical context, which may limit the transferability of our findings to some cities.

Prioritizing direct investment in disadvantaged communities, starting with community-led projects, would be useful to emphasize procedural justice in practice. Transportation and energy programs that consider equity could be more effective if they considered both top-down and bottom-up evaluative approaches. Installing public charging stations in charging deserts could reduce transportation and energy burdens and promote an equitable EV transition, yet efforts to do so should be mindful of the potential for undesired consequences, such as stimulating dynamics that might lead to increases in property taxes and the resulting effects thereof (e.g., gentrification). Vouchers and other incentives, that do not rely on a tax burden, for installing solar photovoltaics in underserved areas and low-income households to reduce the energy burden, may also increase the adoption of EVs. For example, allowing households (including renters) to invest in solar energy compensation programs could help offset household electric bills, and removing legal and administrative barriers to integrating bidirectional EVs into the electricity grid could help manage grid stability and buffer against disruptions. To mitigate climate and environmental burdens, there is a need to reduce disparity in heat waves and pollution exposure by adding tree canopy and enforcing stringent measures against outdoor air pollutants, regardless of the source.

6. Conclusions

Overall, our findings show that the inequitable distribution of burdens across transportation, energy, climate, and environment deprive capabilities for EV adoption. To the extent to which the interviews represent the dispositions of those in disadvantaged communities, there is broad interest and motivation to participate in the EV transition. But the outcomes of the burdens impede that participation and are perpetuated or exacerbated by personal, social, and environmental disadvantages that impose constraints on adopting EVs. If not recognized and remedied, these socio-spatial disadvantages could reproduce existing injustices in the new context of the EV transition. As a result, no single justice perspective on the barriers embedded in the EV transition is sufficient. Therefore, achieving a just transition to EVs requires a bottom-up evaluation of deprived/enhanced opportunities (i.e., capabilities) for EV adoption and top-down approaches to enable capabilities in transportation, energy, climate, and environmental domains.

CRediT authorship contribution statement

Abdirashid Dahir: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jeffrey M. Bielicki:** Writing – review & editing, Validation, Resources, Project administration, Investigation, Funding acquisition. **Jeffrey Jacquet:** Writing – review & editing, Project administration, Funding acquisition, Data curation. **Huyen T.K. Le:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We thank Bishista Shree, Diego Hincapie Ossa and Emma Hanners for their assistance in data collection, and the rest of the FLEETS For All project team for their feedback and support. The project is funded by the U.S. Environmenal Protection Agency (Award number R840555) and supported by the U.S. National Science Foundation Research Traineeship Program (Award number 1922666).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2025.104449.

Data availability

The data that has been used is confidential.

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