Title
An Electric Vehicle Rideshare Business Model: Transportation network company pilot program providing electric vehicles for low-income rideshare driver use

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Abstract

Rideshare services are a significant part of the transportation mix, increasing vehicle emissions that cause environmental and social impacts. According to the California Air Resource Board (CARB), transportation network company (TNC) fleet emissions per passenger mile traveled are 50% higher than the statewide passenger vehicle average. Rideshare-related emissions are significant, projected to account for 19% of vehicle miles traveled (VMT) by 2040 (Atlas Public Policy, 2019). The Rideshare industry is now regulated in California to reduce 90% of vehicle emissions by 2030 (CARB). Reportedly, only 0.2 percent of TNC vehicles were electric as of 2018 (International Council on Clean Transportation, 2019). Additionally, Low-income rideshare drivers face barriers to accessing electric vehicles and electric vehicle charging, further complicating achieving regulatory mandates.

This project identifies the barriers to electric vehicle charging and electric vehicles. The paper provides a business model outline for the transportation network company industry that identifies criteria and location of pilot sites for rideshare electric vehicle fleets with EV charging ability in low-income communities. Additionally, the project outlines the estimated costs of this pilot project, the expected income and appreciation on investments, and a proposed public rebate program to incentivize the private sector deployment of EV fleets at identified sites.

Introduction & Background

Transportation greenhouse gas emissions

The transportation sector remains the largest source of greenhouse gas (GHG) emissions in California. Twenty-eight percent of GHG emissions come from passenger vehicles (Environmental Protection Agency, 2018). Car-dependent regions such as southern California have high vehicle miles traveled (VMT), producing ever-increasing vehicle emissions. The California Air Resources Board (CARB) found a projected increase of VMT from 384 billion in 2010 to 475 billion in 2020. Internal combustion vehicles emit environmental toxins such as carbon dioxide (CO2), Methane (CH4), and nitrous oxide (N2O) emitted by vehicle exhaust systems, according to the Environmental Protection Agency (EPA). In densely populated urban areas, dependent primarily on passenger vehicles to commute, tropospheric ozone (smog) is created as a short-lived climate pollutant. Vehicle emissions such as methane and nitrogen oxide interact with sunlight, producing low air quality (caccoalition, 2021). Carbon dioxide emitted from vehicles is a significant contributor to the recorded increase of carbon dioxide in the atmosphere. Greenhouse gas emissions account for 32% of total externalities cost from Internal Combustion Engine Vehicles (ICEV) (Mitropoulos et al., 2017). The Keeling Curve (daily record of global atmospheric carbon dioxide concentration maintained by Scripps Institution of Oceanography) reported 418.17 parts per million (ppm) of carbon dioxide in the atmosphere as of 5/20/21.

Transportation Emission Health Impacts on Low-Income Communities

In addition to the impact of transportation on the climate, the same pollutants have lasting health impacts disproportionately in low-income communities. Emissions from vehicles produce low air quality. Breathing in-vehicle emitted toxins can damage lung tissue, causing inflammation and ongoing damage in the airways. Exposure can create lasting health effects such as asthma, infections in the lungs, or cause chronic obstructive pulmonary disease (EPA, n.d.). The Center for Disease Control reports that exposure to transportation emissions is linked to adverse birth outcomes and childhood cancer. The Air Quality Index (AQI) indexes air quality across the United States (EPA, n.d.). As of 2017, the AQI reported San Diego County had 62 days between the AQI range of 100-150. The 100-151 "orange" range classified as - "air quality is unhealthy for sensitive groups." According to the American Lung Association, low-income neighborhoods in San Diego, such as Barrio Logan, rank third in the nation in lung-related health effects like asthma. These low-income communities are at high risk of health-related issues due to transportation emissions and proximity to industry and highly trafficked areas.

Transportation Network Companies (TNC)

California has implemented regulations to reduce VMT by internal combustion engine vehicles (ICEV), incentivize electric passenger vehicle adoption, and expand the electric vehicle charging network to mitigate vehicle emissions by deploying zero-emission vehicles. Senate Bill 1014 Clean Miles Standard and Incentive Program (2018) directs the California Air Resource Board (CARB) and California Public Utilities Commission (CPUC) to develop new emission reduction requirements actively. Transportation network companies (TNC) are regulated to curb GHG emissions through converting rideshare vehicles from ICEVs to electric vehicles (EV). California regulators have assessed the rapid increase of ridership using application-based transportation network companies (TNC) and have regulated TNC fleet greenhouse gas emissions. According to CARB, TNC emissions per passenger mile traveled is 50% higher than the statewide passenger vehicle average. Transportation network company-related emissions are significant, projected to account for 19% of vehicle miles traveled by 2040 (Atlas Public Policy, 2019). Senate Bill 1014 (2018) mandates that 90% of all rideshare vehicle miles traveled are zero-emission by 2030.

Companies mandated by the Clean Miles Standard, the TNC industry leaders, have responded by requesting further support of government aid to deploy electric vehicles and charging to low-income TNC drivers to contribute to the conversion cost. Lyft has stated that taxpayers should finance the transition because current government subsidies are only sufficient to make EVs affordable for “typically high-income white homeowners” (Reuters, 2021), while most California Lyft drivers are low-income households.

The rideshare industry could have their businesses under distress to meet compliance. The ridesharing business model has seen labor disputes and attempted regulation costing the companies significant capital and considering leaving entire markets such as California. Uber reported losing $6.77 billion in 2020, down from $8.51 billion in financial losses in 2019 (Kolodny, 2021). Industry leaders like Uber have depended on the confidence of investors to continue to fund the rideshare industry. This confidence, in part, comes from Wallstreet's speculation that vehicle automation will bring down the operating cost for rideshare companies. As reported by Nasdaq, UBS shows that the rideshare company's cost per mile when adding automated vehicles to the fleet will be about 80% less than that of a traditional taxi (Shetty, 2020). Such a significant decrease could lead to a profitable business model. Investors and TNCs are eager to have a fully automated vehicle and motivated to implement it into their business model.

The estimated deployment time for level four and five automated vehicles – fully autonomous - is between 2027 and 2035 (Milakis, 2020). There will be an autonomous conversion to vehicle fleets from 15% in 2030 to 75% in 2040 (RPA, 2017). Autonomous vehicles may promote reduced car ownership and increased demand for rideshare services due in part to low initial cost and the potential of automated driving efficiency and convenience (Zhang, 2015).

In addition to benefiting the TNC model, vehicle automation provides less traffic (reduced GHG), greater vehicle accessibility (Geurs & van Wee, 2004), and reduced need for convenient public parking producing infill development and a reduction in available public parking spaces. (Milakis, et al., 2017). Therefore, the California Air Resource Board included language in the Clean Miles Standard regulation design:

"*: Account for driverless automated vehicle operation and other new modes of transportation emerging from continued innovation in TNC fleets to encourage low-emission vehicles and pooling in new mobility modes."*

The deployment and realized benefits of automation are years away; in the meantime, TNCs will need to plan for providing EV accessibility to their drivers. Low-income rideshare drivers, likely most impacted by vehicle emissions and benefit from improved air quality by electric vehicle adoption, will require accessibility to an electric vehicle. Unfortunately, accessing new technology can be financially unfeasible for low-income households and communities.

Rideshare services are often considered supplemental income, but reportedly thirty-eight percent of Uber drivers have no additional source of income (Wagner, 2017). According to Glassdoor, the average income of an Uber driver is $33,168.00 gross (before costs such as fuel, taxes, maintenance) per year. Per hour, working a forty-hour workweek (full-time), the average rideshare driver's income is $15.94 an hour (minimum wage in California is $15.00 as of 1/1/22). This estimated wage puts full-time drivers in the classification of low-income earners (Covered California, 2021).

A UC Davis (Fleming & D'Agostino, 2020) research study on the demographics and driver experiences of TNC drivers found rideshare drivers are less educated and less wealthy than electric vehicle drivers. TNC drivers lack accessible charging options at home, particularly in urban areas, where TNC services and driver population is highest. Within these cities, drivers are more likely to be renters in multi-unit dwellings (Fleming & D'Agostino, 2020). Low-income TNC drivers face EV charging accessibility barriers creating a challenge in electric vehicle adoption (regulatory compliance). Barriers to charging impact transportation network company (TNC) drivers who do not have convenient and accessible charging for those who live in multi-unit dwellings (MUDs), preventing electric vehicle use.

Low-Income Rideshare Drivers Barriers to Transportation

According to CARB, one of the Clean Miles Standard regulated design objectives is to maximize transportation access equitably – "*explore how the regulation design and incentives can promote access to all Californians' transportation opportunities" (CARB)*. Low-income households and communities have been negatively impacted and continue to face significant economic and social mobility barriers due to inequitable access to transportation (Wells, 2012). There is a risk that as zero-emission and autonomous technologies are deployed, more significant barriers to these technologies and supportive infrastructure will not be evenly distributed to low-income households and communities. In particular, those who depend on their vehicles as a source of income, such as rideshare drivers, will not access advanced mobility options. Uneven distribution of EVs and supporting infrastructure for the low-income population will penalize those dependent on personal vehicles for mobility and income by costing more to operate.

