Increasing Equity in Access to Electric vehicles and Electrified infrastructure through Perceptions, Opinions and Knowledge of Underrepresented Communities in the Paso del Norte Region

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Liliana Lozada-Medellin is a Hispanic female, first-generation Ph.D. Candidate in the Environmental Science and Engineering Doctoral program at the University of Texas at El Paso. She holds a Master's degree in Construction Engineering and Management and a Bachelor's Degree is in Architecture. Most of her professional experience has been in the private sector as a design architect. During her time in UTEP graduate school, she conducted research for the civil engineering (CE) department on Unmanned Aerial Vehicles technology on construction-site workers safety. She also conducted joint research for the National Science Foundation's ASPIRE (Advancing Sustainable through Powered Infrastructure for Roadway Electrification) Engineering Research Center and the US Department of Transportation's CARTEEH (Center for Advancing Research in Transportation Emissions, Energy, and Health). She evaluated the environmental and social justice impacts of the electrified technologies (electric vehicles (EVs), EV charging stations, and electrified roadways) with a focus on underrepresented communities.

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Dr. Ivonne Santiago is a wife, mother, Environmental Engineer, and teacher. She is an Associate Professor of the Civil Engineering (CE) Department at the University of Texas at El Paso (UTEP). Dr. Santiago has a combined experience of over 20 years in the areas of community engagement, water quality, water treatment and wastewater treatment in Puerto Rico (PR), New Mexico and Texas. Currently, she is Chair of the El Paso Water Public Service Board (PSB), where she is a member of Engineering Selection and the Communications subcommittees, and the ad-hoc committee for storm water priorities. She has been a member of the Environmental Protection Agency National Advisory Committee (NAC), that advises the Administrator of the EPA on environmental policy issues related to the implementation of the former North American Agreement on Environmental Cooperation and was a member of the Good Neighbor Environmental Board (GNEB) that advises the President and Congress of the United States on good neighbor practices along the U.S. border with Mexico. Dr. Santiago's history of service started in Puerto Rico as Director of the Water Quality Area of the PR Environmental Quality Board, in charge of Compliance, Permit, and Planning Bureau, that included Industrial and Non-Industrial permits, Leaking Underground Storage Tanks (LUSTs), and watershed restoration activities. As Director, she implemented the first Beach Monitoring program in coordination with the PR Tourism Office and the Blue Flag program (A world renowned eco-label) and implemented the first Total Maximum Daily Load Program in PR. Professionally Dr. Santiago has been recognized with the 2019 El Paso Engineer of the Year by the Texas Society of Professional Engineers. This is the first time in more than 30 years that a UTEP faculty wins this prestigious award and the 2018 American Society of Civil Engineers' Texas Section "Service to the People" award. This award honors civil engineers who have distinguished themselves with special service to the people and bring credit to their profession through community activities that are visible to the public. As Associate Professor her mantra has been to connect education to professional practice inside and outside the classroom as demonstrated by the local and state awards she has won: 2014 UTEP's CETaL Giraffe Award (for sticking her neck out); 2014 College of Engineering Instruction Award; 2014 The University of Texas System Regents' Outstanding Teaching Award; the 2012 NCEES Award for students' design of a Fire Station. In her work, Dr. Santiago helps to find innovative engineering solutions through an understanding of the balance between sustainability, social equity, entrepreneurship, community engagement, innovation, and leadership to improve the well-being of people. A few examples include: interdisciplinary projects that provide safe drinking water to underserved communities in El Paso, Ciudad Juárez, Puerto Rico, and Haiti; a bridge that connected communities in Puerto Rico; a solar charging station for natural disasters in Puerto Rico; innovation and entrepreneurship activities on water quality sensors and phyto-remediation; remote sensing applications using Hyperspectral cameras on UAVs for water quality and agricultural applications; and study abroad opportunities that

advance the emerging field of Peace Engineering in Curitiba, Brazil; native communities in the Amazon in Villavicencio, Colombia; and underserved communities in Piura, Perú. Dr. Santiago is passionate about providing experiential learning opportunities to both undergraduate and graduate students with a focus on Hispanic and female students. She is currently Co-PI of UTEP's NSF-AGEP program focusing on fostering Hispanic doctoral students for academic careers; the Department of Education's (DoE) STEMGROW Program to encourage students Latino(a) students and students with disabilities to pursue STEM careers; and DoE's Program YES SHE CAN that provides support and mentoring to female pre-college students. She is also a member of two advisory committees to the UTEP's President: The Diversity, Equity, and Inclusion committee and of the Women's Advisory Council, in which she served five years as Chair. She is also Co-PI in the NSF Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE), where she co-Directs the Diversity and Culture of Inclusion Program, where she is also a researcher in the Adoption Thrust.

