EV Charging for All

How Electrifying Ridehailing Can Spur Investment in a More Equitable EV Charging Network

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About Us

About RMI

RMI is an independent nonprofit founded in 1982 that transforms global energy systems through market-driven solutions to align with a 1.5°C future and secure a clean, prosperous, zero-carbon future for all. We work in the world's most critical geographies and engage businesses, policymakers, communities, and NGOs to identify and scale energy system interventions that will cut greenhouse gas emissions at least 50 percent by 2030. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing.

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Executive Summary

Executive Summary

Road transportation must electrify to reduce emissions at least 45% by 2030 to align with a 1.5°C future. That will require 70 million electric passenger vehicles on the road in the United States over the next 10 years, in addition to a 20% reduction in vehicle miles traveled. While much focus has been placed on accelerating the development and sale of EVs, deploying the public charging infrastructure needed to power tens of millions of EVs has lagged. Currently, most charging in the United States is level two (L2), oftentimes in a private garage or at the workplace. This is ideal for drivers who have private parking, but not sufficient to support a full transition to EVs. That transition will require much more publicly available fast-charging infrastructure.[1]

While the need for public fast-charging infrastructure is pressing, the pace of deployment in the United States has remained slow. Part of the reason is that early EV adopters tend to have private, off-street parking and therefore can rely on home and workplace charging.[2] As a result, the demand for public high-speed charging (i.e., direct-current fast charging [DCFC]) has been limited at this early stage and insufficient to support the broad network needed for widespread EV adoption.

This lack of DCFC has the potential to limit transportation electrification in the United States just as more affordable EVs are coming to market. Ultimately, this would limit EV ownership to those with easy access to home charging. This excludes the large portion of US residents who do not own a garage in which to install a charger or do not have reliable access to a charger at their workplace.

To successfully transition from early adoption to mass market deployment of EVs, the United States will need to accelerate the growth of a high-coverage public DCFC network. Deploying that network will require massive amounts of capital which, with current demand dynamics, may not earn a reasonable return. However, as certain types of commercial fleets electrify rapidly, they can provide stable demand to financially underpin public DCFC charging. This, in turn, will provide the incentives for the scaled deployment of capital required to build a robust DCFC network. One segment with high-potential fleets is transportation network companies (TNCs) such as Uber and Lyft.

EVs are poised to rapidly gain market share in TNC applications for several reasons:

- EVs are fully capable of meeting the demands of TNC drivers as automakers bring more capable and affordable EVs to market.[3]
- EVs typically have lower operating costs than internal combustion engine (ICE) vehicles.[i] For high-mileage applications such as TNC driving, these lower operating costs can offset the higher purchase price of EVs and can bring them to cost parity or even superiority on a per-mile basis.
- An increasing number of government mandates and policies aim to accelerate the adoption of EVs by TNCs. For example, California Air Resources Board's (CARB's) Clean Miles Standard (CMS) requires 90% of TNC fleet miles to be electric by 2030.[4]
- As the first generation of readily available, lower-cost EVs come off lease and original owners sell, the used market—almost nonexistent to this point—is poised to supply a new source of even lower-cost EVs over the next few years.[5]

This combination of performance, cost-effectiveness, policy, and market dynamics has led to support for TNC electrification from TNCs themselves, with Uber and Lyft committing to electrifying their US fleets by 2030.[6]

[i] While operating costs are typically lower for EVs, at present whether total cost of ownership is lower depends on a variety of factors described in detail in RMI's report titled *Racing to Accelerate Electric Vehicle Adoption: Decarbonizing Transportation with Ridehailing*.

This potential for rapid electrification of TNC miles creates a unique opportunity to help build a DCFC network that is not only financially sustainable, but also provides inclusive access to charging in currently underserved areas, which are predominantly lower-income communities. The current network is built to meet demand where it exists today. Because the market is nascent, most EV purchases are new vehicles, which concentrate in wealthier communities. The socio-economic status and charging needs of TNC drivers are often very different from current EV owners.

A TNC driver typically has lower household income, does not have a lot of downtime during which to charge, and usually does not have access to a private charger at night.[7] This leads TNC drivers to rely heavily on public DCFC. And, as detailed below, there is ample TNC demand in low-income areas. The fact that electric TNC vehicles today operate in wealthier areas is not because there is insufficient demand elsewhere, but because there is insufficient charging infrastructure.

The combination of rapid electrification of TNC vehicles and TNC driver preference for DCFC will create an urgent need to rapidly deploy a DCFC network as well as a substantial source of demand to enable that network. Given the time needed to plan, permit, and install DCFC,[8] it is critical to immediately begin building the DCFC network to support widespread TNC electrification by 2030.

Although there is broad awareness that TNC electrification will require a larger network that serves many more communities than the one that exists today, several key uncertainties exist that are slowing progress. These include:

- **The needed size and capacity of the network**
- **The distribution of charging stations across the city that would both meet the needs of TNC drivers and keep infrastructure costs to a minimum**
- **The financial viability of the DCFC network**
- **The ability of that network to meet city needs beyond just TNC electrification—specifically the provision of inclusive access to EV charging in lower-income communities—that justify public investment**

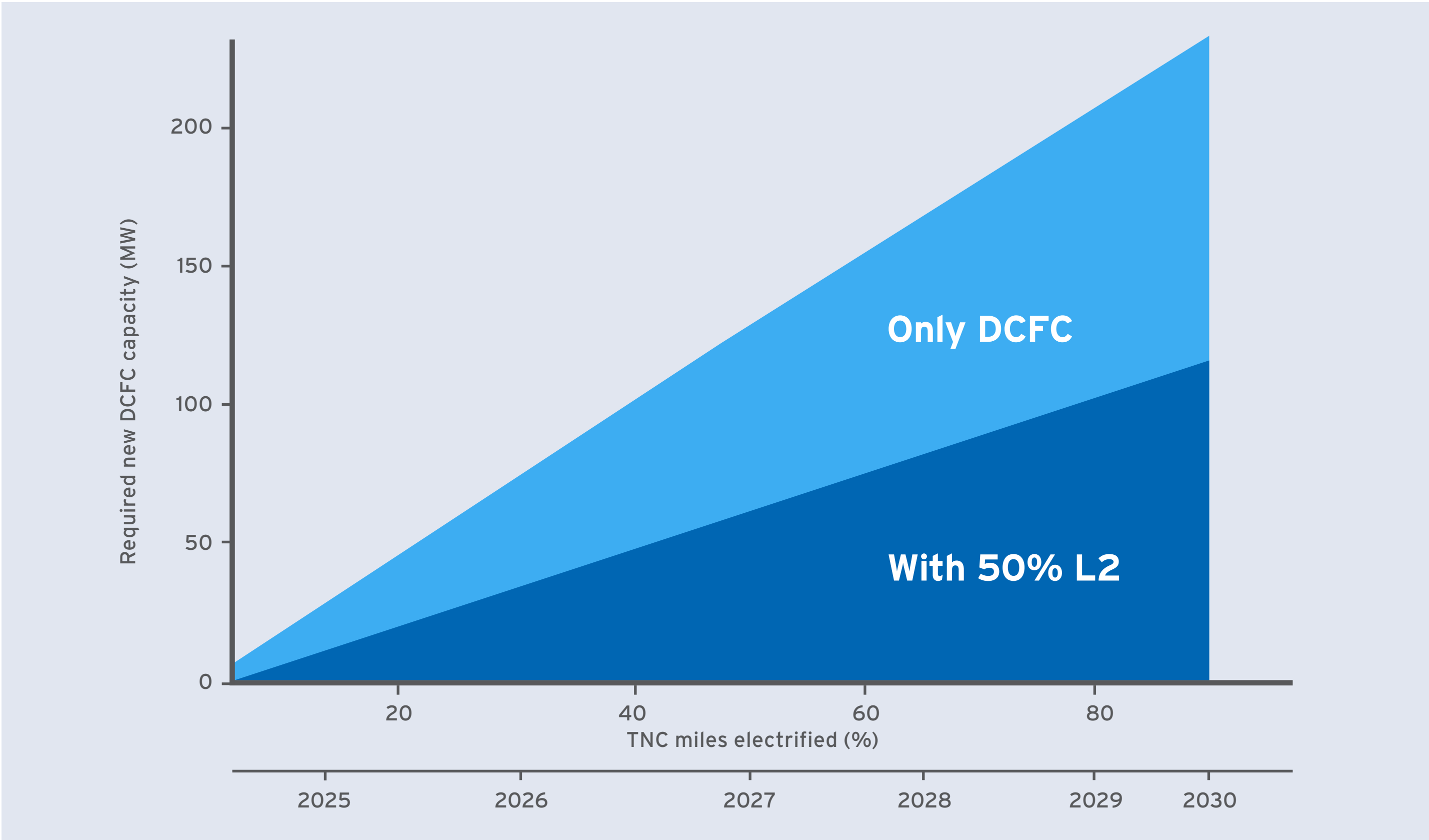
We addressed these critical uncertainties by collaborating with GM to leverage deidentified data from 101 million miles of actual EVs and ICE vehicles driving in TNC applications. By observing real charging patterns in the field, we are able to account for the inefficiencies and vagaries of human behavior.

The results of this analysis speak to the difficulty of the challenge and magnitude of the opportunity. Los Angeles—already a leader in public DCFC deployment—will require multiples of the currently available DCFC capacity just to meet the demand for EV charging that will be created by the CMS (Exhibit ES1). Under the optimistic assumption that 50% of TNC miles are powered by L2 charging,[ii] the network would need to grow by three times. If TNC drivers were to rely exclusively on DCFC to charge their vehicles, the network required to provide that electricity would be about six times bigger than the current one. These increases do not account for additional demand that will come as the private car market also electrifies.

[ii] We assess DCFC infrastructure requirements under two bounding scenarios. The lower bound assumes 50% of TNC miles are powered by L2 charging, as CARB assumes in its CMS targets (California Air Resources Board 2020). The upper bound assumes that all TNC charging needs are met by DCFC.

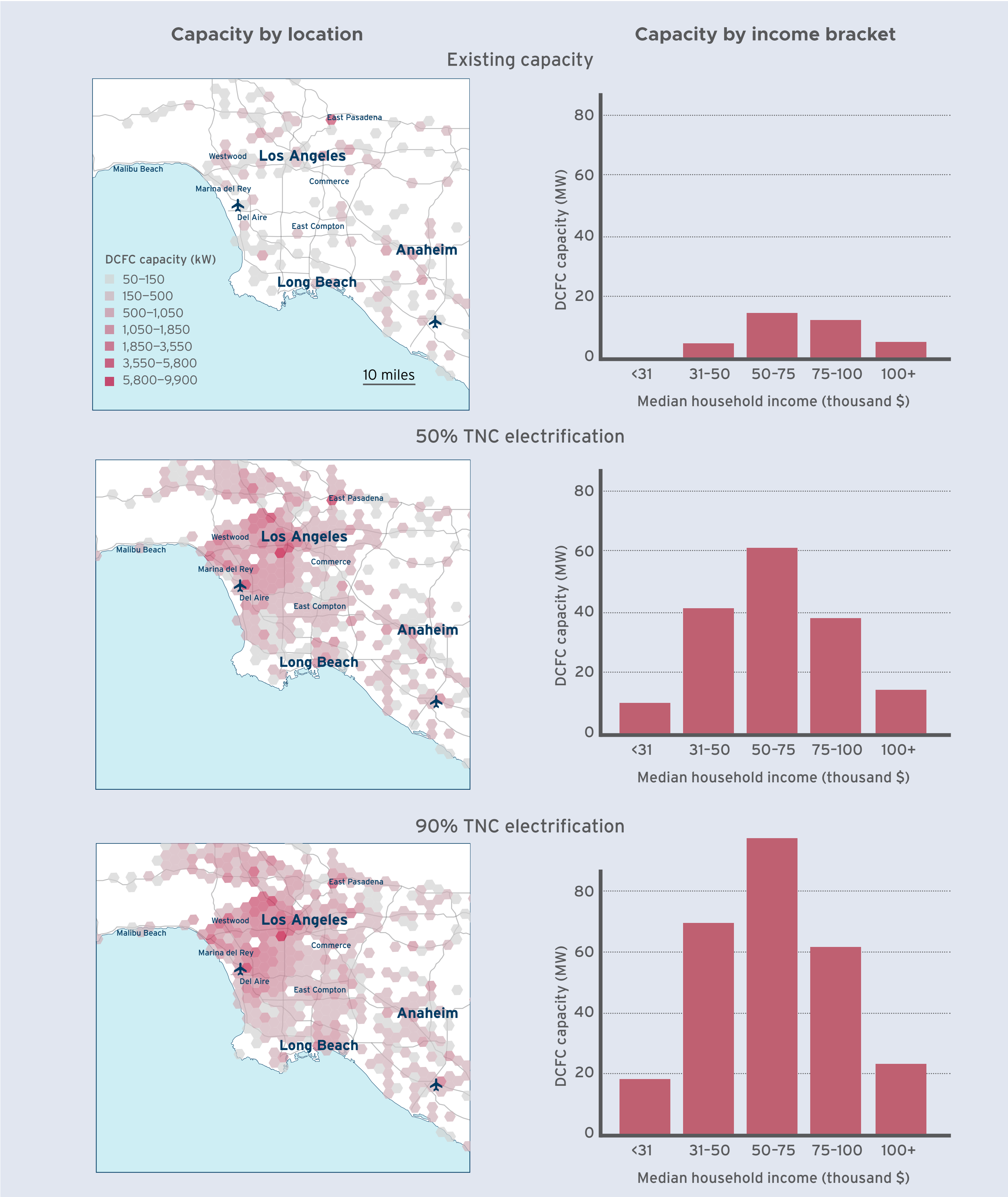
Exhibit ES1

Additional DCFC capacity required in Los Angeles to meet CMS timeline of TNC electrification



Furthermore, the distribution of DCFC stations across Los Angeles that would meet the demand of TNC drivers is much more ubiquitous than the network that exists today. While significantly more infrastructure is needed everywhere, the greatest need for investment in the network is in low-income communities that currently have little access to public charging (Exhibit ES2). In other words, by supporting charger deployment in areas where the drivers live and operate, TNC electrification could remove a critical barrier to EV adoption in underserved communities.

Exhibit ES2 Increasing network coverage with TNC electrification



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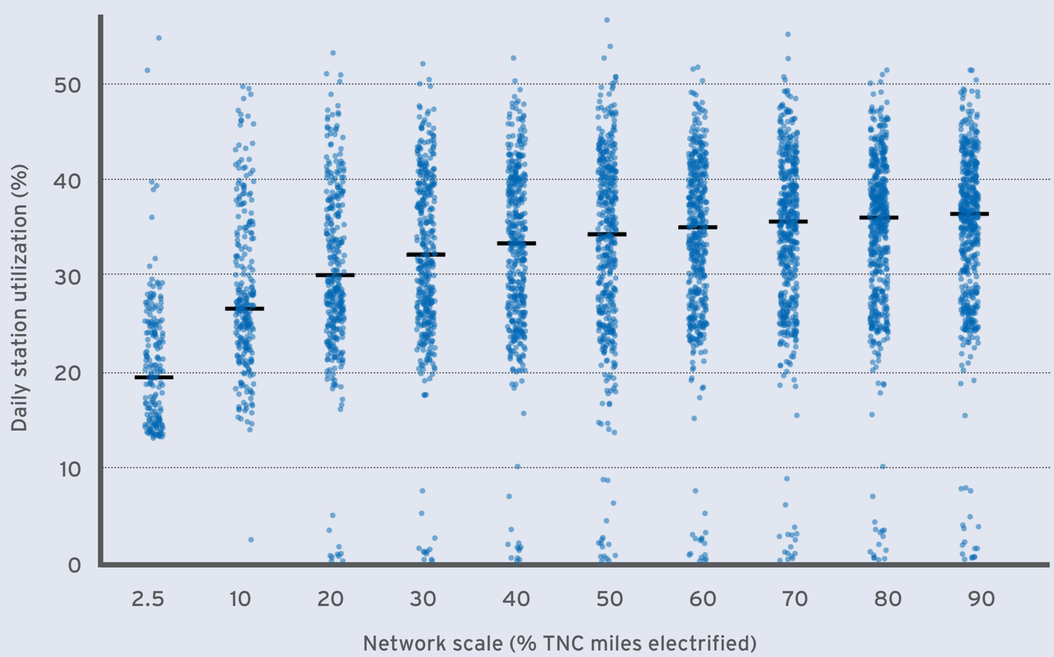
The investment required to create this network will be substantial. Equipment and installation in Los Angeles alone could range between $116 million and $234 million just for the chargers needed by TNCs.[iii] However, the data suggests that the long-term return on that investment will be attractive for the network as a whole. Because there are significant fixed costs associated with building DCFC and it earns revenue from charging over time, the utilization of a station is the key determinant of its profitability while maintaining a competitive retail price to the drivers. Most DCFC stations become profitable between 15% and 30% utilization. In our projections, average utilization across the network is approximately 36% (Exhibit ES3).

This high utilization spreads the fixed costs over more revenue and thus drives down the cost to provide charging. For example, the network designed for 90% TNC electrification in Los Angeles could earn $53 million to $116 million in gross revenue per year at its projected utilization rate.[iv] This creates a sustainable and scalable business case for the charging providers, especially as the requirements of the CMS ramp up (ES4). The result will be a larger, more complete public DCFC network capable of powering more EVs, including those of the general public, at lower cost per charge while generating adequate return for infrastructure investors.

