White Paper

Not Just Smart: The Importance of Managed Charging

Powered by AMPLY

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In partnership with

AMPLY POWER

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- Heidi Sickler: Director of Policy
- Lexi Wiley: Vice President of Marketing

Any errors are the authors' own.

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List of Acronyms

BEV	Battery-Electric Vehicle
CaaS	Charging-as-a-Service
CMS	Charge Management Services
CORE	Clean Off-Road Equipment Voucher Incentive Project
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
HTUF	High-Efficiency Truck Users Forum
HVIP	California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
kWh	Kilowatt Hour
NE ZEB	Northeast Zero-Emission Bus
NYTVIP	New York Truck Voucher Incentive Program
PHEV	Plug-In Hybrid Electric Vehicle
SEPA	Smart Electric Power Alliance
TCO	Total Cost of Ownership

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Executive Summary

Vehicle electrification is increasingly becoming the reality for many fleet operators across the United States. With the transition to electric vehicles (EVs), each fleet operator must add a new dimension to their job — charging the vehicles. Just as there are many ways to charge EVs, there are a variety of methods and solutions to optimize operations through charge management. CALSTART has partnered with AMPLY Power to assess the knowledge of different managed charging solutions across the transportation industry to help inform the charging infrastructure and managed charging industries on where knowledge gaps exist. Additionally, this partnership aims to inform fleet operators in various stages of electrification on different options for simplifying their operations and lowering costs while making them more predictable. This knowledge was collected through a series of surveys and polling of fleet providers and industry stakeholders administered by CALSTART from May to November 2021. This research found the following key insights:

As of November 2021, 39% of fleet respondents were not aware of managed charging services – communicating a great opportunity for further education.

- **The number of fleets operating EVs is increasing:** 61% of the fleets surveyed in November 2021 are operating EVs, up from 46% from those surveyed in May 2021— a 15% increase in a matter of five months.

- **The number of fleets looking to electrify their vehicles is growing:** From May to November 2021, the percentage of fleets planning to deploy EVs within the next year increased from 21% to 54%.

- **The number of fleets and industry stakeholders familiar with managed charging and charging-as-a-service (CaaS) is increasing:** The percentage of respondents familiar with managed charging increased by 4%. Familiarity with specific approaches to managed charging such as automated regular reporting and smart charging increased by as little as 8% to as much as 38% respectively.

- **Fleet needs vary based not just on vehicle classes, but also on operations and duty cycles:** Vehicles not meeting operational needs is one of the key obstacles preventing fleets from moving towards electrification. Even fleets that are electrifying their vehicles continue to struggle with vehicle limitations.

- **The cost for charging infrastructure is seen as a barrier:** Many private fleets must deploy their own charging infrastructure, and this cost impact is one of the main obstacles of electrification for fleets. This is a challenge that can be directly addressed with various managed charging solutions that can lower both upfront and ongoing costs for infrastructure and charging.

I. What Is Managed Charging?

Managed Charging Defined

When it comes to charging solutions, hardware is not the only thing to consider—managed charging is just as critical. Managed charging is a set of tools that can optimize the operation of charging infrastructure, improve the total cost of ownership (TCO) analysis for fleet electrification, and enable "central or customer control of electric vehicle (EV) charging to provide vehicle grid integration offerings, including wholesale market services" (Blair et al., 2021). Or, as Edward Burgess of Strategen said, managed charging "'is moving when charging is done to align with grid needs'" (Trabish, 2020). This definition can include passive managed charging, in which incentives, varying electricity costs depending on time of use, or communications influence a user's charging behaviors or active managed charging that directly controls charging habits or electrical loads via software and/or specialized equipment (Myers, 2019). Managed charging encompasses smart charging and software solutions, but also goes beyond these approaches to include charging-as-a-service (CaaS).

Managed charging is not exclusive to a particular type of charging and can be used across all charging levels, though its impact will be most noticeable with higher and faster charging rates. It is also applicable to fleets of all sizes. Similarly to charging rates, it has exponentially greater effects as the number of EVs deployed within a fleet increases, but it is still applicable to small fleets in order to smooth operations, decrease costs, and gain insight into electrical refueling operations.

Table 1 outlines a few key managed charging strategies that were highlighted in a pair of surveys conducted by CALSTART, which will be discussed later in this paper. The strategies below further illustrate what managed charging encompasses.

Table 1. Managed Charging Strategy Definitions

Managed Charging Strategy	Definition	Managed Charging Type
Automated operations	Charging operations that do not require manual activation or switching between vehicles	Active
Automated regular reporting	Reports on EV charging and usage are generated on a regular basis and communicated to relevant parties without requiring user action	Active
Automatic load management	An automated system for monitoring and controlling electrical load "voltage, current, power, phase sequence, and network consistency" (ABB, n.d. b)	Active
Carbon Program (Low-Carbon Fuel Standard) Participation	Programs that grant credits to operators that use fuels below a certain carbon intensity threshold (CARB, n.d.)	Passive
Demand program and grid services participation	Programs to restrict energy usage during peak demand times (Budhiraja, 2019)	Passive
Dynamic response to changing vehicle assignments	Charge management software that automatically shifts charging power to whichever vehicle needs the most charge based on anticipated energy needs	Active
Electric tariff optimization	Identifying and utilizing the tariff that offers the best value (Utilitas Solutions, n.d.)	Passive
Fixed pricing	EV charging costs that do not vary depending on time of use	Passive
Interoperability across heterogenous chargers and vehicle makes and models	Ability of different EVs and chargers to seamlessly communicate and function together	Active
Pay as you use	Paying for electric charging equipment and electricity as it is used	Passive
Remote diagnostics and troubleshooting	Diagnostics and troubleshooting for EV charging equipment performed remotely through integrated software (ABB, n.d. a)	Active
Scheduled charging	EVs can be plugged into charging equipment, but charging does not begin until programmed to do so	Active
Smart charging	When an EV charger has communication technology, such as Wi-Fi, that allows data to be collected and viewed (U.S. Gain, 2021)	Active
Telematics integration	Cloud-based data collection linked with the EV charging equipment	Active

Managed Charging Market Trends

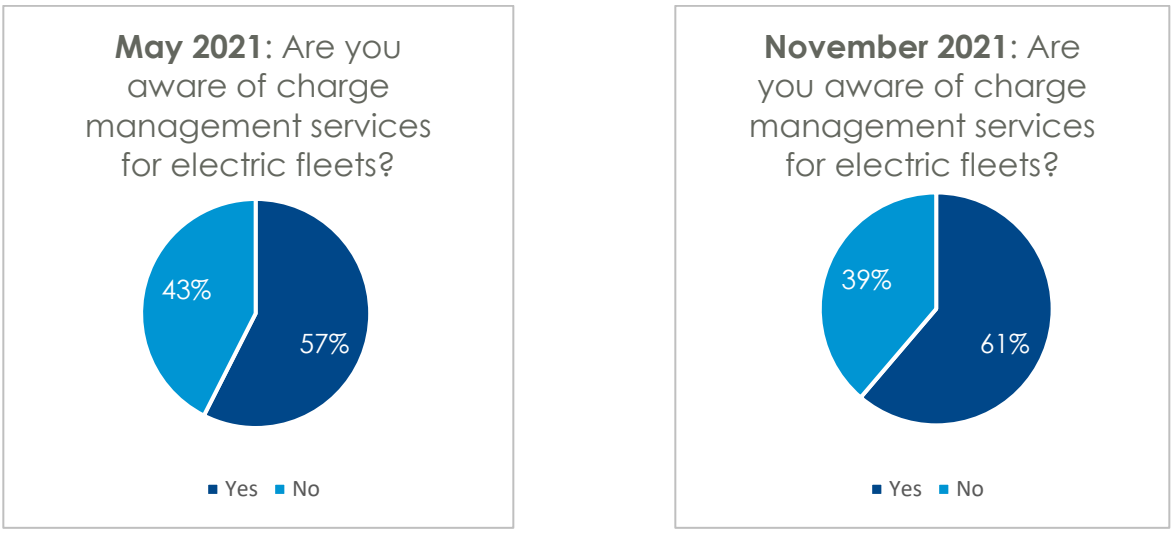
When planning for electrification, fleets need to place equal priority on their plan for charging infrastructure and strategy. Though the cost for charging EVs requires a large capital investment, a major reason fleets are shifting to EVs is that the cost for refueling with electricity is generally low compared to traditional fossil fuels. When the cost of fossil fuels is a fleet's greatest expense, the low cost of electricity can make a huge difference to bottom line operating expenses. However, EV fleet electricity demands can fluctuate greatly, and therefore fleets need to take advantage of off-peak rates or use stored energy solutions to charge EVs during high peak hours to unlock the greatest cost savings through electric refueling. Managed charging offers the ability to control vehicle charging times. Managed charging simplifies a fleet's ability to minimize costs related to charging and has become a critical element in fleet electrification planning. As a result, managed charging solutions among fleets have been growing over the last several years to support fleet operator's critical needs and the increasing number of charging infrastructure deployments. According to CALSTART's survey, at least 54% of the responding fleets are looking to electrify their fleet.

Utilities are also recognizing the benefits of managed charging to increase utility grid efficiency and help support lower electricity rates for all customers. As a result, many utilities are implementing a wide range of rate designs for fleet customers and are looking for innovative ways to increase EV deployments. Research conducted by Smart Electric Power Alliance (SEPA) found that between 2019 and 2021, the number of ongoing managed charging programs from utilities increased from 26 to 71 programs; 29 of those programs included active managed charging (Blair et al., 2021). Various vehicle manufacturers have also become involved in these utility-based projects, helping to ensure compatibility between their EVs and different charging equipment and software (Blair et al., 2021). By adopting managed charging for EVs, utilities are able to improve grid utilization.

Managed Charging Fleet Based Awareness

A key factor responsible for the growth in the number of fleets looking to electrify their fleet is the increased knowledge of the various managed charging solutions across the transportation industry (see Appendix A). Based on the survey data collected from May to November 2021, there was a slight increase (4%) in the percentage of participants that identified themselves as familiar with managed charging (*Figure 1a-b*). As early as November 2021, 39% of respondents stated that they are not aware of charge management services. This high percentage communicates a great opportunity for CALSTART and AMPLY Power to continue educating the market on the benefits of managed charging, and especially for providing a stronger business case and further lowering the TCO when it comes to EV adoption.

Figure 1a-b. Managed Charging Awareness



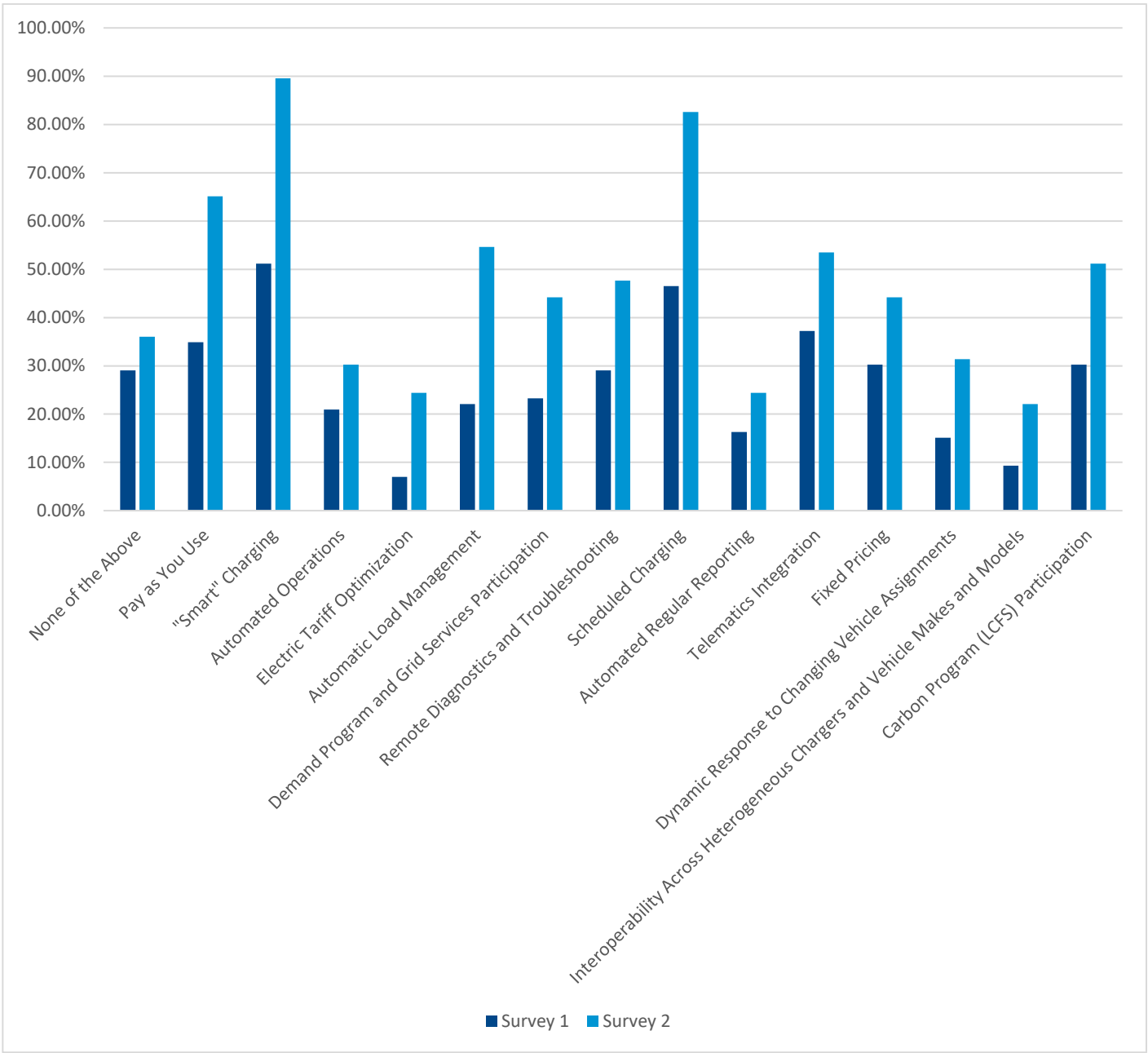
Under the umbrella of managed charging, there are many different solutions. One key approach is known CaaS—a type of managed charging in which the fleet pays only a fixed amount, or subscription, based on the total kilowatt-hours (kWh) used rather than paying for each aspect of EV infrastructure, software, electrical upgrades, and electricity separately. The cost of CaaS includes infrastructure design and buildout, deployment, operation, and support and maintenance (Palmer, 2021). CaaS shifts many duties from the fleet to their CaaS provider. This solution allows for more stable and predictable costs and shifts the burden of charging away from the fleet and on to a third-party charging service vendor.