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Increasing Equity in Access to Electric Vehicles and Electrified Infrastructure through Perceptions, Opinions and Knowledge in Underrepresented Communities in the Paso del Norte Region

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Keywords: Equity, Inclusion, Electric Vehicles (EVs), EVs Charging Stations, Electrified Roadways, Transportation Infrastructure

1. Abstract

As the transportation and the automotive industries continue to grow, the impacts on the environment and human health remain a growing concern on the general public and policy-makers [6], [9]. Although Electric Vehicles (EVs) are entering the market as a green technology solution to counteract greenhouse gas (GHG) emissions from internal combustion engine vehicles (ICEVs), there are still barriers that need to be overcome for EV widespread adoption. These include basic technology information spread for public knowledge, equity concerns, and infrastructure access to all.

This study aims to advance vital knowledge regarding environmental and social justice impacts of the electrified technology, including electric vehicles (EVs), EVs charging stations (ChSs), and electrified roadways (ERWs). This project is a joint collaboration between the National Science Foundation's Engineering Research Center for Advancing Sustainability through Powered Infrastructure for Roadway Electrification (ASPIRE), and the US Department of Transportation's Center for Advancing Research in Transportation Emissions, Energy and health (CARTEEH). The ASPIRE center aims at a sustainable and fair future for transportation infrastructure systems through widespread electrification for all classes of vehicles. The center focuses on the incorporation of electrified roadways and wireless charging solutions for EVs so they can charge either in motion or parked, thus eliminating the gas-station models, and offering health benefits through cleaner air and sustainable infrastructure [1]. CARTEEH focuses on the impact of transportation on human health [2].

The goals of the study are to evaluate perceptions, opinions, and knowledge of underrepresented communities (URCs) about the electrified transportation technologies and examine disparities in access to EV infrastructure. In this study, we define URCs as low-income or minority populations. The study was performed within the city of El Paso, Texas, where its cultural and demographic diversity, with 85% Hispanic population, offers an adequate location as a testbed for the major focus of this work. This project will help inform about the social and infrastructure barriers that need to be taken into considerations in future research directions, design alternatives, and testbed development. In turn, leading to the rollout of the widespread EV adoption to include historically minoritized populations.

2. Background

As EVs make their way into the market as a sustainable solution to reduce fuel-use dependency and lower GHG emissions and environmental pollution [5] - [8], previous studies addressing consumer perception, behavior and tendencies on EV adoption found that cost, style, size and range anxiety are amongst main influential factors on potential purchase and use of the vehicles [9] – [12]. This study, however, provides an insight from the unique perspective of underrepresented minorities in El Paso, TX., that goes beyond these factors. The study evaluated how these communities perceive EVs, EVs ChSs, and ERWs. It also examined communities' access to these, and explored the potential of having ChSs and ERWs installed in their neighborhoods, along with their desire for the technology to develop and become equally accessible for all.

Although consumers in general share familiarity with EVs to some extent, basic knowledge of the technology, capable of influencing consumer perception and potentially leading to adoption, seems to be absent in the general public. The lack of this basic knowledge, perhaps one of the major barriers between EVs and consumers in URCs, goes beyond misconception, range anxiety, style, and pricing that are addressed in previous studies on EVs adoption and consumer behavior [5], [6], [7]. URCs showed greater concern about electrification cost, health impacts, variety of EVs charging options, EVs initial and maintenance costs, and vehicle safety. Once learned, government incentives and tax rebates also developed particular interest from URCs when considering EVs purchase.

Acknowledging and addressing the existing knowledge gap between consumers and EV manufacturers and EV-related infrastructure developers is essential for EVs' widespread diffusion and adoption. Making the information accurate, easily accessible to the public, and addressing their specific needs can mark significant difference towards adoption in new and unexplored markets like URCs.

3. Methodology

The study examined the perception, opinions, and knowledge of URCs in the Paso del Norte region on EVs, EVs ChSs, the ERWs, and on having these technologies installed in their own neighborhoods. For this purpose, the study performed three focus groups and 221 surveys. Herein we present the focus group findings only.

3.1 Selection of communities

The EPA environmental justice screening and mapping tool (EJScreen) [3] and the Texas Commission on Environmental Quality Monitoring Stations [4] were used to select the communities based on majority-minority population, low-income, and high levels of GHG and $PM_{2.5}$ pollutants. The communities selected were Chihuahuita, Montana Vista, and Anthony, TX. Locations are shown in Figure 1 and described in Table 1.