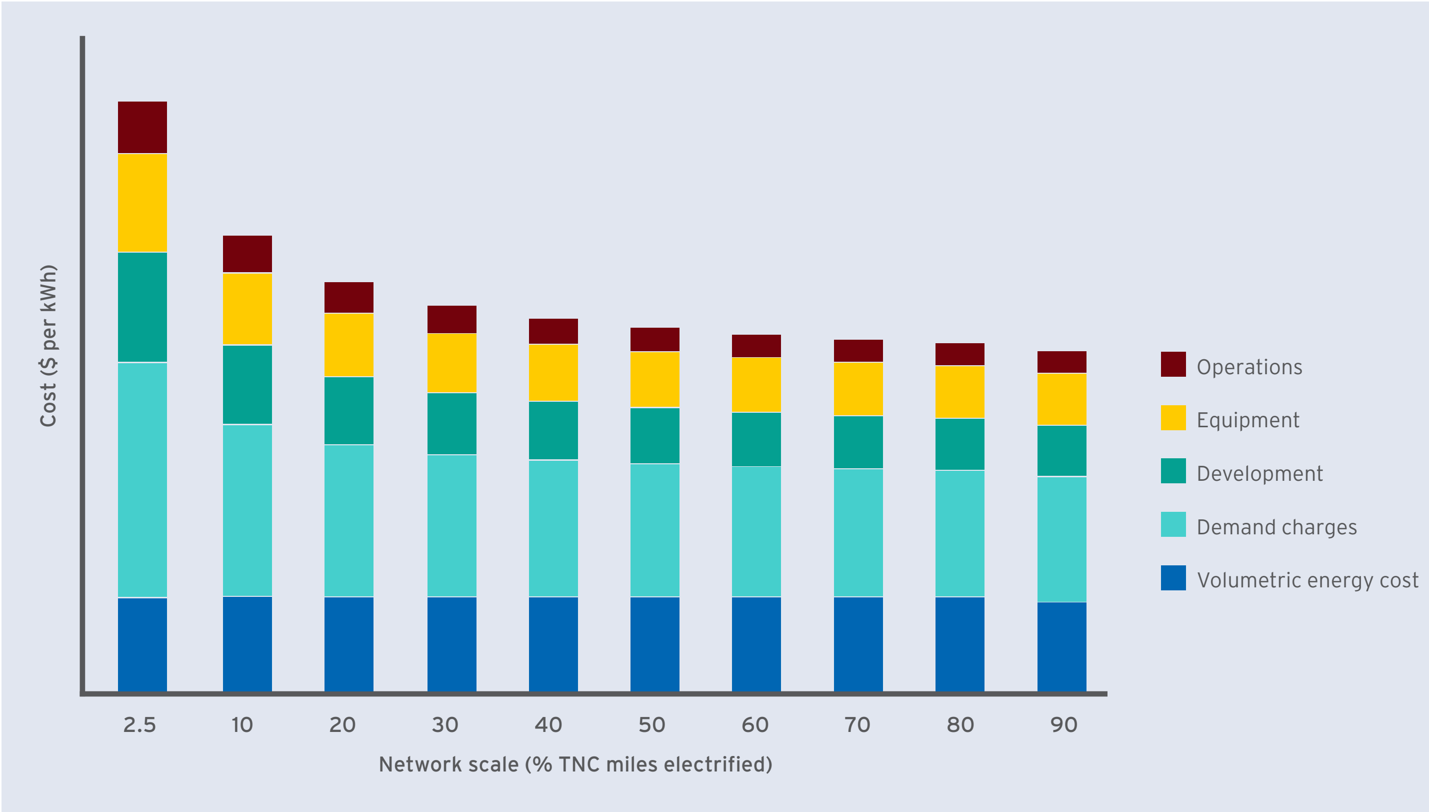
Exhibit ES3

Average daily station utilization across the network in Los Angeles as a function of TNC electrification



[iii] Assuming a cost of $150,000 per DCFC plug, per Brennan Borlaug et al., "Levelized Cost of Charging Electric Vehicles in the United States," *Joule* 4 (2020): 1470–1485.
[iv] Assuming the charging price is $0.263/kWh. This represents the national average price of DCFC ($0.35/kWh) minus a 25% discount.

Exhibit ES4 Cost components of network build-out with increasing network scale



Note: These results are based on the A3 Large Commercial and Multi-Family Service tariff from the Los Angeles Department of Water and Power.

However, this network is not guaranteed to emerge as the CMS is implemented. In fact, its failure to emerge could endanger CMS goals being met. To ensure success, several barriers must be overcome. They include:

- **Lack of firm initial demand for DCFC to enable project finance at scale**
- **High costs of land acquisition and site development**
- **Rate design that makes early investment in DCFC prohibitively expensive**

To overcome these barriers, an array of stakeholders including cities, utilities, TNCs, and electric vehicle service providers (EVSPs)[v] must take action to simultaneously facilitate TNC electrification and DCFC deployment:

- **Increase capital flows by enabling project finance through improved coordination, design, and derisking**
- **Leverage public funds to catalyze DCFC investment in low-income communities**
- **Reduce development costs of DCFC stations**
- **Reform rate design to support DCFC**

[v] An electric vehicle service provider is a company that provides charging services in public, workplace, or large-scale residential settings.

Introduction

Introduction

Road transportation must electrify rapidly to prevent the worst effects of climate change. Transportation accounts for 28% of CO_2 emissions in the United States, over half of which come from passenger vehicles.[9] Transportation electrification could effectively eliminate these emissions if combined with renewable electricity generation. Even with the current mix of fossil fueled and renewables-based EV charging, EVs produce fewer emissions in all parts of the United States.[10] In order to reach the emissions targets in line with a 1.5°C future, the United States must cut transportation emissions at least 45% by 2030. This would require replacing 70 million internal combustion engine (ICE) vehicles with EVs and reducing vehicle miles traveled (VMT) by 20%—both monumental tasks.

Vehicles serving transportation network companies (TNCs) such as Uber and Lyft are critical early candidates for electrification due to their disproportionate impact on CO_2 emissions and urban air quality.[11] Their high annual mileage (roughly 40,000 miles per year) means that electrifying one TNC vehicle generates three times the emissions reductions of electrifying an average private passenger vehicle.[12] And because TNC miles generally occur in populated areas, TNC electrification will also benefit public health by displacing toxic tailpipe emissions and improving urban air quality.[13]

The high mileage that TNC vehicles travel also allows drivers to reap the benefits of the typically lower per-mile operational costs of EVs, which have the potential to lower the total cost of ownership. EVs are mechanically simpler than ICE vehicles, so they typically need less maintenance. Also, the cost of charging an EV can be substantially lower than the price of fueling an ICE vehicle, but this depends on the type of charging used.[14] If drivers have access to home level two (L2) charging, it is much less expensive than fueling with gasoline. However, because of the challenges of providing inexpensive direct-current fast charging (DCFC) in the context of the nascent market, it can be more expensive to charge a vehicle with DCFC than to fuel an ICE vehicle.

As transportation electrification continues and public DCFC utilization increases, contingent on other market conditions, charging with DCFC can also become less expensive than fueling with gasoline. Thus, for high-mileage applications such as with TNCs, EVs will continue to become increasingly cost competitive with ICE vehicles.

A final, critical component for success is the used EV market, which has been virtually nonexistent but is poised to accelerate rapidly in the coming years.[15] The first vehicles with sufficient range for full-time TNC use that were somewhat affordable were the Chevrolet Bolt and Tesla Model 3, released in 2016 and 2017 respectively. With those vehicles poised to enter second-hand markets in the early 2020s, there will finally be a meaningful supply of off-lease and used long-range EVs available to TNC drivers. This is critical for the success of TNC electrification because drivers frequently purchase late-model used vehicles for this purpose.

Total-cost-of-ownership analyses in the industry typically focus on the comparison of new EVs with new ICE vehicles. However, for many TNC drivers, up to this point, the choice has been between a new EV and a used ICE vehicle, and the purchase price difference in this case is substantial. The fact that meaningful numbers of capable used EVs will soon be available is a critical enabler.

Understanding the urgency of TNC electrification, the California state government has TNC electrification targets via the California Air Resources Board's (CARB's) Clean Miles Standard (CMS).[16] The CMS mandates that TNCs progressively electrify their fleets, and that 90% of TNC miles be electric by 2030.[vi] Uber and Lyft have also committed to electrification beyond California, targeting 100% electrification in the United States by 2030.[17] The critical tasks ahead are to identify a viable pathway to ensure TNCs meet electrification targets in an economically sustainable and scalable way, and to remove barriers where necessary. One key barrier to address is filling the gap in public charging infrastructure.

As momentum builds behind transportation electrification, the need to accelerate deployment of charging infrastructure (electric vehicle supply equipment [EVSE]) has become increasingly apparent. Public EVSE will be critical to enable EVs to expand beyond the early adoption phase and replace ICE vehicles more broadly. The International Council on Clean Transportation (ICCT) estimates that to keep pace with projected charging requirements in 2025, EVSE will need to grow by 20% annually in major US cities.[18]

However, charging infrastructure deployment has so far remained slow, partly due to the demographics and charging habits of early EV adopters. The current network is built to meet demand where it exists today. Because the market is nascent, most EV purchases are new vehicles, which concentrate in wealthier communities.[19] Furthermore, most EV owners charge predominantly at home and work, and use public EVSE infrequently, and therefore can use a vehicle even without a strong public network.[20]

This development pattern has created an EVSE network that will not support the use of EVs by residents of many low- and middle-income communities.[21] Lower-income drivers more often do not own a garage or an off-street parking space where an L2 charger can be easily installed, but rather rent homes or live in multi-unit dwellings (MUDs) where charger installation is difficult. Approximately 41% of Americans in the top 100 metropolitan areas live in MUDs,[22] and the proportion of TNC drivers that live in MUDs is likely much greater.[23] Consequently, MUD residents and TNC drivers will rely on public EVSE,[24] and that EVSE must be in the field before the vehicles arrive to give the drivers confidence the network will meet their needs.

For drivers relying on public charging, DCFC is often the most convenient option. Although L2 charging is less expensive than DCFC to install and operate, it requires many hours to reach a full charge and is thus more effective at home, where it can be used overnight. DCFC is more expensive but can charge a vehicle in under an hour. Therefore, until L2 is ubiquitously available in and around homes and workplaces, DCFC will be a dominant source of charging for many drivers. For TNC drivers, the advantage of DCFC over L2 is even greater because the additional time spent charging with L2 represents lost revenue.

Although the reliance of TNCs on the currently sparse DCFC network poses a near term barrier to TNC electrification, it may also create an opportunity for electric vehicle service providers (EVSPs) to rapidly build a large, inclusive public fast-charging network in an economically sustainable way. An analysis of EV charging in California found that electric TNCs can generate as much as 60 times the demand for DCFC compared to a typical private EV.[25] This disproportionate demand for fast charging makes TNCs an ideal anchor customer for newly installed DCFC. The greater demand per vehicle, coupled with massive deployment of EVs in TNC applications driven by electrification commitments from TNCs and mandates from government, means that TNCs have the potential to catalyze the growth of new public DCFC networks.

[vi] To meet the Clean Miles Standard, only battery-electric or fuel-cell electric vehicles are acceptable.

Furthermore, because TNC drivers are more demographically diverse than early EV adopters, this new DCFC network will support the deployment of DCFC stations in low-income areas. Forty-six percent of rides for Lyft start or end in low-income areas,[26] and TNC drivers tend to have lower incomes than typical EV owners.[27]

> **The research presented here shows that if these vehicles were electric, there would be ample demand for charging in currently underserved areas.**

While this is exciting, an actionable roadmap that guides investment into the system and quantifies the benefits of those investments is needed. With this research we seek to:

- Quantify how much EVSE will be required to support TNC electrification
- Estimate where those chargers will be needed across a city to meet the needs of TNC drivers while minimizing cost to EVSPs
- Estimate the economic viability of a DCFC network customized to the needs of TNC drivers
- Quantify the increased access to charging in low-income areas created by a TNC-specific DCFC network

To achieve those objectives, we partnered with GM to analyze driving and charging patterns from 101 million miles of EV and ICE data generated by TNC drivers. With this data, we forecasted demand for EV charging that will be generated by CMS and TNC commitments in Los Angeles. We then estimated the network geography that would minimize the combined cost to infrastructure providers and TNC drivers, the financial viability of that network, and the access to charging it would provide to currently underserved communities.

Analytical Approach

Analytical Approach

Data Used

In this report we focus on Los Angeles as a case study in electric TNC charging network design; however, the models used in this report are applicable in other American cities. All analysis in this report is based on deidentified data from ridehailing vehicles on the former Maven Gig platform. Maven Gig was a subsidiary of GM that offered short-term rentals of GM vehicles to drivers operating for TNCs. Both electric vehicles (Chevrolet Bolt EVs) and ICE vehicles were available on the Maven Gig platform. For EVs, unlimited DCFC was included in the EV rental.

The subset of anonymous Maven Gig data from Los Angeles included approximately 1,000 EVs and 2,000 ICE vehicles operating from January 2018 to November 2019. Data collected from those vehicles include location, speed, battery state of charge (for EVs), and time—at frequent regular intervals.

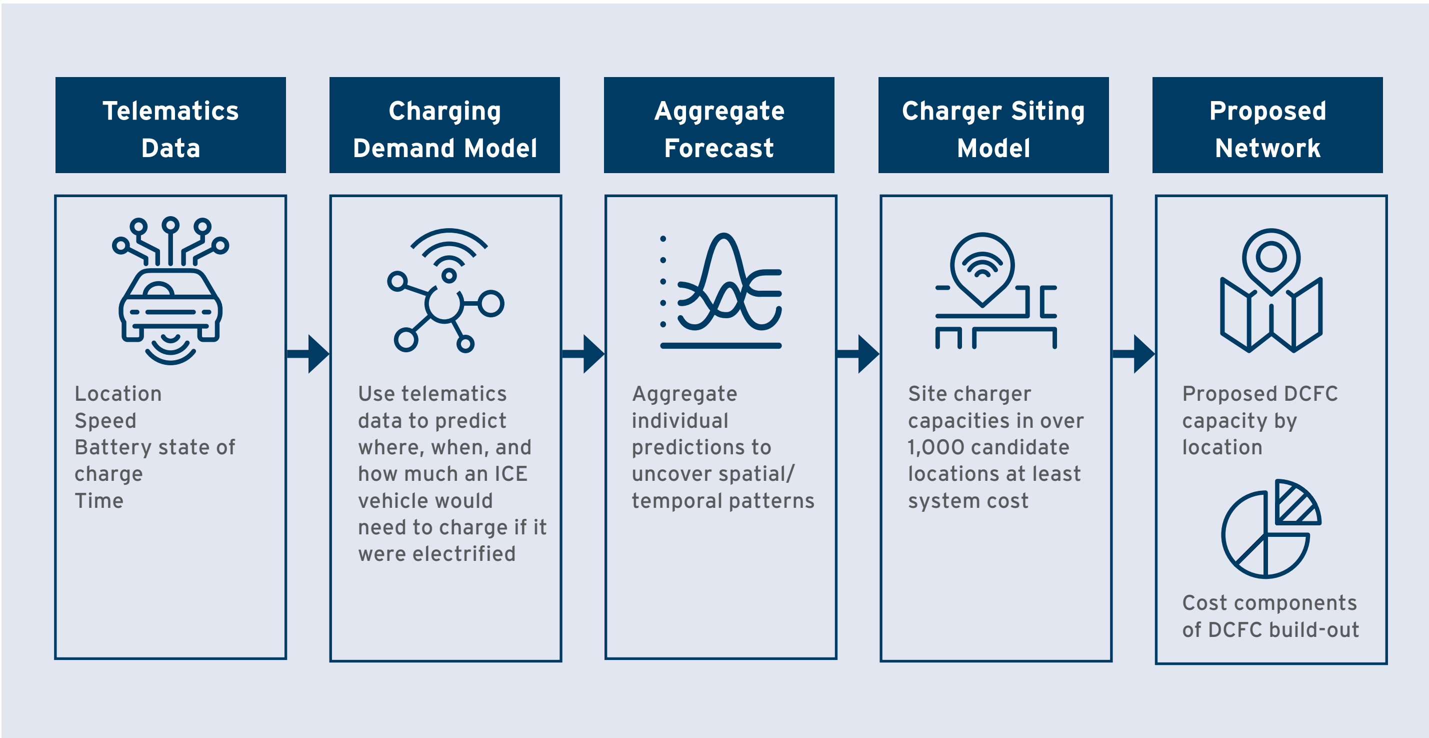
Modeling Framework

To estimate the least-cost DCFC network that would effectively meet demand for charging by TNC vehicles, we developed a multistep modeling framework (Exhibit 1). In the first step we reconstructed the driving and charging patterns of Maven Gig vehicles from January 2018 through November 2019 from the deidentified data.