CaaS relieves much of the pressures that would otherwise be on the fleet and operators. Like managed charging, CaaS is increasing in popularity, but there are still many fleets that are not familiar with this option. Fortunately, this story is quickly changing. In November 2021, 53% of survey respondents to CALSTART's survey were familiar with CaaS, up from 41% in May 2021 (*Figure 2a-b*).

Figure 2a-b. CaaS Awareness

In addition to the CaaS measure, the surveys assessed familiarity across other managed charging strategies identified in *Table 1*. The surveys found that smart charging was the most recognized managed charging strategy, with scheduled charging also being highly recognized. The relative familiarity of each strategy was consistent over time as well, with familiarity for each term increasing between 8% and 38% between May and November 2021. However, between the first and second surveys, there was a slight increase in the percentage of people who selected that they were not familiar with any of the items despite the percentage of people familiar with each term also increasing (*Figure 3*). This means that while there were more people unfamiliar with charge management services, those that were aware of some of the offerings proceeded to learn about additional options in the time between surveys.

Figure 3. Charge Management Familiarity



The charge management services that people were least familiar with were automated operations, electric tariff optimization, automated regular reporting, and interoperability across heterogeneous chargers and vehicles. It is possible that respondents were familiar with the ideas behind them but not the terms themselves (see *Table 1* for terms). Interoperability—the ability for software to manage different charger makes across a heterogeneous fleet—is also something that people are likely aware of but may not have recognized in the context of managed charging. One of the benefits of options like CaaS is that some CaaS providers incorporate potentially unfamiliar services and therefore still allow individuals to reap the benefits those additional services provide.

II. Why Is Managed Charging Important?

Market Growth of Transportation Electrification

Managed charging improves the total business case for fleet electrification. It allows fleets the use of real-time data to respond dynamically to vehicle charging, which benefits the fleet owner, the utility, and the environment. Managed charging solutions are important for protecting the grid, improving EV operations, and lowering costs, which will all be critical given the growth of the EV industry. According to Automotive News, between the first half of 2020 and the first half of 2021, EV registrations have more than doubled in the United States, bringing their market share from 1.5% to 2.5% of total new-vehicles registrations; that is, EV registrations increased from 98,351 to 214,111 (Irwin, 2021; Kane, 2021).

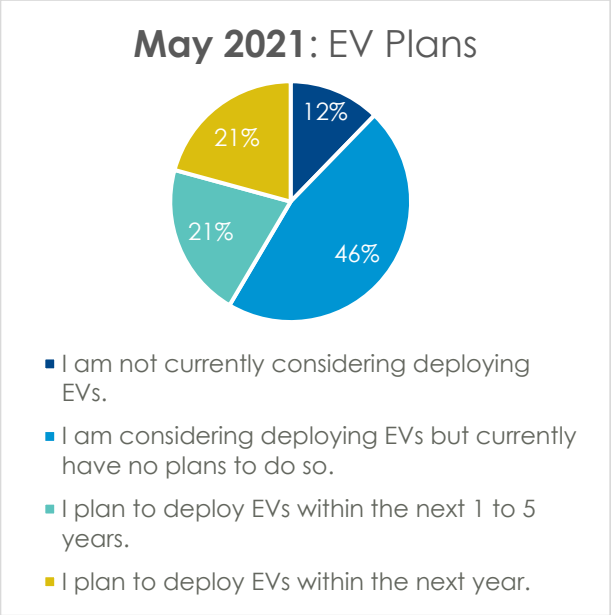
Managed charging also provides the benefits of understanding the state of charge across an entire fleet, which provides the opportunity to anticipate and balance the overall site load and distribute available power across vehicles. Fleets are able to monitor energy use and avoid peak, high-cost energy use for charging while balancing energy use across all operations (buildings and vehicles).

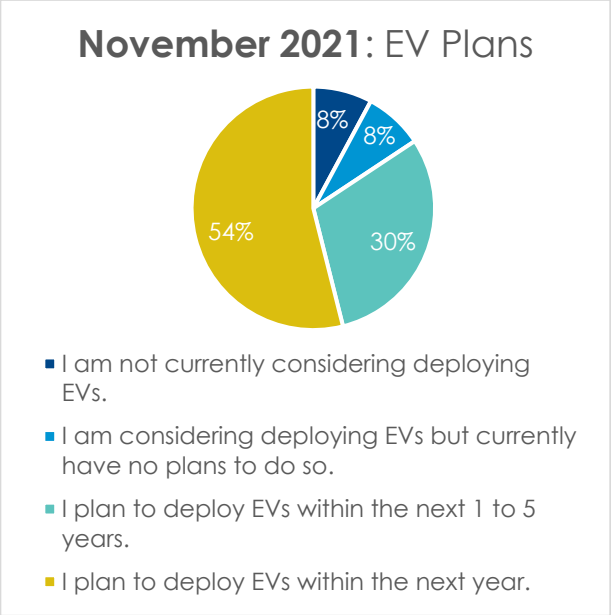
Fleet Electrification

EV Ownership Trends

Today's EV market is growing quickly, and this growth is being driven by manufacturer commitments, model availability, and affordability. The number of medium- and heavy-duty electric fleet vehicles is expected to grow by more than 100% from 2020 to 2022 (Hughes, 2021). The transit and school bus EV market segments are currently the most mature, and other commercial EV markets segments such as medium- and heavy-duty trucks are quickly following as demand grows and manufacturers increase model availability. According to CALSTART's Global Drive to Zero Zero-Emission Technology Inventory (ZETI) tool (2020), there are well over 30 manufacturers with at least one EV model available in their product offering and more entering in the market with additional models available as early as 2022. The Covid-19 pandemic has also accelerated the EV market with increased deliveries of goods and services, which have raised concerns of increased emissions. In response, many fleets are now committed to electrifying their fleets. The decision for fleet electrification is driven by viable business cases and the ability to meet operational needs and requirements.

Figure 4a-b. EV Plans





According to survey results, the move towards electrification is occurring across a wide range of fleets across the United States. The surveys found that the number of respondents with EVs in their fleet increased from 46% to 61% overall between May and November 2021, and in directly comparing responses of respondents who participated in both surveys, the increase was higher (49% to 77%). Likewise, the survey found that the number of respondents with plans to deploy EVs within the next five years increased from 41% to 84% of respondents (*Figure 4a-b*). Many fleets see EVs as an opportunity to achieve sustainability and operational (cost) goals. Some of the available EVs are already more cost-effective than their internal combustion predecessors due to the lower cost of electricity as a fuel, especially when those costs are reduced further with the use of managed charging. Managed charging provides fleets the opportunity to predict and minimize energy use. This is extremely important: while fleet operators are familiar with handling the fossil fuel-based supply chain, many are not familiar with managing the cost and supply of electricity.

Technical Assistance for Fleets

Obstacles to EV Adoption

Most EVs operated by commercial fleet operators today charge exclusively at their depot or hub using charging equipment they own, primarily due to the lack of available public charging. According to survey respondents, the cost of charging infrastructure is one of the most critical barriers to implementation, a challenge that can be directly addressed with various managed charging solutions that can lower both upfront and ongoing costs for infrastructure and charging.

Other key obstacles to EV adoption from the survey (see Appendix A) were cost of vehicles and vehicles not meeting operational needs (range, payload). While the cost of vehicles is not itself directly impacted by managed charging solutions, managed charging can lower the TCO.

Managed charging can lower charging costs, as previously discussed, by reducing demand charges and shifting the bulk of charging to times with lower electricity rates. The use of managed charging can also lower infrastructure costs by reducing the need for or urgency of service upgrades. It can also reduce the size of charging equipment needed through strategic charging approaches. By lowering other costs, managed charging helps balance out the higher costs of the vehicle. Similarly, managed charging does not directly impact an EV's ability to meet operational needs, but managed charging can help with operational changes for a vehicle to better meet these needs. For instance, an EV with less range than a fleet's route planning requires can travel farther distances by utilizing charging infrastructure along its route, and that charging infrastructure can have various managed charging strategies integrated.

Infrastructure Costs

Further illustrating the need for technical assistance with charging infrastructure, survey respondents did not have a clear idea of what portion of overall project costs should be attributed to charging infrastructure. Approximately 25% of respondents answered that they were unsure of the percentage of total fleet electrification costs that should be attributed solely to charging infrastructure or had not yet considered it. This percentage was consistent between both survey responses, so there was no improvement over time. There were also scattered responses from those that did have a guess as to the costs; over 20% of respondents expected infrastructure to account for more than 50% of total project costs.

The cost for infrastructure varies greatly across fleets of all sizes and types and even across fleets that are the same size and type. For example, two transits with 25 buses in their fleet could need two completely different charging infrastructure plans. There are many different factors that determine what infrastructure costs will be. Based on fleet electrification lessons learned, however, the costs associated with charging infrastructure are typically less than 30% of the overall project costs. Only in very extreme cases do such costs account for more than 50% of the overall project costs.

III. Conclusion

Across the United States, the transportation industry is progressing towards electrification. This transformation is occurring across all sectors and is having a growing impact on transporting both people and goods. The topic of charging is vital for the electrification of any vehicle, but charging infrastructure, capabilities, and management become increasingly important for fleets and their operations—any charging efficiencies gained or lost are magnified with each additional vehicle. To tackle these challenges, new options and approaches to charging and charge management are becoming available. These alternatives can make the entire process simpler and more controlled, as well as help lower costs and make them more predictable. Today, there are significant opportunities for educating fleets on different managed charging solutions and how they can help their operations and their costs.

Survey Findings

CALSTART's partnership with AMPLY Power and the research that was conducted resulted in the following findings and conclusions.

Electrification

- **The number of fleets electrifying their vehicles is growing:** Between the two surveys, there was an increase in the number of fleet respondents, from 46% to 61% of participants. Likewise, a measurable growth in the percentage of fleets that plan to deploy EVs was observed, as well as an improvement in how soon fleets planned to deploy EVs.
- **There are barriers to overcome:** One of the key barriers to fleet electrification that was highly ranked in each collection group was vehicles not meeting operational needs. Therefore, if there are vehicles that meet fleets' needs or if there are other operational changes that would allow EVs to meet fleets' needs, manufacturers should better communicate these options to fleets. Cost of charging infrastructure, which can be addressed in part with managed charging, was also consistently ranked high.
- **The cost of charging infrastructure is still a moving target:** Charging infrastructure costs are not well understood among fleets at all stages of electrification. Approximately a quarter of respondents from each survey were unsure about infrastructure costs or had not considered it. Given how much these costs can add up, it is essential that fleets understand them and plan accordingly. Likewise, more than 10% of respondents throughout thought that infrastructure costs would be higher than normal. These fleets need to understand that costs are typically not as high as anticipated; this perceived cost may be preventing fleets from moving forward with electrification.

Managed Charging

- **Knowledge of managed charging is growing across fleets:** There were measurable improvements in managed charging familiarity between the first and second surveys, with a slight increase to over half of respondents being familiar with managed charging. There was also a significant increase in the number of respondents familiar with CaaS.
- **Most fleet and industry stakeholders are familiar with smart charging:** Smart charging was the technology most respondents were familiar with in both surveys. Between the first and second surveys, the percentage of people familiar with smart charging increased from 51% to 90%. The other most recognized managed charging solutions were scheduled charging and telematics integration or pay as you use. The recognition patterns were nearly the same between the two surveys.

When looking at these trends and the 39% of respondents who were unfamiliar with managed charging, one can see that more education about managed charging is needed. The impact managed charging has on costs and operations is critically important for the fleet electrification success story to continue. As operators learn more about different managed charging solutions and are able to break down barriers to fleet electrification, more EVs will replace fossil fuel vehicles – improving the environment and the lives of everyone.

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Appendix A: Survey Detail

Background

CALSTART partnered with AMPLY Power to assess the knowledge of different managed charging solutions across the transportation industry. This project consisted of two online surveys and a webinar with poll questions to gather feedback from the industry. In addition to looking at knowledge of managed charging solutions, this project occurred in two parts to measure any change in knowledge that occurred. The first survey was open from May 6, 2021, until June 25, 2021. This survey received 87 responses during that time. The webinar then occurred on October 14, 2021, and the second survey was open from October 14, 2021, until November 22, 2021.

A total of 203 unique individuals participated in this effort to capture two snapshots of the state of the industry across the country. Participants had fleets domiciled in all 50 states and represent a wide variety of vehicle types, uses cases, and fleet sizes. Forty-eight of the 203 unique individuals participated in both the first survey and the second survey/polls. This core group of 48 respondents facilitated direct comparisons and allowed for a more precise measure of growth.

