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# Policy Brief

October 2017 - Reissue

*Note: A previous version of this brief was published in July 2017. Minor additions to the “Key Considerations” section were incorporated into this new re-release. These additions reflect a need to underscore the significant and strategic investments in EV charging infrastructure needed now, while considering the longer term needs of automated electric vehicle fleets.*

*In November 2016, the Institute of Transportation Studies at the University of California, Davis (ITS-Davis) convened leading academic, government, private industry, and public interest stakeholders to explore science-based policies that could steer the three transportation revolutions- shared mobility, electrification, and autonomous vehicles, toward the public interest.*

*This policy brief reflects the opinions of the authors and not UC Davis. This brief is one in a series that presents a range of policy concepts, recommendations and research needs discussed at the 3 Revolutions Conference.*

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## Electric Vehicle Charging Considerations for Shared, Automated Fleets

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### Summary

The “three revolutions” in the transportation sector—automation, shared use, and electrification—have the potential to significantly reduce greenhouse gas (GHG) emissions. If the advent of automated vehicles<sup>1</sup> is to bring about the deep decarbonization of the transportation sector, these vehicles must be electric and largely shared.<sup>2</sup> However, the proliferation of electric automated mobility could be hindered if electric vehicle charging infrastructure and the electric grid are not able to support an influx of high-mileage, high-usage automated electric vehicles (EVs). This brief identifies key considerations for stakeholders regarding the EV charging infrastructure necessary to enable and optimize an automated, electric, and shared mobility future.

### Policy Recommendations:

- Consider the future uses and charging needs of automated, shared, and electric fleet vehicles when evaluating investments in EV charging infrastructure.
- Promote grid-optimized charging to manage the grid impacts and maximize the environmental and economic benefits of automated electric fleets.
- Establish EV charging pilot programs for fleets of human-driven mobility service vehicles<sup>3</sup> to provide insight into the charging needs of automated electric fleets.

## Electric Vehicle Charging Considerations for Shared, Automated Fleets

### Introduction and Background

The transportation system in the United States is currently dominated by petroleum-powered, personally owned, human-driven vehicles. There are more than 260 million vehicles in the United States alone,<sup>4</sup> and nearly 95 percent of transportation-sector energy consumption is from fossil fuels.<sup>5</sup> In 2016, the transportation sector surpassed power generation as the largest source of energy-related carbon dioxide emissions in the United States.<sup>6</sup> To avoid the worst impacts of climate change, a significant reduction in vehicle emissions—both from a reduction in vehicle miles traveled (VMT) and the adoption of cleaner vehicles and fuels—is urgently needed.

Recent technology and policy advances present a significant opportunity for the three revolutions of vehicle automation, electrification, and shared use to enable a transformation of the mobility system. Rapid advances in battery technology, innovative vehicle design, and state and federal policies already have initiated the transition of personally owned vehicles from internal combustion engines to electric power. The development of automated vehicle technologies and new business models like ride hailing present a potentially transformative opportunity to shift the mobility paradigm from personal vehicle ownership to transportation on demand provided by shared, electric, and automated fleets.<sup>7</sup>

Without effective public policies to promote shared mobility, automated vehicles could increase travel demand and lead to significant growth in VMT from single-occupancy vehicles.<sup>8</sup> If automated vehicles are deployed primarily as high-mileage, shared-used mobility service vehicles, there are strong financial incentives for these vehicles to be electric<sup>9</sup> because the more an EV travels, the greater its life-cycle cost savings compared

to a gasoline-powered vehicle.<sup>10</sup> Shared-use mobility service vehicles are a particularly good application for EVs, because service vehicles log five to ten times as many miles as personal vehicles.<sup>11</sup> Mobility service vehicles can also take advantage of the rapid improvements in electric and automated vehicle technologies, as service vehicles turn over at rate of three to five years—much faster than the turnover rate for personal vehicles.<sup>12</sup>

If effectively deployed, the three revolutions of automation, shared use, and electrification could reduce GHG emissions from transportation by decreasing VMT and accelerating transportation electrification.<sup>13</sup> In order to enable the growth of electric, automated, and shared fleets, the electric grid and electric vehicle supply equipment (EVSE), i.e., charging infrastructure, will likely need to support a rapid influx of high-mileage, high-usage EVs.

### Key Considerations

#### **Fleets of automated EVs may have different charging patterns than personal vehicles.**

To prepare for future transportation scenarios and avoid stranded assets, policymakers can begin to consider how the charging needs of automated and shared EVs may differ from personally owned EVs.

To reduce GHG and criteria pollutant emissions and grow the market for EVs, federal and state agencies, utilities, automakers, and other stakeholders are investing in and enabling EV charging infrastructure. To ensure a cost-effective infrastructure build out, transportation researchers worldwide are conducting modeling and analysis to determine the amount of charging

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infrastructure needed to support widespread EV adoption, as well as the optimal locations to site charging equipment.<sup>14</sup>

Most analyses agree that significant additional investment in EV charging infrastructure is needed now to bring about widespread transportation electrification. This charging infrastructure should continue to focus on human-driven EVs, which will likely dominate the roads for at least the next decade. To However, as we prepare for future transportation scenarios brought about by the three revolutions and avoid stranded assets, policymakers can begin to consider how the charging needs of automated and shared EVs.