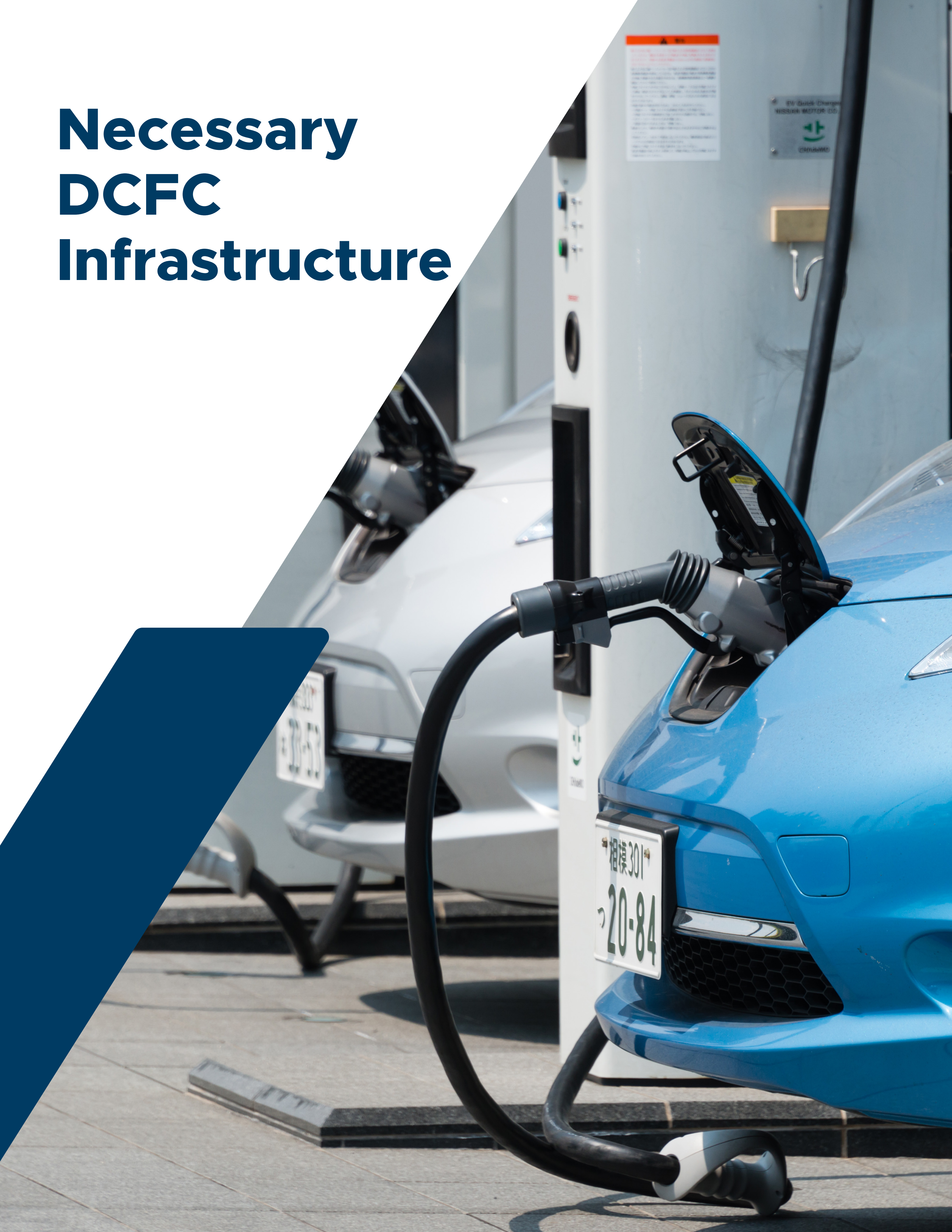
Using these travel records we developed a machine learning model to estimate the likelihood that a vehicle would charge at any given stop over the course of the day. We trained the model using data from EVs, then applied the model to data from ICE vehicles to make predictions about where and when those vehicles would charge if they were electrified. We then aggregated the charging predictions made for each ICE vehicle stop to create a demand forecast. To adjust the forecasted demand to match TNC electrification targets, we scaled our forecasts based on estimates of total TNC travel in the city in September 2018 (5.14 million miles per day)[28] and CARB's timeline for TNC electrification in the Clean Miles Standard.

Next, we developed an optimization model that arranges DCFC capacity into a network that meets all charging demand at the lowest total system cost. Costs included in the optimization were DCFC equipment cost, station overhead costs such as management and maintenance, site development and charger installation costs, electricity demand charges, and volumetric electricity cost. We also included the opportunity cost to the drivers of having to drive to a station that was not exactly where the vehicle stop occurred. This approach balances the competing objectives of minimizing cost for the EVSPs and maximizing network usability for the drivers.

Exhibit 1 Flow chart for model framework



Necessary DCFC Infrastructure



Necessary DCFC Infrastructure

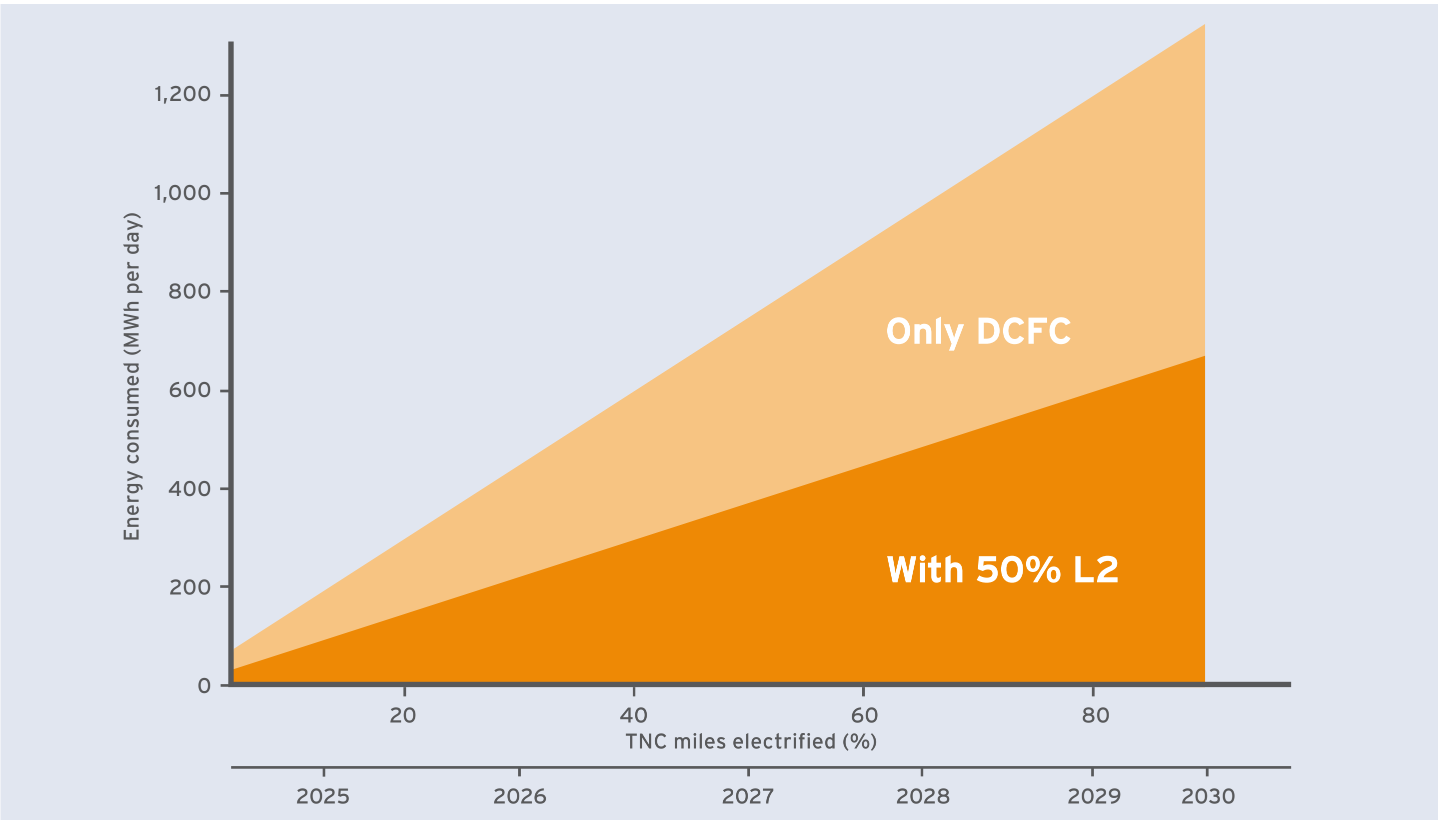
Magnitude of Required Network Build-out

Los Angeles is a leader in DCFC deployment, but the future charging demand from ridehailing electrification will overwhelm its existing capacity. Depending on the amount of L2 charging that drivers are able to use, TNC electrification alone would require a DCFC network that is between three and six times larger than the current network. This is before accounting for the additional demand that will come from private vehicles, urban delivery, and other market segments.

The actual need for DCFC infrastructure will likely fall somewhere in between. The ICCT estimates that only 44% of TNC drivers have access to a suitable location for L2 installation.[29] So theoretically, if all drivers who lived in a home where L2 was possible to install actually did so, a bit less than half of all charging would be covered by L2. However, there are many hurdles that make it unlikely that those drivers will all install L2 chargers in the near future.

To estimate the future demand for DCFC from TNC vehicles, we modeled two scenarios (Exhibit 2). The first assumes that L2 charging is able to meet 50% of total TNC charging demand. This is based on CARB assumptions of L2 use by electric TNCs in the CMS, and the maximum possible penetration implied by the ICCT research. In this scenario, TNC vehicles in Los Angeles get approximately 600 MWh of electricity from DCFC every day. The second scenario assumes no L2 use and is the upper bound on total DCFC need. In this scenario, DCFC charging demand is over 1.2 GWh per day. It is likely that actual demand will fall between these two scenarios.

Exhibit 2 Total daily energy demand of TNC fleet in Los Angeles

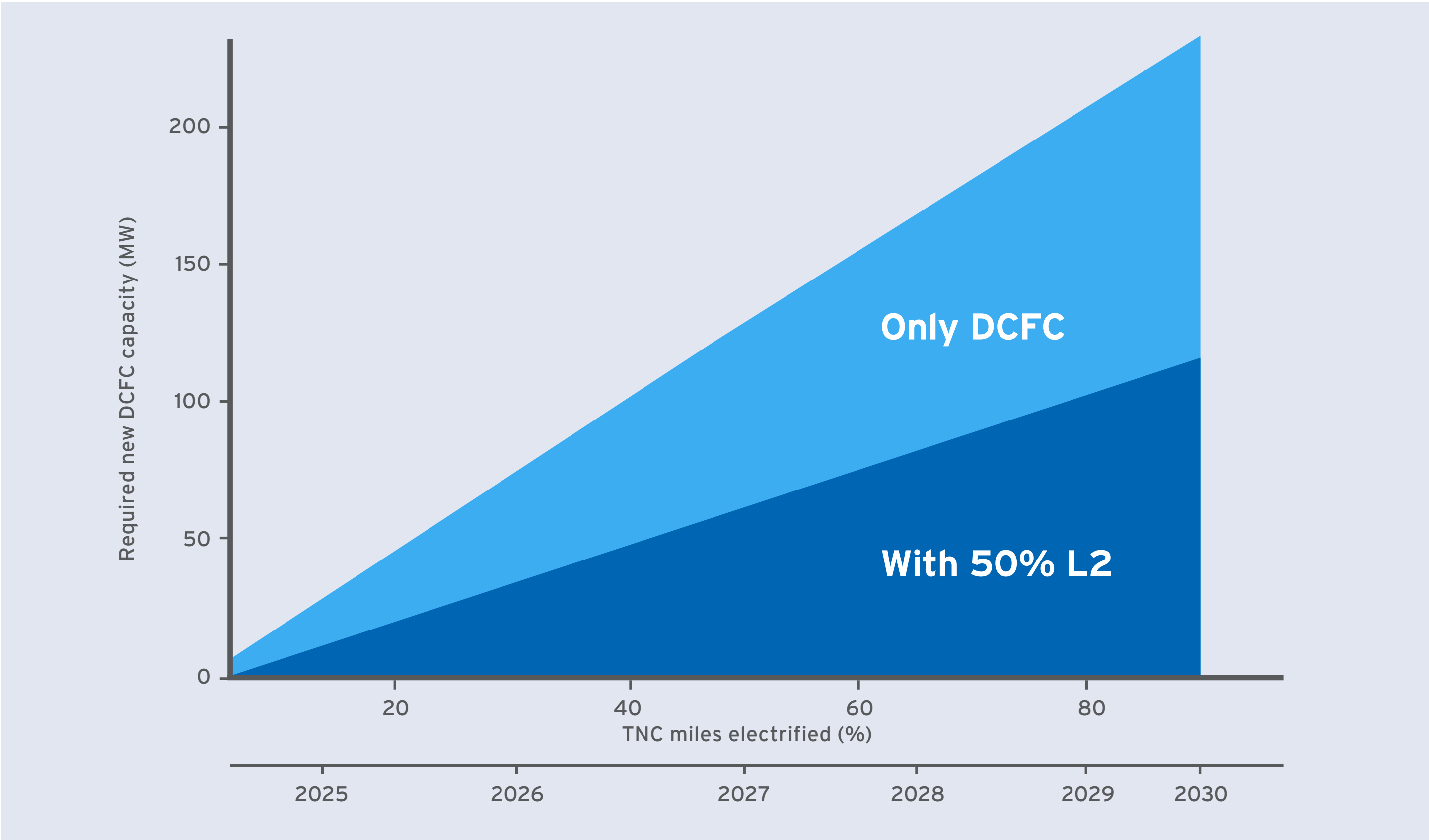


To meet this charging demand of 600–1,200 MWh per day, we expect that between 100 and 250 MW of charging capacity will need to be installed (Exhibit 3).[vii] The number of chargers required is driven not only by the fleet's total demand for DCFC, but also by the average station utilization rate over the network and the average power delivered during charging events.

Here, we assume hourly station utilization could not exceed 60% to account for inefficiencies due to station congestion.[30] We also estimate that actual capacity is 40% lower than nameplate capacity, based on the observed data, because the vehicles cannot charge at full power from 0%–100% state of charge. Newer vehicles will likely experience a somewhat higher ratio of actual charging power to nameplate capacity and larger stations with more chargers may be capable of higher maximum hourly utilization. Under those circumstances, the required capacity would be less.

Even under a generous L2 charger penetration scenario in which 50% of electric TNC miles are powered by L2 chargers, the additional DCFC capacity required would be three times the size of the 2020 capacity of 37.9 MW. If 100% of electric TNC miles were powered by DCFC, TNC electrification would require six times the current network capacity.

Exhibit 3 Required new DCFC capacity to support TNC electrification in Los Angeles



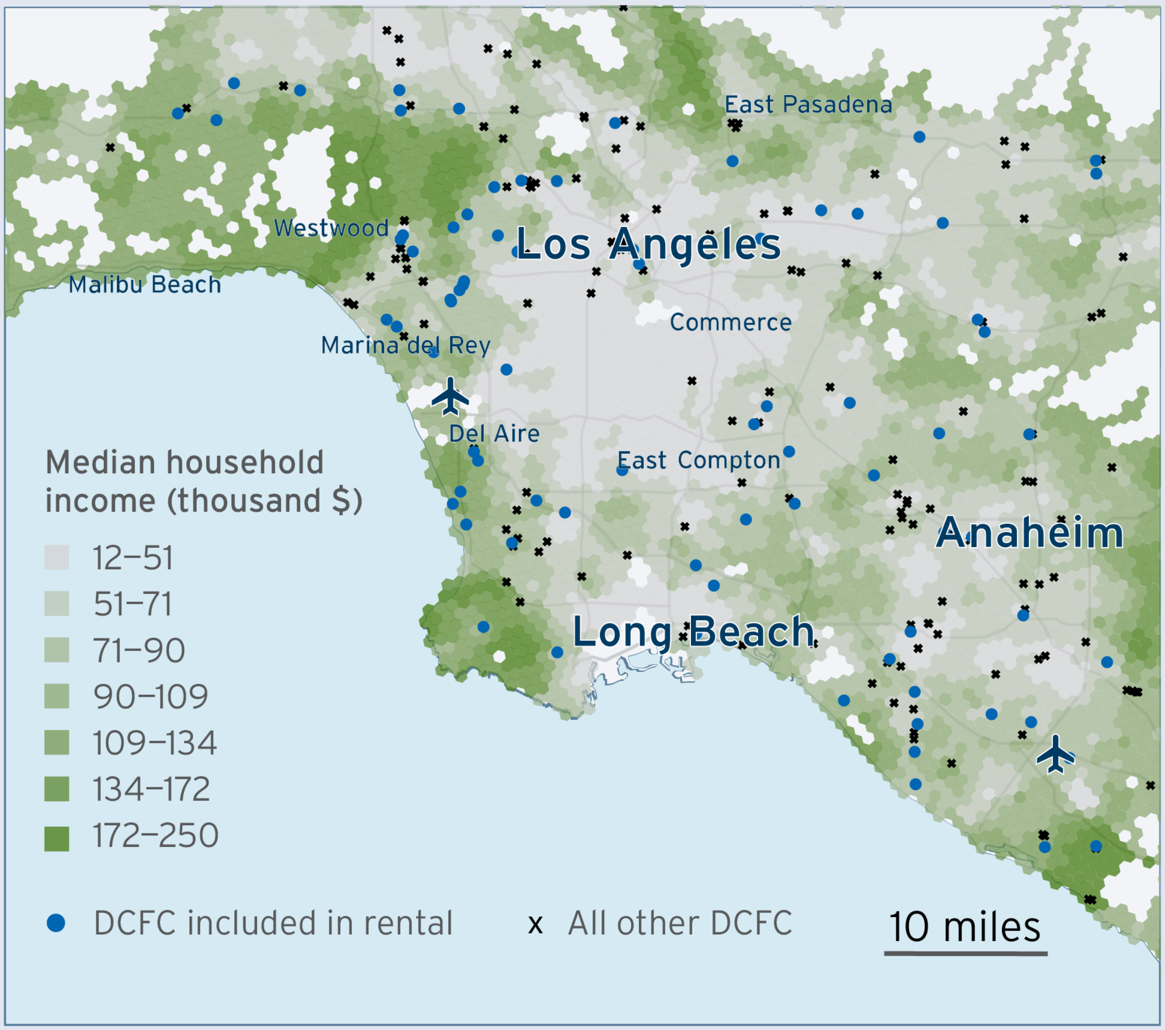
[vii] Our projections are based on vehicle charging patterns on a network of 50 kW chargers. Most new installations feature 150 kW chargers and even some 350 kW chargers, so our recommendations may differ slightly from what is actually needed. However, at the system level, we expect our results to align closely with the necessary capacity build-out in the next decade regardless of individual charger capacity. Going forward, it will be useful to continue to adjust projections of infrastructure needs as technologies and driver behavior change.