Survey 1

The first survey was open May 6, 2021, through June 25, 2021. Outreach included CALSTART's network of fleet contacts, including California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), Clean Off-Road Equipment Voucher Incentive Project (CORE), New York Truck Voucher Incentive Program (NYTVIP), High-Efficiency Truck Users Forum (HTUF), Northeast Zero-Emission Bus (NE ZEB), Fleet Readiness Working Group, and Sustainable Fleets programs. A total of 723 fleets were contacted via targeted emails and asked to complete the survey in SurveyMonkey. Only one contact from each organization was included in the main outreach to eliminate repeated responses from an organization. To reach additional fleets, the survey was also included in the CALSTART Compass weekly newsletter. This survey served two purposes: it provided current industry information on fleet electrification plans, barriers to adoption, and knowledge of managed charging, and served as the baseline for comparison with the second survey responses to measure growth in managed charging understanding. A total of 87 participants completed the first survey during the collection period.

Survey 2

An evaluation of the first survey questions and collection methods was completed prior to distributing the second survey. While the content remained largely the same, the format for a few questions was updated to provide more clarity. In particular, a question regarding different obstacles to electric vehicle (EV) adoption was re-formatted, and a question regarding EV

ownership and plans was split into two separate questions to allow for clearer answers.

Based on the response rate from the first survey, the second survey was administered through both a webinar format and an online survey. This second survey was launched approximately five months after the first survey as poll questions during a managed charging webinar on October 14, 2021 and remained open as an online survey for approximately five weeks until November 22, 2021. A total of 103 participants completed the second survey via either collection method and, an additional 61 participants provided partial responses.

Webinar Polls

On October 14, 2021, Not Just Smart: The Importance of Managed Charging to Keep EV Fleet Costs Low was conducted via Zoom. This webinar, held in conjunction between CALSTART and AMPLY Power, was to inform and serve as a new collection method. This webinar was open to the public and therefore introduced some non-fleet respondents into the data. These non-fleet respondents included government employees, non-profits, consultants, dealers, and vehicle manufacturers. Although the target respondents for this project were fleet operators, these individuals are still involved in the transportation industry and should have similar knowledge of different charging strategies to inform their work. As such, their feedback was still important for this effort and was included in much of the results. Many of the non-fleet respondents did not answer the fleet-specific questions but did respond for the managed charging questions.

The managed charging webinar was an hour and a half in duration and included discussion of how managed charging solutions optimize operations and keep costs low, why energy management is the key to scaling an EV fleet, and a fleet's experience before and after adopting managed charging. Some basic questions, such as fleet domicile locations and size, were asked during registration for the event. A total of 32 participants completed all eight poll questions asked during the webinar. Since poll questions were asked throughout the webinar and some individuals were not able to attend for the entire duration or were not able to respond within the allotted time for each question, 61 participants completed a subset of the poll questions. These partial responses were used when looking at data as a whole, but depending on the unanswered question, partial responses may not have been used in some of the comparative analysis.

Online Survey 2

In addition to the poll questions in the managed charging webinar, the second survey was distributed via email campaigns for completion in SurveyMonkey. The second survey was first sent to those that attended all or part of the webinar but did not provide answers to all poll questions. Second, those who registered but did not attend the webinar were asked to complete the survey in order to access the webinar recording. The survey was then also sent via email to fleet contacts, as was done for the first survey. Finally, those who participated in the first survey were contacted individually in order to receive complete data sets for comparisons. A total of 68 participants completed the second survey that did not complete any of the poll questions in the webinar. Three additional participants completed the second survey after having responded to only some

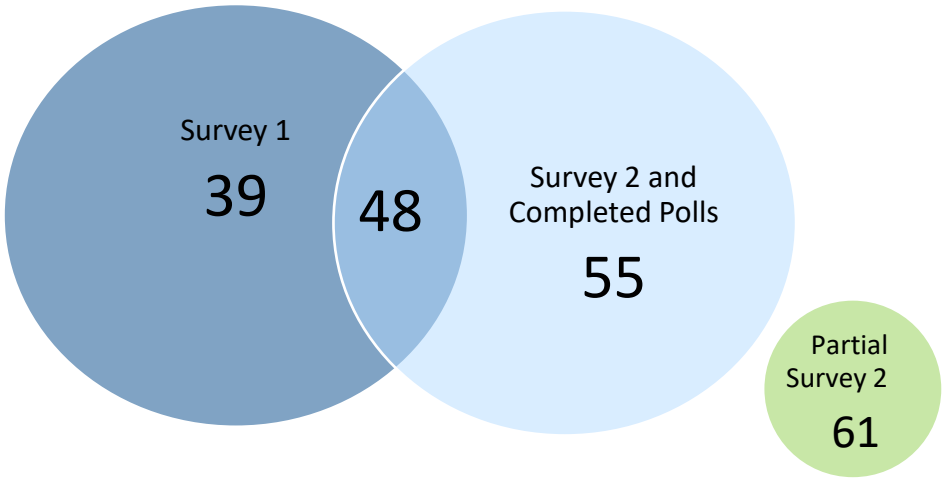
of the poll questions in the webinar, so their responses to both were combined in order to obtain complete sets of responses.

Participants

Response Overview

A total of 190 complete responses were collected between the two online surveys and polling during the webinar. Forty-eight people participated in both the first survey and the second survey or polls, so 142 unique participants gave complete responses (*Figure A-1*).

Figure A-1. Participants by Response Method



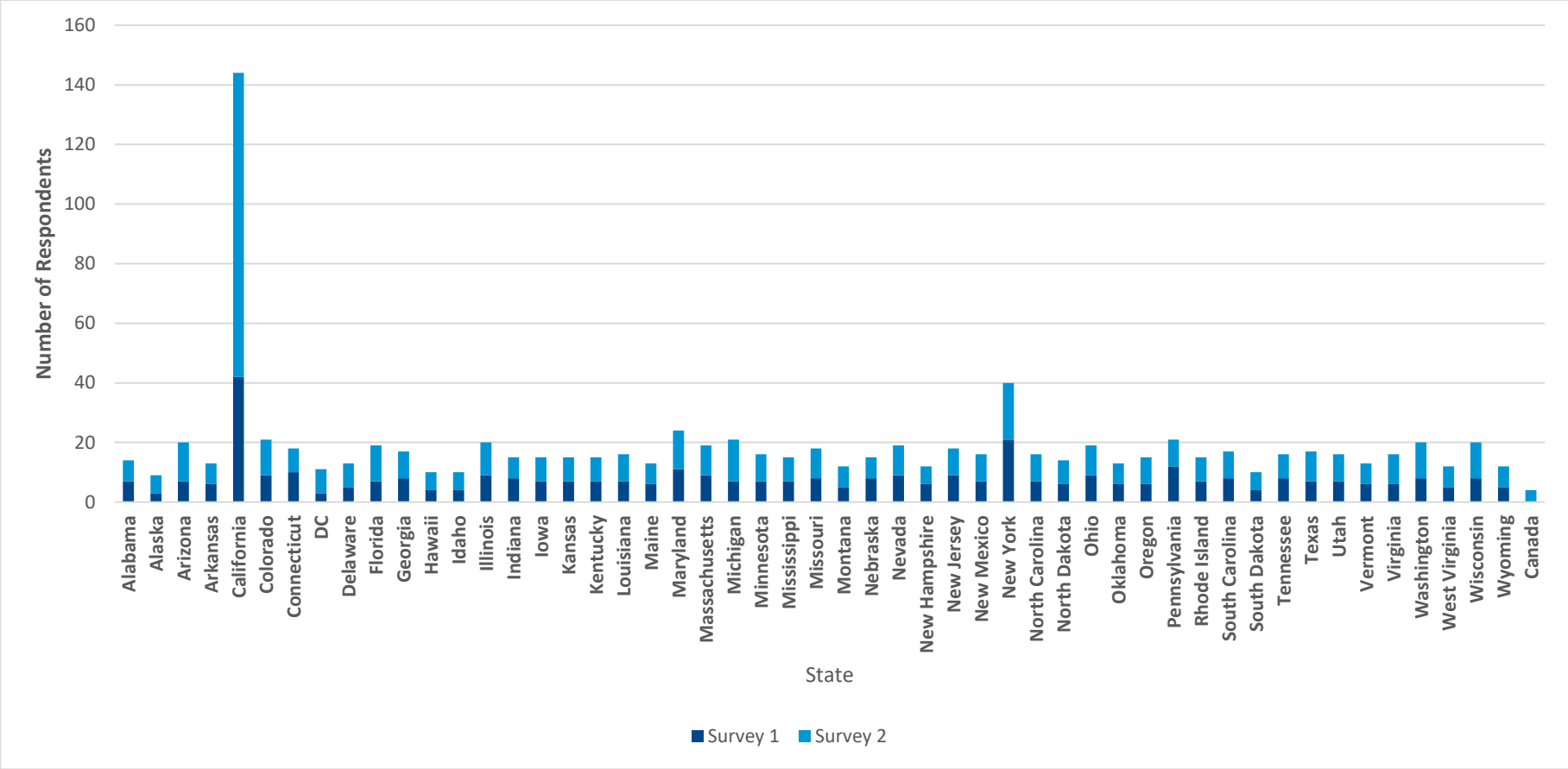
Total Unique Complete Results: 142

Total Number of Unique Individuals that Contributed: 203

Fleet Domicile Location

Participants in both surveys, including the webinar polling as part of the second survey, represented a variety of fleet types and sizes and had domicile locations across the United States, in addition to a few in Canada (*Figure A-2*). Domicile location refers to "the vehicle's 'home base' / deployed location; where the vehicle stays overnight, returns after its route, or is parked when it is not working" (California HVIP, n.d.). All 50 states were represented within the data, with California being the most common, followed by New York, for common domicile locations among participants. This result is reflective of the state of fleet electrification trends across the country.

Figure A-2. Fleet Domicile Locations

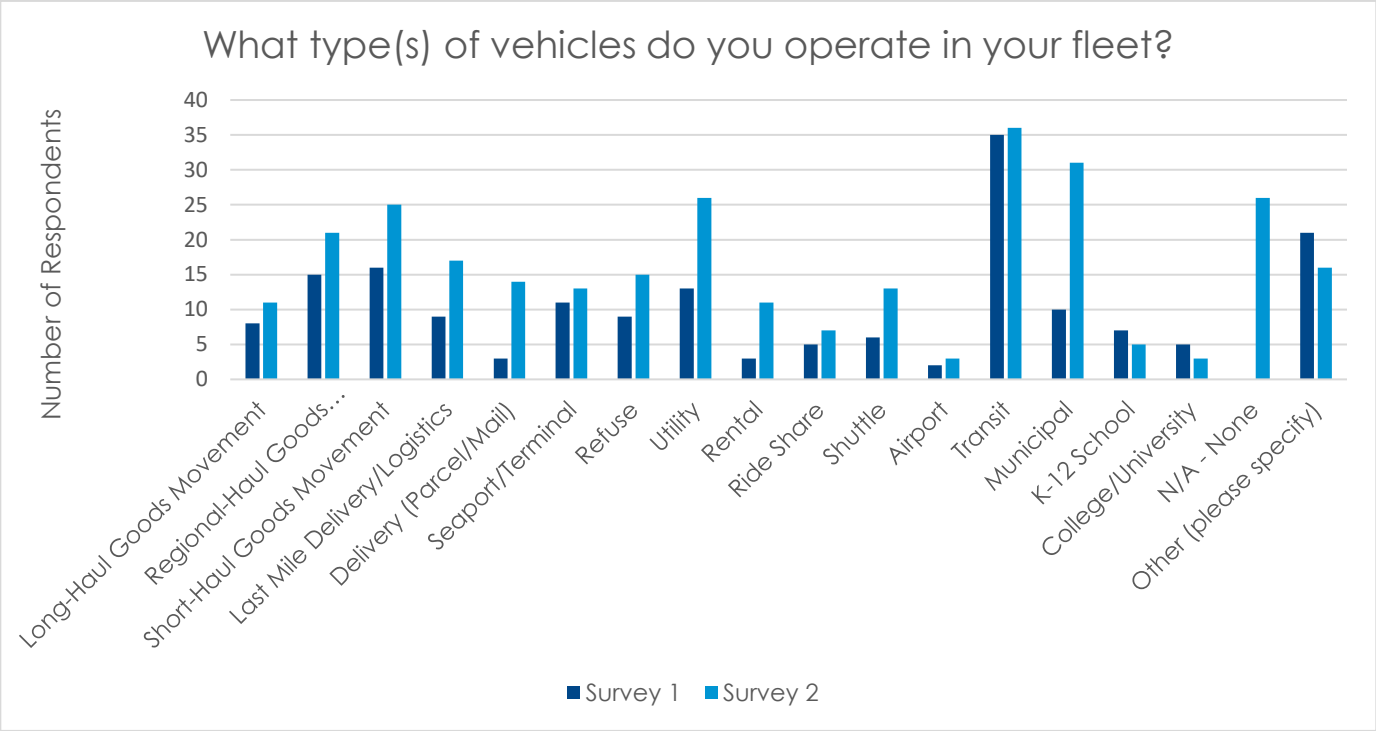


Fleet Type

The types of fleets reflected in the responses were diverse and representative of the transportation industry (*Figure A-3*). Across each collection method, transit was the most represented sector. Responses accompanying the "Other" selection varied widely. Some responses include ground support equipment, emergency response, transport refrigeration units, rail yards, petroleum, agricultural, and light-duty vehicles for shopping and for administrative fleets.

As seen in *Figure A-3*, 26 respondents from the webinar and second survey do not operate a fleet. As previously mentioned, these respondents included government employees, non-profits, consultants, dealers, and vehicle manufacturers. Despite not operating fleets, these individuals are still involved in the industry and can provide valuable input. They did not answer the fleet-specific questions but did respond to the managed charging questions.