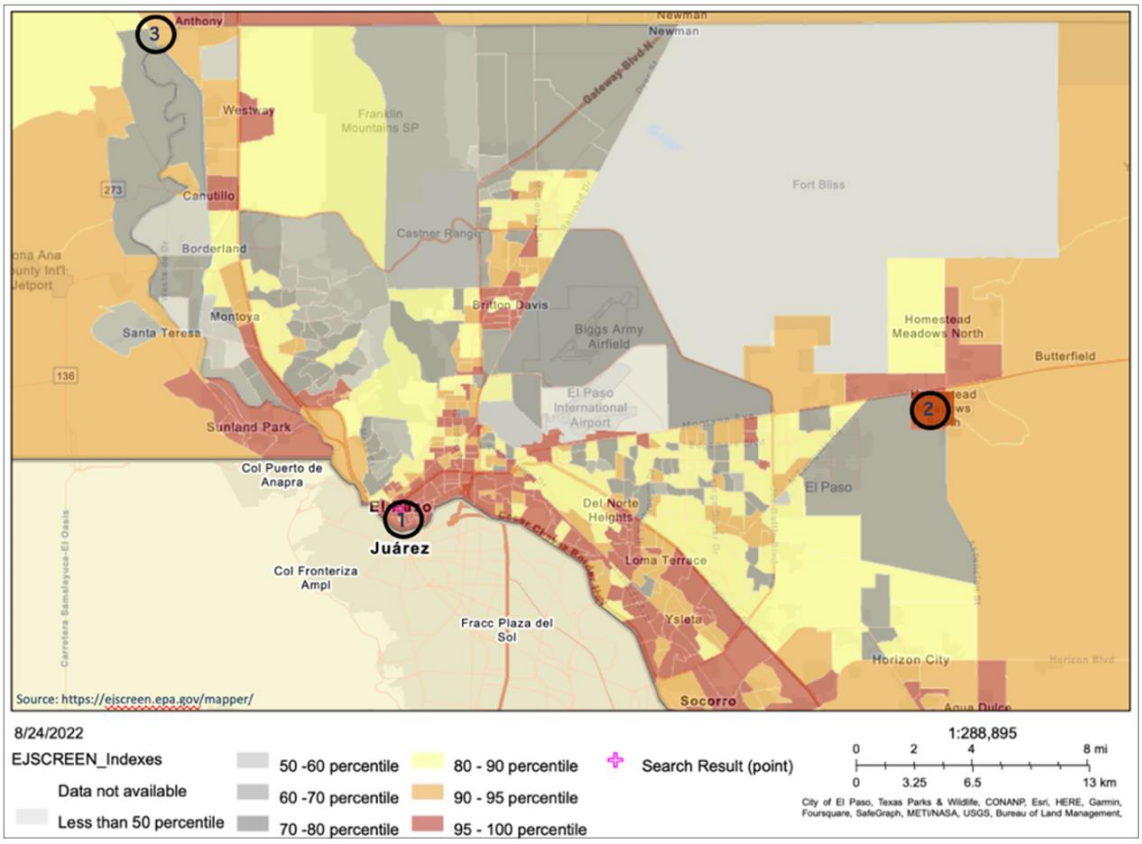


***Figure 1**. Location of selected communities using the EJScreen:1- Chihuahuita, 2- Montana Vista, 3- Anthony, TX.*

Chihuahuita

Chihuahuita is a historic district located in south downtown El Paso on the borderline between Mexico and the United States. It is the oldest neighborhood in the city and most members have lived there for over twenty or thirty years [14], [15]. This community is vulnerable to multiple environmental hazards like pollution from the commercial areas of the nearby downtown, the urban bus terminal, the US 62 Paisano drive a few blocks away, the Loop 375 state highway that passes above the community, the commercial rail road that dissects the community and blocks the only entry/exit point to/from the community when train travels through, the neighboring Mexican border Juarez city that is located immediately south of the neighborhood, and the Santa Fe international port of entry, which operates 24 hours a day, seven days a week. As a historic district, this community has specific design guidelines established by the city for restoration and/or new construction in the neighborhood that could modify or affect its original historic construction and preservation [18]. This, in turn, prevents them from any contemporary addition or modification, such EV ChSs or ERWs.