Distribution of Chargers

The Current Network Pulls EV Drivers out of Low-Income Communities

Most public DCFC stations in Los Angeles are in or near high-income areas of the city because that is where early adopters tend to live and EVSPs needed to support the only customers that existed (Exhibit 4).[viii] However, this existing network poses a problem—it is well suited to the driving patterns of existing EV owners, but poorly suited to driving patterns of TNC drivers.

Exhibit 4 **Distribution of median household income and DCFC charging network across Los Angeles**

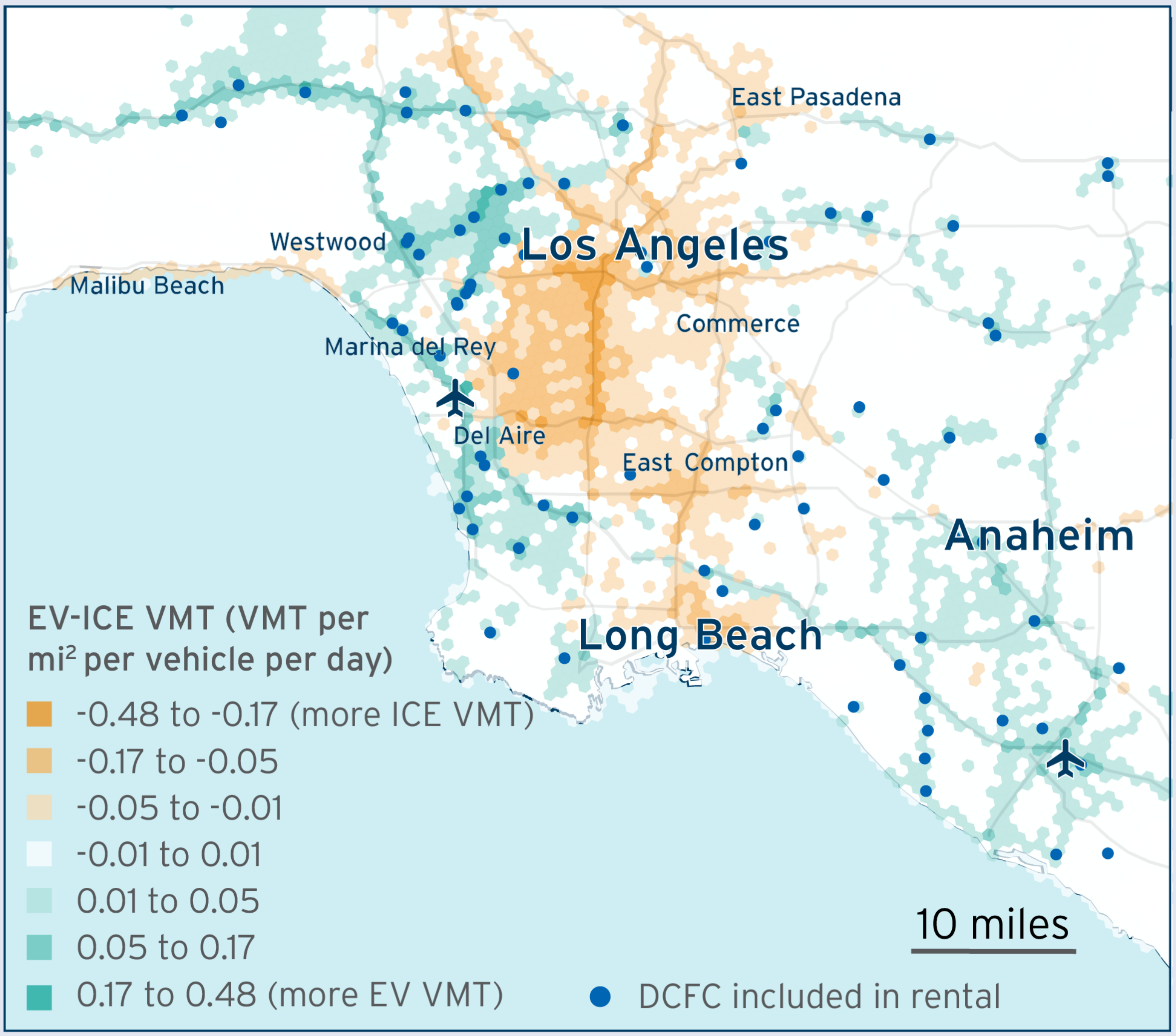


Source: Base maps adapted from "toner-lite" by Stamen Design under CC BY 3.0, https://creativecommons.org/licenses/by/3.0/

[viii] Maven Gig EV rentals included unlimited charging at certain stations. Throughout the exhibits in this report, we identify these stations as "DCFC included in rental."

By comparing anonymous driving patterns of EV and ICE vehicles in the former Maven Gig fleet, the shortcomings of this network and its effect on TNC EV use become clear. Because public DCFC is concentrated in wealthier areas, drivers of electric TNCs ended up operating more in high-income neighborhoods, whereas ICE vehicle drivers operated more in low-income neighborhoods (Exhibit 5). If this dynamic continues to play out, when 50% of TNC miles are electrified, some areas of the city along highway 110, predominately low-income communities, could experience between 2 million and 3 million more gasoline miles per square mile, per year.

Exhibit 5 Difference between EV and ICE VMT



Source: Base maps adapted from "toner-lite" by Stamen Design under CC BY 3.0, https://creativecommons.org/licenses/by/3.0/

This disparity between the density of EV and ICE activity is caused by the availability of suitable charging infrastructure and is apparent in how different types of stops are distributed over income bins in the city.[31] The domicile locations of EVs and ICE vehicles (Exhibit 6) are nearly equivalent across income bins.[ix] However, EV operational stops tended to skew toward higher-income areas (Exhibit 7).[x] The Maven Gig drivers in our analysis typically lived in low- and moderate-income neighborhoods regardless of which type of vehicle they rented.[xi] However, those who rented EVs tended to provide more rides in wealthier areas of the city, which have a robust DCFC network, while those who rented ICE vehicles provided fewer rides in wealthier areas.

[ix] A domicile location is a location in which a vehicle stopped for longer than five hours on at least five separate occasions. Income ranges are those commonly used by the US Department of Housing and Urban Development. They correspond to percentages of LA County median family income (MFI) as follows: moderate income (80% to 120% MFI), lower income (50% to 80% MFI), and very low income (0% to 50% MFI).
[x] Operational stops are stops greater than five minutes in duration that do not include charging events.
[xi] Vehicles analyzed were part of the former Maven Gig program from January 2018 to November 2019.

Exhibit 6 Distribution of domicile locations across income bins

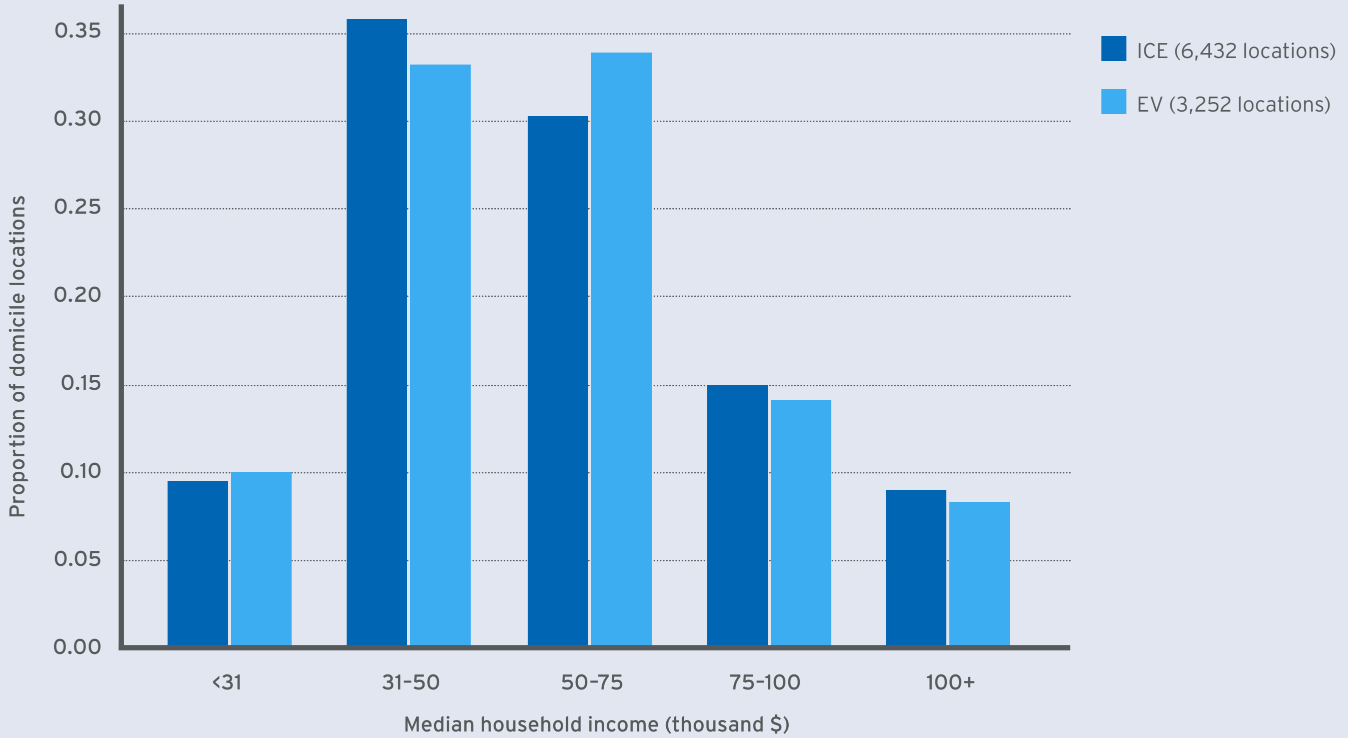
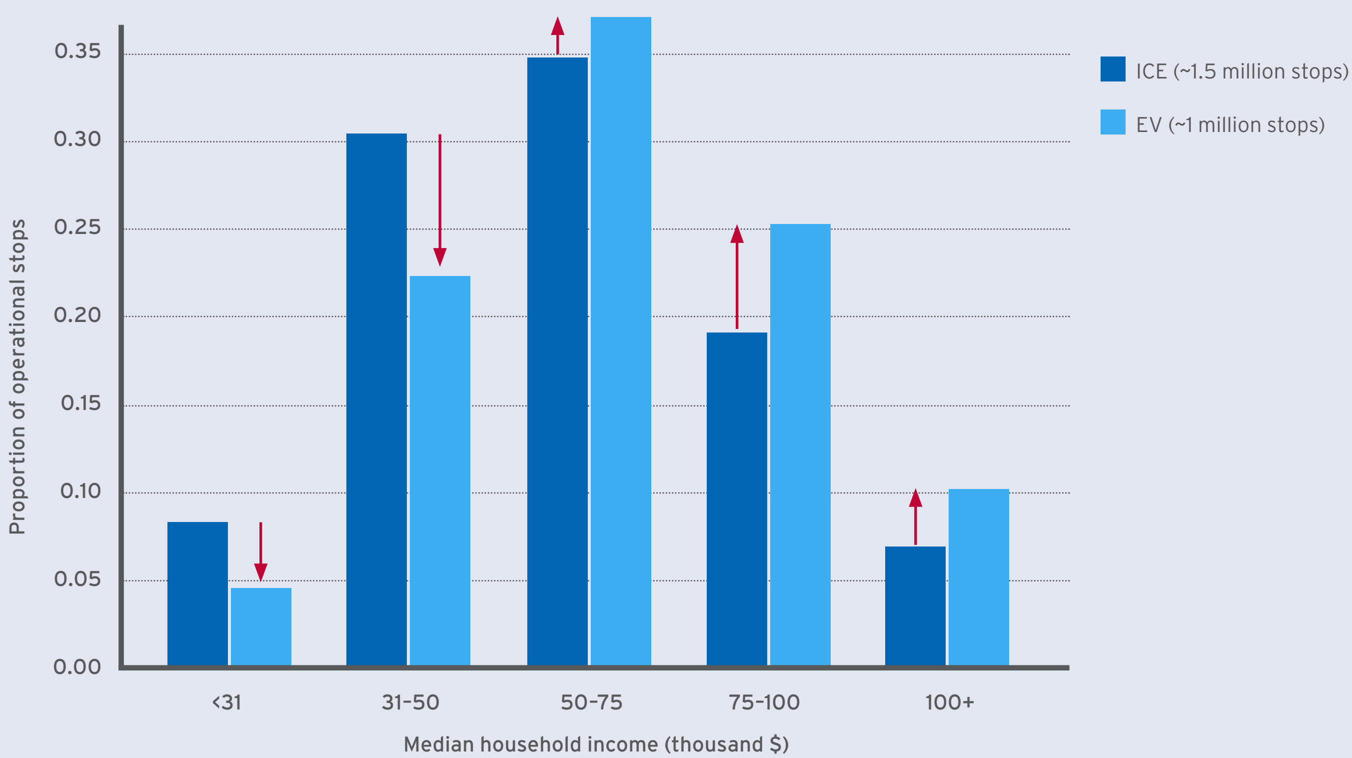


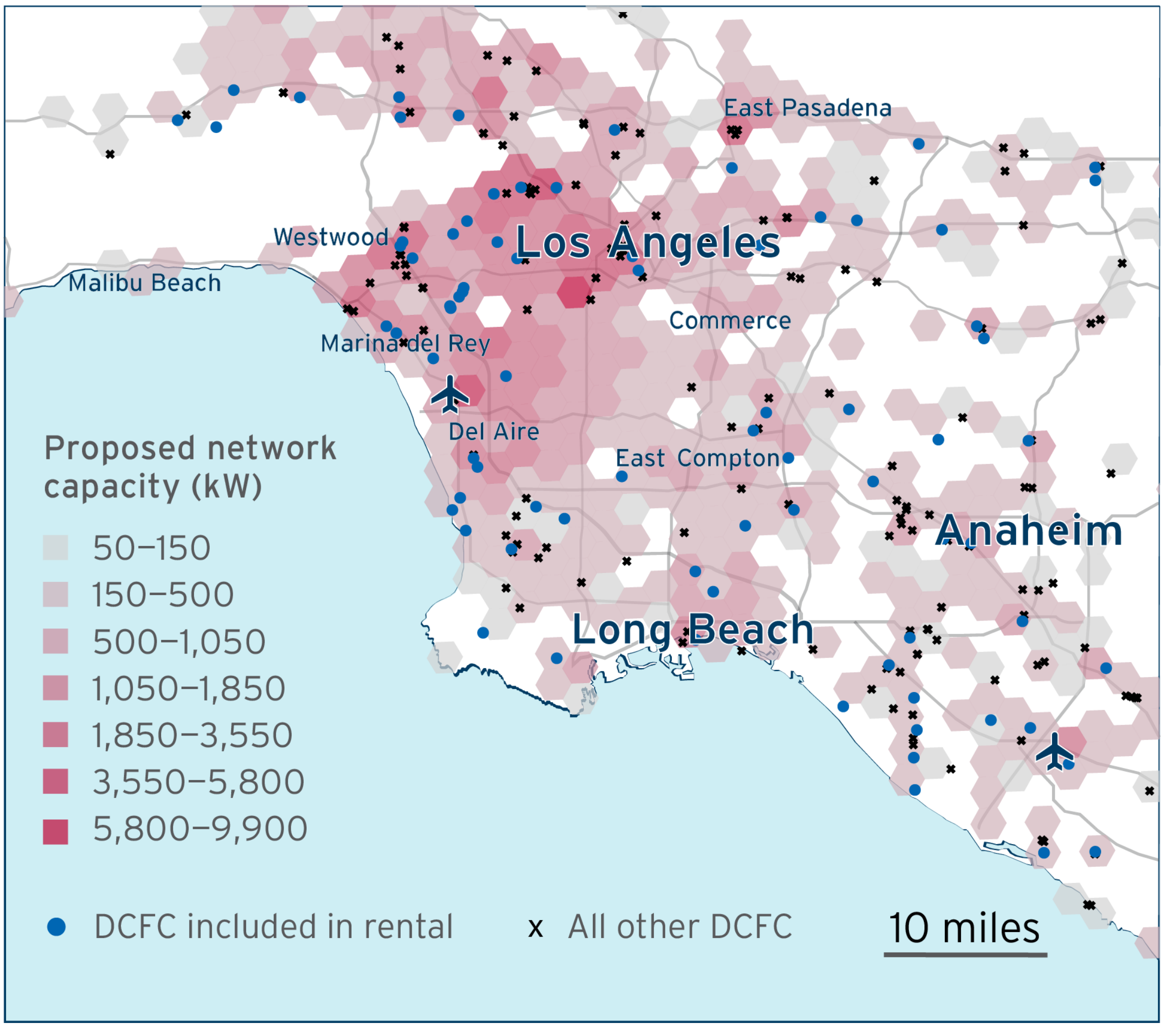
Exhibit 7 Distribution of operational stops across income bins



An Optimized Network Would Meet Demand for TNC Charging across the Entire City

Using our modeling framework, we designed a theoretical DCFC network that would meet the needs of TNC drivers without requiring drivers to change where they operate. We find that substantial build-out of DCFC is required throughout Los Angeles, especially in areas that currently host little or no DCFC (Exhibit 8). In other words, both the capacity and the coverage of the network would need to increase significantly to support ridehailing electrification. For example, Central and South-Central Los Angeles, Long Beach, and the areas around LAX currently have little charging infrastructure; a TNC-focused network would require substantial infrastructure in those locations.