Low-income populations, often impacted by the low-air quality, face disproportionate barriers to mobility. Low-income households have a disadvantage in the usability of automobiles and increase transportation costs. Data from the 2009 National Household Travel Survey found that low-income households purchase less fuel-efficient vehicles. Additionally, they are more likely to buy used cars with higher maintenance costs and vehicle emissions due to price barriers. The average transportation cost can be as high as 30% for low-income households, according to a survey conducted by the Center of Neighborhood Technology of 28 metropolitan areas across the country (ACEE.Org, 2016). San Diego residents primarily depend on personal vehicles for mobility. According to a 2012 SANDAG study, the average daily vehicle miles traveled (VMT) per capita in San Diego County was 25.2 miles. Of all San Diego County drivers, 84.93% used private vehicles. Those who live within San Diego's low-income communities likely require a car to commute to work successfully, and low-income rideshare drivers depend on their vehicles to generate income.

Access to an electric vehicle can save low-income households on transportation costs. Reportedly, electric vehicle operating costs are lower than internal combustion vehicles, potentially saving low-income households. According to Consumer Reports, EV drivers pay half as much to repair and maintain their vehicles. The report states that EV annual maintenance costs average $900.00.

Vehicle refueling is a high cost to operate vehicles, particularly in California, where gasoline per gallon is often the highest in the nation. The CARB Clean Miles Standard Regulation report states that 90 percent traveled less than 200 miles per day. Electric vehicle charging is priced less than gasoline - in California is about 16.58¢ per kilowatt-hour (kWh). At this price point, charging a 40–kWh battery with a 150–mile range would cost about 4.42 cents per mile or about $6.63 to charge fully. Comparatively, fueling a 25–mpg gas vehicle at California's average gas price of $3.11 per gallon (gas prices are even higher at present) would cost about 12.44 cents per mile or about $18.66 for enough gas to drive approximately 150 miles (Cleanvehiclerebate.org, n.d). Reducing the fueling cost of a vehicle further reduces the ownership cost of a car and allows for greater access to jobs and services.

Although electric vehicle operation costs are reduced comparability to internal combustion engine vehicles and could benefit low-income households who experience mobility restriction, electric vehicle purchase prices have been higher than combustion engine vehicles. Electric vehicles are projected to reach price parity with conventional vehicles within five to ten years (Baik, 2019; Lutsey & Nicholas, 2019). At present, EV upfront cost to purchase and adding in maintenance still exceeds an ICEV after tax credits (low-income likely won't qualify for). The average driver's VMT is 26.7 miles. Based on that mileage, the payback to EVs compared to an ICEV is reportedly ten years. If a driver increases VMT to 133.59 a day, the payoff time is two years (Rajagopal & Phadke, 2019). The CARB Proposed Clean Miles Standard Regulation report states that 95 percent of TNC vehicles traveled less than 250 miles per day, and 90 percent traveled less than 200 miles per day. VMT for a TNC driver will widely vary depending on several factors, including how often the driver works for the TNC and the distance traveled of pickup locations producing variables in EV adoptability for low-income TNC drivers. Still, a full-time TNC driver will produce higher than average VMT expediting the payback period when purchasing an EV.

To reduce the barrier of purchasing an EV, rideshare companies have partnered with automotive manufacturers and car rental companies to offer discounts on buying or renting electric vehicles. But only 0.2 percent of TNC vehicles were electric in 2018 (International Council on Clean Transportation 2019), indicating a low percentage of programs being utilized and reducing the likelihood of meeting emission reduction goals.

Accessibility to Electric Vehicle Charging Stations

The low electric vehicle adoption rate for TNC drivers in low-income, high-density communities is partly due to a lack of electric vehicle charging infrastructure. Access to EV charging is correlated to an increase in the EV adoption rate (Egner & Trosvik, 2018; Sierzchula et al., 2014). EV charging access disparity across income has been identified in California. While the policy has focused on EV charging deployment, early adopters likely have access to EV charging at single-family homes. As of 2017, roughly 85% of all EV owners used home charging as a primary charging source (California Energy Commission, 2017). But at home, charging units for renters of multi-unit dwellings have significant barriers that lead to reduced adoption of EVs, such as installation, electricity use, and equipment costs contribute to a cost parity of $50.00 a week (CARB, 2020). In addition, residents in MUDs have less off-street parking or private garages producing less availability to install more affordable in-home chargers (Hsu & Fingerman, 2020).

Furthermore, for MUD residents and renters, homeowners association rules, building codes, and other policies in an established building can deter from installing electric vehicle charging at such sites. A challenge in electric vehicle adoption (regulatory compliance) of transportation network company (TNC) drivers are barriers to convenient and accessible charging for those who live in multi-unit dwellings (MUDs). Low-income MUDs with little to no access to private electric vehicle chargers would depend on public charger access.

Public charging station deployment has been a focal point for electric vehicle charging station services and a need for transportation network drivers. TNC EV drivers use 35% of total public charging availability averaging public direct current fast-charging use 2.5 times a day (Crisostomo, et al., 2021). For those low-income TNC drivers owning an EV as a multi-unit dwelling resident leads to higher reliance on public charging stations (Hsu & Fingerman, 2020).

California Emissions Policies

California has passed legislation to regulate fleets and support zero-emissions transportation to meet state greenhouse gas reduction goals, address the health effects of poor air quality in at-risk populations and provide equitable access to EVs and charging stations. These efforts include the deployment of electric vehicle charging and transportation network company (rideshare) emissions regulations. Electric vehicle charging infrastructure deployment must meet mass adoption of the zero-emission (vehicle emissions) transportation technology. Consumers will likely not purchase electric vehicles unless charging infrastructure is readily available (Gnann and Plötz 2015; Melaina, 2017).

California has passed legislation that forces zero-emissions technologies to market and set ambitious greenhouse gas reduction goals to expedite the reduction of GHG emissions and support EV deployment and infrastructure. The policy of technological forcing requires regulated industries to produce and sell electric vehicles and infrastructure (Calef & Goble, 2007). Mandates by State Senate Bill 535 and 550 allocate that at minimum 25% of Greenhouse Gas Reduction Funds are earmarked for funding GHG reduction programs in disadvantaged communities and an additional 10% to low-income households (Hsu & Fingerman, 2020). The set of EV adoption and deployment of infrastructure attempts to support the transition from ICEVs to EVs. California's cap-and-trade program provides funds to the Greenhouse Gas Reduction Fund (lao.ca.gov, n.d.).

The Clean Vehicle Rebate program incentivizes EV purchases with a budget of $238 million to distribute in the fiscal year 2019-2020. Additionally, the Alternative and Renewable Fuels and

Vehicle Technology Program allocated $95 million of funding generated by the Department of Motor Vehicles related fees to install up to 10,000 chargers (California Energy Commission). Low Carbon Fuel Standards (LCFS) zero-emissions fuels earn credits that can be purchased to offset carbon intense fuels that exceed CARBs emission cap. The LCFS credit market for clean fuels strengthens clean energy industries' EV charging deployment, and companies use the funding for EV and EV charger purchases. The largest utilities have been approved for cost recovery of $197 million as of 2020, of which 10-15% of funding is to be allocated to EV charging deployment in disadvantaged communities (Hsu & Fingerman, 2020). The CEC distributes $130 million annually to Electric Program Investment Charge Program, which funds research and development in decarbonizing the electricity sector. The CEC reportedly has used this program’s funding in EV charging deployment projects. The CALeVIP program provides funding to EV charging deployment of $7500 for Level 2 chargers and $80,000 for DC fast chargers, which is mandated to spend 25% of funding to disadvantaged communities. The Alternative Fuel Vehicle Refueling Property Credit is a one-time tax credit of up to $30,000 or 30% of installation costs, whichever is lower.

Policy Results

The current policies have increased EV adoption as California is the largest EV market in the U.S. Despite California having some of the strongest policies and incentives globally, EV adoption and infrastructure deployment are still inadequate, particularly in low-income communities and households. Electric vehicle car sales still make up a small portion of total sales in California. The California Department of Motor Vehicles reported electric vehicles as just 1.2% of all registered vehicles and further reduced adoption rates in low-income households and communities. Although programs explicitly allocate significant funding to low-income households and communities, California's Clean Vehicle Rebate Project data suggest that only 6% of the California rebates were distributed to such communities (Rajagopal & Phadke, 2019). Programs are not meeting legislative mandates to distribute funding for low-income EV and EV charging accessibility. Tax credits for low-income households are likely not beneficial as there potentially is not a tax liability for low-income earners. Reportedly, programs are generally underfunded. The CALeVIP program, according to a source from SANDAG, allocates funds for EV chargers within the first day of opening the program. As a result, funding and EVs deployment and EV charging are distributed to wealthier households and communities (Rajagopal & Phadke, 2019). The financially burdened TNCs cannot take advantage of the significant tax credits for EV charging deployment for their drivers, resulting in limited direct TNC financial support for low-income TNC drivers to access EVs and chargers.