Figure A-3. Fleet Type



Within the surveys and webinar, the different fleet types were not defined (*Table A-1*). Participants self-selected which category they fell into without additional directions. For the webinar, this question was included in the registration questions and was formatted as a free response. For responses that did not match a category, they were assessed on a case-by-case basis to sort appropriately after the surveys closed.

Table A-1. Fleet Type Definitions

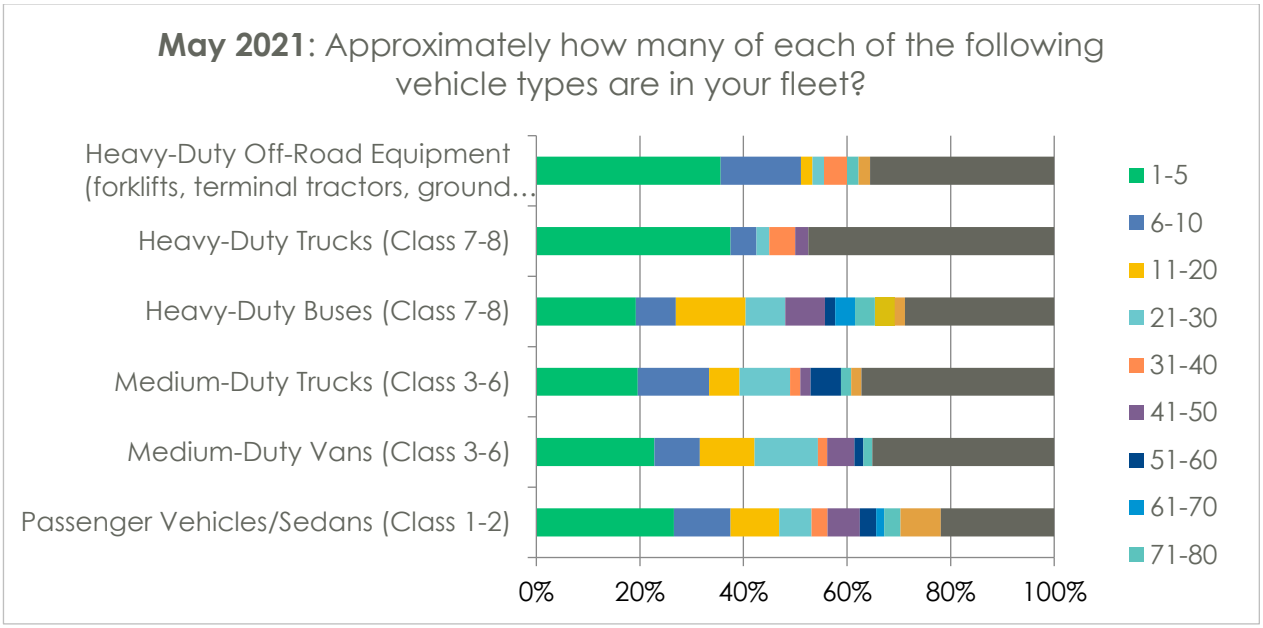
Answer Choices	Definition
Long-Haul Goods Movement	Fleets that typically transport goods over 1,000 miles in a route – fixed or variable
Regional-Haul Goods Movement	Class 8 delivery vehicles that travel between 500 to 1,000 miles from domicile location
Short-Haul Goods Movement	Fleets that typically transport goods within 150 miles from their domicile location
Last Mile Delivery/Logistics	Fleets that travel on multi-stop routes at low to moderate speeds within or close to an urban region
Delivery (Parcel/Mail)	Fleets for delivering mail and packages
Seaport/Terminal	Also referred to as yard spotters and yard tractors, fleets predominantly operating at low speeds to move cargo containers at off-road locations
Refuse	Fleets that perform refuse, or garbage, collection
Utility	Fleets of small to medium trucks that serve as work trucks carrying equipment
Rental	Fleets consisting of vehicles that are leased to customers for their use
Ride Share	Fleets that are comprised of passenger vehicles and are used by customers for personal transportation
Shuttle	Fleets of small buses or vans for transporting people between locations
Airport	Fleets that operate at airports comprised of passenger vehicles, shuttle vehicles, and ground service equipment
Transit	Fleets of transit buses, shuttle buses, and vans for passenger transportation
Municipal	Public fleets comprised of public works vehicles and emergency vehicles
K-12 School	Fleets that provide student transportation for kindergarten through high school; school buses
College/University	Fleets that provide student and/or staff transportation for colleges and universities; may include passenger vehicles, vans, shuttles, and buses
Other (please specify)	This option allowed participants to provide a different classification for their fleet. Many also used it to clarify what types of vehicles they had.

[a](Zender et al., 2021) [b](Spectro Scientific, n.d.) [c](Samsara, 2021)

Fleet Size

Fleets of all different sizes were represented among respondents. This data was accessed differently for each collection method, and exact vehicle counts are not available from the first survey. The first survey did not specifically ask for a measure of the fleet size, instead asking how many of each type of vehicle was in the respondent's fleet (*Figure A-4*). Fleets of passenger vehicles and sedans (Class 1-2) and heavy-duty buses (Class 7-8) tended to be smaller fleets overall.

Figure A-4. Survey 1 Fleet Size



For the second survey and webinar, respondents were asked to provide clearer estimates of their fleet size than they were in the first survey, which allowed for more thorough analysis (*Figure A-5*). Almost half (45%) of respondents to the second survey (polls and online version) had fleets classified as small (< 100 vehicles), and the online version of the second survey found that the largest fleets were primarily comprised of medium-duty trucks. Fleet sizes from the online version of the second survey were calculated by summing the number of vehicles they reported for each vehicle type.

When registering for the webinar, registrants were asked to classify their fleet as small (< 100 vehicles), medium (100-999 vehicles), or large (> 999 vehicles). Nearly half of all Survey 2 respondents were small (45%), nearly a third were medium (31%), and nearly a quarter were large (24%) (*Figure A-6*).

Figure A-5. Survey 2, Online: Quantity of Each Vehicle Type

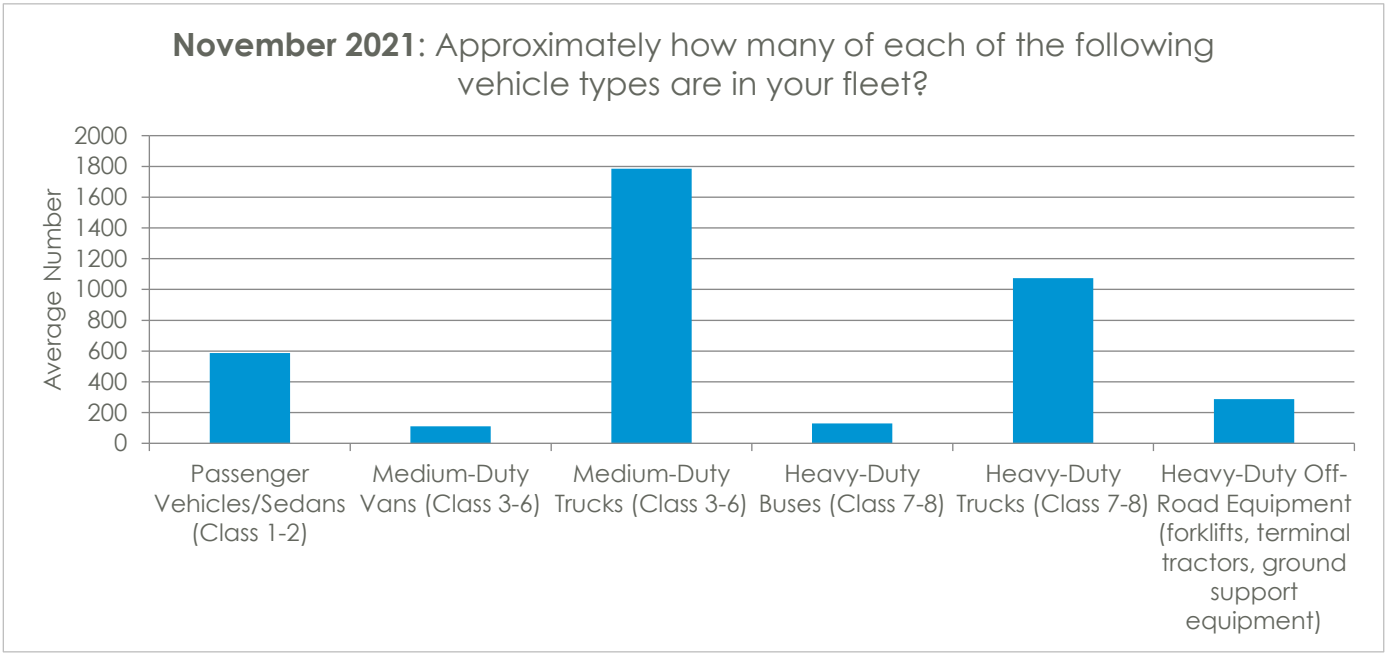
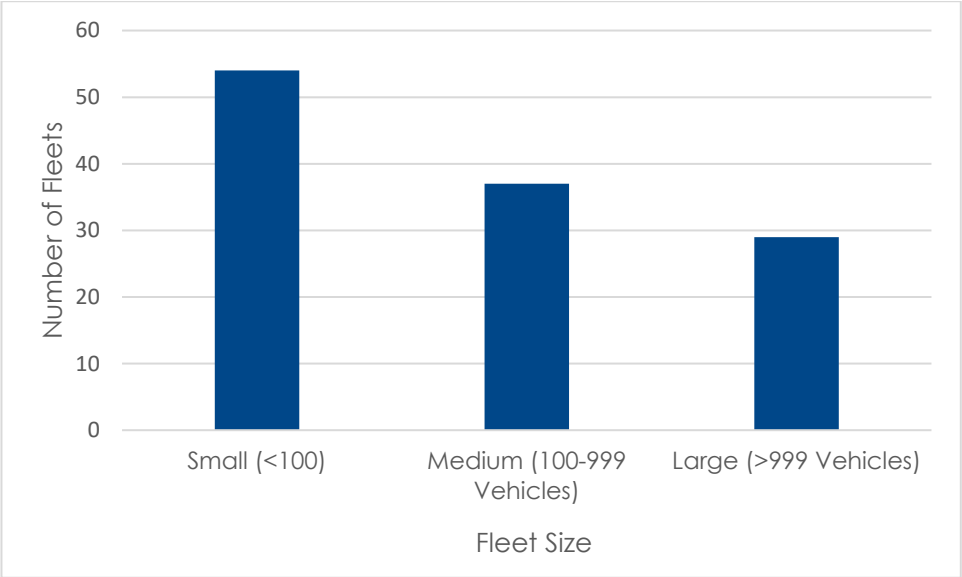


Figure A-6. Survey 2: Fleet Size

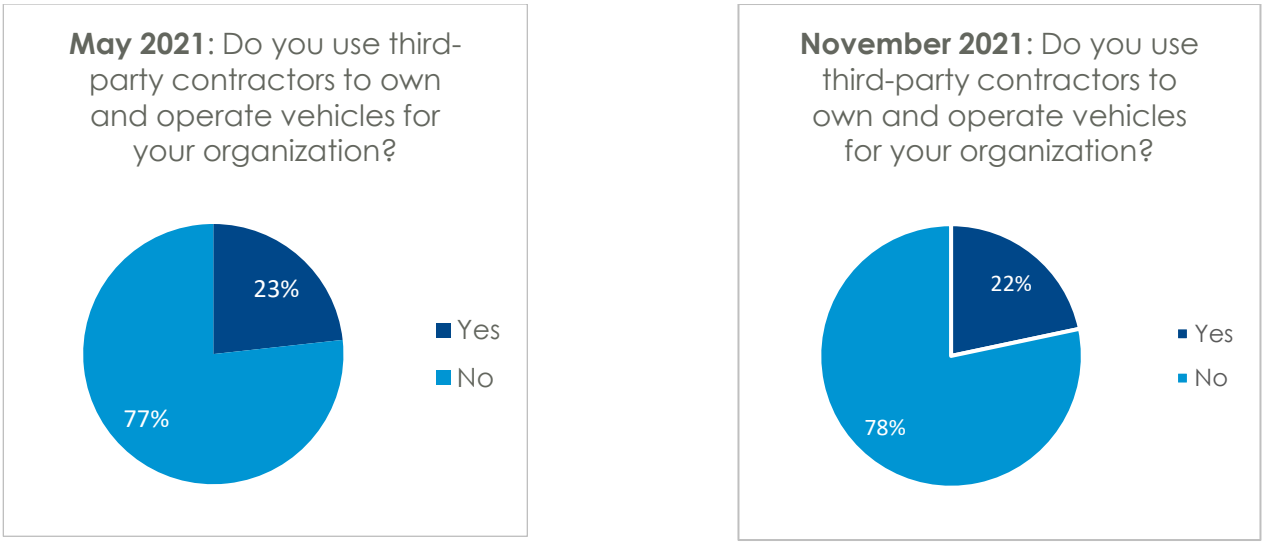


Third-Party Contractors

The final question that served partially to assess the state of the industry and to better understand the specific participants asked whether respondents used third-party contractors to own and operate their vehicles. Over 75% of respondents reported that they do not use third-party contractors to own and operate vehicles for their organizations. This percentage was consistent

throughout both phases of data collection (*Figure A-7a-b*).