Exhibit 8 Distribution of DCFC capacity needed to support 90% TNC electrification



Source: Base maps adapted from "toner-lite" by Stamen Design under CC BY 3.0, https://creativecommons.org/licenses/by/3.0/

While these recommendations are robust, they provide only a high-level picture. In this analysis we aggregated required TNC capacity into two-square-mile hexagonal bins. In reality, deciding on actual sites requires local analysis of several factors that have significant cost implications for the station. Important considerations for determining specific locations for infrastructure include utility interconnection costs, the cost and availability of land, nearby amenities, and accessibility from main roads.

Utility interconnection costs can vary depending on the distance to and capacity of feeder lines, and the required trenching to connect to those lines. Land cost and availability are also highly variable and critically important to infrastructure development cost. Granular data about land availability and the distribution of feeder lines would be valuable tools for refining infrastructure recommendations in the future.[32]

Furthermore, the distribution of infrastructure shown here is based on the travel patterns of former Maven Gig vehicles. The ideal distribution of DCFC could differ from our projections to the extent that overall ridehailing operational patterns differ from those of former Maven Gig vehicles. That said, Uber and Lyft did not know whether a vehicle was Maven Gig supplied or not and did not make dispatch decisions on that basis. In addition, GM research confirms most drivers were driving for multiple platforms. As a result of these several factors, we argue that former Maven Gig travel patterns are representative of the broader TNC population.

Utilization Can Drive Scale

Utilization Can Drive Scale

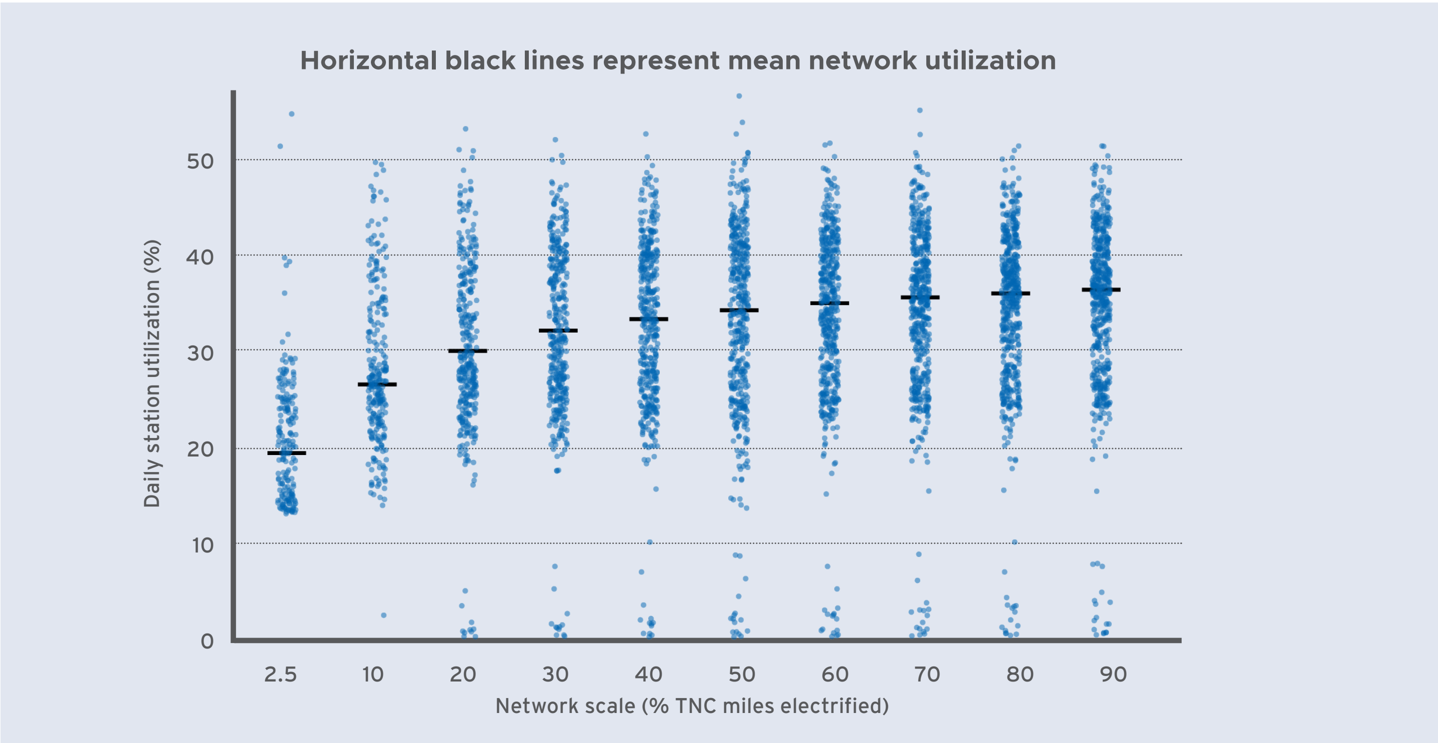
A Low-Cost, Profitable Charging Network

Building a DCFC network to support TNC electrification has clear benefits for drivers, but such a network will only be built if it is economically sustainable for EVSPs. Reaching economies of scale in station construction and high station utilization are critical for EVSPs to be able to build and operate a self-sustaining charging network.

Economies of scale reduce the per-charger cost of site preparation and utility interconnection,[33] and greater utilization decreases the costs per kWh of electricity. Therefore, a network of larger-scale stations with strong utilization enables EVSPs to earn a sustainable profit margin without exceeding the price drivers are willing and able to pay. The exact level of utilization needed to be profitable varies within a range between 15% and 30%,[34] with larger stations typically having lower breakeven utilization requirements.[35]

In a charging network that is mostly reserved for TNC use, 90% electrification of TNC miles in Los Angeles would provide enough demand to deliver 36% average utilization on a network that is three to six times larger than the current public DCFC network (Exhibit 9).[xii] However, that high utilization does not immediately materialize. At 2.5% TNC electrification, the network includes few new stations, and the average utilization (indicated by the black line) is around 20%. As a greater proportion of TNC miles are electrified, the optimal network becomes larger, and the average utilization of each station increases.

Exhibit 9 Distribution of average daily utilization for each station as network scale increases

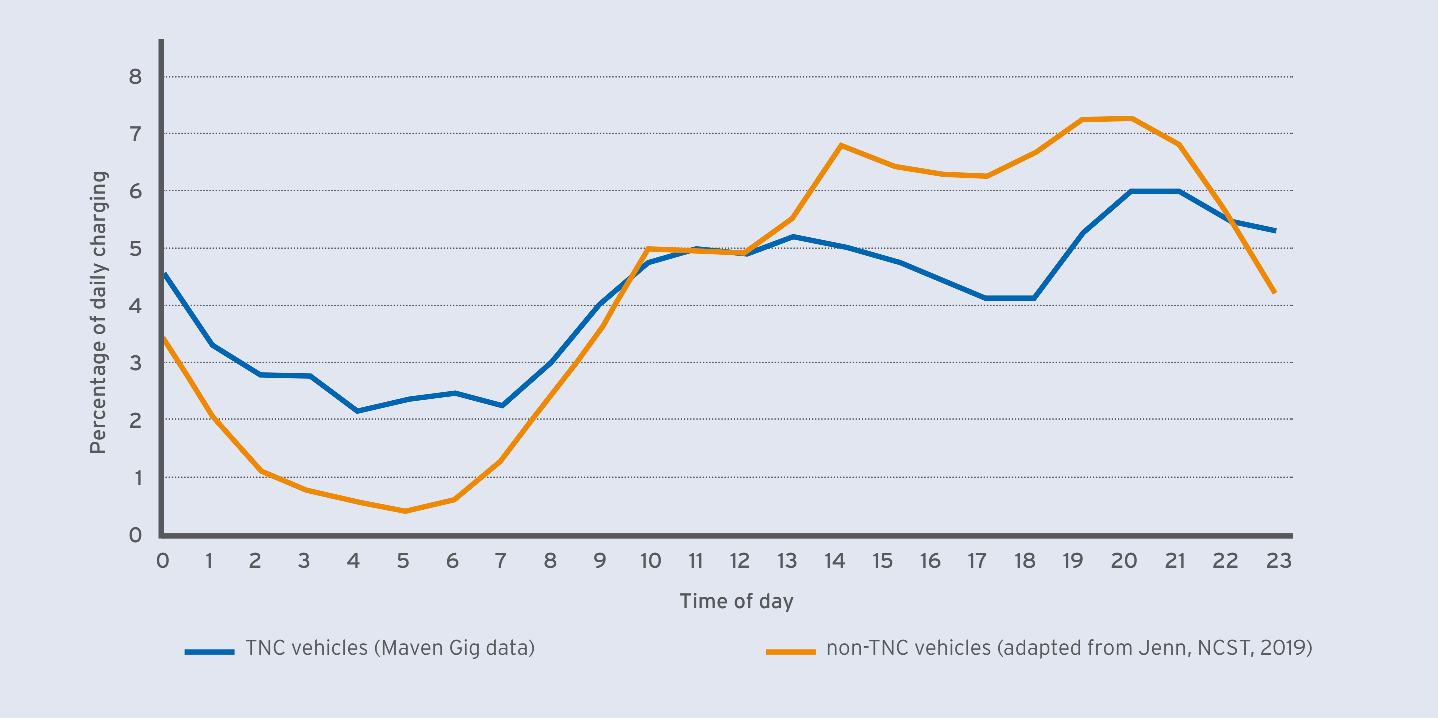


[xii] The infrastructure siting model was designed to meet all demand without requiring drivers to drive longer than 15 minutes. As such, a small number of stations achieve low utilization in the proposed network. In reality, these stations would not be built due to low return on investment. We also assumed a background utilization rate of 13% by non-TNC vehicles at existing stations in the network and allowed TNC vehicles to use the remaining available capacity. All newly built capacity was reserved exclusively for TNCs.

Furthermore, there is evidence from this research and others' that TNC vehicles and normal passenger EVs may charge at somewhat different times (Exhibit 10).[36] Combining these two customer segments could lead to greater utilization. While attractive in theory, combining TNC charging with normal passenger vehicle charging also comes with its potential pitfalls. Because TNC drivers lose money every minute they wait in line for a charger, conflict can arise when non-TNC vehicles occupy a charger and force a TNC driver to wait. In fact, it is possible that the different demand curves shown in Exhibit 10 result from TNC drivers actively avoiding times when there is significant retail demand. As the market progresses, further work is required to better understand this dynamic and its potential to improve utilization.

In the near term, when stations are relatively small, these dynamics are particularly severe. As stations get larger (i.e., have more individual chargers per site), turnover becomes more frequent, and thus wait times become more predictable. This should make conflicts less severe. In certain locations, some dedicated chargers may also be required. In any case, EVSPs will need to manage the balance between maximizing utilization and providing a high-quality customer experience on a station-by-station basis.

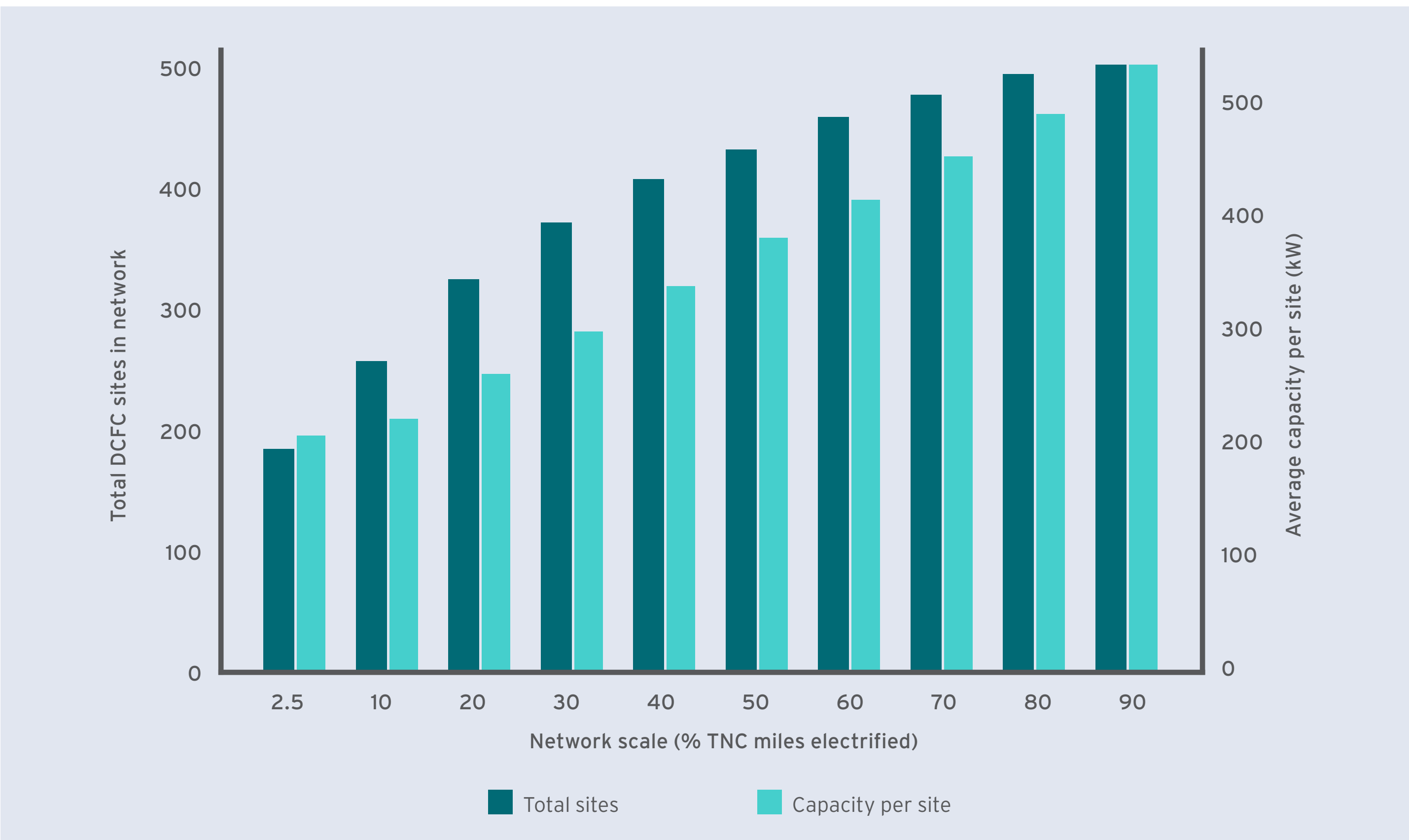
Exhibit 10 Daily DCFC utilization patterns by TNC and non-TNC vehicles in Los Angeles



Growing demand also allows EVSPs to install greater capacity per site, reducing the site development costs per charger. As the network grows, EVSPs can spread fixed costs across a greater number of chargers at each station. At early stages of growth, our analysis recommends building a large number of relatively small stations to meet demand. This is reflected in the rapid increase of the number of stations built when TNC electrification increases from 2.5% to 20% (Exhibit 11). However, once the network reaches sufficient coverage, it becomes more cost-effective to increase the capacity of existing sites rather than build new ones. The rate of increase in the number of stations therefore slows, and the per-site capacity increases.

This dynamic emphasizes the need to plan a network based on future demand, not only present demand, despite potentially higher costs in the near term. EVSPs and utilities should select sites that can be expanded in the future, and make far-sighted choices in how the supporting infrastructure is built. In this way, they can minimize cost of DCFC infrastructure as the transition to TNC electrification accelerates in the second half of this decade.

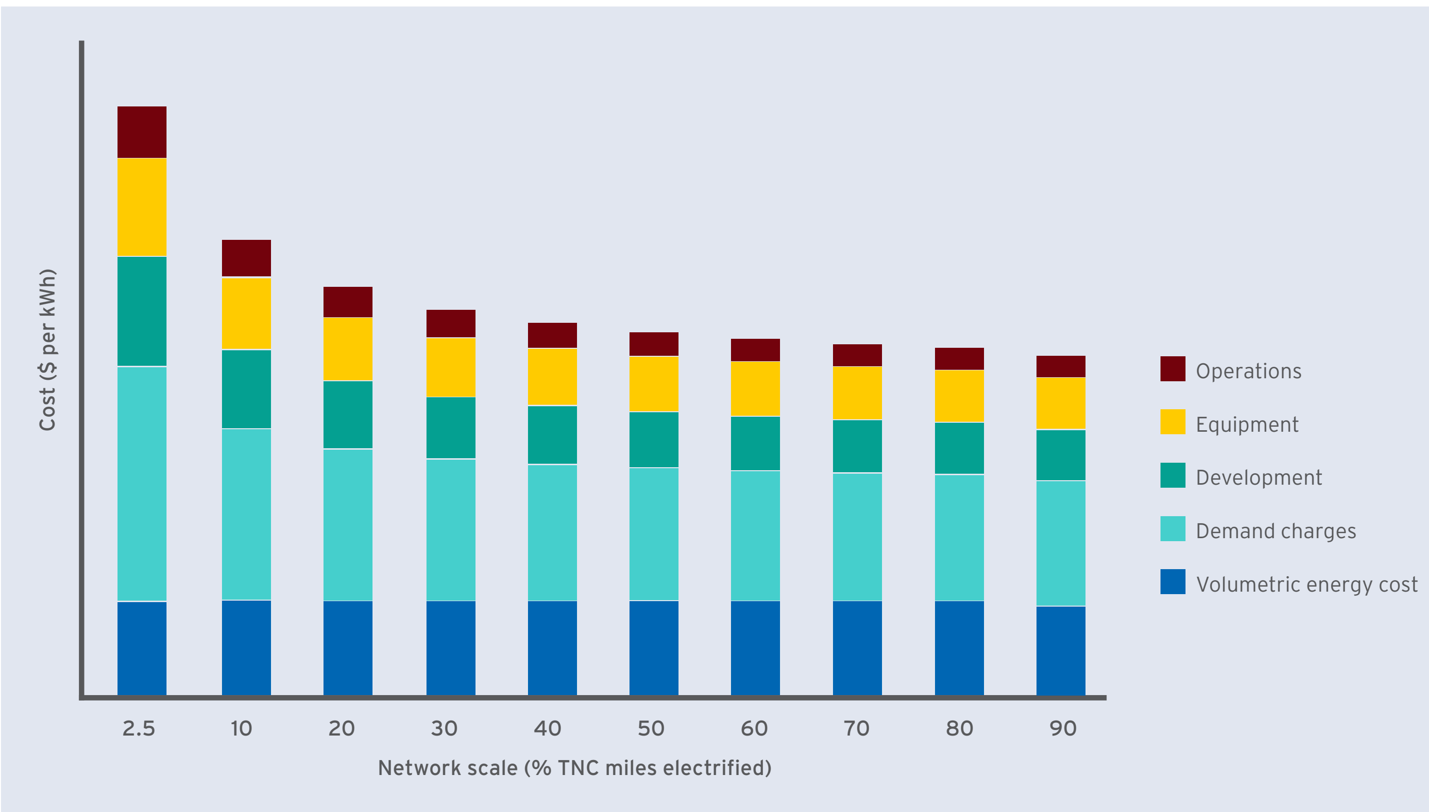
Exhibit 11 Total number of sites and average capacity per site in the DCFC network as TNC electrification increases in Los Angeles



Increasing utilization reduces multiple elements of the cost stack for EVSPs (Exhibit 12). Demand charges are a key element of this operational cost reduction. These fees are charged by the electric utility based on the maximum monthly power usage (typically measured in a 15-minute window). By increasing utilization, that fixed fee is spread over more charging, reducing its impact on unit cost.