Policies have not allowed California to meet EV charging deployment. California Executive Order B-48-18 works to deploy charging infrastructure to meet consumer needs by setting deployment goals of 250,000 chargers (including 10,000 direct current fast chargers) by 2025. There is presently a deployment gap of 62,000 charging stations, failing to meet the goal. Furthermore, the California plan to have 5 million zero-emission vehicles by 2030 is estimated to require an average of 968,000 chargers. The state will need an additional 780,000 chargers deployed between 2025 and 2030 to meet charging demand and achieve zero-emissions vehicle adoption for TNCs and the general public (Crisostomo et al., 2021). To reach California's EV charging goals and for communities to be electric vehicle ready, the consumer must have accessible and convenient charging. California's Planning and Research Community Readiness

Guidebook (2013) states, “install of PEV (EV) charging stations during the early market development helps to build consumer confidence that this technology is ready for use and helps reduce range anxiety.” This report also states that public programs may not have sufficient funding to deploy charging by selecting prime locations for charging access could benefit deployment by private site hosts.

Private Site Host

Companies such as Electrify America are investing heavily in electric vehicle charging infrastructure. Electrify America has allocated $800 million to EV charging deployment in California as the state has made up 47% of the nation’s total electric vehicle car sales as of 2018 (usafacts.org, n.d.). Costs to deploy vary depending on charger type. The San Diego Gas & Electric (SDG&E) Power Your Drive program reported public L2 chargers (non-residential) costs customers $9,384.66. Including EVSE charger, installation cost, engineering costs, project management, and other material costs such as conduit SDG&E estimates a total cost of $16,000 per charging nozzle.

-ChargePoint+ - an EV charger provider – Station Cost Guidance (10.23.20) for L2 charger. Equipment cost variance for a CT4000 series networked charger with single and or dual ports has a reported price variance of $4,500.00 - $7,210.00, the average being $6,400.00. Combining all costs based on sources, the price per L2 public charging station deployment (including installation) is $12,420.00. The cost for a fleet is reduced. Fleet charging does not have the equipment cost, and installation of a DC Fast Charger (DCFC) is between $30,000 -

$100,000 per unit according to the U.S. Department of Energy Costs Associated with Non-Residential Electric Vehicle Supply Equipment 2015 report.

Site Installation and Electricity Costs

Private sector deployment of public EV charging stations is critical to meeting EV charging demand in low-income communities. An industrial business located in low-income mixed-use communities can be motivated to provide EV charging accessibility and services for a monetary return. In addition, industrial and commercial sites that operate during traditional business hours (8 am-5 pm) have underutilized property during off-hours that could be used as EV charging sites. However, infrastructure costs and variables in electricity pricing can disincentive deployment.

Trenching is a significant one-time expense during the installation phase. According to SANDAG, typical costs are about $100 per foot. A projected installation costs $14,210.00 as an average. A site that requires significant trenching could exceed that number and potentially prevent an EV charging station installation. Transformers cost $15,000, plus another $8,000 in labor costs; bringing additional power to a site can add significantly to the project's total cost (Rocky Mountain Institute, 2019). If a subpanel is required to create greater space for breakers by running a line, the estimated cost is up to $2000.00 depending on the panel's distance to the subpanel.

Project Objective

This project intends to address barriers to electric vehicle and electric vehicle charging. Developing a business model that provides a TNC owned electric vehicle fleet located at a TNC owned EV charging at a commercial site in low-income, high-density, mixed zoning neighborhoods. This project will use a hypothetical TNC company as the host business pairing EV rideshare vehicle and charging deployment with the near and long-term transportation network company business needs to meet compliance and financial viability. Additionally, it will consider the social benefit of providing electric vehicles and charging accessibility to low-income communities and the public policy value and financial support of such efforts. This project uniquely deploys EV charging infrastructure under a private business model to low-income households and communities. The result will mitigate ICEV GHG emissions, improve air quality, increase EV mobility and provide a business model for transportation network companies to support fleet conversion to EVs.

The City of San Diego as Case Study

This project proposes pilot sites within the City of San Diego (California). San Diego has been a leader in adopting environmental policies to mitigate vehicle emissions. The region is a proving ground for autonomous vehicles and a pilot city for Uber's EV program. Additionally, the City and County actively provide equitable and accessible policies to low-income communities making the city qualified as a case study for this project.

San Diego Climate Action Plan

San Diego policies are supportive of transportation emissions reduction in low-income communities. As of 2015, San Diego became the largest city to adopt a legally binding climate action plan (CAP). In 2010 transportation emissions were 55% of the total inventory, with a goal of 11% of emissions derived from transportation by 2030. San Diego's CAP does not set its emission standards; instead, it refers to the US EPA, and Department of Transportation National Highway Traffic Safety Administrations established rules for GHG emission reduction vehicles. Part of CAP, the Complete Communities initiative works to provide more transportation accessibility to low-income communities. Infrastructure now is a program that includes infrastructure and neighborhood amenities to be implemented for long-term solutions. CAP and supportive programs are focused primarily on active mobility and public transportation accessibility. Working to understand neighborhood needs, the City of San Diego developed the first-of-its-kind Climate Equity Index (CEI) to map disparities faced by Communities of Concern. Those communities also face barriers to EV accessibility and low air quality. There are potentially viable funding and the political will to support EV charging deployment financially. As of FY21, the CAP budget allocated $675,182.00 to mobility.

San Diego County Office for Environment & Climate Justice

San Diego County officials have recognized and are actively working to mitigate the effects transportation emissions have on low-income communities. As of 2021, the San Diego County Board of Supervisors voted to create an office of environment and climate justice (Environmental Justice Element). The Element will be a part of the County's General Plan (San Diego County). In addition, the office will work with the San Diego Air Pollution Control District to address air pollution in the region.

Uber EV Program

San Diego is one of seven cities Uber chose to pilot their EV Champions initiative. The program's goal as of 2018 is to provide 5 million EV rideshare rides (Uber). The "EV Champions Initiative aims to increase access to clean electric mobility for the driver-partners and riders who use Uber," said Adam Gromis, Uber's global lead on sustainability and environmental impact (Cleantech San Diego, n.d.). The program works to inform rideshare drivers of EV resources and support shared EVs.

Automation – San Diego Regional Proving Ground

Governments are working in conjunction with the private sector to provide sufficient proving grounds for emerging vehicle automated technology. San Diego County is one of these locations with multiple automation companies located within the region. The U.S. Department of Transportation chose San Diego County as one of ten automated proving ground sites (SANDAG). A smart city approach to building infrastructure to support automated vehicle deployment has begun in the region. Chula Vista (City with San Diego County) deployed 29 intelligent traffic signals to communicate with automated vehicles to notify the car to stop or go. San Diego has several tech companies working to develop vehicle automation technology. Comma.ai develops systems installed on current vehicle models. TuSimple is working on automation for commercial trucks. Qualcomm has a self-driving technology that allows cars to communicate directly with cellular technology (San Diego Business Journal, 2021). San Diego has university programs, such as the Contextual Robotics Institute at UC San Diego, producing a skilled job market for the automation sector.

Methods

Study Design

This project uses Arc GIS Mapping to explore and identify potential spatial locations to increase EV charging accessibility and viable sites for a TNC EV business model. This project 2019 applies census tract data from The San Diego Association of Governments (SANDAG): High density, population, median household income, established EV charging sites, and zoning buffer locations as primary data points.

Input Data Used to Locate Sites

In this section, census data from SANDAG is indexed to provide the proposed method of identifying EV charging station sites. In addition, census tracts are applied to ArcGIS mapping to represent physical locations.

Electric Vehicle Charging (Alternative Fuel Stations)

The purpose of the EV charging site data is to identify areas that disproportionately have less public EV charging accessibility. The data provided by the National Renewable Energy Laboratory (National Renewable Energy Laboratory, 2020) locates geographically current electric vehicle charging locations. In addition, the Alternative Fueling Station Locator contains information on public and private non-residential alternative fueling stations in the United States. Finally, the project applies the selected data to the City of San Diego using ArcGIS to determine areas of public EV charging vacancies.

Also, the project applied the distance from the census track border direct to EV charging stations within a ¼ mile distance. This project accounted for the total amount of currently available public chargers in each of the identified low-income censuses tracks to understand current EV infrastructure availability. Note: the distance is based on the census tract border directly to an established EV charging station.

Median Household Income

The map uses a census tract of median household income for San Diego County in 2019. Household income is the combined adjusted gross income over fifteen years of age (BizFluent, 2019) and lives within a household. By applying the median household income data, the project map will inform specific communities within San Diego that have low-income levels below the average full-time rideshare driver annual salary. Household income is used as the primary indicator of where recommended EV fleet and charging sites are located. The GIS map provides markers of where the bottom 50th percentile of household income is within San Diego. The project considers census tracts with a median household income of $35,000 or less in the index.

Population Density

Population density is applied in determining high-density areas that could produce a high percentage of TNC drivers and users. The population data is divided into tertile - divide an ordered distribution into three parts, each containing a third of the population – identifying the highest tertile census tract areas.

Zoning Buffer Locations

A buffer of industrial and commercial zoning is used to identify a quarter-mile radius. These sites are considered to be applying reported information from the U.S. Department of Transportation - the public is willing to walk ¼ of a mile to access public transportation. This report assumes that an EV rideshare driver will walk the same distance to access an EV charger at a commercial space from their residence. The census data uses San Diego work zones from SANDAG data. Zones include commercial and industrial zoned properties. This data point allows the report to identify spatial locations for TNC EV rideshare deployment in mixed zoned within low-income communities.