Fleets of automated electric service vehicles may not be well served by EV charging infrastructure designed for personally owned EVs. For example, multi-unit dwellings and workplaces (commonly cited as priority locations for additional investment in EV charging infrastructure) may not be optimal locations for, or even accessible to, fleets of shared mobility service vehicles.

Currently, EV charging infrastructure is sited in locations that offer amenities to drivers while vehicles are charging, often corresponding to the type of charging infrastructure. For example:

- Level 2 charging is often added to long dwell-time locations, such as homes, workplaces and hotels.
- DC fast charging is primarily installed in short dwell-time locations in city centers and along interstate highway corridors.<sup>15</sup>

If the convenience of human drivers is no longer the primary consideration in the siting and utilization of EVSE, other factors, such as cost and grid impacts, may take on greater importance.

- It may no longer be a high priority to install vehicle charging infrastructure in locations where people are spending time, or with amenities for drivers.
- If vehicles are able drive themselves to recharge during hours of low travel demand, infrastructure could be sited at locations with low property value or that optimize electric grid distribution.
- Zero-passenger trips from vehicles traveling to remote charging locations could increase VMT and congestion, including among non-automated and internal combustion engine vehicles.

### **Effective electric utility rate structures and grid management can maximize the climate and financial benefits of automated electric vehicles.**

To prepare for the electricity demand and distribution grid impacts of automated EVs, electric utilities can learn from ongoing studies of the charging patterns of personally owned EVs.<sup>16</sup> However, current EV charging patterns are often based on driving habits, the availability of charging infrastructure, and utility rate structures. For example, most charging currently takes place at home or, if workplace charging is made available, at work.<sup>17</sup>

Automated, shared-use EVs will likely have very different charging patterns. Fleets of vehicles used for mobility services may have much greater daily travel demand, and thus require multiple charging events per day.<sup>18</sup> This may be a combination of high-speed charging between high-demand travel periods and longer charging times overnight and during other periods of low demand. If vehicle fleets prioritize charging at times and locations that optimize transportation

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services without consideration for grid impacts, it will be essential that electric utilities prepare for and accommodate these new loads.

Managed or “smart” charging of EVs can be used to maximize the climate and social benefits of vehicle electrification.<sup>19</sup> In order to increase system utilization and provide grid balancing services utility rate structures can be designed to create incentives for charging at times and locations with low power demand and sufficient available capacity.<sup>20</sup> Additionally, EV charging can accelerate the grid integration of renewable energy sources if vehicles are charged at times of peak renewable availability.<sup>21</sup>

**New business models for EV charging infrastructure may be needed to support shared, automated fleet vehicles.**

As with gas stations, public EV charging site hosts generally do not make money selling fuel, but rather by providing ancillary goods and services to drivers.<sup>22</sup> With driverless fleets, new revenue models may be needed. Shared-use, high-mileage EVs would consume more energy per day than a personal vehicle, and EVSE strategically deployed to serve these vehicles could have a high rate of utilization. At this high rate of utilization, it may be possible for EV charging stations to have a positive net present value without subsidy or the need to capture indirect revenue streams. Additionally, while ancillary services for automated vehicles will differ from those provided to human drivers, vehicles will still require maintenance and servicing, which will provide additional potential revenue streams.

### Policy Recommendations

**Consider the future uses and charging needs of automated, shared, and electric fleet vehicles when evaluating investments in EV charging infrastructure.**

To prepare for a future transportation system dominated by automated, electric mobility service fleets, stakeholders may need to reevaluate EVSE deployment strategies and programs. Policymakers, electric utilities, automakers, and other stakeholders can begin to incorporate automated vehicle usage and charging patterns into EV infrastructure planning and scenario analyses. This planning will help to “future-proof” charging infrastructure and avoid stranding assets.

**Promote grid-optimized charging to manage the grid impacts and maximize the environmental and economic benefits of automated, electric fleets.**

Electric utilities and grid regulators should begin now to evaluate how fleets of automated EVs may affect the grid based on projected charging patterns. If automated fleet vehicles charge in locations that optimize mobility services (such as high-frequency trip start and end points), utilities and regulators might consider what grid infrastructure investments may be required to accommodate this charging.

One important issue for consideration is whether charging infrastructure for automated fleets should be distributed or centralized. One potential option for fleet charging infrastructure is large charging depots that provide charging to hundreds of vehicles simultaneously and could be located in low-cost, high-grid capacity areas. Transportation planners and policymakers might consider how this model could be used in lieu of, or in addition to, the continued build out of distributed charging

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infrastructure in cities, as well as the net emissions and congestion implications of each model for charging infrastructure deployment.