Similar dynamics are at play in fixed site development costs. Upgrading transformers, digging trenches, laying cables, and buying chargers are all one-time expenses that an EVSP and utility must undertake regardless of how many vehicles actually charge at the station. However, the more that station is actually used, the more revenue there is to offset those fixed costs, improving the investment case. Together, these cost savings improve the economic sustainability of EVSPs and result in a lower total cost of supplying electricity to TNC drivers.

Exhibit 12 Cost components of network build-out with increasing network scale



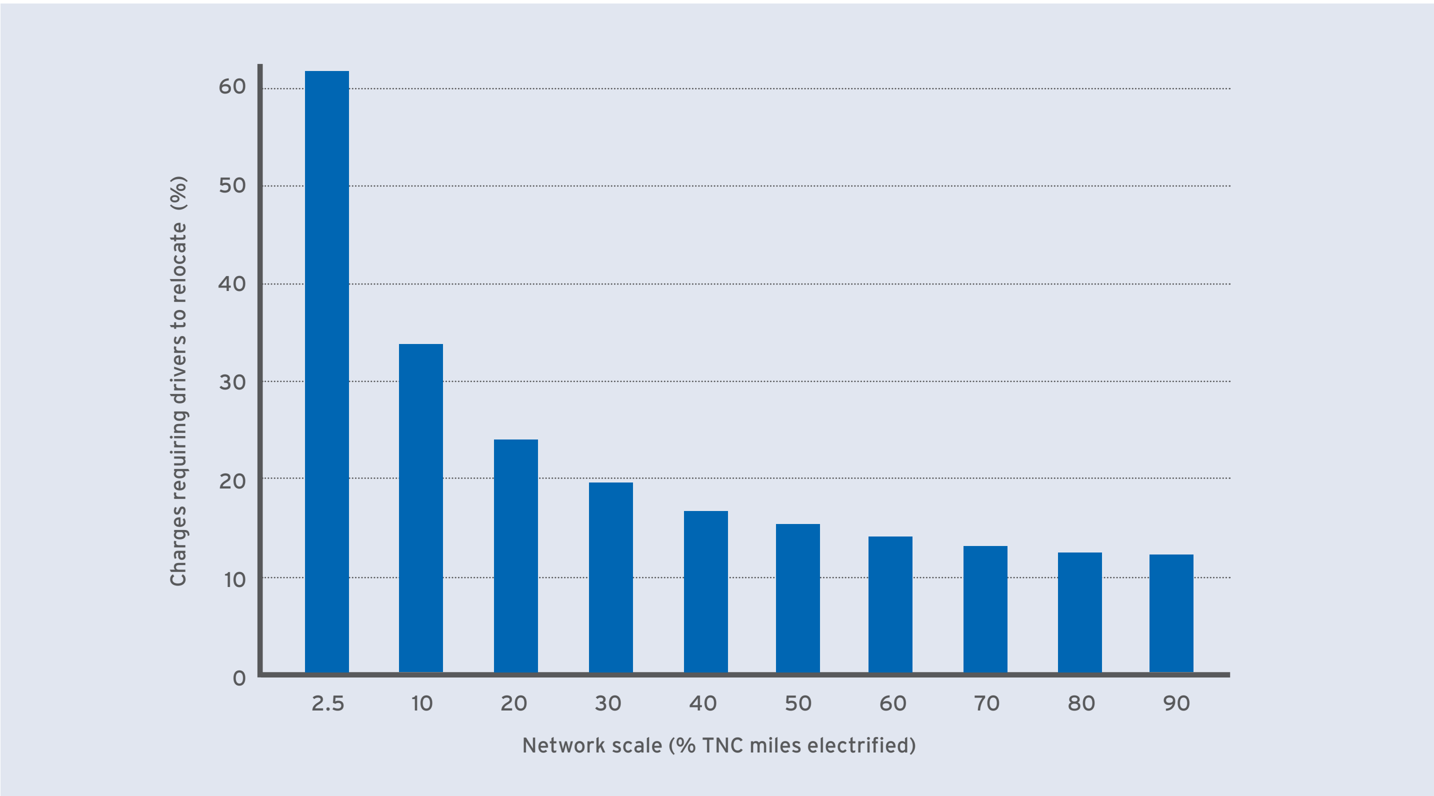
Note: These results are based on the A3 Large Commercial and Multi-Family Service tariff from the Los Angeles Department of Water and Power.

Convenience for Drivers through Critical Mass

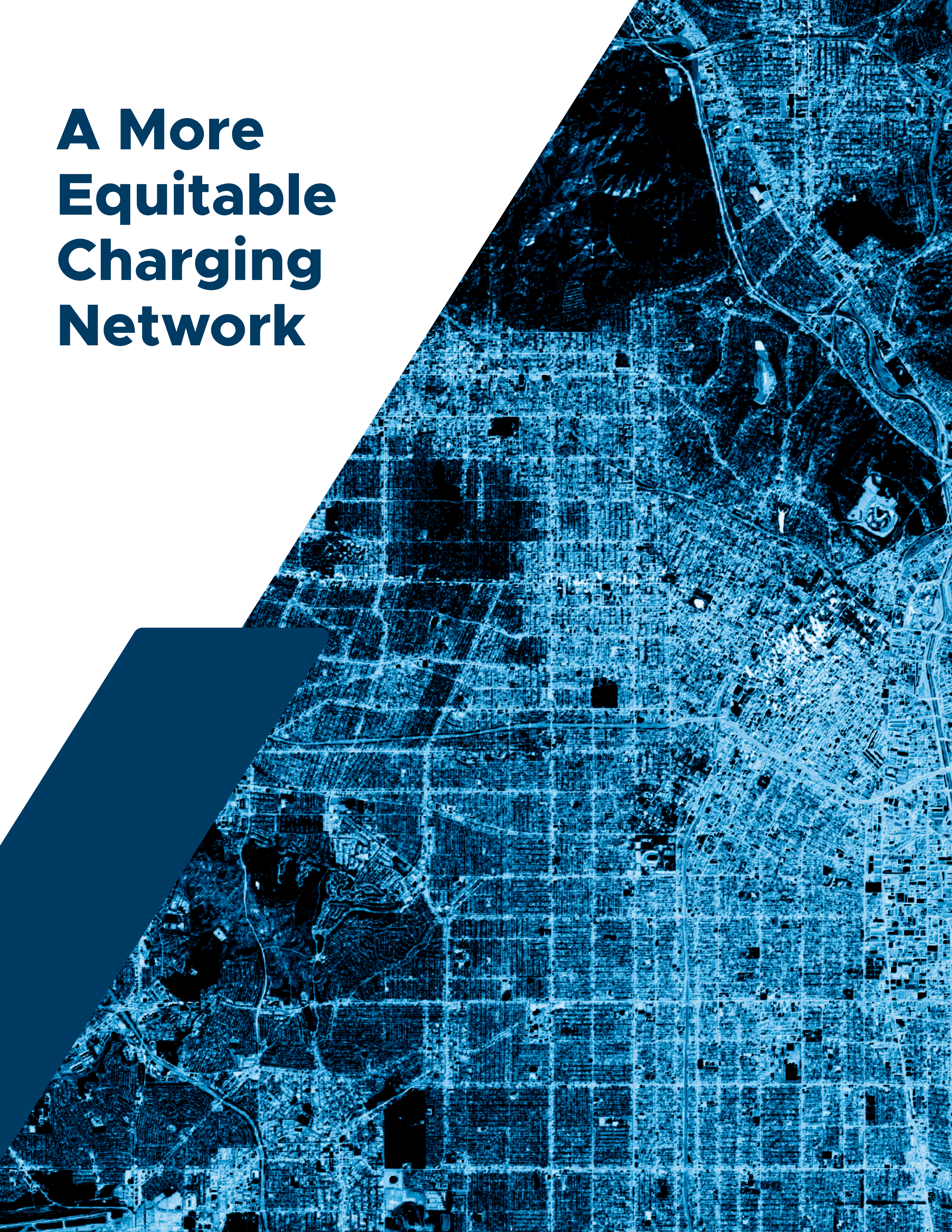
As the network grows in coverage it will become dramatically more convenient to use. This will allow more drivers to rely on public DCFC without paying a significant time penalty to find available charging in a sparse network. With a network built to support the electrification of 10% of TNC miles, a driver will only have to go out of the way to charge 34% of the time; at 90% electrification, that decreases to 12% (Exhibit 13). Meeting the 2025 CMS electrification target would provide dramatic gains in network coverage and convenience. The importance of adequate charging network coverage for bolstering EV adoption would simultaneously encourage TNC drivers and the public to voluntarily switch to EVs.[37]

Furthermore, as the cost to provide DCFC falls, the price to drivers can also fall—although exactly how much cost savings is passed onto the driver versus retained by the EVSP as profit will depend on the competitive dynamics of the market. At present, an EV in full-time TNC use and 100% reliant on public DCFC is 9% more expensive than an ICE vehicle.[38] However, if the DCFC network achieves the scale described here, an EV can become 6% *less* expensive than an ICE vehicle. If the price of using DCFC falls in proportion with the estimated cost of providing it as discussed above (Exhibit 12), an EV would cost about $0.30 per mile to operate versus $0.32 for an ICE vehicle. This shift in economics from the driver's perspective will be critical in driving EV adoption and ensuring the TNCs' interests are fully aligned with electrification.

Exhibit 13 Inconvenience of relocating to charge with increasing network scale in Los Angeles

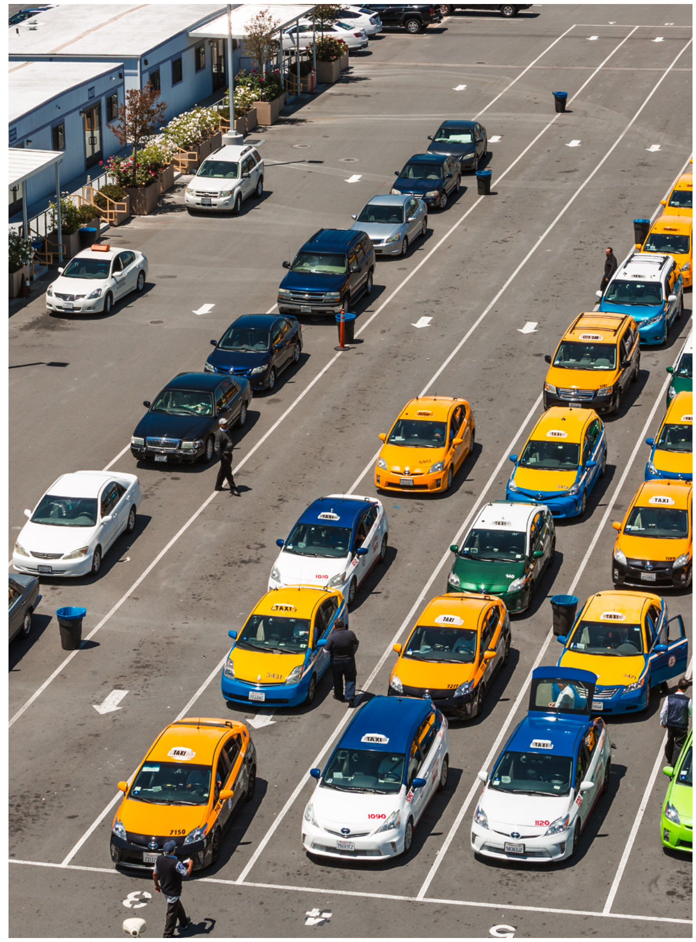


A More Equitable Charging Network



A More Equitable Charging Network

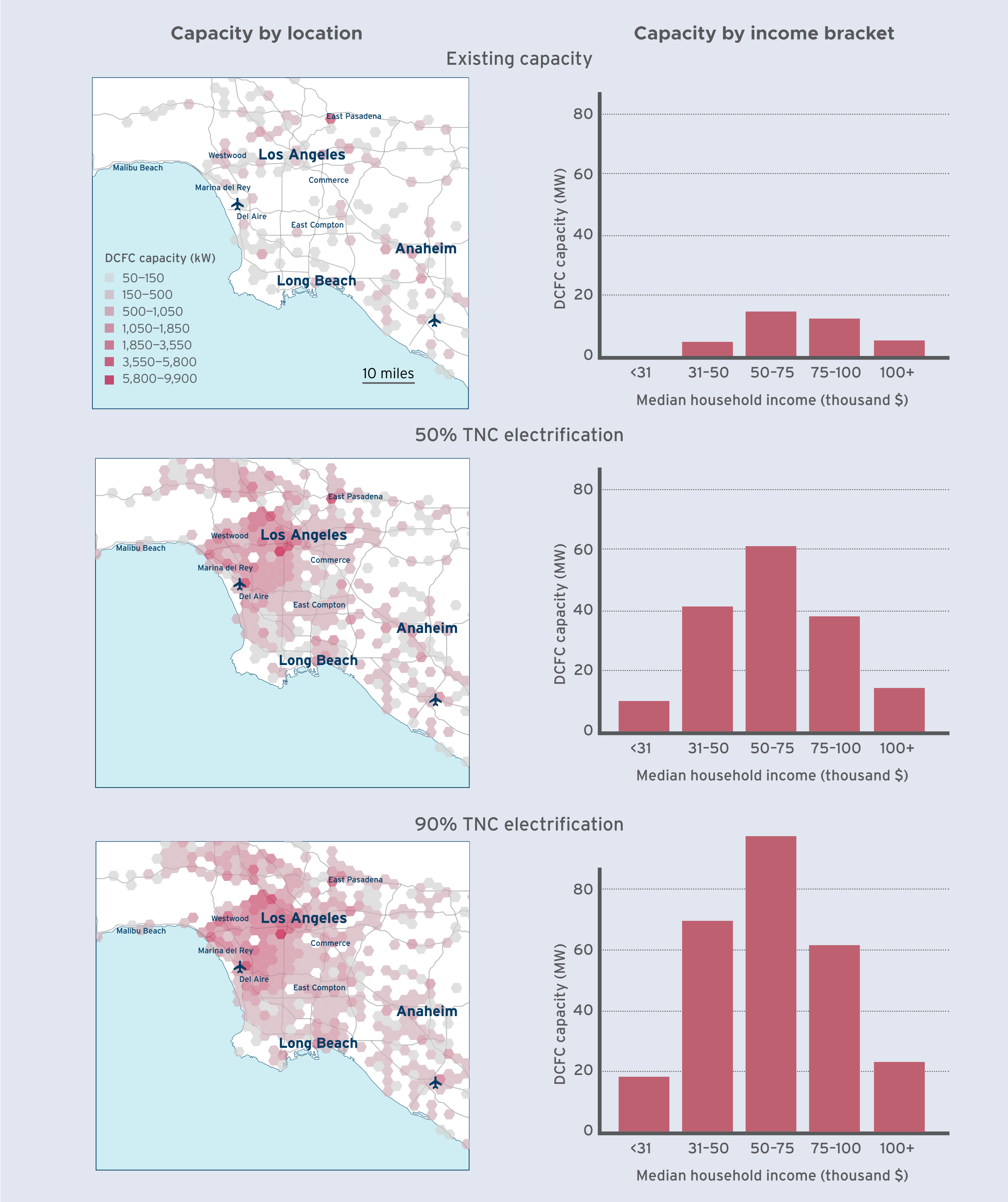
TNC electrification also creates the opportunity to cost-effectively address one of the most pressing barriers to full transportation electrification: the dearth of charging infrastructure in low-income neighborhoods.



> **Building infrastructure for the TNC drivers who often live in underserved neighborhoods has the effect of building infrastructure for their communities.**

This dynamic is visible from how the network evolves over the course of TNC electrification, both in terms of coverage over the city as well as availability of infrastructure in low-income neighborhoods (Exhibit 14). The importance of this opportunity to support future EV adoption in these communities cannot be overstated. Absent the demand from TNCs, we believe low-income areas would likely be the last to receive meaningful amounts of infrastructure.