Census Track	Neighborhood or City	Median Household Income| Lower 50th Percentile	Top Tertile Population	Public Charging Locations ¼ Mile	Proximity to Industrial or Commercial Zoning
22.01	East San Diego	$32,191.00	3,328	Zero	Within census track
22.02	East San Diego	$33,731.00	5,477	One	Within census track
23.02	East San Diego	$32,081.00	7,300	Zero	Within census track
24.02	East San Diego	$33,224.00	5,189	Zero	Within census track
26.01	East San Diego	$32,698.00	5,609	Zero	Within census track
27.09	East San Diego	$33,958.00	4,470	Zero	Within census track
40	Logan Heights	$35,056.00	4,513	One	Within census track

Data sourced from SANDAG/SANGIS and NHGIS, 2019

Using the sourced data and applying it to ArcGIS, the project identified potential EV charging sites that meet all of the data criteria: industrial and commercial zoning (locations). Public charging locations within the ¼ mile distance from the census tract. The analysis identified two of the seven areas to have one public EV charging station within the index.

Population data with the top tertile only considered when applied to identifying the census tract. The lower 50th percentile of household income is specified to meet the proposed census tract sites. In particular, those households earning $35,000.00 or less.

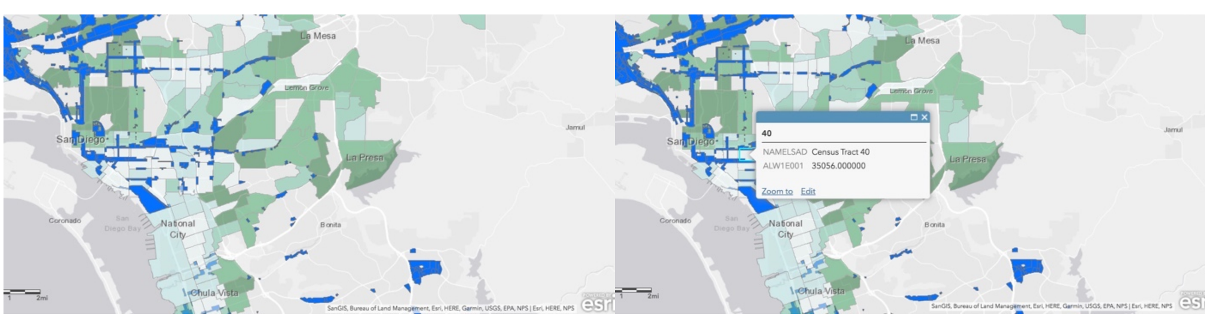
Objective 1: Understanding electric vehicle charging station locations that benefit the project model

The following sites are within the identified census tracts meeting all markers of the data criteria.

Census track 40

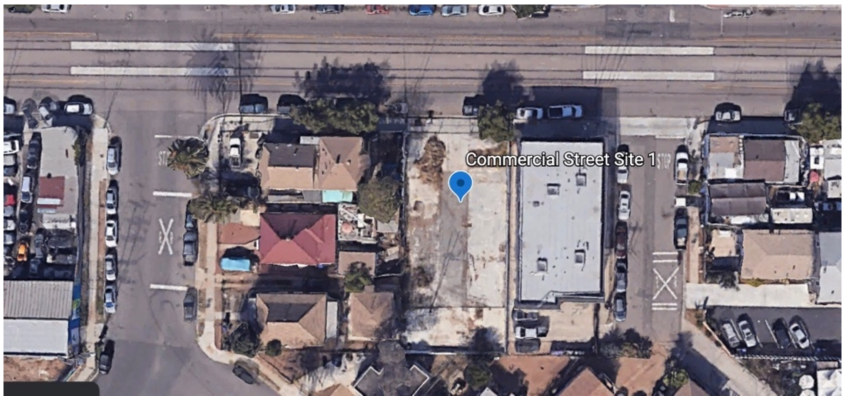
The identified census tract location's median household income is $35,056.00. Outside of the primary dataset, this site's location's proximity to potentially available industrial and commercial sites provide an opportunity. Lastly, the sites are located within three major freeway systems. They are located one mile east of high trafficked communities such as Downtown San Diego, Balboa Park, and the Coronado Bridge.

Blue represents industrial and commercial zoning



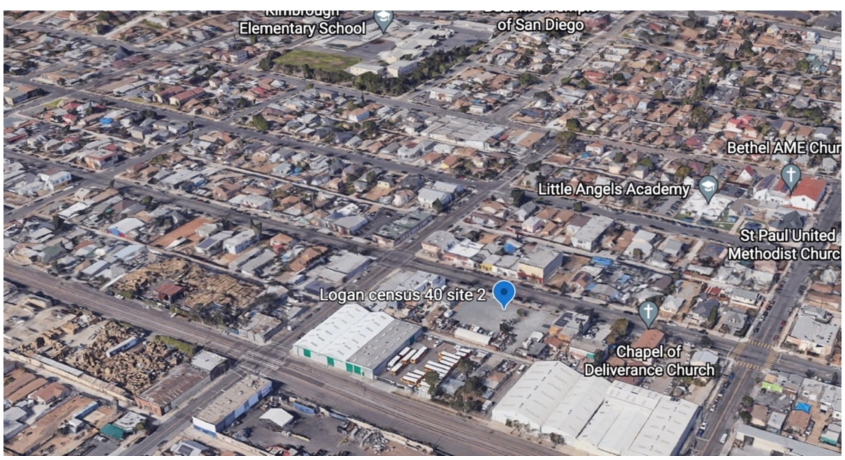
(San Diego Work Zone Buffer. Sourced from SANDAG/SANGIS and NHGIS, 2019)

Identified sites are within the census tract. Vacant properties that are within commercial zoning are provided. This imaged site shows one example of paved and vacant parking near mixed-use commercial and residential properties.



(Google Earth Image)

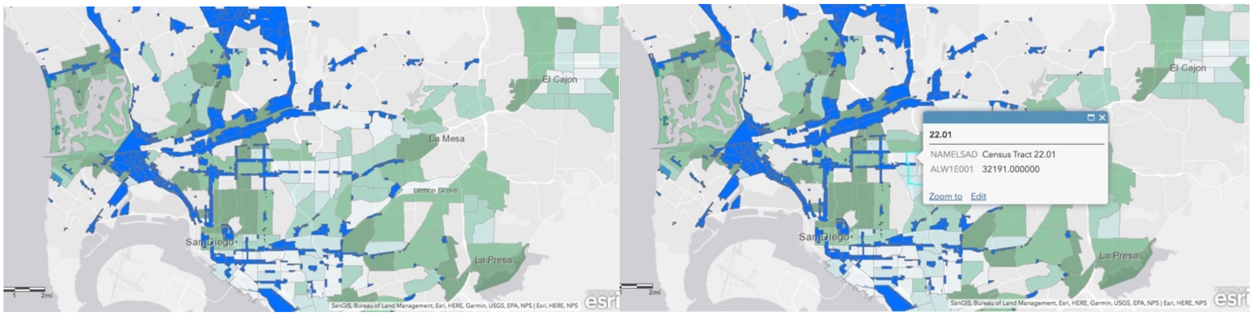
The following image is within census tract 40. The blue marker indicates a location of a proposed site example (industrial yard). This site border residential space.



(Google Earth Image)

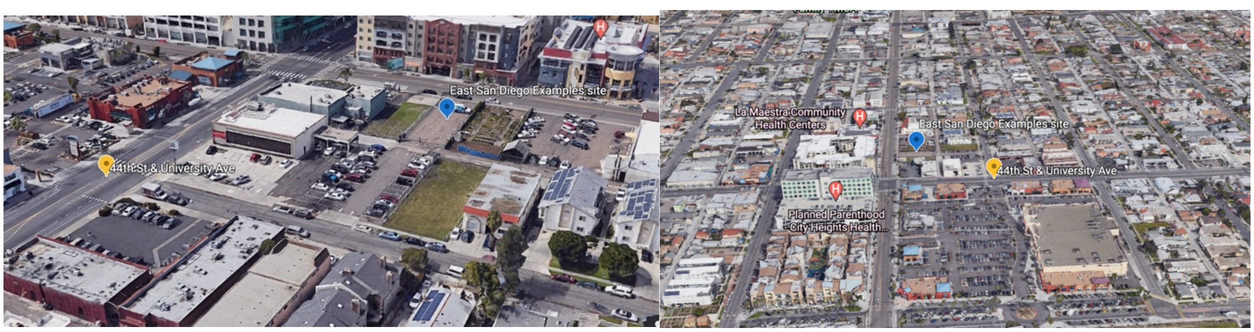
Census Tract 22.01,22.02,23.02,24.02,26.01,27.09

The listed census tracts border one another in East San Diego. All tracts are meeting the low-income levels and top tertile population density. There are no EV chargers within the ¼ mile distance of each tract. Commercial zoning runs along the primary corridors running the center of the tracts. The locations are boarding the 805FWY, which connects to the 8FWY as the main corridor to San Diego communities. The site is also one mile east of the densely populated North Park.