The perception on EVs from most members of this community was positive. They considered that EVs could make a considerable difference improving their air quality (AQ), due to the pollution they face, specifically from different sources of traffic. Nevertheless, they considered EVs out of their reach mainly due to initial cost. Regarding ChSs and ERWs, they still perceived the

technology out of their reach due to the restrictions that their historic district has, meaning that ChSs and ERWs could not be installed in their neighborhood. These factors made them lack interest in EV adoption, they also ignored the existence of incentives and tax rebates available for EV purchase, and that their near-downtown neighborhood has easy access to EV public ChSs within one mile. The community members had never heard about ERWs before. Although they considered them a great resource, as they eliminate the need to drive to a charging station, they still highlighted that most of their community members could not afford an EV, thus, ERWs would not be useful for them.

Montana Vista

Montana Vista is an unincorporated rural community located far east in El Paso County and part of the metropolitan statistical area. [19]. Some participants have lived in the neighborhood for less than three years while other for over 10 years. Although Montana Vista has a power plant nearby and the highly commuted US 62/180 highway (Montana Ave.) going through their neighborhood, the community members do not consider they face big environmental issues.

Participants of this middle age working-class community were in favor of the EV technology. Although they perceived it as costly, they showed great interest in the benefits that the technology could provide for their work. Their main EV inquiries included availability of heavy-duty pick-ups, maximum payload capacity, and maximum vehicle miles traveled per charge on full load. Regarding ChSs, they knew El Paso has public ChSs in service and that they are located far from their community.

In respect to ERWs, the topic was fully unknown to this community. They perceived ERWs useful as they eliminate ChSs and EV range anxiety, although unnecessary for now as the number of EVs is small. Withal, the topic generated particular interest about the effects of electrification on human health, the safety of users, construction and maintenance costs, and its effects on their community power supply.

Anthony, TX.

This rural community, located far west in the county of El Paso, is also an unincorporated community [19]. This community, comprised mostly of retirees, perceived EVs as highly beneficial as they help providing better air quality and are cost-effective compared to regular vehicles' fuel expenses. The community is vulnerable to nearby traffic pollution from the I-10 interstate, commercial areas, gas stations including trailer rest travel areas, and a local elementary school.

The members of this community were particularly interested in what EVs can offer them in terms of safety, comfort, and savings. Their primary inquiries included whether EVs offer new technologies, such as movement and vehicle detection to prevent accidents, for example, whether EVs can drive autonomously in the case that the driver experiences a heart attack. Also, whether EVs require less maintenance than ICEVs. They also perceived EVs as costly, and they had no knowledge of incentives or tax rebates availability for EV purchase, which increased their interest to learn about the topic.

Regarding ChSs, this community had knowledge about stations in service in the city, although not much about the locations or approximate number. Thus, they perceived having charging stations installed in their neighborhood as beneficial if they eliminate the need to drive to a station and EV range anxiety.

As per ERWs, this community had never heard about the technology. Their perception was positive, yet, they expressed concerns about ERWs construction and maintenance that may cause traffic issues and the effects on their community's power supply.

Table 1. *Overview of Selected Communities*

Community	Group Age	Education Level	Annual Household Income	Technology Perception	Neighborhood Overview
Chihuahuita	35-65 years	Some high school and Associate degree	$17 - $38K	*Advantages:* Could potentially help enhance their community's air quality *Disadvantages/Concerns:* EV initial cost, having historic district design restrictions keeps them from having EV ChSs and ERWs installed	Affected by pollution from bus station and downtown commercial areas nearby, the 62 and 375 state highways, the commercial rail road that goes through the neighbor and blocks the one entry/exit to/from the community, the Mexican neighboring border city, and the daily commuted Santa Fe international port of entry [14], [15]. Did not know their downtown location has close access to current EV ChSs. Never heard about EV purchase incentives and ERWs before.
Montana Vista	25-55 years	High school and College	$38K - $75K	Advantages*:* EV could potentially facilitate work activities especially electric pick-ups. Showed special interest in home EV charging stations Disadvantages/Concerns: EV initial cost. Will ERWs increase taxes? Who will assume ERWs construction and maintenance costs? Can ERWs cause community power outage?	Rural middle age working community located far east [19]. An unincorporated community in El Paso County, affected by pollution from the US 62 and electric plant nearby. Perceived EVs as useful for their work. They had

					knowledge of local EV ChSs in service and locations. Never heard of EV incentives and ERWs
Anthony	45- 65 years	High school and College	$49K - $75K	Advantages: Highly beneficial to cleaner air and cost effective as compared to fuel expenses from ICEVs Disadvantages/Concerns: EV initial cost. What new technology do EVs offer to help drivers prevent accidents? Will ERWs cause traffic congestion or community power outage?	An unincorporated far west town in El Paso County [19]. Mostly retirees. Community affected by pollution from the commercial areas nearby, the interstate 1-10 including gas station stops and rest areas. Found EVs beneficial. No knowledge about EV incentives. Never heard of ERWs.