Figure A-7a-b. Third-Party Contractors



Electrification within Fleets

Fleet Electrification Status

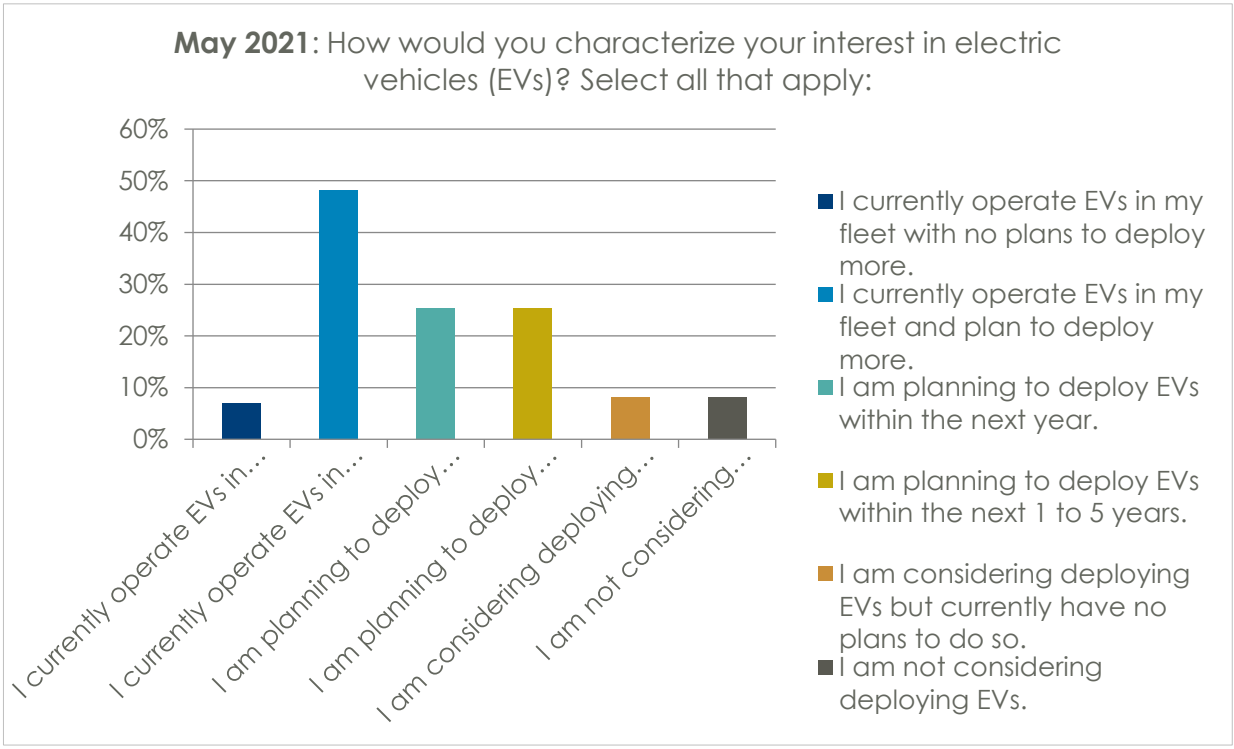
Managed charging is an emerging infrastructure strategy growing in popularity with the increase in fleet electrification. To contextualize the findings from this report, the electrification status of the participating fleets must be understood. Fleets that have not started conversations about electrifying their vehicles have little reason to know about managed charging solutions, but as fleets consider EVs—and then order and deploy them—understanding what managed charging is and how it can help fleets becomes extremely important.

Participants were asked to describe their fleets in terms of electrification status: whether they currently have EVs in their fleet and whether they plan to add EVs to their fleet (*Figure A-8*). The survey did not define EVs—in the context of this research, an EV primarily refers to a battery-electric vehicle (BEV). Managed charging was specifically called out in each method of outreach and in the webinar description, which naturally precluded participants from responding about hydrogen fuel cell electric vehicles given that BEVs are charged in a different manner.

In addition to BEVs, plug-in hybrid vehicles (PHEVs) can also fall under the broader classification of EVs and can be impacted by charging. However, the majority of responses, if not all, reflect BEVs for two reasons: first, charging is not as essential to the function of PHEVs as it is to BEVs, and PHEVs use fossil fuels. PHEVs have smaller battery sizes, so charging time is not as large of a factor in their operation. Second, given the focus on outreach to medium- and heavy-duty fleets, it is unlikely

that respondents had PHEVs in mind when answering the questions. Electrification efforts and vehicle availability in these classes and categories is focused on BEVs. Likewise, electrification efforts across fleets are focused on BEVs rather than PHEVs. Legislation and regulations centered on EVs and the environmental impact of traditional transportation target BEVs rather than PHEVs; PHEVs still generate pollution and do not have the strong environmental benefits of BEVs.

Figure A-8. Survey 1: Interest in Electric Vehicles

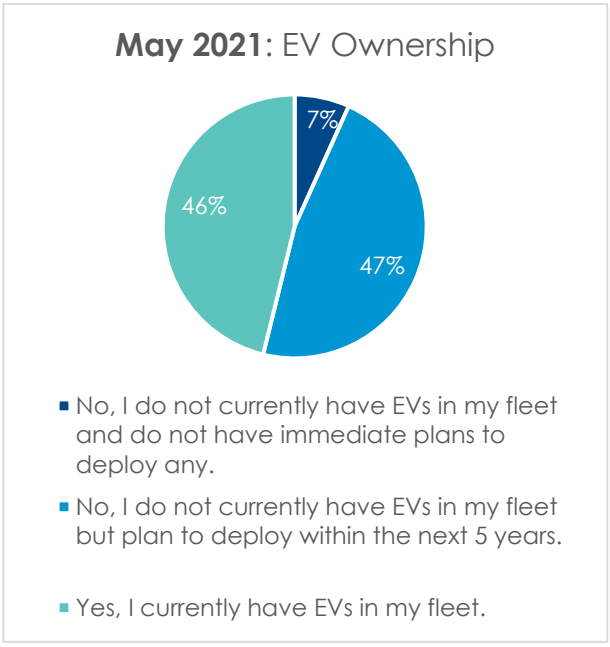


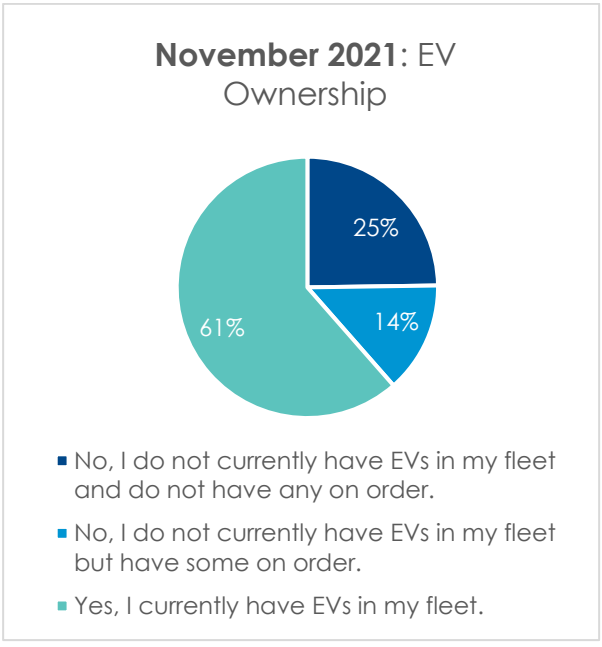
EV Ownership

Overall, EV ownership increased from 46% to 61% between the first and second surveys. In the first survey, participants were asked to classify their EV ownership and fleet electrification plans within the same question (*Figure A-8*). This format was then changed for the second survey, so information from the first survey was re-formatted in this analysis for a more straightforward comparison. Additionally, respondents who did not represent a fleet were excluded from the results, as some individuals responded that they do not have EVs in their fleet and do not plan to deploy EVs. This information skewed results from reflecting EV ownership and plans among fleets.

Between administration of the first survey and second survey, the number of fleets with EVs increased by 15%. However, the number of respondents who did not have any on order increased and the number with EVs on order decreased (*Figure A-9a-b*).

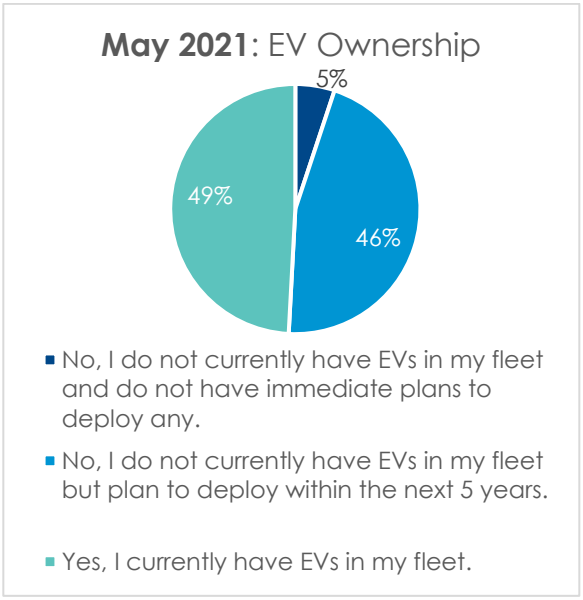
Figure A-9a-b. EV Ownership

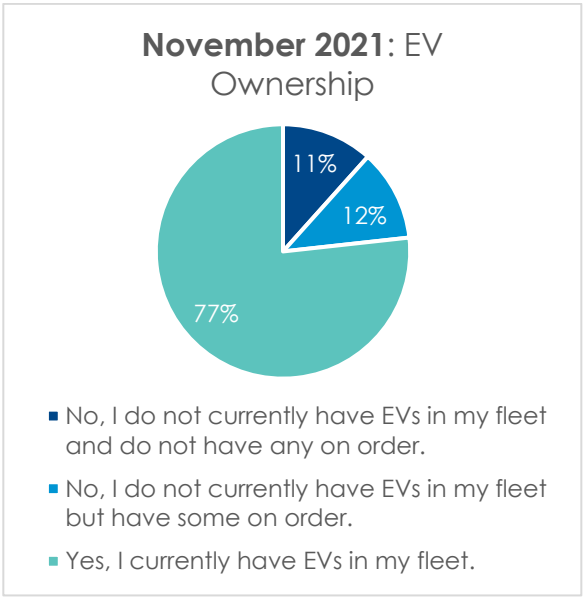




These results can seem concerning, as there was an increase in the percentage of fleets without EVs or EVs on order. To eliminate variability from different respondents in the first versus second survey, responses from only the 48 participants that participated in both were assessed. When looking at these 48 respondents, the trend of EV ownership, including an increase in the number of respondents who do not have EV or have any on order, was the same. A likely explanation for these findings is due to the different question formats; the answers from the first survey did not translate well into those of the second. In the first survey, EV orders were never specifically asked about, so answers about deploying EVs within the next five years were counted as the closest measure. Inconsistency between Survey 1 and 2 is most likely related to respondents answering that they were planning to deploy EVs within five years but did not have any ordered. The response about owning EVs, however, was very clear in both versions, so one can conclude that there has been an increase in EV purchases and deliveries between the two surveys (*Figure A-10a-b*).

Figure A-10a-b. EV Ownership – Direct Comparison



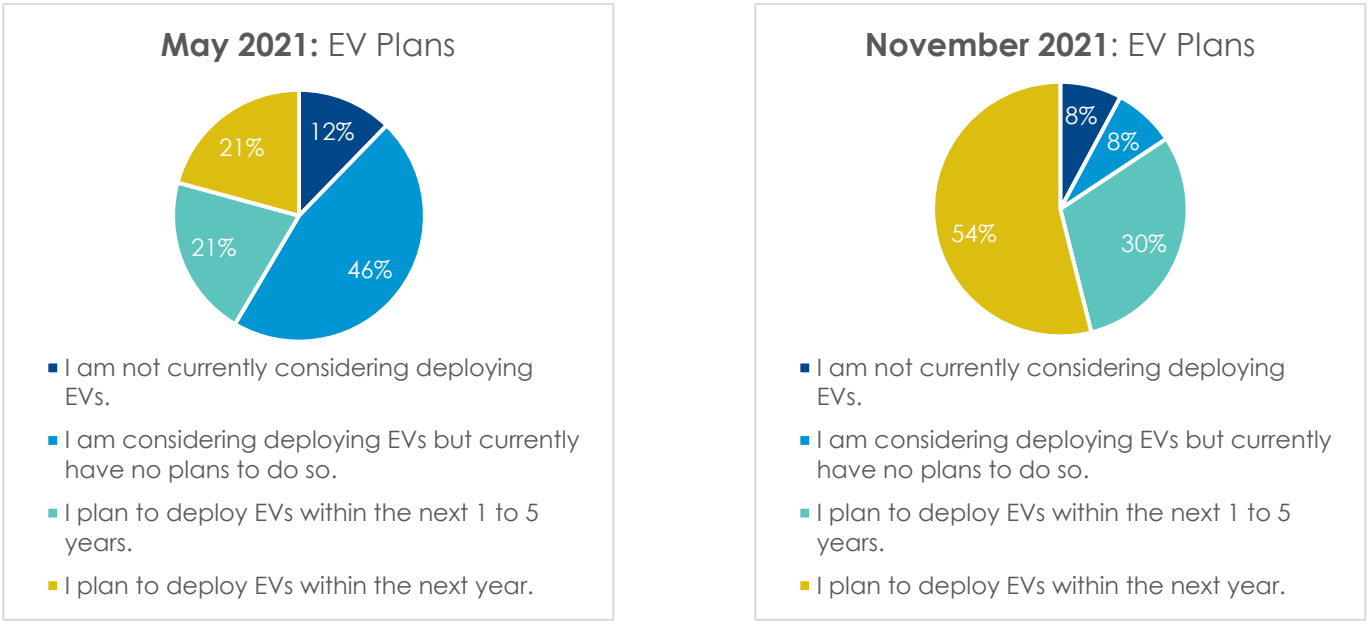


Electrification Plans

Similarly, to EV ownership, it is important to understand more generally respondents' plans related to owning and operating EVs. The closer a respondent is to having a full fleet of EVs, the more critical it is to understand different managed charging strategies. At the other end of the spectrum, educating people who do not plan to procure EVs on managed charging options is important, as some of the concerns they may have about owning EVs may be remedied with managed charging solutions.