(San Diego Work Zone Buffer. Sourced from SANDAG/SANGIS and NHGIS, 2019)

Using 22.01as an example site: There are available and vacant lots as indicated by the blue tag. Such space is approximate to single-family and multi-unit dwellings.



(Google Earth Image)

Rideshare workforce and customer demand

The following data is used to determine rideshare users within the proximity of the EV fleet and charging sites.

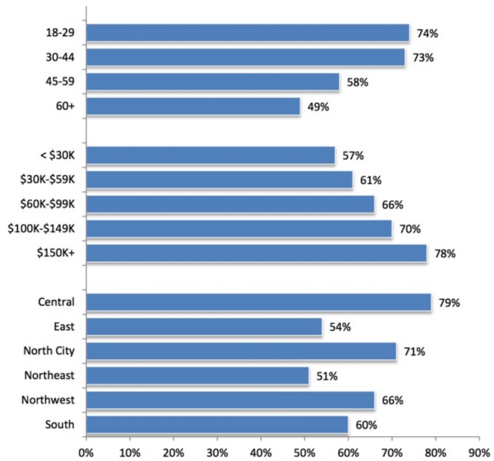
Locations near high-density populations with likely high rideshare demand

A considered factor in where a business would likely place EV charging location for fleet deployment is its proximity to rideshare users. Low VMT from the charging site to the first rideshare passenger benefits the company efficiency in reducing deadhead time. Efficiency in eVMT also reduced the frequency of EV charging, allowing for more rideshare service time.

Demographics for Lyft based on who is using the app in 2020 reported the following. Almost two-thirds (68%) of San Diego County residents have at least tried TNC services (SANDAG, 2019). Of the areas statically analyzed in the 2019 Transit Public Opinion Survey (SANDAG), central communities that include this project census tract locations and adjacent neighborhoods have the highest TNC adoption rates in San Diego County. The central areas have an adoption rate of TNC us of 79% and makeup 6% of total transportation. The SANDAG report presumes high density is a contributing factor to this adoption rate.

The SANDAG report additionally finds populations based on household income that utilized TNC at what percentage. As has been broadly reported, the 18-44 age group are high percentage TNC users. The San Diego County report reflects this trend with 18-29 making with 74% and 30-44 with 73% useability.

The report also reflects the national census of high household income earners using TNCs at a higher rate. Reportedly, 57 percent for an income group with less than $30,000, to a high of 78 percent for those with a household income of $150,000 or more (SANDAG, 2019).

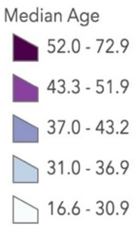


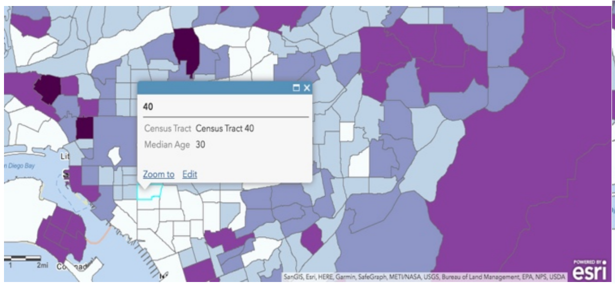
2019 Transit Public Opinion Survey (SANDAG)

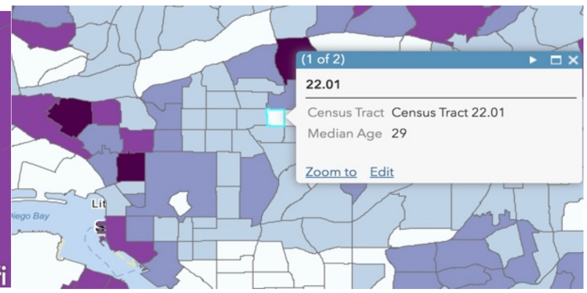
The census tract identified locations have a median population age within the 25-34 (high rideshare user) bracket. To determine the distance from the proposed piloted EV fleet charging sites, the project assessed census tracts located within 3 miles or the average length of a rideshare trip (Rayle et al., 2016). The project found that census tracts in the identified East San Diego locations are within one mile of the North Park community. Census tract shows primarily median population within 25-34 this neighborhood exceeding the average income of Lyft riders. The same is true within a two-mile distance to Fashion Valley.

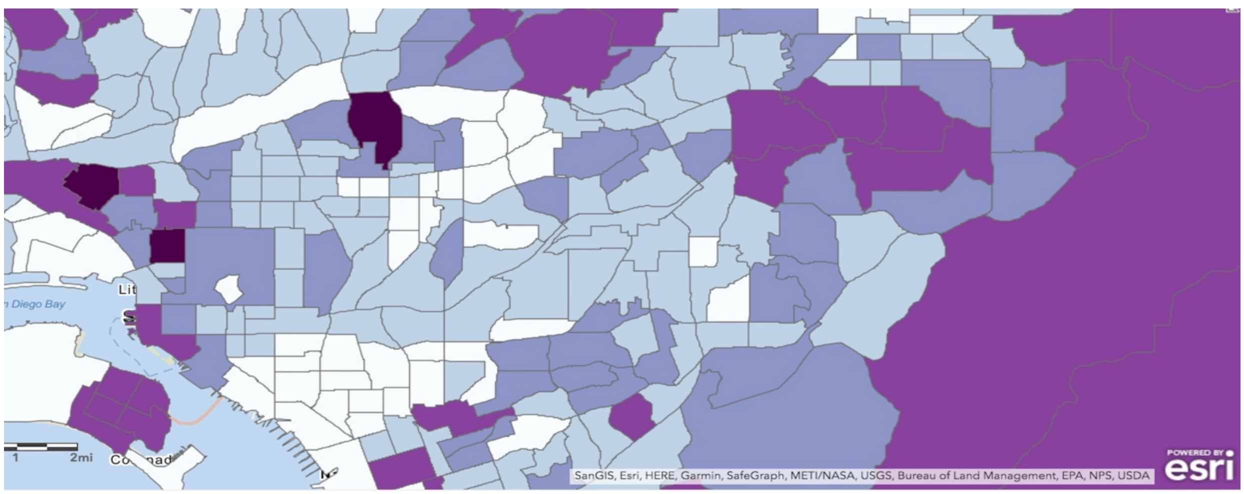
Logan Heights (Census Tract 40) is within a half-mile to Golden Hill and South Park communities. Both also have a primary mix based on SANDAG census data of median age and income within the primary Lyft driver profile. This site is also within two miles of North Park.

The identified census tract locations to deploy a rideshare EV fleet and charging is located within adjacent areas with the highest rideshare use areas reflecting a strong TNC market.

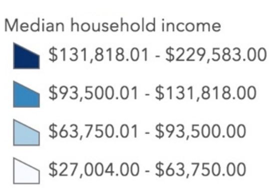


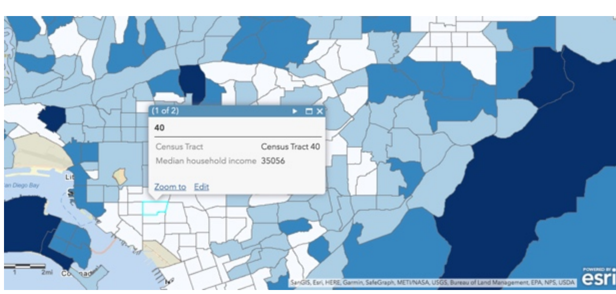


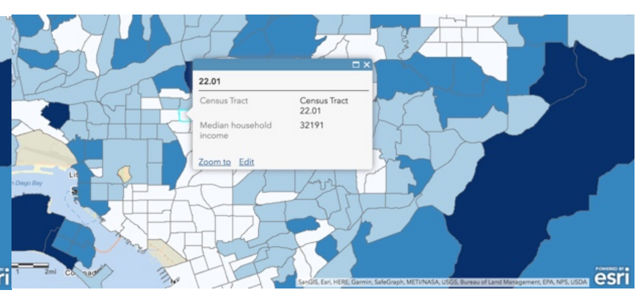


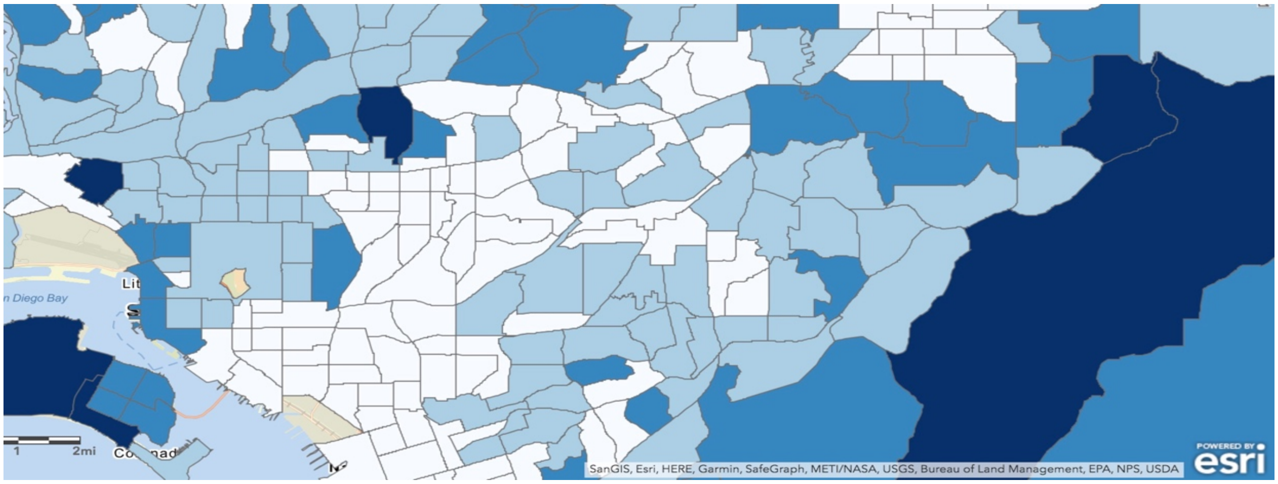


(Median Age. Data Sourced from SANDAG/SANGIS and NHGIS, 2019)