The research consisted of a focus group questionnaire following the protocol with Institutional Review Board (IRB) approval. Key participants included current residents of each community only, who are considered the best candidates to convey their experience and perspectives as for their residency in the neighborhoods. Participation was open to any resident of these areas being at least 18 years of age. The protocol included the following section and topics:

- Section I: Perception on local AQ and EVs as environmental benefit
- Section II: Knowledge and perception on EVs
- Section III: Knowledge and perception on EVs Purchase and Incentives
- Section IV: Knowledge and perception on EVs ChSs and ERWs

The data was analyzed using qualitative research methods with the use of the MAXQDA qualitative data analysis software. The study considered the following vehicles [13], [16], [17]:

- Battery electric vehicles (BEVs): Fully powered by plug-in rechargeable electric batteries
- Hybrid electric vehicles (HEVs): Powered by an electric motor and a fuel engine simultaneously (fuel engine recharges the battery that powers the electric motor)
- Plug-in hybrid electric vehicles (PHEVs): Powered by an electric motor and gasoline engine, where the electric motor is powered by a plug-in rechargeable electric battery and the gasoline engine is used as a backup
- Internal combustion engine vehicles (ICEVs): The conventional gasoline and diesel engine vehicles

4. Discussion

The focus group sessions provided valuable information regarding consumer perception, opinions and knowledge that could potentially affect EV adoption, including the use of ChSs and ERWs. As stated earlier, topics included local AQ, EVs, EV ChSs and the ERWs. No specific response was provided or required from participants other than their personal perceptions and ideas. Table 2 presents the sentiment analysis of the study among the three communities. Responses per community are shown and summarized vertically. Sentiment is represented with a square, varying in size according to the feeling intensity. The larger the square, the larger the feeling or emotion from responders to the question in turn. The comparison between communities can be assessed horizontally. No square is shown where no responses were obtained.

Table 2. *Focus Groups Sentiment Analysis*

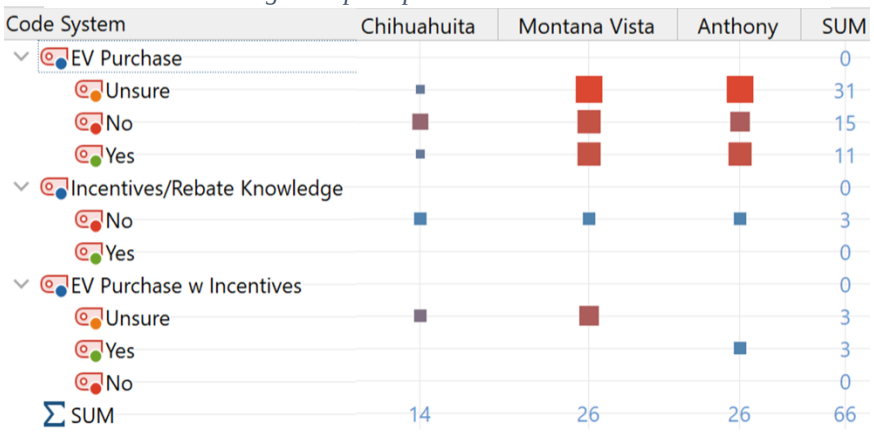
Section I: Perception on local AQ and EVs as environmental benefit

Code System	Chihuahuita	Montana Vista	Anthony	SUM
AQ Community				0
Bad				2
Regular				3
Good				5
Factors affecting AQ				0
Transportation				8
Industries				3
Juarez city				2
Another				2
EVs on AQ				0
Unsure				0
Positive Impact				9
Negative Impact				0
SUM	16	7	11	34