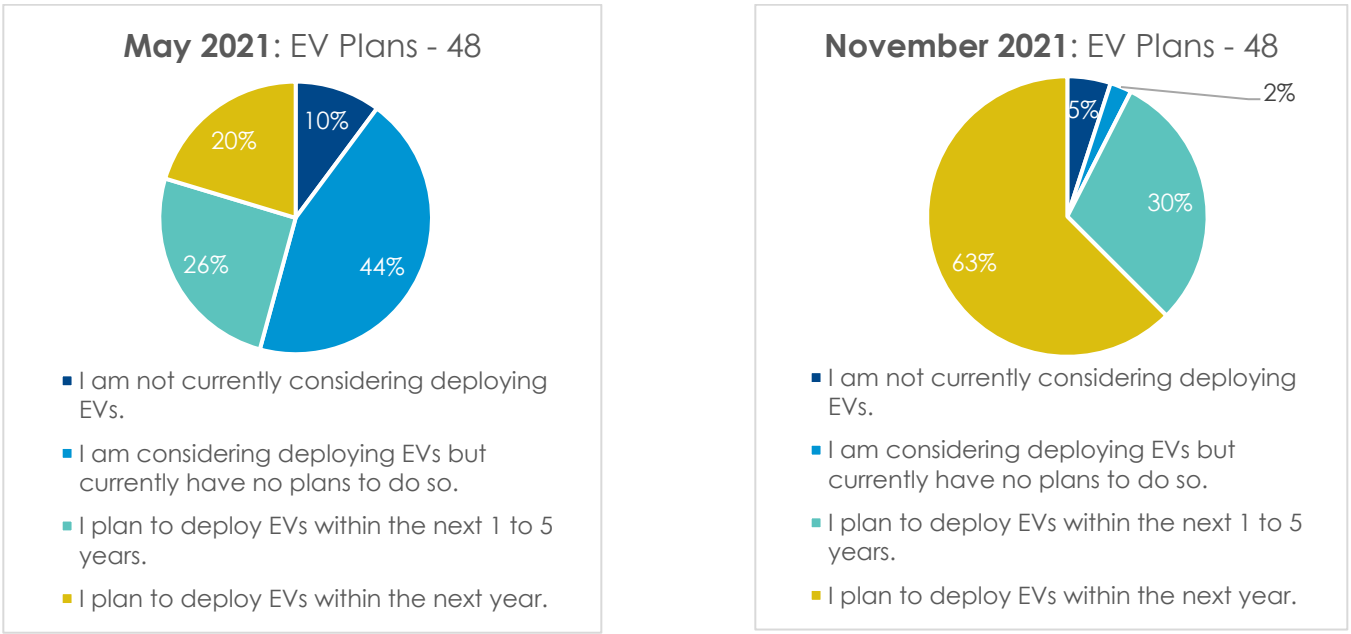
Between the two surveys, there was a growth of 33% in the number of participants that planned to deploy EVs within the next year and a decrease of 4% in terms of respondents who are not considering deploying EVs. Unlike the comparisons for EV ownership, the response options about EV plans within the first survey directly correlate with answers in the second survey. In the first survey, responses about EV plans were mixed with responses about EV ownership within the same question, so these responses were reorganized according to the plan portion of the responses (*Figure A-11a-b*).

Figure A-11a-b. EV Plans



Between the time that the first survey was administered and the time that the polls and second survey were administered, there was a large increase in the percentage of respondents who plan to deploy EVs. A total of 41% of respondents in the first survey and 84% of respondents in the second survey had plans to deploy EVs in five years or less (*Figure A-12a-b*).

Figure A-12a-b. EV Plans – Direct Comparison



In looking at the number of respondents who currently operate EVs but do not have plans to deploy more (*Figure A-12a-b*), CALSTART considered the possibility that those respondents were smaller fleets that were already fully or almost fully electrified. Given how responses were framed, this theory was investigated using data from the first survey. Exact fleet sizes were not measured in the first survey, but estimates were made by summing the number of vehicles estimated in each vehicle type. Half of the respondents that had EVs and did not plan to deploy more had five or fewer vehicles in their fleets, so it is possible that they were fully electrified. The other respondents that had EVs and did not have plans to further electrify primarily had fleets with less than 100 vehicles. Only one respondent had a fleet with over 100 vehicles.

Obstacles to EV Adoption

The final key piece to understanding fleets and their electrification status and plans is to know the greatest barriers to their adoption of EVs. This is important for fleets in all stages, from fully electrified fleets to fleets that have no plans to electrify their vehicles, so that different solutions can be crafted to help fleets, or in cases where the solutions already exist, education and outreach can be shaped to inform fleets of what they most need to know.

The first survey found that the cost of vehicles, vehicles not meeting operational needs, and the cost of charging infrastructure were the greatest obstacles to fleet electrification, while the lowest ranking obstacles were uncertainty regarding cost of electricity and uncertainty regarding how to get electricity. In the first survey, participants were asked to rank each of the nine obstacles from most to least important. The responses were then weighted according to their rank (*Table A-2*). A score of 9 would represent if every person selected the same answer as the most important, and a score of 1 would represent if every person selected the same answer as the smallest barrier to EV adoption.

Table A-2. Survey 1: Rank of Obstacles to EV Adoption

Obstacle	Score
Cost of vehicles	7.02
Vehicles not meeting operational needs (range, payload)	6.7
Cost of charging infrastructure	6.5
Lack of EVs with desired vehicle specifications	5.22
Utility service upgrade timeline and costs	4.58
Refueling times	4.49
Needing to modify maintenance/operations practices	4.31
Uncertainty regarding cost of electricity	3.84
Uncertainty regarding how to get started with the process of planning for EVs	2.56

During the collection period for the first survey, some respondents provided feedback stating the mechanism for ranking the obstacles was confusing or took time to decipher. The survey was structured so that respondents could either click and drag the obstacles into order of greatest obstacle to smallest, or they could use a dropdown menu to select a rank number from 1 to 9. If using the dropdown menu, participants were restricted from selecting the same rank for more than one obstacle. As a result of this feedback, this question was reformatted for both collection methods of the second survey.

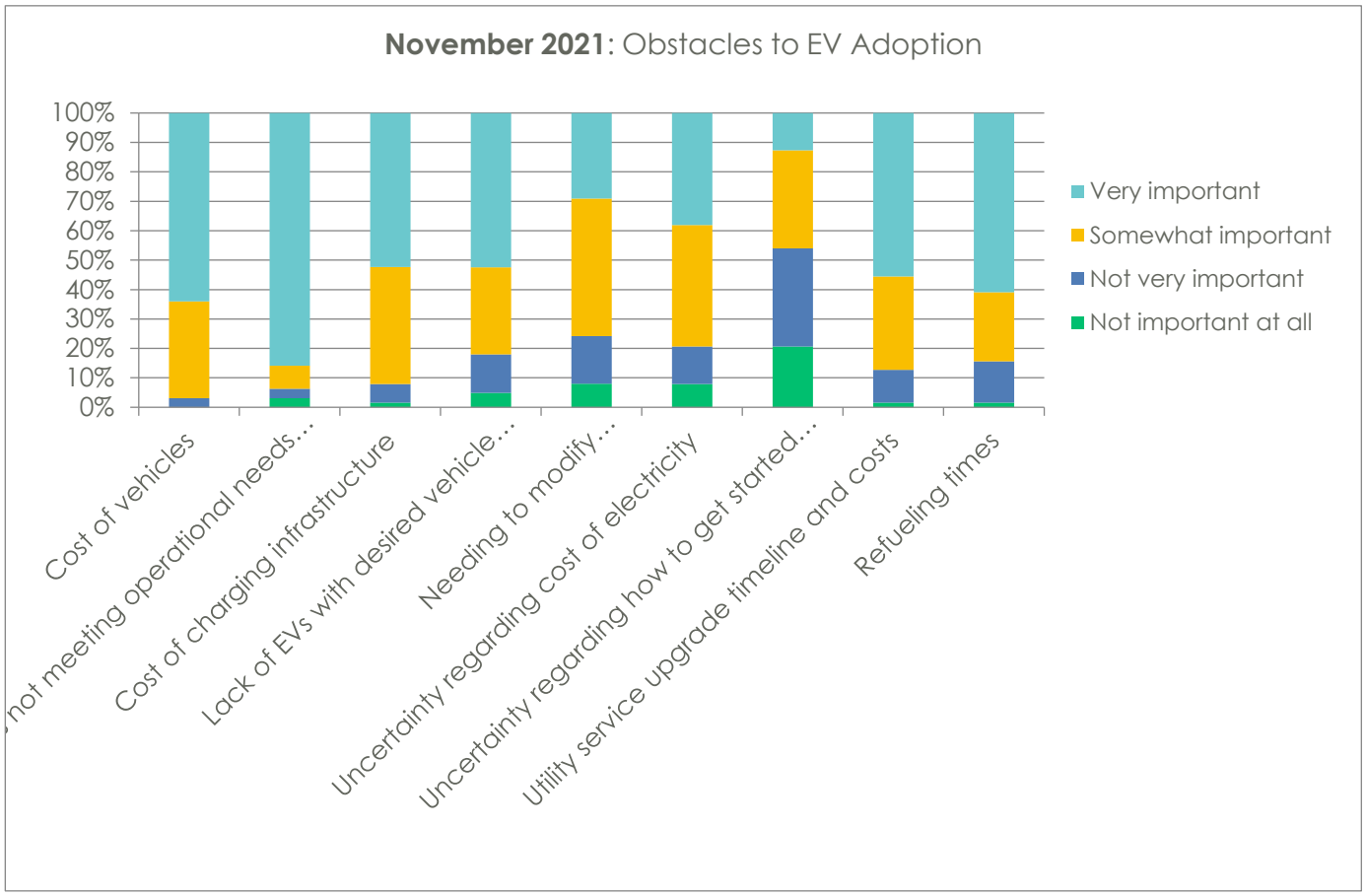
The webinar polls found that vehicles not meeting operational needs was the most critical barrier to EV adoption, and utility service upgrade timeline and costs was also a significant obstacle. During the webinar, based on the functionality available within Zoom polls and time constraints within the webinar, participants were asked to select the one obstacle they considered to be the greatest in preventing their organizations' adoption of EVs. These answers were then used to rank the obstacles from most important to least important based on the number of participants that selected the item as most important (*Table A-3*).

Table A-3. Poll: Greatest Barrier to Fleet's EV Adoption

Obstacle	Count
Vehicles not meeting operational needs (range, payload)	20
Utility service upgrade timeline and costs	12
Cost of charging infrastructure	8
Lack of EVs with desired vehicle specifications	7
Uncertainty regarding how to get started with the process of planning for EVs	4
Refueling times	2
Needing to modify maintenance/operations practices	1
Cost of vehicles	0
Uncertainty regarding cost of electricity	0

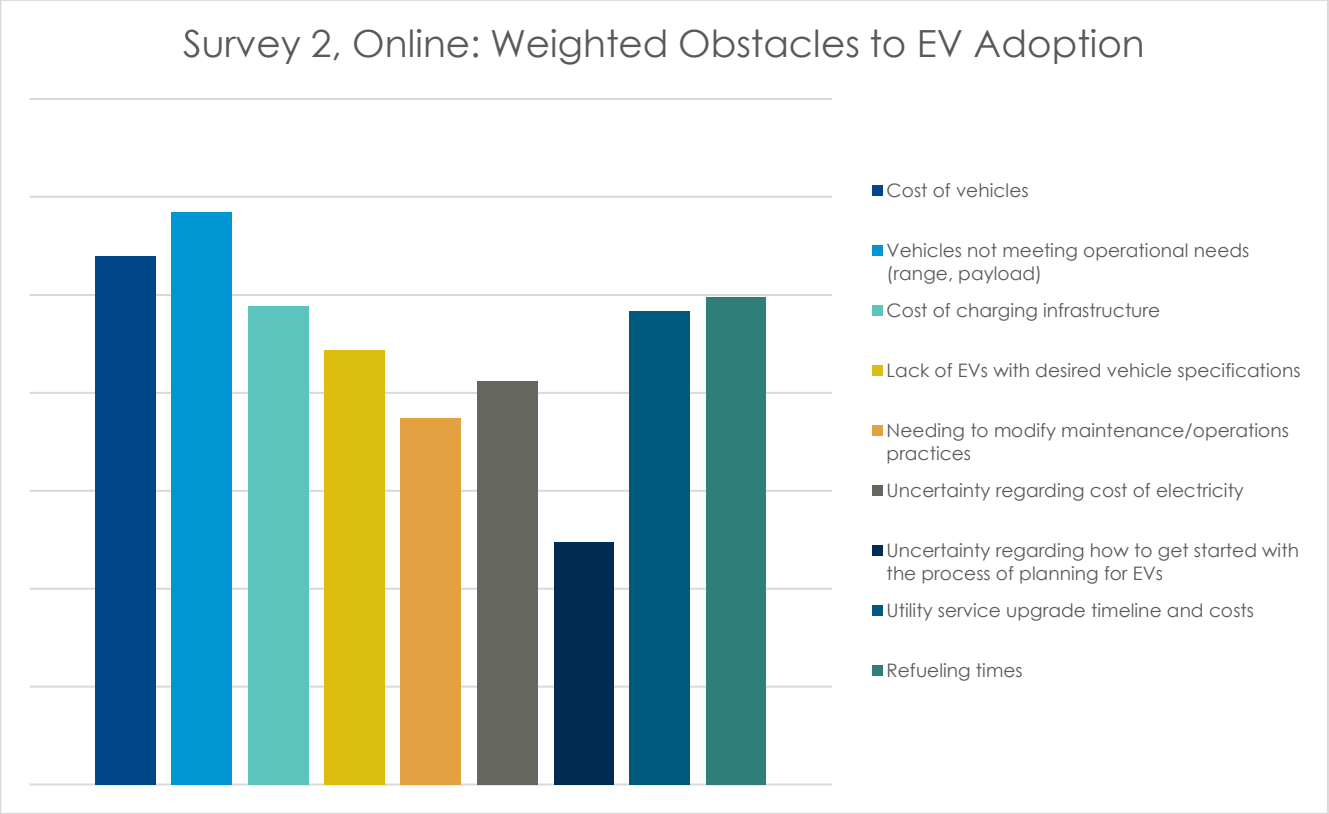
Finally, the online version of the second survey asked respondents to rate the importance of each of the obstacles (*Figure A-13*). This format was different from both the first survey and the webinar polls based on feedback collected throughout. Because this question allowed participants to rate multiple barriers with the same level of importance, additional calculations were necessary to measure how they compared. For instance, vehicles not meeting operational needs had the greatest number of participants rank it as very important, but some still said it was not important at all. On the other hand, less participants said that the cost of vehicles is very important, but none said that it is not important at all. In order to reconcile these results and combine them into one cohesive finding, the online results from the second survey were weighted. "Very Important" was given a weight of 5 points, "Somewhat Important" a weight of 3, and "Not Very Important" was given 1 point (*Figure A-14*).

