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ENERGY FINDINGS

Transit Fleet Electrification Barriers, Resolutions and Costs

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Findings

This paper synthesizes insights from a workshop on fleet electrification at the 2023 Transportation Research Board Annual Meeting, which included participants from transit agencies, national labs, industry, government and academia. Participants identified barriers to fleet electrification including lack of knowledge on fleet electrification, high utility demand charges, lack of charging infrastructure, delays in grid infrastructure upgrades and high up-front costs. To overcome these challenges, panelists emphasized partnering with OEMs and utilities, and having flexible charging infrastructure with software support tools. Finally, participants identified opportunities for integrating with electricity markets on peak demand management, time-of-use charging, participation in wholesale markets, and various vehicle-to-grid solutions. Based on these findings, we propose specific steps that various stakeholders like fleet operators, utilities and regulatory authorities could take.

1. Questions

In the pursuit of society-scale decarbonization, transportation is a key sector accounting for nearly 29% of all GHG emissions in U.S. in 2019 (EPA 2019). Within the transportation sector, transit fleets are a significant portion of the emissions.[1] This makes fleet electrification a major step towards the decarbonization of the economy. However, several factors could possibly delay this transition. The main questions asked in this paper are: (1) which barriers fleet operators face towards electrification, (2) which best practices can be replicated to achieve fleet electrification goals, (3) what sort of grid opportunities exist and what role utilities need to play in this area. In the following sections, we outline the main findings from the presentations and discussions on the workshop panels.

2. Methods

The workshop was organized to learn from industry leaders and experts on the challenges faced in fleet electrification. The workshop panelists and moderators included representatives from transit agencies like AC Transit in California, Everett Transit in Washington and CARTA in Tennessee, national labs like PNNL, state agencies like Washington State Department of Commerce, industry like Amazon, Tesla and NextEra Mobility, federal agencies like Department of Transportation (DoT) and academia like Columbia University and Johns Hopkins University. The workshop was divided into three panels

1 https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions

focusing on: (a) barriers to fleet electrification (b) checklist for fleet electrification and (c) cost of ownership/operation and grid opportunities. Each panel session involved a short presentation from the participants followed by a Q & A session. The notes on the presentations and ensuing discussions were taken by panel moderators, and later combined and compiled together into this paper. To put the panel discussions into context, some of the top reports on various topics related to fleet electrification from literature are highlighted in Table 1, along with the corresponding findings from the workshop panels. The main points raised in the panel sessions and the main findings from the discussions are outlined below:

3. Findings

3.1. Barriers to fleet electrification

- **Transit knowledge:** Transit agencies have long history and deep understanding of operating diesel fleets in a variety of weather and geography, including mechanics that know how to work on diesel buses. There is, however, a significant knowledge gap to pursue fleet electrification (Bae et al. 2022).

- **High demand charges:** Demand charges (monthly fees proportional to the customer's peak power draw in the month) are often very high for charging fleets, especially for transit operators, which reduces the fuel costs saving benefit of shifting to EVs substantially (Borlaug 2022). These demand charges have to be paid for the entirety of the month, even if the high demand was for just one instance.

- **Deploying charging infrastructure:** Deploying on-route charging infrastructure is difficult for transit operators as most agencies do not own the right of way (Burns 2022). The panelists point out that this makes it difficult to schedule charging and manage battery state of charge, leading to range anxiety and increasing the complexity of fleet operation.

- **Grid interaction with utilities:** Transit operators have to deal with delays in obtaining permits to install and upgrade infrastructure from utilities (IREC 2022). Based on this, the panelists think that utilities need to make sure that such upgrades are compatible and within safe grid-capacity increase limits.

- **High up-front costs:** The up-front costs for procuring equipment required to transition fleets to EVs can be very high, especially for small transit fleet operators (Buholtz 2020; Burns 2022). Along with new equipment and routes with need for multiple charging stations, the panelists think that facilities dealing with maintenance of the fleet such as machine shops can be inadequate to deal with EVs and need to be upgraded.

3.2. Checklist for fleet electrification

- **Partnering with OEMs:** For fleet operators, the panelists think that partnering with OEMs to procure EVs to meet their specific needs can be very beneficial. They point out that such partnerships can make the vehicles easy, convenient and comfortable for drivers as well as better match the drive cycles required for the particular fleet.

- **Partnering with utilities:** Partnering with utilities early on is critical for a successful transition to EVs as coordination or timeline issues with utilities can arise (IREC 2022). The panelists think that fleet operators should also forecast the energy demand growth of their fleet and share these with the utilities to ensure timely upgrades to grid infrastructure.