Exhibit 14 Evolution of the DCFC network in Los Angeles as TNC electrification increases



Source: Base maps adapted from "toner-lite" by Stamen Design under CC BY 3.0, https://creativecommons.org/licenses/by/3.0/

This trend becomes even more apparent when considering charger density (i.e., the charger capacity in an income bin in relation to the total area covered by that income bin). The current network is anchored on the $50,000–$75,000 household income bracket with significant charging in the income brackets immediately above and below (Exhibit 15). In contrast, our hypothetical network designed for TNCs is anchored on the lowest income bracket (Exhibit 16).

This does not imply that DCFC should only be built in low-income neighborhoods—the growing market for new personal EVs will continue to spur growth in more affluent areas of the city. It does however provide the economic argument for accelerating charger installation in areas of the city that are otherwise unlikely to get them in the near term. This increased DCFC in lower-income areas would bring more electric miles to these communities, displacing harmful tailpipe emissions and allowing for a more equitable transition to electric mobility.

Exhibit 15 Distribution of the current DCFC network in Los Angeles across income ranges

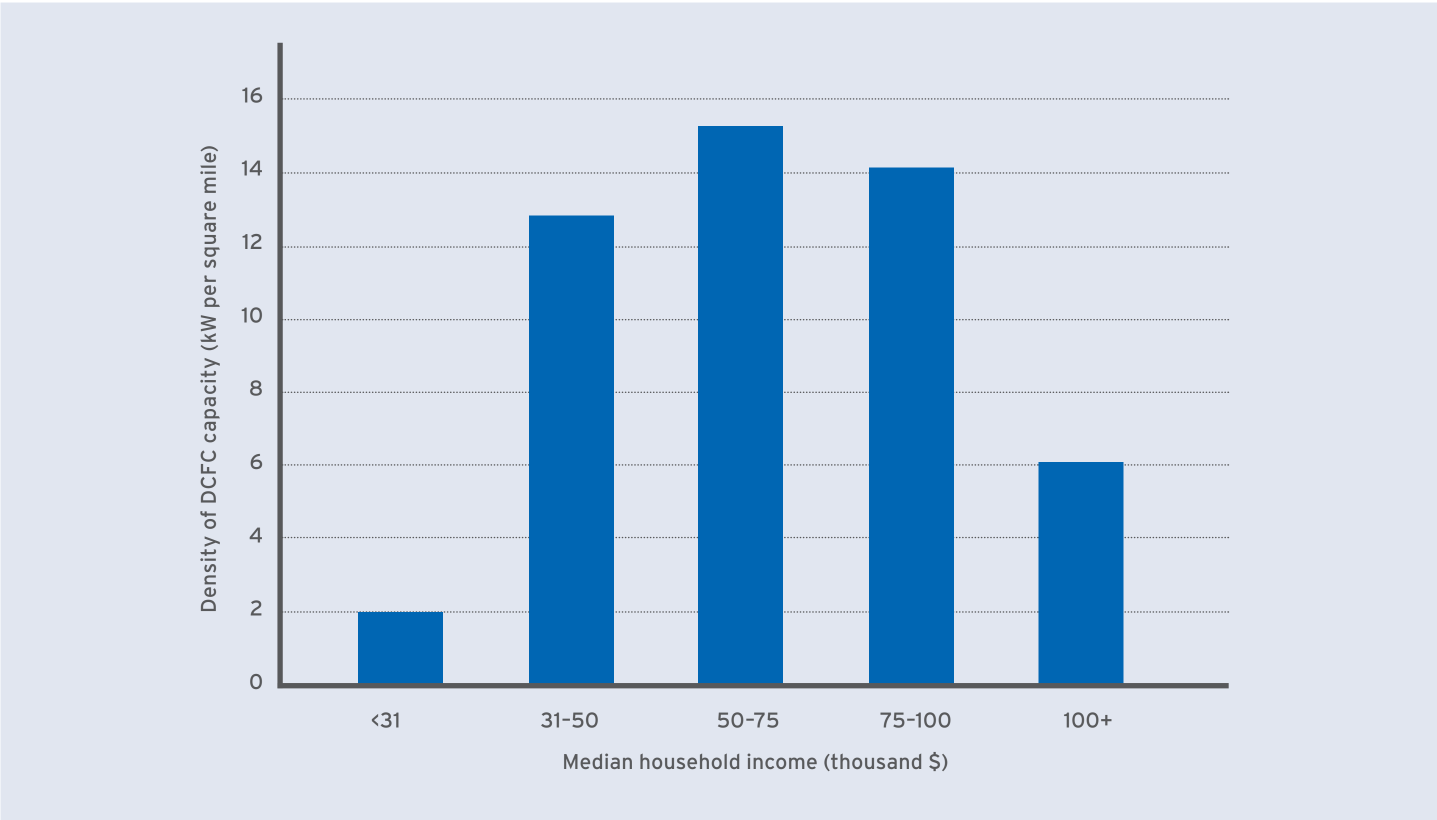
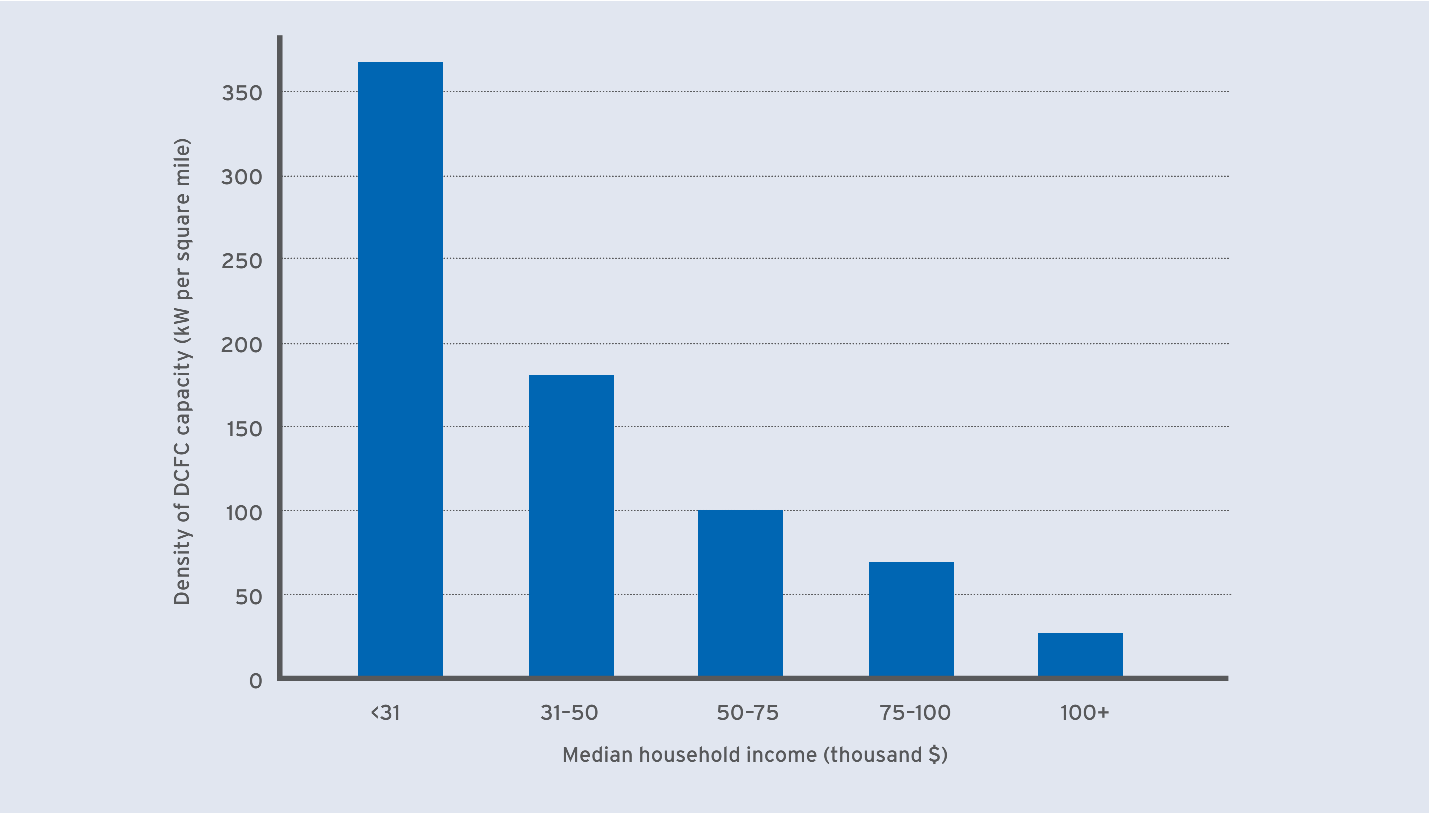


Exhibit 16 **Distribution of the proposed DCFC network in Los Angeles for 90% TNC electrification across income ranges**



The Need for Stakeholder Coordination

The Need for Stakeholder Coordination

While the potential benefits of scaling DCFC to meet charging demand from TNC electrification are clear, there are key barriers which must be overcome to capture that potential. These barriers include:

- **Lack of firm initial demand for DCFC to enable project finance at scale:** DCFC cannot be built at scale without utilization, and utilization can only come from large-scale deployment of electric vehicles. TNC drivers are a direct path to the needed scale. However, without access to adequate infrastructure throughout the city, TNC drivers are unlikely to adopt EVs. This could significantly slow the overall transition and prevent other states from following California's lead with policies like CMS.

- **High costs of land acquisition and site development:** Finding and developing sites is expensive, especially large ones that will be needed for TNCs and those in the high-traffic, densely populated areas that are ideal charging locations.

- **Rate design that makes early investment in DCFC prohibitively expensive:** Demand charges can make it costly to provide fast charging at stations that have not yet reached high utilization.

Below, we offer several recommendations for stakeholders to reduce these barriers to EVSE deployment and usher in the benefits of a more equitable large-scale DCFC network.

Coordination between EVSPs and TNCs to Create Firm Demand for DCFC Charging

The capital required to build out a DCFC network to serve TNC drivers will be enormous—equipment and installation costs in Los Angeles alone could range between $116 million and $234 million not including land and grid costs. EVSPs, many of which are relatively new startups, do not have the equity capital necessary, and public funds, while a useful catalyst, cannot pay for the entire network. To invest in infrastructure at this scale, major players in project finance must back these projects. While the revenue from this network in Los Angeles could eventually reach $53 million to $116 million per year, gaining project finance backing will require bankable demand for the services offered by DCFC stations and a firm backstop which derisks the overall investment.

Existing policy, such as the Clean Miles Standard, and commitments from TNCs to electrify their fleets are necessary, but not sufficient, to attract large-scale capital to these investments. It is critical to minimize the investment risk and then spread that risk appropriately among the stakeholders. There are a number of risks in play including whether and when EVs do in fact become less expensive for TNC use; how, when, and where they will charge; how fast the transition happens, etc. TNCs may find a way to prioritize L2 chargers over DCFC, contract with any number of EVSPs for DCFC, or see their business volume and consequently charging demand reduced by regulatory action or other unforeseen circumstances. Any of those could create a loss to the financier and that risk makes capital more difficult and expensive to obtain.

One possible approach to creating contractually guaranteed demand, which has been widely adopted for renewable electricity generation, is through a power purchase agreement (PPA).[39] A solar PPA is a financial arrangement in which a third-party developer owns, operates, and maintains the photovoltaic (PV) system. An off-taker or buyer agrees to purchase the system's electric output from the solar services provider for a predetermined period, usually from 10 to 20 years. The key feature is the guarantee of long-term revenue upon which capital is obtained. While not identical, EV infrastructure development is analogous to renewable generation project development in that both have large upfront costs, long payback periods, and a similar development pipeline. For that reason, some variation on a PPA may also be applicable to DCFC deployment.

It is unlikely that TNCs will be able to provide contractually firm demand for each individual charging station because that would entail an unacceptably large transfer of risk from EVSP to TNC—but some analogue may help spur market development. While a TNC may not be willing to guarantee offtake of a particular station at a particular time, it may be willing to guarantee offtake from an entire network over a longer time horizon in exchange for preferential pricing and additional build-out to support its drivers.

EVSPs already recognize the value of the utilization that TNC drivers can bring to their network and offer discounts to their drivers who use the existing network. For example, EVgo offers discounts of up to 25% on charging to full-time Uber drivers without any specific commitment for offtake. These discounts, which are essentially a way for EVSPs to capture TNC utilization, can lay the groundwork for more formal, bankable partnerships between EVSPs and TNCs in infrastructure development.

However, in order for a TNC company to be willing to guarantee offtake from a DCFC network, it would need to be assured that the network is aligned with the needs of its drivers. That would entail considerable coordination between the TNCs and EVSPs—potentially supported by analyses such as the one described in this report. This type of close collaboration in network design between EVSPs and their customers to maximize station utilization has enjoyed success elsewhere in the world. For example, in China, EVSPs contract with major EV leasing companies to provide customized charging capacity suitable to their vehicles.[40]

Beyond their role in accelerating capital deployment to DCFC, arrangements like PPAs serve another valuable purpose in policymaking—they can quantify the financing gap needed to make a project viable. If financing is not available for the network based on the firm demand that TNCs are willing to provide, the shortfall in funding needed to attract that financing is then known.

Given that a TNC-specific network will create improved access to charging in low-income neighborhoods and a more inclusive transportation system overall, there are grounds for using public funds to bring about that network. In this case, not only would policymakers know the result of their investment, they would also know, with relative certainty, that the benefit would be realized and what the cost would be to taxpayers. Again, similarities exist with renewable energy markets where renewable energy credits (RECs), mandated by renewable portfolio standards, both quantified and filled the revenue gap to enable project finance.

There are several other stakeholders that may be part of an eventual project finance solution. Through regulation and/or incentive, cities and states have significant ability to reduce the projects' risk by ensuring that TNCs increasingly electrify their fleets, thus ensuring demand for charging. Green banks and green bonds can be leveraged to be the first lender at a lower cost of capital, which then reduces the needed private capital and therefore the overall average cost of capital on the project.

The exact formula is not yet clear, and it is likely that several permutations will be required depending on the local situation. However, what is clear is that capital must flow into this space to enable the speed and scale of infrastructure deployment required to rapidly electrify TNC fleets.

Leverage Public Funds for Charging in Low-Income Communities

While the DCFC network must ultimately pay for itself, public funds can act as a targeted supplement to private-sector capital to catalyze DCFC network growth in the early stages of TNC electrification. The case for allocating public capital is especially compelling in the context of TNC electrification. Lower-income communities have long suffered from reduced access to transportation services and infrastructure as well as disproportionate health impacts resulting from transportation-related air pollution. Developing DCFC infrastructure in low-income communities, with TNC drivers as anchor customers, has the potential to meet the dual objective of improving air quality and access to clean transportation in currently underserved neighborhoods.

In response to this policy goal, public funding has been allocated for improving equitable access to EV charging in several states.[41] Federal tax incentives also provide favorable tax treatment on investments in underserved communities—which are applicable to EVSE deployment.[42]

Focusing on California, the California Electric Vehicle Infrastructure Project (CALeVIP), a program funded by the California Energy Commission and implemented by the Center for Sustainable Energy, provides incentives for DCFC and L2 chargers. Those incentives are greater for chargers in low-income areas and the project has a requirement that at least 25% of its funds be allocated to charging infrastructure in disadvantaged communities.

California also has the Low-Carbon Fuel Standard (LCFS), which directs funding to EVSE deployment and has the ability to benefit low-income neighborhoods. Under the LCFS, owners of EV chargers earn credits that can be sold, and fuel producers who do not meet LCFS requirements must purchase those credits to come into compliance.[43] When utilities sell these credits, a large portion of the revenue from those sales is required under CARB Resolution 19-27 to fund transportation electrification projects that benefit disadvantaged, low-income, and rural communities. Similar to CALeVIP, this revenue stream creates the opportunity to leverage private funds for public charging infrastructure in low-income areas.

Oregon also has a Clean Fuels Program,[44] which creates a cap on carbon intensity that declines over time and allows those who overperform to sell credits to those who are at a deficit. Additional states are also considering related measures.

However, an analysis of California's EV infrastructure showed that these public funds have so far failed to provide equitable access to charging in the state.[45] That is because, even with public support, low utilization at those stations means that EVSPs cannot recoup their costs. TNC electrification, with its potential to deliver high utilization to DCFC stations in low-income areas over the next several years, provides a means of deploying this dedicated funding into chargers that will be used. Furthermore, because CMS ultimately will drive full TNC electrification and financial sustainability to the DCFC network, this public funding need not be perpetual, but rather provide the catalyst to spur initial investment.

Reduce Development Costs for DCFC Stations

Reducing the upfront cost of creating DCFC infrastructure can attract investment and accelerate infrastructure development. While many upfront costs can only be effectively managed by EVSPs, a few elements are beyond their control and require support and engagement from policymakers and electric utilities. Those costs include site acquisition costs, grid interconnection costs, and soft costs resulting from long and uncertain permitting and land use processes.

Soft costs, explored in depth in RMI's report *Reducing EV Charging Infrastructure Costs*, are frequently higher than charging station hardware costs in the United States.[46] Reducing these hidden costs that are very difficult to know, let alone plan for in advance, can greatly accelerate DCFC deployment.

EVSPs currently bear a high cost for identifying suitable land for DCFC deployment, negotiating its use, and ultimately gaining the right to install chargers. There are rarely any economies of scale in this process—each new station costs as much as the previous one. However, the shared interests between city government and EVSPs do create space for collaboration and cost sharing.

City governments are often some of the largest landowners in the city and can leverage that land to develop a DCFC network with greater scale and efficiency. For example, parking spaces at public parks, park and rides, and other city-owned land can be ideal locations for large-scale DCFC deployment. Curbside access is another potential avenue. Cities can offer access to that land on a free or discounted basis for a specified time period to reduce site development costs in key areas. This could represent a valuable lever for cities to encourage EVSE deployment, especially in low-income communities.