Section II: Knowledge and perception on EVs

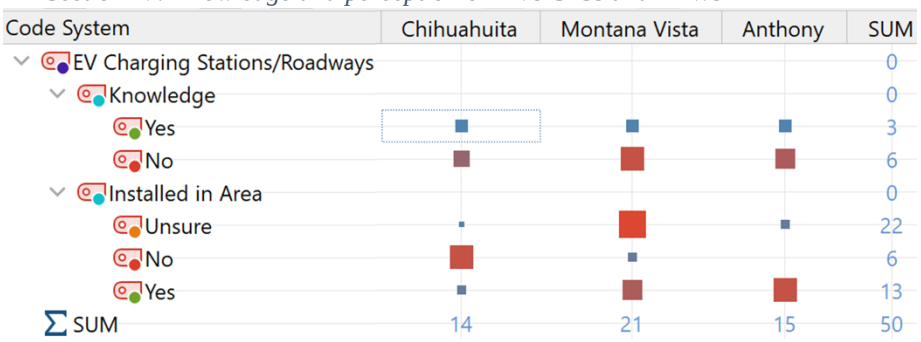
Code System	Chihuahuita	Montana Vista	Anthony	SUM
EV Knowledge				0
No				0
Unsure				2
Yes				10
EV Perception				0
Negative				14
Concern				62
Positive				8
SUM	25	39	32	96

Section III: Knowledge and perception on EVs Purchase and Incentives



Code System	Chihuahuita	Montana Vista	Anthony	SUM
EV Purchase				0
Unsure				31
No				15
Yes				11
Incentives/Rebate Knowledge				0
No				3
Yes				0
EV Purchase w Incentives				0
Unsure				3
Yes				3
No				0
SUM	14	26	26	66

Section IV: Knowledge and perception on EVs ChSs and ERWs



Code System	Chihuahuita	Montana Vista	Anthony	SUM
EV Charging Stations/Roadways				0
Knowledge				0
Yes				3
No				6
Installed in Area				0
Unsure				22
No				6
Yes				13
SUM	14	21	15	50

Source: MAXQDA Qualitative Data Analysis software

4.1 Perception on local AQ and EVs as environmental benefit

The focus group sessions included questions on perceptions, opinions and knowledge on major factors that affect their local AQ, AQ improvement needs, and EVs as a beneficial factor to improve local AQ.

As seen in Table 2, section I, participants from Montana Vista in far east of El Paso, considered their AQ good and clean, whereas participants from Chihuahuita showed more concerns on pollution and fumes from interstate highway traffic, commercial railroad, the neighboring Ciudad Juárez, Mexico, and the International Paso del Norte Port of Entry highly commuted on a daily basis. For participants from Anthony, the major AQ concerns were from the nearby interstate highway (I-10) traffic, gas stations, trailer rest areas, commercial areas, and school traffic. The three communities identified EVs as a technology able to positively improve their AQ. Anthony showed the highest positive sentiments. Chihuahuita, despite having more factors affecting AQ, showed fewer positive sentiments due to EV cost, while Montana Vista had the fewest positive sentiments as they perceived their local AQ good. Both Chihuahuita and Montana Vista agreed that replacing current ICEVs transiting the interstates in their areas with EVs would highly benefit their local AQ.

4.2 Knowledge and perception on EVs

The focus group sessions also evaluated EV perception, opinions, and knowledge in URCs to identify factors that may influence consumer preferences and behavior towards EV adoption in low-income minority populations.

The three groups (Table 2, Section II) showed some degree of EV knowledge, although they felt unsure if it was accurate knowledge. They knew that EVs are available in the market, they help the environment and human health by reducing fuel emissions, and EVs are more expensive than ICEVs. Participants from Montana Vista had knowledge about different EVs in the market, although they did not know them by their names but as cars that "use electricity only" (BEVs), or "use electricity and fuel" (HEVs). They, however, did not know about PHEVs and their different components or characteristics. They also had knowledge about home EV chargers. Participants from Anthony also knew about EVs as a new and cost-effective technology that could save them fuel expenses.

Purchase cost was perceived as the first disadvantage of EVs by the three communities. They stated that it limits equal access for all as opposed to ICEVs' more affordable cost. They also considered it a remarkable disadvantage that they did not know about EVs driving range under normal conditions and in a traffic jam, charging time and cost, vehicle maintenance costs, and location of charging stations. These issues limited their ability to make informed decisions about whether to buy EVs. Participants from Chihuahuita also expressed that as historical district, the city would not allow infrastructure modifications in their neighborhood, such as installing charging stations, and this was perceived as a disadvantage of EV use. Regarding positive sentiments on benefits and advantages, the three communities expressed only two opinions, EVs help the environment by reducing fuel emissions and can be a cost-effective technology due to savings from fuel expenses. They wanted to learn more about the actual monetary benefits and the time frame for the return of investment.