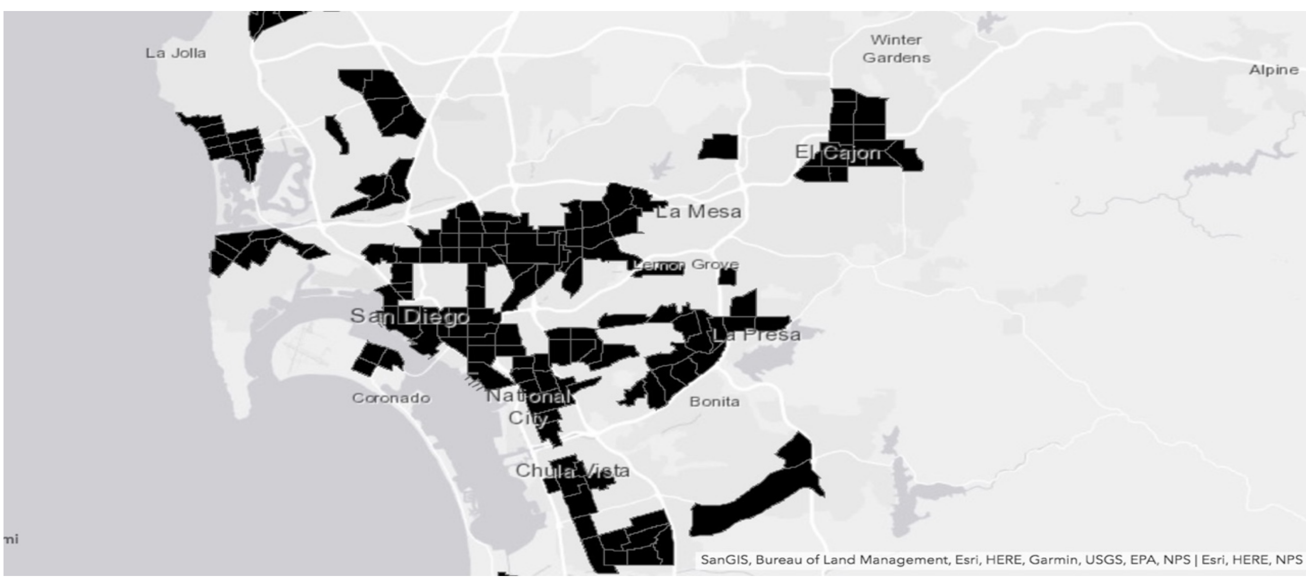


(Median Household Income. . Data Sourced from SANDAG/SANGIS and NHGIS, 2019)

Proximity to top tertile population

Reportedly, high-density areas correlate with high rideshare use (Tirachini, 2020).

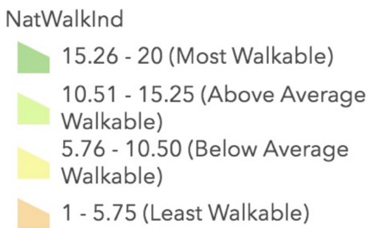
As previously referenced, the central communities with the highest adoptability of TNC transportation according to SANDAG to be in high-density areas. Therefore, census tract site criteria place the recommended EV fleet and charging sites within identified high-density tracts.

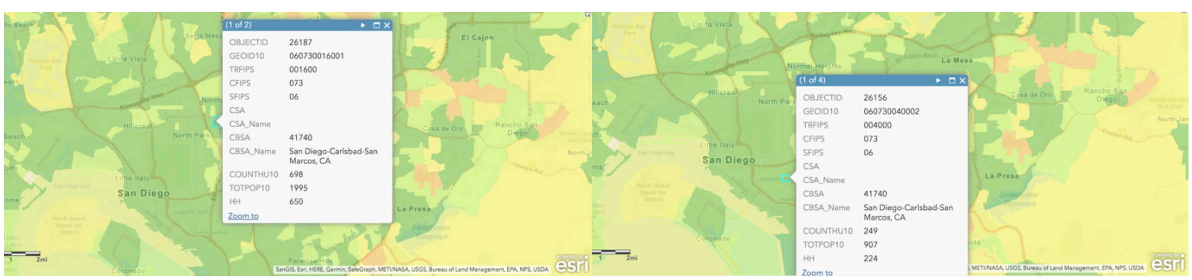


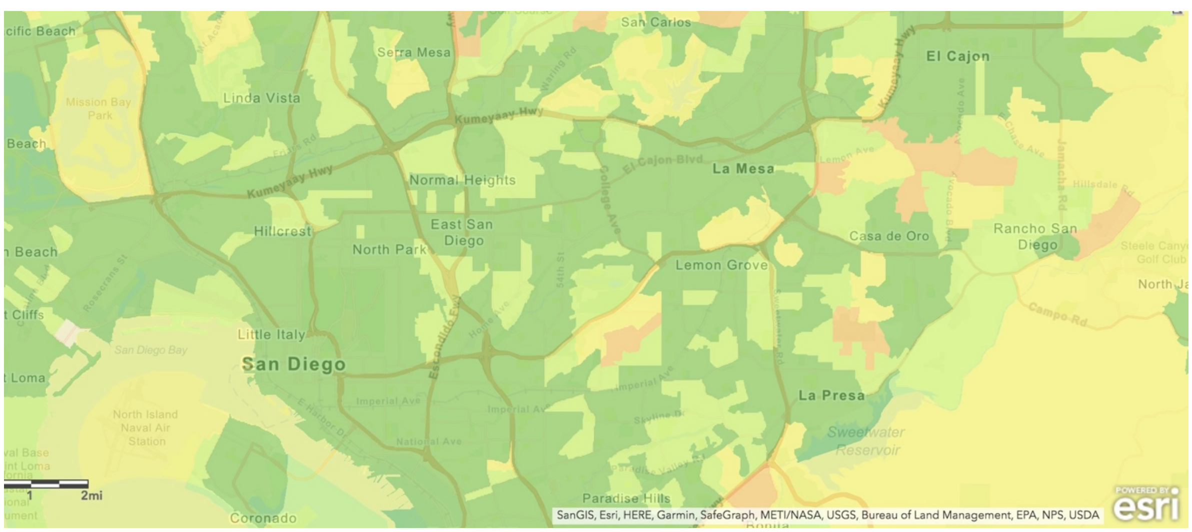
(Top Tertile Population Density. Data Sourced from SANDAG/SANGIS and NHGIS, 2019)

Walkability index (safety and accessibility to charging sites)

This project applies the walkability index as a criterion to determining where the EV stations should be placed. Safe and accessible active mobility from a TNC drivers' residence to an EV charging station and back is an essential factor in ensuring interest and use of EV stations and TNC fleets. Walkability for the identified census tracts is in the "most walkable" category.