Cities can also streamline and standardize permitting requirements and zoning rules. Currently, EVSPs must navigate a balkanized framework of regulations, and often must reengineer projects because they were based on incorrect information, among other challenges. In just one metro area, there could be a dozen or more different sets of processes and regulations that must be discovered, understood, and complied with to build the network. This adds significant time, risk, and cost, and limits economies of scale.

Another major element of upfront cost in DCFC deployment is connecting those sites to the electric grid. This is increasingly significant as stations grow larger. Both the planning and approval process, and the actual construction, can take significant time, while final costs are frequently not available until well into the process. This adds significant risk, including schedule risk, and thus cost to the EVSPs.

With DCFC stations that have multiple high-powered chargers, the power required can quickly overwhelm the installed capacity of a feeder or substation to supply power. Upgrades to that infrastructure are expensive and time consuming. For very large charging stations, the distribution network may not suffice and connection to higher voltage supply becomes necessary. Utilities can fast-track planning and approval for interconnection requests to reduce these risks.

The extent to which investments are paid for by the utility or the EVSP is subject to the terms of approved programs in a given utility's territory and varies considerably. The process of designing and approving new programs is lengthy and filled with pitfalls. To enable TNC electrification, regulators can ensure the utilities are able to earn cost recovery on these investments on the basis of the public good they provide.

At least two public utility commissions have approved cost recovery for make-ready infrastructure programs. In 2018, the California Public Utilities Commission (CPUC) approved a proposal that authorized Pacific Gas and Electric and Southern California Edison (SCE) to invest a cumulative $430 million for make-ready infrastructure.[47] In 2020, the CPUC approved SCE's request for $437 million to bulk up its previous make-ready infrastructure pilot. SCE's new "Charge Ready 2" program requires that 50% of investments go to disadvantaged communities and 30% to multi-unit dwellings, significantly increasing charging access to low-income communities.[48]

Similarly, in 2020, the New York Public Services Commission (NYPSC) approved NY utilities to make $701 million in investments in make-ready infrastructure. The NYPSC's Make Ready Program authorizes utilities to cover up to 50% of the make-ready costs for proprietary plugs (like Tesla), 90% of the costs for standardized plugs, and 100% of the costs for plugs in disadvantaged communities.[49] If more utility commissions were to follow suit, it would significantly increase the number of cities that could benefit from rapid TNC electrification.

If cities, utilities, and regulators collaborate with EVSPs in a way that streamlines and standardizes rules, regulations, and procedures, it can save significant time and cost and reduce risk. In addition to the processes, resources and personnel will also be needed to meet the pace and scale of this endeavor. In aggregate, this then enables infrastructure to be built more quickly and more locations to be economically viable, thus creating a more robust and useful charging network.

Design Electricity Rates That Promote DCFC Development without Burdening Rate Payers

Electricity rate design dramatically affects the economic sustainability of charging stations, especially before they reach high utilization. One key element of electricity rates that discourages DCFC network development is demand charges. Demand charges—monthly fees based on the maximum power that month—can create electricity bills for EVSPs that cannot be recouped by reasonable retail charging prices when utilization is low.[50] One of the main purposes of demand charges is to incentivize customers to manage electricity use to keep a relatively constant load profile, which is less expensive for utilities to serve. However, in the case of DCFC stations, EVSPs have little control over the shape of their load. When a customer arrives to charge, they must provide electricity to that vehicle at that time.

Fortunately, as increasing EV adoption drives up utilization rates, the impact of demand charges on EVSPs becomes manageable. Once TNC electrification reaches approximately 30% of miles in Los Angeles (the 2026 CMS target), average station utilization will exceed 30%. At that point, demand charges are spread across enough charging that it becomes profitable.

There are several ways that utilities can help DCFC providers and their customers address the near-term economic challenges of demand charges. Solutions include a more intelligent EV-customized rate design or a short-term demand charge holiday. A demand charge holiday, when combined with appropriate volumetric rates, could support the rapid emergence of a DCFC network. Alternatively, intelligent rate design can allow high-powered EV charging to benefit utilities and the grid.

When most EV owners use DCFC, it is for convenience, and they want to charge immediately. TNC drivers, however, are likely to be flexible in when they charge if offered the right incentives to do so. Utilities can offer those incentives to drivers via time-of-use (TOU) rates that financially reward drivers when they shift charging to times that are more friendly to the grid. These TOU rates are potentially highly valuable when integrating intermittent renewables into the grid. California has a well-known issue in which a large share of total power is provided by solar PV during peak daytime hours and often needs to be curtailed because supply exceeds demand. By providing TOU rates to drivers that incentivize charging at DCFC stations during high solar generation times, utilities can both effectively deploy more low-cost renewable energy and lower the cost of charging to drivers.

RMI offers detailed suggestions to utilities around demand charges and demand charge holidays in its study on *Rate-Design Best Practices for Public Electric Vehicle Chargers*.[51]

Conclusion

Conclusion

Electrification of TNCs in particular, and transportation electrification more broadly, depends on the rapid development of a robust public DCFC network. This is especially true in low-income areas where access to overnight charging is likely to be limited. However, DCFC network development in the United States has been far slower than what is needed to scale transportation electrification and cut emissions in half by 2030—necessary to limit warming to 1.5°C. TNC electrification could change that. While this report focuses on Los Angeles, the same dynamics apply across the state and, indeed, the country.

TNC electrification could be near 100% in California by 2030 if the mandates from CARB and the electrification commitments from Uber and Lyft are complemented by the right policies, programs, and collaborations. All of these ingredients are necessary and do not yet fully exist. This rapid shift to EVs, combined with the unique demographics of TNC drivers, can deliver enough charging demand to accelerate the development of a robust DCFC network. Furthermore, this network can be capable of providing cost-effective charging to all city residents, including those with lower incomes who have, to date, been largely left on the sidelines of transportation electrification.

While the construction of this network will not be cheap (between $116 million and $234 million for equipment and installation costs alone), with the right set of policies and programs, in the long run it will be profitable. With TNCs providing massive demand for charging, the long-term economics of operating a DCFC network with TNCs as anchor customers look very attractive—revenue from electric TNC charging in Los Angeles could surpass $100 million annually in 2030. Getting to those long-term economics poses something of a challenge, but one that is far from insurmountable.

Policymakers are already signaling a readiness to support DCFC infrastructure development, especially in lower-income neighborhoods. This public sector support can take the form of tax breaks for station operators, preferential access to public land for station installation, or grants that defray the cost of making these large capital investments. Similarly, utilities are rapidly adjusting their investment priorities and tariff structures to enable the emergence of this network and the benefits it can create, especially in low-income communities.

The opportunity presented by TNC electrification for the development of a ubiquitous, inclusive DCFC network is unique.

> **It is rare that policy priorities, climate needs, and the needs of lower-income individuals align with industry sustainability commitments and the economics of building and operating infrastructure. However, when they do, it is a recipe for rapid, disruptive change.**

Those forces have aligned for DCFC network investment with TNCs as anchor customers, and Los Angeles has a chance to chart a path that every city in the United States can follow.

Endnotes

1. Michael Nicholas, Dale Hall, and Nic Lutsey, *Quantifying the Electric Vehicle Charging Infrastructure Gap Across US Markets,* International Council on Clean Transportation, 2019.

2. Z. Andrew Farkas, Hyeon-Shic Shin, and Zmirreza Nickkar, *Environmental Attributes of Electric Vehicle Ownership and Commuting Behavior in Maryland: Public Policy and Equity Considerations*, Morgan State University, 2018; Gil Tal, Jae Hyun Lee, and Michael A. Nicholas, *Observed Charging Rates*, UC Davis Institute of Transportation Studies, 2018.

3. Ross McLane et al., *Racing to Accelerate Electric Vehicle Adoption: Decarbonizing Transport with Ridehailing*, RMI, 2020, **https://rmi.org/insight/accelerating-the-electric-vehicle-transition/**.

4. California Air Resources Board, *Clean Miles Standard Workshop: Proposed Regulation Targets*, 2020; California Air Resources Board, "Clean Miles Standard," 2018, Accessed March 17, 2021, **https://ww2.arb.ca.gov/our-work/programs/clean-miles-standard/about**.

5. Gordon Bauer, Chih-Wei Hsu, and Nic Lutsey, *When Might Lower-Income Drivers Benefit from Electric Vehicles? Quantifying the Economic Equity Implications of Electric Vehicle Adoption*, ICCT, 2021, **https://theicct.org/publications/EV-equity-feb2021**.

6. "Our Road to Zero Emissions," Uber, Accessed March 16, 2021, **https://www.uber.com/us/en/about/sustainability/**; "Leading the Transition to Zero Emissions: Our Commitment to 100% Electric Vehicles by 2030," Lyft, Accessed November 11, 2020, **https://www.lyft.com/blog/posts/leading-the-transition-to-zero-emissions**.

7. Deepak Rajagopal and Allison Yang, *Electric Vehicles in Ridehailing Applications: Insights from a Fall 2019 Survey of Lyft and Uber Drivers in Los Angeles*, UCLA Institute of the Environment & Sustainability, 2020.

8. Chris Nelder and Emily Rogers, *Reducing EV Charging Infrastructure Costs*, RMI, 2020, **https://rmi.org/insight/reducing-ev-charging-infrastructure-costs/**.

9. "US Transportation Sector Greenhouse Gas Emissions 1990-2018," US EPA, 2020.

10. Joyce McLaren et al., *Associated with Electric Vehicle Charging: Impact of Electricity Generation Mix, Charging Infrastructure Availability, and Vehicle Type*, National Renewable Energy Laboratory, 2016, **https://afdc.energy.gov/vehicles/electric_emissions.html**.

11. Jeremy Hunt and Sarah McKearnan, *Accelerating Ride-hailing Electrification: Challenges, Benefits, and Options for State Action*, NESCAUM, 2020; and Dale Hall, Mike Nicholas, and Marie Rajon Bernard, *Guide to Electrifying Ride-hailing Vehicles for Cities*, ICCT, 2021.

12. Alan Jenn, *Emissions Benefits of Electric Vehicles in Uber and Lyft Services*, National Center for Sustainable Transportation, 2019.

13. Jeremy Hunt and Sarah McKearnan, *Accelerating Ride-hailing Electrification: Challenges, Benefits, and Options for State Action*, NESCAUM, 2020.

14. Ross McLane et al., *Racing to Accelerate Electric Vehicle Adoption: Decarbonizing Transport with Ridehailing*, RMI, 2020.

15. Gordon Bauer, Chih-Wei Hsu, and Nic Lutsey, *When Might Lower-Income Drivers Benefit from Electric Vehicles? Quantifying the Economic Equity Implications of Electric Vehicle Adoption*, ICCT, 2021.

16. California Air Resources Board, *Clean Miles Standard Workshop*, 2020; California Air Resources Board, "Clean Miles Standard," 2018.

17. "Our Road to Zero Emissions," Uber, Accessed March 16, 2021, **https://www.uber.com/us/en/about/sustainability/**; "Leading the Transition to Zero Emissions: Our Commitment to 100% Electric Vehicles by 2030," Lyft, Accessed November 11, 2020, **https://www.lyft.com/blog/posts/leading-the-transition-to-zero-emissions**.

18. Michael Nicholas, Dale Hall, and Nic Lutsey, *Quantifying the Electric Vehicle Charging Infrastructure Gap Across US Markets*, International Council on Clean Transportation, 2019.

19. Kathryn Canepa, Scott Hardman, and Gil Tal, "An Early Look at Plug-in Electric Vehicle Adoption in Disadvantaged Communities in California," *Transport Policy*, 2019, 78: 19-30.

20. Gil Tal, Jae Hyun Lee, and Michael A. Nicholas, *Observed Charging Rates*, UC Davis Institute of Transportation Studies, 2018.

21. Chih-Wei Hsu and Kevin Fingerman, "Public Electric Vehicle Charger Access Disparities Across Race and Income in California," *Transport Policy*, 2021, 100: 59-67.

22. Michael Nicholas, Peter Slowik, and Nic Lutsey, *Charging Infrastructure Requirements to Support Electric Ride-hailing in U.S. Cities*, International Council on Clean Transportation, 2020.

23. Deepak Rajagopal and Allison Yang, *Electric Vehicles in Ridehailing Applications: Insights from a Fall 2019 Survey of Lyft and Uber Drivers in Los Angeles*, UCLA Institute of the Environment & Sustainability, 2020.

24. Jeremy Hunt and Sarah McKearnan, *Accelerating Ride-hailing Electrification: Challenges, Benefits, and Options for State Action*, NESCAUM, 2020.

25. Alan Jenn, *Emissions Benefits of Electric Vehicles in Uber and Lyft Services*, National Center for Sustainable Transportation, 2019.

26. *Economic Impact Report: United States*, Lyft, 2021.

27. Deepak Rajagopal and Allison Yang, *Electric Vehicles in Ridehailing Applications: Insights from a Fall 2019 Survey of Lyft and Uber Drivers in Los Angeles*, UCLA Institute of the Environment & Sustainability, 2020.

28. Melissa Balding et al., *Estimated TNC Share of VMT in Six US Metropolitan Regions (Revision 1)*, Fehr & Peers, 2019.

29. Michael Nicholas, Peter Slowik, and Nic Lutsey, *Charging Infrastructure Requirements to Support Electric Ride-hailing in U.S. Cities*, International Council on Clean Transportation, 2020.

30. Ibid.

31. "HCD - Income Limits," California Department of Housing and Community Development, Accessed March 17, 2021, **https://www.hcd.ca.gov/grants-funding/income-limits/index.shtml**.

32. Chris Nelder and Emily Rogers, *Reducing EV Charging Infrastructure Costs*, RMI, 2020.

33. Ibid.

34. Garrett Fitzgerald and Chris Nelder, *DCFC Rate Design Study*, RMI, 2019.

35. Zhe Wang et al., *Putting Electric Logistics Vehicles to Work in Shenzhen: Enabling ELV Utilization Through Well-planned Charger Deployment*, RMI, 2020, **https://rmi.org/insight/putting-electric-logistics-vehicles-to-work-in-shenzhen/**.

36. Michael Nicholas, Peter Slowik, and Nic Lutsey, *Charging Infrastructure Requirements to Support Electric Ride-hailing in U.S. Cities*, International Council on Clean Transportation, 2020; Alan Jenn, *Emissions Benefits of Electric Vehicles in Uber and Lyft Services*, National Center for Sustainable Transportation, 2019.

37. Gail Helen Broadbent, Danielle Drozdzewksi, and Graciela Metternicht, "Electric Vehicle Adoption: An Analysis of Best Practice and Pitfalls for Policy Making from Experiences of Europe and the US," *Geography Compass*, 2018, 12 (2).

38. Ross McLane et al., *Racing to Accelerate Electric Vehicle Adoption: Decarbonizing Transport with Ridehailing*, RMI, 2020.

39. "Power Purchase Agreement Checklist for State and Local Governments," National Renewable Energy Laboratory, 2009, **https://www.nrel.gov/docs/fy10osti/46668.pdf**; and *Achieving Our 100% Renewable Energy Purchasing Goal and Going Beyond*, Google, 2016, **https://static.googleusercontent.com/media/www.google.com/en//green/pdf/achieving-100-renewable-energy-purchasing-goal.pdf**.

40. Zhe Wang et al., *Putting Electric Logistics Vehicles to Work in Shenzhen: Enabling ELV Utilization Through Well-planned Charger Deployment*, RMI, 2020.

41. "Expanding Equitable Access to Electric Vehicle Mobility: Examples of Innovative Policies and Programs," NESCAUM, 2020.

42. "Tax Reform Creates Opportunity Zone Tax Incentive," US IRS, Accessed March 17, 2021, **https://www.irs.gov/newsroom/tax-reform-creates-opportunity-zone-tax-incentive**.

43. "Low Carbon Fuel Standard," California Air Resources Board, Accessed March 17, 2021, **https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard**.

44. "Oregon Clean Fuels Program Overview," Oregon Department of Environmental Quality, Accessed April 7, 2021, **https://www.oregon.gov/deq/ghgp/cfp/Pages/CFP-Overview.aspx**.

45. Chih-Wei Hsu and Kevin Fingerman, "Public Electric Vehicle Charger Access Disparities Across Race and Income in California," *Transport Policy*, 2021, 100: 59-67.

46. Chris Nelder and Emily Rogers, *Reducing EV Charging Infrastructure Costs*, RMI, 2020.

47. "CPUC Issues Proposal That Would Approve Transportation Electrification Projects to Reduce Greenhouse Gas Emissions and Improve Air Quality," California Public Utilities Commission, 2018, **https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/Utilities_and_Industries/Energy/Energy_Programs/Infrastructure/TE%20PD%20-%20v2.pdf**.

48. *Decision Authorizing Southern California Edison Company's Charge Ready 2 Infrastructure and Market Education Programs*, 2020, **https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M345/K702/345702701.PDF**.

49. "Governor Cuomo Announces Nation-leading Initiatives to Expand Electric Vehicle Use to Combat Climate Change," New York State, July 16, 2020, **https://www.governor.ny.gov/news/governor-cuomo-announces-nation-leading-initiatives-expand-electric-vehicle-use-combat-climate**.

50. Garrett Fitzgerald and Chris Nelder, *DCFC Rate Design Study*, RMI, 2019.

51. Chris Nelder, "Rate-Design Best Practices for Public Electric-Vehicle Chargers," RMI, 2020.

John Schroeder, Edward J. Klock-McCook, Shenshen Li, Ross McLane, and Dave Mullaney, *EV Charging for All: How Electrifying Ridehailing Can Spur Investment in a More Equitable EV Charging Network*, RMI, 2021, www.rmi.org/insight/EV-charging-for-all.

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