Beyond considering advantages or disadvantages of EVs adoption, the participants from the three communities expressed mostly concerns and inquiries about EVs that they were not able to articulate because they lacked the information. Safety drew particular interest from participants with questions on general effects about EV charging, such as whether it is safe to charge more than one vehicle at home, whether batteries can affect cellular phones or vice versa, and whether it is safe to one's health to spend long periods of time inside an EV while charging. Regarding battery safety, the main concerns included how high or low temperatures affected battery performance and lifespan, specifically, whether batteries will be safe and not "explode" under the extreme heat temperatures in El Paso. They also asked questions such as whether using or being close to an EV battery affect human health in the long-term, and whether batteries are safe for pacemaker users.

Participants from the three communities had the same general questions about EVs, including the different charging options in the market, their cost, maintenance, safety, and environmental benefits. Regarding vehicle types available in the market, they wanted to know why EVs cost more than ICEVs and what components or features make different EVs cost more than others. Participants also asked if EV repair shops are available in the city or is only by EV dealerships,

EVs maintenance frequency, and if EV repair and insurance will cost more than ICEVs. They also inquired about EV batteries, types, maintenance required, lifespan, and replacement cost. Regarding home chargers, their main concerns included levels of charging available, purchase and installation cost, life-span, electricity consumption rate and cost, and if a regular electrician can install them or specialized electricians are required. They also asked if a home charger was safer and faster than a public ChSs. Specifically, they asked what happens to both chargers and batteries once they complete their life span.

Participants from the three communities had other similar concerns, such as how safe are EVs at high speed, how safe are EVs when in car crashes as compared to ICEVs, whether EVs are at a lower risk of explosion in an accident as compared to ICEVs, whether EVs offer new technologies like contact and movement sensors to help prevent accidents, whether EVs can be driven autonomously in the case that driver passes out or has a heart attack, and lastly, since EVs are quiet, whether they safe for blind and deaf pedestrians.

4.3 Knowledge and perception on EVs purchase and incentives

Regarding EV purchase (Table 2, Section III), participants from Montana Vista and Anthony were in general unsure about EV technology mainly due to the high initial cost and the lack of information regarding the different EV options and benefits. Participants from Chihuahuita showed the most interest in EVs. However, as they felt they could not afford them and could not have a public charging station installed in their neighborhood, because of constraints in their historical district, they lost interest. Nonetheless, they had no knowledge that they have access to public charging station in less than one mile. Regarding EV purchasing, the Montana Vista participants had questions about availability of electric heavy-duty pick-ups in the market, their maximum payload/towing capacity, maximum distance they can drive on a single charge at full payload capacity, what the costs are and the availability of insurance and road assistance. Participants from the three groups also wanted to learn how to calculate the actual cost/benefit of owing an EV and savings from fuel expenses, especially on long-distance work trips.

Ultimately, as previously mentioned, pricing was the main limitation expressed by the participants in the three communities. No participant had any knowledge about federal tax credits, state and local incentives and rebates. This topic generated significant interest among all the participants. It improved their perception of EVs as they perceived that EVs could be an affordable option for them, given incentives and rebates available. Their questions included what the maximum incentive amount is based on, which vehicle gets the maximum amount, how is the incentive applied, whether incentives are applicable for retirees, whether more than one incentive can be grated per household, whether used EVs are available for purchase as ICEVs, and whether ICEVs can be traded in for EVs purchase.

4.4 Knowledge and perception on EV ChSs and ERWs

The last topic discussed EV ChSs and ERWs (Table 2, Section IV). Although the three communities had knowledge about public ChSs in El Paso, participants from Anthony and

Chihuahuita did not know of any location or approximate number of stations in town. Only the participants from Montana Vista knew of some locations and that they are far from their homes. None of the participants from the three communities had knowledge of the different charging levels (Level 2 or DC fast charging) currently available in El Paso, nor charging time or cost. None of the participants had knowledge of Internet applications or Internet search engines to find locations of available ChSs.

Perceptions and opinions about having ChSs installed in their neighborhoods varied. Participants from the rural communities of Anthony and Montana Vista, located far west and far east of El Paso, respectively, were receptive and saw benefit to having ChSs installed in their neighborhood since they currently do not have any nearby. They felt this could keep them from driving long distances to charge EVs, if they chose to purchase one, and it could promote EV adoption in their communities contributing to decrease traffic pollution as EV adoption increases. Their concerns about ChSs included who will cover the station installation and maintenance cost, and also, if new stations are installed, whether the community would face electricity supply issues.

The participants from Montana Vista asked if it would result in more emissions from electricity generation at the power plant that is located near their homes. On the other hand, participants from Anthony were concerned whether having ChSs in their neighborhoods could cause more traffic issues since they already face traffic from the interstate, gas stations, trailer rest stops, commercial areas, and schools nearby. Participants from Chihuahuita still expressed that EVs are unaffordable to most members in their community due to cost and the impossibility of having a public station due to their historic district restrictions. They also felt uncomfortable or unsafe about having "random strangers" coming to their small neighborhood to use the station, especially at night.