Another key factor is the extent to which automated mobility fleet vehicles utilize DC fast charging, rather than Level 2 charging infrastructure. Increased use of DC fast charging will create new challenges and opportunities for vehicle-grid integration. Additionally, increasing the utilization of fast chargers (due to frequent charging from fleet vehicles), may improve the business case for higher-capacity (300kW+) DC fast chargers by recovering the fixed demand charge cost over more charging sessions.<sup>23</sup> EV charging service providers are already researching the fast charger utilization of mobility service fleets and evaluating opportunities to increase charger utilization during peak generation periods when more electric load is needed.<sup>24</sup>

By anticipating the uses and charging patterns of automated fleets by working with stakeholders and receiving data from transportation network companies (TNCs) such as Lyft and Uber, and other mobility service providers, utilities can develop rate structures that maximize the grid benefits of these vehicles by reducing demand peaks and promoting the integration of renewable resources. For example, in areas with high wind penetration, it may be optimal to have automated EVs charge at night when power demand is low and wind power is high. In other markets like California, it may be optimal to have the vehicles charge at midday, in between rush hours and when solar power is at its peak.<sup>25</sup> One rate design that provides an incentive for grid-optimal vehicle charging uses a volumetric energy rate based on hourly wholesale pricing.<sup>26</sup>

**Establish EV charging pilot programs for fleets of human-driven mobility service vehicles to**

**provide insight into the charging needs of automated electric fleets.**

Utilities, EV charging providers, cities, and other stakeholders have an opportunity to study the charging patterns of EVs used by taxi services and TNCs such as Lyft and Uber. In January 2017, the three major California investor-owned utilities submitted a second round of EVSE investment proposals that include pilot programs to install and promote the use of EV charging for TNC drivers.<sup>27</sup> Additionally, EVgo has partnered with Maven (GM's car sharing and mobility service) to provide DC fast charging to Lyft drivers using the Chevy Bolt EV.<sup>28</sup> As these and similar programs are implemented, stakeholders and regulators can gain important insight into where and how mobility service vehicles are charged, and what additional charging infrastructure may be necessary as electric shared mobility proliferates.

In particular, partnerships between TNCs, charging providers, and electric utilities to share data on vehicle use and EV charging is critical to identifying charging locations that optimize both grid utilization and mobility for fleets of automated EVs. For example, establishing a large charging depot as a pilot for electric mobility services drivers could provide important insight into the viability of such a charging model.

### Opportunities for Future Research

There are many uncertainties regarding the environmental, economic and social consequences of automated vehicle deployment, including the effects on congestion and vehicle emissions, the implications for employment for drivers and transportation revenue for states and cities, and impacts on land use and public transit.



## Electric Vehicle Charging Considerations for Shared, Automated Fleets

The following questions identify research needs specifically related to the charging requirements of automated electric fleets, including the potential effects of automated vehicle charging on the electric grid and EV charging infrastructure investments.

### **How might automated fleet vehicle charging patterns differ from personally owned and human-driven EVs (and human-driven mobility service EVs)?**

Additional analyses, modeling, and pilot program implementation are needed so that policymakers and other stakeholders can better anticipate the charging patterns of high-mileage, high-usage automated electric vehicles.

- What charging use cases (e.g., residential charging; workplace charging; public charging; long-distance corridor charging) will see increased or decreased utilization?
- What charging infrastructure types (Level 2, 50kW, 150kW, 300 kW+) and locations will be most utilized by automated fleet vehicles?
- What are the potential effects of technology developments (e.g., inductive “wireless” charging) on automated vehicle charging?
- How will vehicle use and charging patterns differ between area types (urban, suburban, rural) and regions of the country?

### **What are the potential electric grid and emissions impacts from a rapid proliferation of electric, automated mobility fleets?**

If EV charging infrastructure is used at times and in locations that optimize mobility (rather than optimizing electric grid utilization or emission

reductions), this could significantly alter the projected grid, societal, and ratepayer costs and benefits of EVs.

- What would be the effect of ‘mobility optimized’ charging infrastructure on net emissions and the electric grid?
- What rate designs or other utility regulatory policies could optimize mobility while providing benefits to the electric grid and reducing emissions from electric generation?
- Can mobility service providers manage the charging patterns of automated mobility fleet vehicles to improve vehicle-grid integration and provide ancillary grid services into energy markets?<sup>29</sup>

### **How can regulators and policymakers enable cost-effective charging infrastructure deployment?**

- How can utilities, automakers, and charging providers design charging infrastructure to accommodate automated fleet charging and future mobility trends?
- How can charging infrastructure facilities support both personally owned EVs and shared-mobility fleet vehicles?
- What new forms of EVSE will be needed for automated vehicles to authenticate their identity, recharge, and pay for charging without human intervention?
- What are the business cases and potential sources of indirect revenue (e.g., vehicle maintenance or ancillary grid services) for EVSE for automated fleet vehicles?
- How many fast charging sites strategically located to meet mobility demand (rather than at grid- or cost-optimized locations) may be

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