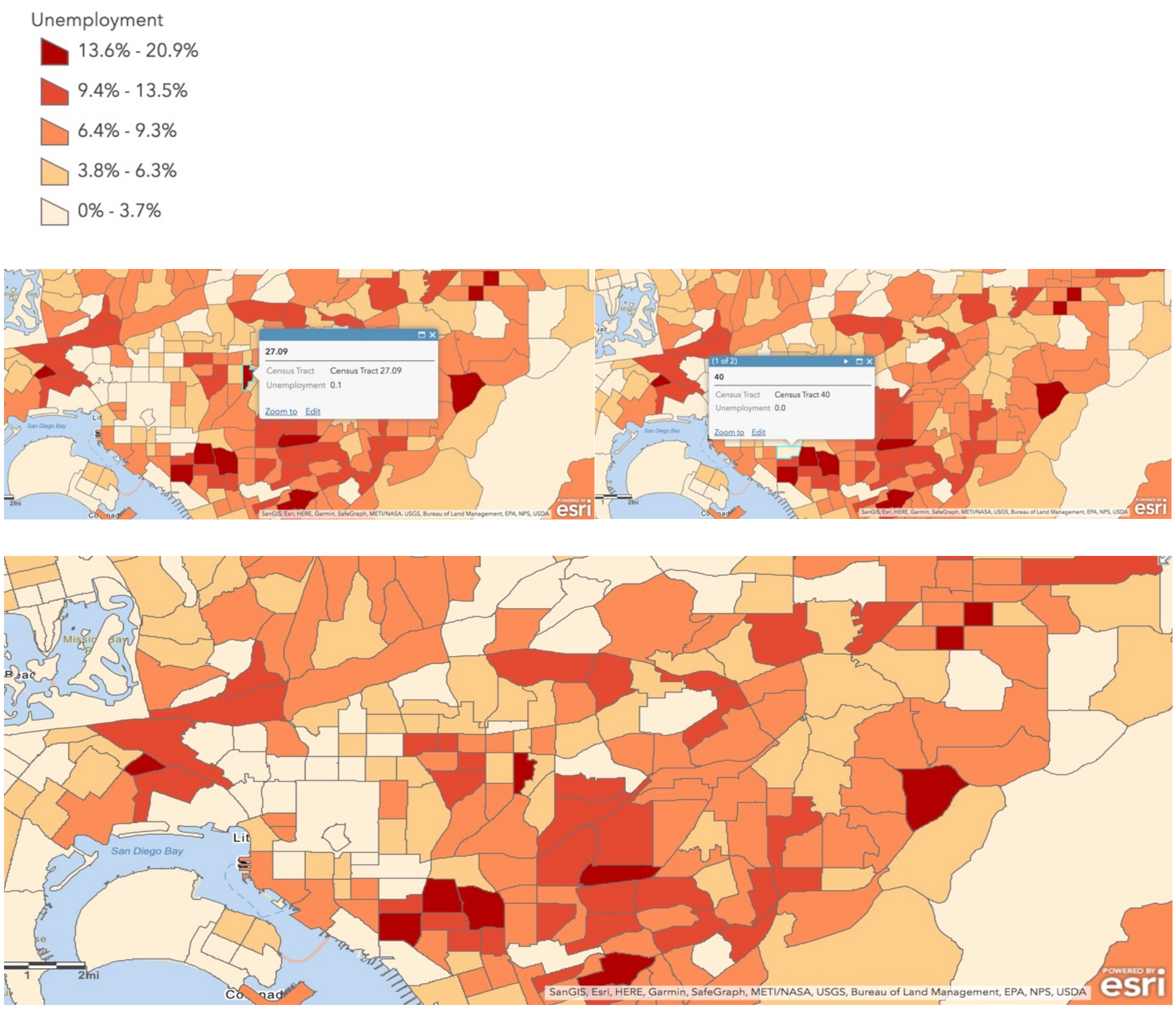






The Walkability Index dataset characterizes every Census 2010 block group in the U.S. based on its relative walkability. Walkability depends upon characteristics of the built environment that influence the likelihood of walking being used as a mode of travel. The Walkability Index is based on the EPA's previous data product, the Smart Location Database (SLD).

Unemployment rate - Job accessibility (rideshare) for low-income households reduces unemployment and improves household income (Jin & Paulsen, 2017). The project's identified census tracts have an unemployment rate in the top 50th percentile. Unemployed will have accessibility to the TNC EV fleet providing a low barrier to an income source. An available workforce is needed for the business and identified within the model as utilization of vehicles produces higher income for drivers and increased market share and revenues for the TNC.



(Unemployment. Data Sourced from SANDAG/SANGIS and NHGIS, 2019)

Objective 2: Understanding a viable business model that deploys electric vehicle charging and rideshare fleets

The Case for Investment – Initial expenses to deploy EV charging varies and will need to be accounted for to determine the viability of this pilot project. Additionally, a business proposal must be developed to showcase potential financial gains to stakeholders (investors) that incentivize the deployment of TNC EV fleets and charging in identified areas.

This project has already addressed the consumer side providing vehicle and EV charging accessibility and identified targeted EV locations near TNC high use areas. In this section, the project examines transportation trends that could incentivize investment for EV charging deployment following this project model and outlines initial and ongoing costs.

Automation is poised to change the transportation landscape. As previously stated, automation has a ten-to-fifteen-year projection for full-automation deployment. The transformation is set to disrupt the vehicle market, provide a profitable TNC business model, and change parking demand. As part of the transformation, available parking will be reduced as automated vehicles reduce the need for personal vehicles and vehicle use becomes more efficient, reducing the amount of time parking is required. Reportedly, parking areas for recharge of automated EVs will no longer need to be parked at the point of pickup; instead, these vehicles can travel outside of the city center or another highly trafficked area to available charging outside (Begg, 2014). Parking areas outside the highly trafficked areas can provide 97% of the daily parking demand (Zakharenko, 2016). According to Zakarenko, due to the removal of parking availability with the high-density areas, land rents could be 34% higher than today. Rents typically rise as land value appreciates; hence, the higher the rent, the more valued the rented land. Therefore, land acquisition for fleet EV parking will appreciate value for the landholder (TNC).

Lyft's Director of Operations and Strategy reported that in Los Angeles, San Francisco, and Denver, more than 130,000 people who expressed interest in driving for Lyft did not have access to vehicles (LA Times 2016). This project includes TNC owned EV vehicles for rideshare. At present, the rideshare industry has companies adopting a fleet model where the company owns the fleet. Alto is one such company that employs drivers and provides a fleet of vehicles. Additionally, Waymo is using its fleet to pilot automation rideshare services practicing the likely long-term business model for the TNC industry.

This pilot project is unique in that the fleet will provide contracted rideshare drivers access to zero-emission vehicles within the identified census tracts providing economic, environmental, and social benefits to the area. The fleet offers increased vehicle accessibility to a low-income community and reduces the potential of fleet emissions from the identified demographic.

The applied criteria for selecting e-cars are cost, range, and vehicle manufacturer. Competitive cost to purchase EVs will provide lowered upfront costs to deploy the pilot project. Additionally, the vehicle manufacturer that applies purchase price discounts to fleet purchases will further reduce initial costs. Some manufacturers have also offered fleets (rental car industry) buyback options of fleets. Finally, the vehicle range is considered. Rideshare drivers high VMT and stated high use of charging; it is in the interest of reduced charge time (downtime) to deploy vehicles with a higher range.

EV charging is accessible to TNC EV drivers who have access to the fleet, available self-owned TNC vehicles fleet such as Waymo. In the near term, variable costs will be passed on to the drivers before the automation model such as EV charging. As provided earlier, EV charging is less costly than gasoline, negating cost barriers to EV drivers mitigating any high-cost barriers to the consumer. In general, the electricity cost varies depending on Time-of-Use (TOU) and electricity consumption. A model in which TOU is during off-peak hours would benefit the payer of the fees. It is feasible to provide access to charging of the EV TNC fleet during off-peak hours to charge the vehicle(s) at the lowest rate per kWh. The low-income rideshare driver is expected to have less fueling costs in an EV TNC than in an ICEV personal rideshare vehicle.

TNCs under this project have a captured consumer base. The technology to provide features on the TNC applications could consider having EV charging technology tracking driver's use of charging, calculating the value, and deducting the variable expense from the TNC driver as an example of one potential variable expense recovery concept. Additional charging service operation costs are reduced under the TNC model due to established infrastructure and captured consumers. Communication costs and overhead staff costs are limited as communication is established with the consumers, and staff is limited to EV charging program services. Ongoing operation costs will be accrued in TNC EV fleet maintenance costs and charger repairs.

<u>Estimated Primary Operating Capital Per Site Annually</u>

Electricity Costs + EV Maintenance + EV Charging Station Maintenance + Staff/Overhead + Debt + Fees + Insurance

Utility	$0.00	Electric vehicle charging costs will be passed on to TNC drivers as a service cost.
EV Maintenance	$18,000.00 ($1,500 a month)	Avg of $900.00 per EV annually. Estimated fleet of twenty cars for one location (Consumer Reports)
EV Charging Station Maintenance and Services	$8,160.00	$280 per port per year networking (ChargePoint) $400 estimate maintenance costs (DOE)
Staff/Overhead	$168,450.00	IT Support Specialist = est. $52,655 annually (Glassdoor) x 2 Onsite security per site= $31,560.00 annually (Glassdoor) x 2
Insurance	$11,650.00	The average car rental company in America spends between $450-$1,000 per year for $1 million in general liability coverage (Truic). Use $450.00 per vehicle x 20=$9000 General liability cost $300-5000 annually. Estimating $2,650.00
Fees	$30,000.00	Misc. Fees: Business license, property tax, vehicle registration, etc.. Estimated amount.
Mortgage	$28,992.00	Annual estimated mortgage. 20-year mortgage at 2.2% (valuepenguin) $468,763.00
Estimated Operating Capital Annually	$265,252.00	$10,169.00 one TNC EV Low-Income Fleet Hub of 20 vehicles and EV charging ports.

Initial Significant Cost of EV charging site deployment

Property values are priced per square foot (SF). This project determined the estimated present value of a commercial or industrial zoned paved parking yard to be valued at $.20-$.25/SF. Because the locations this project identifies are underutilized and in low-income areas, the project will use the $.20SF price in the cost assessment.