The last topic regarding ERWs attracted the greatest of interest. ERWs aim at substituting charging stations with inductive embedded charging elements in the pavement, allowing vehicles to wirelessly charge as they drive or park on electrified roadways [1]. This last section evaluated URCs perceptions, opinions, and knowledge of ERWs and their willingness to have this technology installed in their neighborhoods. None of the groups had previously heard about electrification of roadways, which generated diverse perceptions and concerns in line with the specific needs of each group.

General perception of ERWs was positive if they are able to eliminate public ChSs, and with it, driver's range anxiety, although not for the present moment. The three communities agreed that promoting and making EVs accessible to all, including their URCs, should be prioritized before investing into roadway electrification, considering the low percentage of EVs in the market now as compared to ICEVs. The participants expressed concerns about cost, health effects, and safety of ERWs. Most concerns related to cost focused on who will assume construction and maintenance cost of ERWs, whether ERWs construction will increase property taxes, and whether ERWs will be freely accessible or will they include an access fee. Most concerns about human health included how safe ERWs will be for users, specifically, for cancer survivors, people undergoing chemotherapy, people with pacemakers, and pregnant or lactating women. Most safety concerns focused on how safe would ERWs be in rainstorms, flooding, and extreme heat/freezing temperatures. Other concerns included what is ERWs lifespan, whether electrification can damage

fuel vehicles, and whether fuel vehicles like cranes or ambulances can safely circulate ERWs to assist in road accidents.

Regarding EWRs installed in their neighborhoods, participants from Chihuahuita considered it unnecessary as none of their residents could afford an EV now besides their historic district restrictions. Participants from Montana Vista and Anthony showed mixed attitudes towards EWRs. They expressed concerns about electrification, such as whether electrification would cause community electricity outage, and whether electrification construction and maintenance would take long, thus causing roadway-closure and traffic congestion as the highway extension currently does. Participants from Montana Vista suggested that when the number of EVs in El Paso increase considerably, electrification could begin then by focusing on highways and main roads alone.

5. Conclusions

This study has helped understand perceptions, opinions, and knowledge of EVs, public EV ChSs and EWRs of URCs in both urban and rural areas in the Paso del Norte region. Results from the focus groups provided valuable information that can help to increase equity and inclusion as EV adoption increases to bridge engineering with social and environmental justice. In engineering, these are considerations that must be part of any design criteria that involves deployment of technologies within communities. If the needs and concerns of the communities are not understood and addressed, through outreach and education, it will not be possible to increase adoption of EVs. Additionally, this study will contribute a foundation that can be used to choose locations for the deployment of electrified technology based on the resilience of the power grid that takes into consideration the public perception for infrastructure development.

The results showed that URCs have remarkable interest in EVs, ChSs and ERWs. Most participants showed some knowledge about EVs, to a lesser degree on ChSs, and none on ERWs. Results also indicate an evident gap of essential knowledge of EV technology in URCs being the main barrier to EVs widespread diffusion and adoption. Given the fact that most URCs residents lacked EV technology information, they expressed the need to have their doubts and concerns clarified before even considering purchasing an EV.

The study provides evidence that markets in URCs are all different and concerns about EVs, EV ChSs, and EWRs are diverse, based essentially on the specific needs of each community. To increase EVs adoption in URCs, comprehensive outreach and education that is of easy access and tailored to each community must be provided, as not one size fits all. Areas of concern vary in different degrees by community but include:

- Types of EV’s and their benefits and costs
- Incentives: develop and openly promote inclusive and diverse government incentives and tax rebates as they play an important role towards EVs diffusion and adoption in URCs
- Learning about locations and charging cost of public ChSs
- Learning about home charging stations and purchase rebates that help reduce upfront cost

- Learning about electrification environmental and health effects and benefits

Providing knowledge and understanding of EVs are essential steps to advocate EVs as an accessible technology. This helps addressing public main adoption barriers to increases public interest and adoption for all, including historically minoritized populations. In the same manner, it prepares the market for the future of electrified infrastructure. These steps also raise awareness in bridging the gap between higher engineering education and community outreach when planning and developing equitable transportation infrastructure, including ChSs and ERWs. This methodology shows that fostering equity and social and environmental justice in engineering education, by taking into account public perceptions and needs, and including underrepresented groups during the process of planning and developing public transportation infrastructure, is extremely important.

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