Figure A-13. Survey 2: Importance of Obstacles to Adoption of EVs



When comparing responses from the different collection methods and times, there was a change in the ranking of the obstacles. In the first survey, cost of vehicles was the most important, and it was very important in the second survey as well. However, not one participant in the webinar selected cost of vehicles as the biggest barrier to their EV adoption.

Figure A-14. Survey 2, Online: Weighted Obstacles to EV Adoption



In looking at the ranking of the obstacles and how it changed over time, the webinar polls and online distribution for the second survey occurred at the same time but were largely different (*Figures A-13 and A-14*). As such, most comparisons over time could not be made. Between the first and second surveys, the importance of vehicles not meeting operational needs increased from second most important in the first survey to most important in both the webinar polls and online distribution of the second survey (*Table A-4*). Other obstacles that were consistently ranked as important across each group were cost of charging infrastructure and cost of vehicles. Obstacles that were generally not ranked as very important compared to the other obstacles were uncertainty regarding how to get started with the process of planning, uncertainty regarding cost of electricity, and needing to modify maintenance/operations practices.

Table A-4. Ranks of Obstacles to EV Adoption

May 2021 Online Survey	October 2021 Webinar Polls	November 2021 Online Survey
Cost of vehicles	Vehicles not meeting operational needs (range, payload)	Vehicles not meeting operational needs (range, payload)
Vehicles not meeting operational needs (range, payload)	Utility service upgrade timeline and costs	Cost of vehicles
Cost of charging infrastructure	Cost of charging infrastructure	Refueling times
Lack of EVs with desired vehicle specifications	Lack of EVs with desired vehicle specifications	Cost of charging infrastructure
Utility service upgrade timeline and costs	Uncertainty regarding how to get started with the process of planning for EVs	Utility service upgrade timeline and costs
Refueling times	Refueling times	Lack of EVs with desired vehicle specifications
Needing to modify maintenance/operations practices	Needing to modify maintenance/operations practices	Uncertainty regarding cost of electricity
Uncertainty regarding cost of electricity	Cost of vehicles	Needing to modify maintenance/operations practices
Uncertainty regarding how to get started with the process of planning for EVs	Uncertainty regarding cost of electricity	Uncertainty regarding how to get started with the process of planning for EVs

Looking further into the most important obstacles to EV adoption, respondents in the first survey who responded that they had no plans to deploy EVs had the same top three obstacles as in the general pool of respondents. However, there was a stronger difference between the ratings of the top three and the rest of the obstacles, indicating that there was stronger agreement for the top three obstacles within this sub-group.

Another consideration when looking at barriers to EV adoption is the impact of incentive programs. While various incentive programs for EVs exist in various parts of the country, California and New York have more robust incentive projects than other states. As such, the ranking of obstacles for fleets domiciled in California and New York from the first survey were compared against the rest of the country (*Table A-5*).

Table A-5. Rank of the Importance of Obstacles by State

By State: Rank of the importance of obstacles to your organization's adoption of EVs		
Rank	**Respondents from California and New York**	**Respondents from outside California and New York**
1	Cost of vehicles	Cost of vehicles
2	Vehicles not meeting operational needs (range, payload)	Vehicles not meeting operational needs (range, payload)
3	Cost of charging infrastructure	Cost of charging infrastructure
4	Lack of EVs with desired vehicle specifications	Lack of EVs with desired vehicle specifications
5	Utility service upgrade timeline and costs	Utility service upgrade timeline and costs
6	Refueling times	Refueling times
7	Needing to modify maintenance/operations practices	Needing to modify maintenance/operations practices
8	Uncertainty regarding cost of electricity	Uncertainty regarding cost of electricity
9	Uncertainty regarding how to get started with the process of planning for EVs	Uncertainty regarding how to get started with the process of planning for EVs

For those with vehicles in California and New York, the top three ranked obstacles were cost of vehicles, vehicles not meeting operational needs, and cost of charging infrastructure, in that order, so cost is still an obstacle. When compared with fleets without vehicles in California or New York, all the obstacles were ranked in the same order. This result indicates that even with the

incentive projects available, fleets across the country still face the same relative challenges with EV costs, regardless of incentive availability.

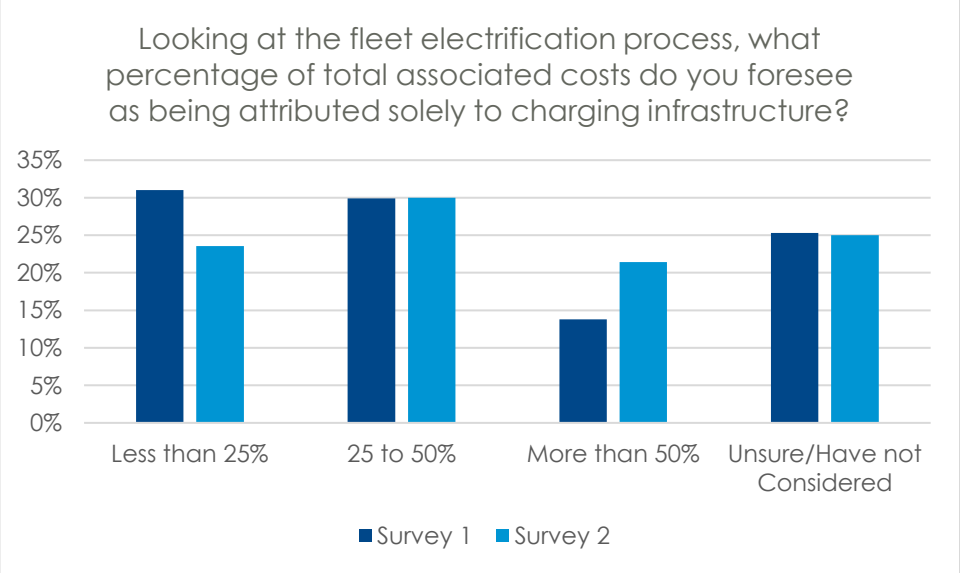
Expected Infrastructure Costs

When electrifying a fleet, the cost of the vehicles is only one part of the overall project costs—the cost of infrastructure must be accounted for. As seen when looking at which barriers were ranked as important to respondents, costs of vehicles and infrastructure are both large barriers to EV adoption. While vehicle costs have been decreasing overall and are generally clear to purchasers, infrastructure costs are still obscure to many people and are not as well understood. Part of this confusion stems from the various elements that go into infrastructure costs. These costs include not only the charging equipment itself but the wiring and any electrical upgrades needed to support it. Electrical upgrades can range from relatively minor, such as a new electrical panel, to including substation upgrades and major renovations.

To find out what people expect charging infrastructure costs to be, participants were asked what percentage of total associated costs of the fleet electrification process they foresee as being attributed solely to charging infrastructure. One main determinant of cost is the size of the EV fleet, which varies greatly. Asking for a percentage of total project costs would allow for a more standardized measure that could apply evenly to all EV deployments.

Between the first survey and the poll and second survey, the percentage of respondents unsure of infrastructure costs remained consistent (25%). There was also a slight shift towards thinking charging infrastructure costs would be a higher percentage of project costs (*Figure A-15*).

Figure A-15. Charging Infrastructure Costs



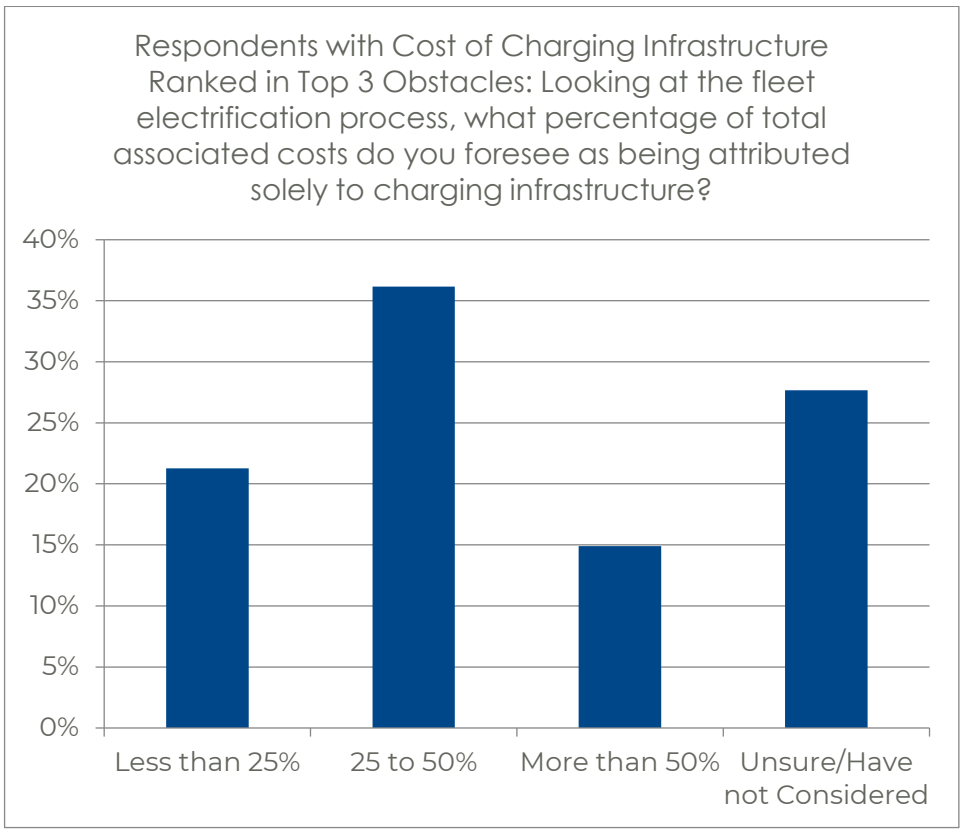
Even when fleet size is controlled, many different factors determine what infrastructure costs will

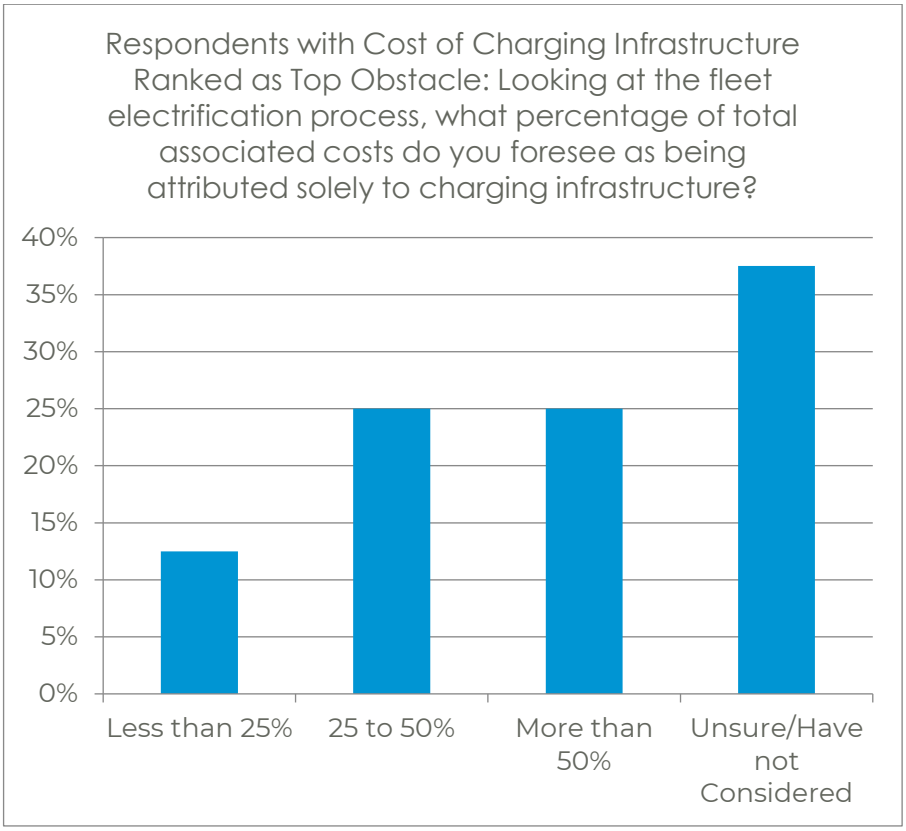
be. Based on experience with fleet electrification, the costs associated with charging infrastructure are typically less than 30% of the overall project costs, and only in extreme cases do such costs account for more than 50% of the overall project costs.