Parking construction in San Diego is, on average, $72.31 per square foot (WGI, 2020). This cost includes 8'-6" to 8'-9" wide parking spaces by 18 feet (162 SF), signage, LED lighting, and fencing. Additionally, items that would not be included in the proposed sites but are included in the per square foot costs are elevators, concrete for multiple levels, and fire sprinklers for multiple level car garages. Consider the price per square foot varies depending on location. The projects proposed site are strategically placed in low-income and property values less than coastal or city center locations.

EV charging and infrastructure costs vary, as previously stated. Depending on the charging unit, services offered, the infrastructure required, such as trenching and electrical capacity on site. There are significant discounts in fleet charging over consumer charging. The project will use the San Diego Gas & Electric Power Your Drive estimated price for charging unit and installation at a total of $16,000 per nozzle. Model of 20 cars per site.

<u>Estimated Startup Expense for One Pilot Site With 20 EV Fleet Vehicles</u>

Real Estate-Land + Leasehold Improvements + Equipment + Infrastructure + Vehicles

Real Estate-Land	$468,763.00	$72.32SF per parking space (162SF) x 20 + 2000SF additional lot space = 5,240SF = $378,956.80. A 20-year mortgage at 2.2% interest = $468,763.00
Leasehold Improvements	$207,766.00	Fencing, signage, LED lighting, pavement
Equipment	$64,000.00	ChargePoint average price for commercial CT4000 Series dual nozzle. Ten stations for a fleet of 20
Infrastructure	$14,210.00	Avg price between SANDAG and SDG&E reported cost
Vehicles	$599,920	Sample Chevy Volt cost $37,495 minus manufacturer fleet discount estimated 20% (-7,499) x 20
Estimated Startup Expenses	$1,354,659.00	

Potential Sources of Appreciation and Income

Willingness to Pay

Willingness to pay (WTP) is applied in environmental economics to determine the maximum amount of income an individual or household will spend for a good (see Freeman, 2003). In this project that applied to increase spending, rideshare users are willing to pay for the use of TNC electric vehicles.

Uber has already begun increasing the cost of reduced emissions trips through their Green trips program. When a customer chooses a green trip $1.00 fee is applied. Half goes directly to your driver for their use of a hybrid or electric vehicle; the other half will help other drivers with fossil-fuel vehicles transition to electric. The increased fee would go absolutely to the TNC to recoup the additional cost of deployment in the fleet model. A public poll conducted by YouGov Today found that 52% of respondents in seven European countries would pay 15-20 cents more per kilometer (0.6 miles) to use an electric rideshare vehicle.

The pilot program is advised to conduct a willingness-to-pay in San Diego to determine the additional revenue that can be covered by providing zero-emission services. Applying an estimated EV fee of 20 cents per mile traveled is applied x 150 miles traveled per day x 365 days = $8,212.50. Therefore, a pilot location of 20 vehicles could recoup operation costs by holding higher trip costs totaling an estimated $164,250.00.

Estimate Annual Rideshare Fee

Assuming a fleet will have 100% utility (utilized 365 days a year), 150 miles traveled each day (battery capacity), and a per-mile charge of $2.92, comparable to an Uber Black Rate in California (Uber), the project finds the estimated return per fleet vehicle per year.

$2.92 x 150 x 365 = $159,870.00

The report shows the actual fee Uber applies to drivers is 42.75% (ridester, n.d.). Applying the fee percentage the return of TNC revenues is $68,344.42 per vehicle per year. A fleet of twenty TNC EVs - the total gross revenue is $1,366,888.50.

Estimated operating cost $265,252.00– estimated gross revenue $1,366,888.50 = estimate. annual net profit $1,101,636.50 (based on this site model)

Note: Because there is minimal vehicle driver cost (maintenance, vehicle payment, etc..), the TNC can likely recouple a higher percentage, but this project will use the established TNC model.

Asset Value

The value-added investor component of this pilot program is the appreciation of land value from the EV charging location. As previously stated, automation is expected to increase land allocated for parking by 38%. This likely is higher given the increased value of land from the present to the time of full automation. For example, the October 2020 Commercial Property Price Indices U.S. summary report commercial real estate rose 1.4% annually from 2019 to 2020 - holding the asset for 20 years, the length of the mortgage, and post timeline of automation adoption, the property would accrue in value 28%. In addition, parking scarcity due to vehicle automation will further appreciate the property with an estimated 38% increase in value due to parking scarcity.

Example pilot program property - $378,956.80 x 66% = $250,111.488 (asset appreciation)

Objective 3: Proposing public rebate that benefit the program deployment

As reported prior, low-income households and communities disproportionately receive a lower percentage of the overall EV-related subsidies impacting communities and reducing the opportunity for TNCs to convert the rideshare fleet to electric vehicles. Therefore, the project considers a targeted public policy approach model that supports TNCs that provide available EV fleet vehicles to low-income communities.

Economists have advocated for targeted subsidies as effective policy measures with minor inefficiencies (Eriksson & Kaserman, 1998). This position is historically supported by California Property Assessed Clean Energy (PACE), an investment PV with double residential PV (Ameli & Kammen, 2017).

The following is a drafted outline of a targeted subsidy to provide EV accessibility for the project's population. What distinguished the rebate feature compared to many of the current public programs is that the proceeds are processed to the beneficiary at the qualification time. Thus, the immediate rebate reduces the cost to fund the pilot project (Transportation Research Board and National Research Council, 2015). In addition, this approach will benefit the TNC to promptly receive funding to reduce the increased cost burden of operating expenses.

Use base model where a portion of subsidies goes to the TNC for eVMT

It is incentivizing EV TNC vehicles by reducing the operating cost to use fleet TNC EV vehicles. The public policy will place a value on the eVMT of each TNC EV fleet vehicle. The rebate can be applied to financing an EV fleet vehicle operating cost to support the TNC fleet transition (Rajagopal & Phadke, 2019).

Tracking of eVMT can be done by utilizing the TNC application. TNC drivers VMT are tracked presently by company applications. This data can be aggregated as eVMT and provided to granter to calculate subsidies earned. Furthermore, the reporting mechanism for TNCs should already be in place as any regulated business under the California Clean Miles Standard is required to report mileage annually (CARB).

The census tracking data set identifies TNC EV fleet vehicles and location that fleet vehicle is stationed to verify the use of an EV accessible in a low-income community.

Applying an established formula, we can determine the estimated subsidy amount issued monthly. First, the project estimates an average mileage rate by the eVMT per day. Then, this amount is multiplied by thirty day (or number of calendar days in a given month) to determine the rebate amount.

$$Monthly\ Rebate = (mileage\ rate)(eVMT\ TNC\ per\ day)(30\ days)$$

To determine the value of the mileage rate, this project considers the value of removing an ICEV from a low-income rideshare driver. The formula determines the social cost of carbon (SCC) cost the ICEV would have on the environment per average miles per gallon to determine the cost per ICEV VMT.

Considering the value of reducing ICEV externality costs: Burning a gallon of gasoline (that does not contain ethanol) produces about 19.5 pounds of carbon dioxide (EPA). According to the World Bank, carbon pricing is estimated at $40-80 per ton as of 2020 and $50-100 per ton by 2030 (High-Level Commission on Carbon Prices, n.d.). One ton is equivalent to 240 gallons. The average household fuel efficiency is 23.9 for urban low-income households of $0-$24,999 and 24.6 for the same demographic earning $25,000-$34,999. Average being 24.24 MPG (Mineta Transportation, n.d.).

$$\frac{cost\ of carbon}{ton}\ x\ \frac{1ton}{240\ gallons} = \frac{cost\ of\ carbon\ pergallon}{average\ miles\ per\ gallon}$$

$$\frac{\$80.00}{1\ ton} x \frac{1\ ton}{240\ gallons} = \$0.333\ gallon\ x\ \frac{1}{24.24\ miles\ per\ gallon} = \$0.013\ per\ mile$$

$$\$0.013\ per\ mile\ x\ 150\ miles\ per\ day = \$1.95\ x\ 30 = \$58.50$$

The value to society of removing one low-income rideshare drivers ICEV to a TNC EV fleet car is estimated to be $58.50 a month per vehicle. This project proposed the value of eliminating the SCC from low-income communities be provided in the form of the described monthly rebate to TNC EV fleets.

Conclusion

This paper proposes a pilot project that addresses the environmental, social, regulatory, and profitability of electric vehicle charging and fleet deployment. The project provides a detailed analysis of potential electric vehicle charging and EV fleet access at locations in communities most impacted by the low-air quality, unemployment, costs, and barriers to transportation. The proposed sites are identified as having a highly available workforce and the highest percentage of rideshare users in the San Diego County market. The identified areas provide a competitive advantage logistically to access rideshare users' market share. By providing a startup and operating cost expense of an example pilot site, including the most likely significant expenditures, the project assessed the investment and working capital to deploy the pilot project. Additionally, providing the business stakeholder benefits of deploying this model, including a cash flow positive rideshare concept and long-term appreciation in assets and justification for retaining property sites for the TNC long-term business model of automation. Lastly, the project addressed the lack of EV and EV charging-related public program proceeds benefiting low-income communities by outlining a direct rebate to those EV fleets stationed and used by low-income rideshare drivers. The rebate amount was justified by formulating the social carbon cost the average low-income rideshare driver produces per VMT.

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