- **Flexible charging infrastructure:** It is important to have a flexible and diverse charging infrastructure in place in order to enable a smooth transition to EVs (ACTransit 2022; Burns 2022). This includes having a balance between slower depot charging (upto 150 kW) and faster on-route opportunity charging (upto 600 kW) enabling optimization between charge speed and energy costs. As a result, the panelists point out that different forms of infrastructure solutions may apply depending on fleet characteristics, like en-route highway charging, customer-owned depot charging and dedicated off-site charging hubs.

- **Support tools:** Software tools for charge management and energy optimization of fleets can minimize costs and help with operations, maintenance and generating reports on costs and sustainability (Zhang 2022). The panelists think that optimizing transit operations for different modes of transportation and predicting passenger volume, energy prices and traffic data is important and can lead to significant cost savings and emissions reduction.

3.3. Cost of ownership/operation and grid opportunities

- **Peak demand management:** Due to EVs' high and immediate charging power and drivers' correlated travel patterns, EV charging can easily contribute to increased peak demand, thus significantly increasing the cost of electricity (Borlaug 2022). Thus, the panelists point out that reducing peak charging demand should be the first objective of EV charging management to reduce costs.

- **Time-of-use charging tariffs:** Many utility companies now offer time-of-use (ToU) charging tariffs for EVs to encourage off-peak charging.[2] The panelists think that taking advantage of ToU tariffs can significantly drive down the charging cost.
- **Wholesale market opportunities:** The wholesale price of electricity varies significantly by time of day and location in the transmission system (Johnson 2016). As a result, in specific markets like Texas, vehicle manufacturers can directly participate in the wholesale market as an electricity retailer purchasing wholesale electricity at low prices for their customers. The panelists point out that this way they can offset energy costs by economically and algorithmically bidding storage on the wholesale market.
- **V2G opportunities:** V2G (vehicle-to-grid) technology can provide revenue-generating opportunities if the EV can discharge energy back into the grid during periods of high prices (EPRI 2019). Studies have shown that significant cost savings can be achieved with V2G (Ribeiro et al. 2022; Maitre 2020; Zhukovskiy et al. 2019).

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2 https://www.coned.com/en/our-energy-future/technology-innovation/electric-vehicles/electric-vehicle-drivers/electric-vehicles-and-your-bill

Table 1. Top reports for EV fleet management along with findings from the workshop panels.

Focus area	Topic	References	Workshop findings
Barriers to fleet electrification	(i) Knowledge gap on fleet electrification	(Bae et al. 2022)	(i) Transit operators have limited knowledge on operating EVs
	(ii) Workforce development	(ACTransit 2022)	(ii) Not many mechanics know how to maintain EV fleets
	(iii) Challenges with demand charges	(Borlaug 2022)	(iii) Reduces fuel costs saving benefit of EVs substantially
	(iv) Charging rate tariff rules	(Buholtz 2020)	(iv) Rules often obscure, hard to compare charging options
	(v) On-route charging infrastructure	(Burns 2022)	(v) Difficult to deploy as operators do not own right of way
	(vi) EV buses parking requirement	(ACTransit 2022)	(vi) Parking space required not equivalent to diesel buses
	(vii) Delays in grid infrastructure upgrades	(IREC 2022)	(vii) Significant delays in obtaining permits from utilities
	(viii) Up-front costs of procurements	(Burns 2022; Buholtz 2020)	(viii) Coordination between fleet operators and state/federal funding agencies is key
Checklist for fleet electrification	(i) Benefits of coordinating with utilities	(IREC 2022)	(i) Sharing energy demand growth forecast with utilities is key
	(ii) Benefits of flexible charging infrastructure	(ACTransit 2022)	(ii) Beneficial to have a balance between depot charging and oppportunity charging
	(iii) Benefits of software support tools	(Zhang 2022; Burns 2022)	(iii) Tools to optimize transit modes based on traffic data can result in cost savings
Grid opportunities	(i) Peak demand management	(Borlaug 2022)	(i) Charging management be utilized to reduce peak demand
	(ii) Advantage of ToU tariffs	(CONED, n.d.)	(ii) Take advantage of ToU tariffs to drive down charging cost
	(iii) Variation in wholesale electricity price	(Johnson 2016; NYISO, n.d.)	(iii) Bidding storage on wholesale market can offset energy costs
	(iv) Storage as a derisk buffer	(Denholm et al. 2010)	(iv) Storage is a buffer for derisking charging price fluctuations
	(v) VPP's reducing energy costs	(electrek, n.d.)	(v) Fleet operators can use VPPs to deploy DERs
	(vi) V2G generating revenue opportunities	(EPRI 2019; Maitre 2020)	(vi) Up to 40% cost savings can be achieved with V2G
	(vii) Flexibility of EV fleet	(Ribeiro et al. 2022)	(vii) Difficult for utilities to tap into EV flexibility

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