When looking at EV infrastructure costs, one variable that can have a large impact is whether a fleet has planned ahead. When upgrading a property to support EVs, it is important to make spaces EV-ready for future vehicles. The cost to retrofit a parking space with EV infrastructure can be around four times the cost of installing infrastructure during initial construction (CALSTART et al., 2020).

Using only data from the first survey, respondents who ranked cost of charging infrastructure in their top three barriers to EV adoption were assessed for infrastructure costs expectations. Their estimations of charging infrastructure costs were scattered (*Figure A-16a-b*). Likewise, when looking only at those that selected charging infrastructure cost as the number one obstacle to their adoption of EVs, there was not a clear trend in cost estimations. Only one such respondent believed costs would be less than 25%.

Figure A-16a-b. Charging Infrastructure Cost Estimations When Viewed as a Top Obstacle




Respondents with Cost of Charging Infrastructure Ranked as Top Obstacle: Looking at the fleet electrification process, what percentage of total associated costs do you foresee as being attributed solely to charging infrastructure?
40%
35%
30%
25%
20%
15%
10%
5%
0%
Less than 25%
25 to 50%
More than 50%
Unsure/Have not Considered

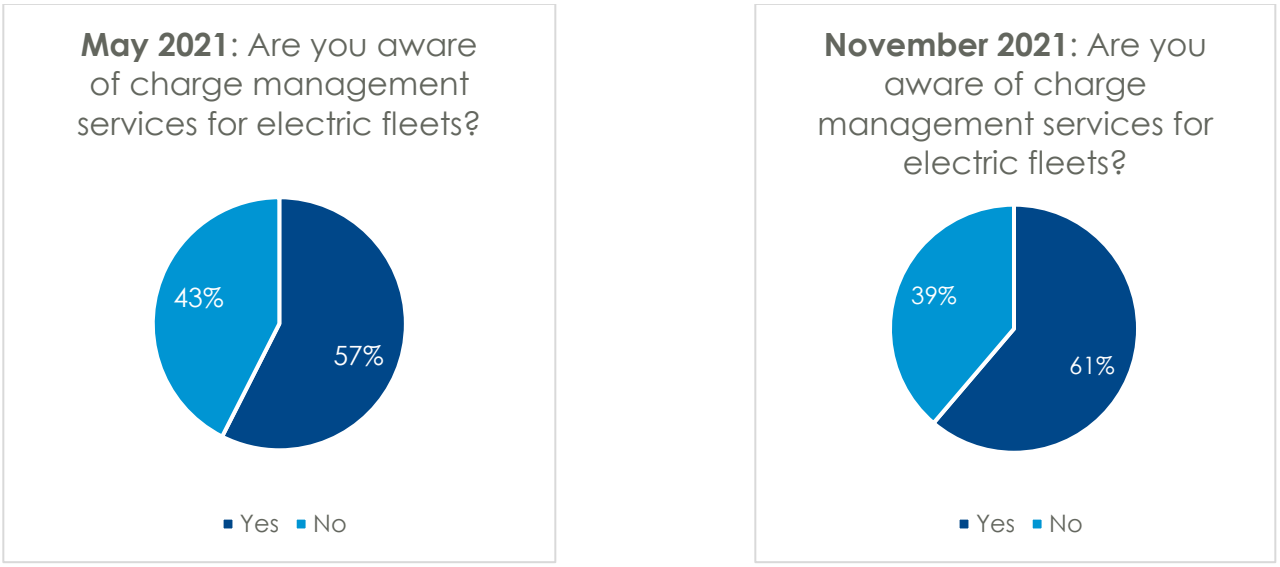
Managed Charging

Managed Charging Awareness

As is evident in the responses to the other survey questions, the costs, planning, and operational changes associated with charging EVs are important to address when looking at fleet electrification. Managed charging, which includes a variety of different approaches, has the potential to address all those barriers and concerns. Managed charging means EV charging has "central or customer control of EV charging to provide vehicle grid integration offerings, including wholesale market services" (Blair et al., 2021).

For the purposes of this data, managed charging or charge management services (CMS) was not defined for participants when completing either survey. Managed charging was defined and explained during the webinar at which the polls were distributed, but the questions related to managed charging were asked before any discussion on or explanation of managed charging occurred.

Figure A-17a-b. Managed Charging Awareness



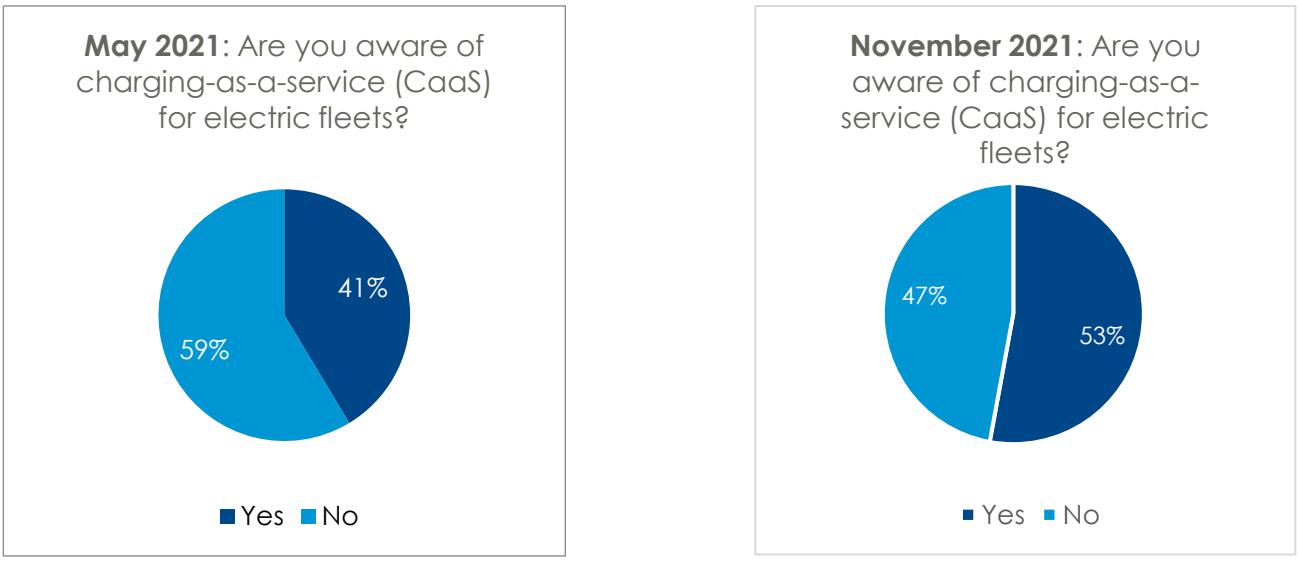
As seen in *Figure A-17a-b*, there was a slight increase (4%) in the percentage of participants that identified themselves as familiar with managed charging between the first and second surveys. Although the increase is promising, there is still a significant amount of work to do in this area. At the time of the second survey, 39% said that they are not aware of CMS. Given the percentage of people that plan to electrify part or all of their fleet, one would hope and expect that more respondents would be familiar with CMS.

Charging-as-a-Service (CaaS)

Under the umbrella of managed charging, there are many different solutions. One key approach is known as charging-as-a-service (CaaS). CaaS is a type of managed charging in which rather than paying for each aspect of EV infrastructure, equipment, software, and electrical upgrades in addition to paying for electricity, the user pays a fixed amount, or subscription, for each kilowatt-hour used, which includes the costs for the project design, deployment, operation, and support and maintenance (Palmer, 2021).

CaaS shifts many duties from the fleet to their CaaS provider. It allows for more stable and predictable costs and allows companies and organizations with the proper expertise to handle all charging services. This approach relieves much of the pressures that would otherwise be on the fleet and operators. CaaS is increasing in popularity, but there are still many fleets that do not know this approach is an option. Within the first survey, less than half (41%) of respondents said that they were familiar with CaaS. However, the second survey found that just over half (53%) were now familiar with CaaS, so there was measurable growth within the second half of 2021 (*Figure A-18a-b*).

Figure A-18a-b. CaaS Awareness



Types of Managed Charging

In addition to CaaS, there are a variety of other strategies and approaches to EV charging that help eliminate barriers to electrification. The terms below in *Table A-6* are all different solutions or other approaches under the umbrella of managed charging to help fleets adopt EVs. These terms were not defined within the surveys; rather, each participant selected which they were already familiar with.

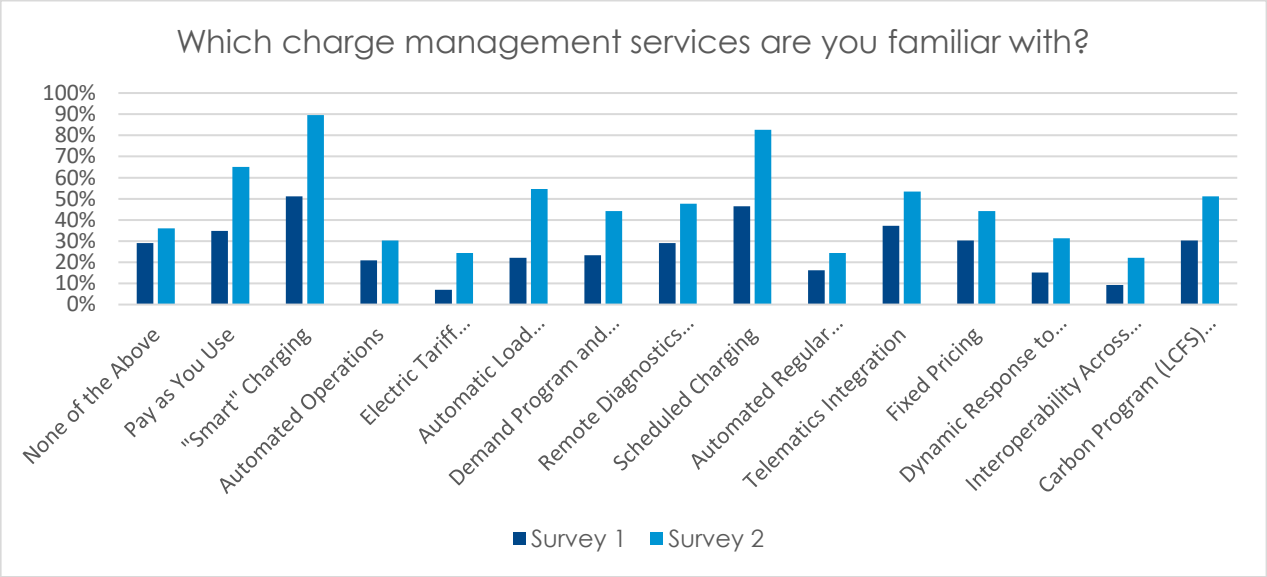
Table A-6. Managed Charging Strategy Definitions

Managed Charging Strategy	Definition	Managed Charging Type
Automated operations	Charging operations that do not require manual activation or switching between vehicles	Active
Automated regular reporting	Reports on EV charging and usage are generated on a regular basis and communicated to relevant parties without requiring user action	Active
Automatic load management	An automated system for monitoring and controlling electrical load "voltage, current, power, phase sequence, and network consistency" (ABB, n.d. b)	Active
Carbon Program (Low-Carbon Fuel Standard) Participation	Programs that grant credits to operators that use fuels below a certain carbon intensity threshold (CARB, n.d.)	Passive
Demand program and grid services participation	Programs to restrict energy usage during peak demand times (Budhiraja, 2019)	Passive
Dynamic response to changing vehicle assignments	Charge management software that automatically shifts charging power to whichever vehicle needs the most charge based on anticipated energy needs	Active
Electric tariff optimization	Identifying and utilizing the tariff that offers the best value (Utilitas Solutions, n.d.)	Passive
Fixed pricing	EV charging costs that do not vary depending on time of use	Passive
Interoperability across heterogenous chargers and vehicle makes and models	Ability of different EVs and chargers to seamlessly communicate and function together	Active
Pay as you use	Paying for electric charging equipment and electricity as it is used	Passive
Remote diagnostics and troubleshooting	Diagnostics and troubleshooting for EV charging equipment performed remotely through integrated software (ABB, n.d. a)	Active
Scheduled charging	EVs can be plugged into charging equipment but charging does not begin until programmed to do so	Active
Smart charging	When an EV charger that has communication technology, such as Wi-Fi, that allows data to be collected and viewed (U.S. Gain, 2021)	Active
Telematics integration	Cloud-based data collection linked with the EV charging equipment	Active

Of these different solutions, smart charging was the most recognized across both surveys, with

scheduled charging also being highly recognized. Participants across all three collection methods were able to select all the CMS options that they were familiar with from the list above. The general pattern of which services were most familiar was the same between both surveys. Additionally, between the first and second surveys, there was a slight increase in the percentage of people who selected that they were not familiar with any of the items, but generally, the percentage of people familiar with each term increased (*Figure A-19*). This means that while there were more people unfamiliar with CMS, those that were aware of some of the offerings proceeded to learn about additional options in the time between surveys.

Figure A-19. Charge Management Term Familiarity



The CMS terms that people were least familiar with were automated operations, electric tariff optimization, automated regular reporting, and interoperability across heterogeneous chargers and vehicles. It is possible that respondents were familiar with the ideas behind them but not the terms themselves. Interoperability—the ability for software to manage different charger makes across a heterogeneous fleet—with different chargers and vehicles is also something that people are likely aware of but may not have recognized in the context of managed charging. These all represent areas for increased education. One of the benefits of options like CaaS is that some CaaS providers incorporate potentially unfamiliar services and therefore still allow individuals to reap the benefits those additional services provide.