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Electrifying California Fleets: Investigating Light-Duty Vehicle Purchase Decisions

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Summary

This paper uses interviews conducted with 23 fleet managers across California to investigate fleet adoption of Plug-in Electric Vehicles (PEVs). The interviews examined how fleet managers make vehicle purchase decisions and the motivations and barriers for PEV adoption. The results provide a greater understanding of fleet PEV purchasing. Results show PEVs do not align with conventional vehicle purchase processes, but fleet managers are purchasing PEVs, typically due to requirements to do so set by the organization in which the fleets reside. The results can inform how stakeholders could facilitate increased electric vehicle adoption in fleets.

Keywords: EV (electric vehicle), Fleet, Light Vehicles

1 Introduction

This paper investigates how fleet managers make vehicle purchase decisions and how Plug-in Electric Vehicles (PEVs), including Battery Electric Vehicles (BEVs) and Plug-in Hybrid Electric Vehicles (PHEVs), align with this. We use insights from semi-structured interviews with 23 fleet managers conducted across California in 2019. Each interview examined how fleet managers make vehicle purchase decisions and explored the motivations and barriers for the adoption of PEVs. A comparison of these processes within each organization is analyzed to provide a complete picture of the ways in which current fleet purchase processes allow or dissuade PEV purchases.

The results presented here are a truncated version of the full study published in Transportation Research Interdisciplinary Perspectives [1]. It develops an understanding of the degree to which purchase motivations are internal or external, and how PEVs are aligned with conventional vehicle purchasing. This helps create a broader understanding of how fleets make vehicle purchase decisions with a focus on the motivation of the fleet managers, how electric vehicles fit it into that, and how to foster growth in fleet vehicle electrification.

The high average mileage of fleet vehicles makes the replacement of these vehicles with low and zero emission equivalents an important milestone for meeting tightening emissions targets. While this work is most closely tied to helping California meet their standards [2], it also has global ramifications as it can be used to help other regions transition to electrification and meet global emissions targets, such as commitments made under the Paris

Climate Agreement [3]. Given the centralized purchasing of fleet vehicles, there is a greater opportunity to electrify many vehicles with a smaller number of people involved.

California fleet vehicles are eligible for several incentives including the state-run Clean Vehicle Rebate Program and local programs through utilities and air districts. While fleets can qualify for the federal tax credit for PEVs, many public fleets do not have a federal tax liability, therefore the credit amount cannot be applied. California fleets are also subject to the recent executive order N-79-20, requiring all in-state vehicle sales to be zero-emission by 2035. The interviews presented here were conducted before this regulation was enacted, but can help inform the needs of fleets to help meet these goals [4].

1.1 INTRODUCTION TO SELF-DETERMINATION THEORY

We use Self-Determination Theory (SDT) to provide a deeper understanding of the underlying motivators for fleet managers when making purchase decisions. Understanding fleet manager motivations provides a clearer view of what influences fleet purchasing and what aspects of fleet purchasing policymakers or other stakeholders should seek to influence to increase fleet electrification.

Figure 1 provides a simplified summary of SDT, which categorizes motivations along a spectrum of intrinsic and extrinsic motivations, as well as amotivation [5]. Amotivation is the lack of motivation or attention given to something, it is done without much thought or reason. Intrinsic motivations are derived from a person's own desire to do something because they receive satisfaction from doing the activity itself. This contrasts with extrinsic motivations where a person is motivated externally in some way. The theory defines four separate types of extrinsic motivations: integrated regulations, identified regulation, introjected regulation, and external regulations. "External regulations" are the most externally regulated and are controlled, initiated, and maintained by an external source. The next most controlled motivation is "introjected regulation" which includes pressures to do something to protect a person's self-esteem or ego. Here, regulations originate from an external source, but have begun to be internalized by the individual. In the middle of the spectrum, "identified regulation" involves behaviors that are more aligned with an individual's personal goals and identities, meaning they help them achieve something they are working towards and are mostly from internal sources. "Integrated regulation" is the most internalized type of extrinsic motivation and involves behaviors seen as being a true part of a person's identity and aiding in their sense of self. This type of motivation comes from a person's own understanding that the action is fundamentally the right thing to do. Though the latter two categories are partially or fully internally motivated, the goals they are working towards are still due to reasons extrinsic to the self, hence they are not intrinsic motivations.

SDT defines internalization as a process where people take the external values, attitudes, or regulatory structures and transform them into self-motivations. In this process, employees begin to accept the company's goals as their own and thus commit to achieving them. This moves extrinsic motivations down the spectrum, closer to intrinsic motivations.

This theory describes personal motivations within an organization and is outlined by Gagné and Deci [5] as describing "work motivation" and organizational behavior and management. It helps understand individual's motivations within organizations and how these motivations in turn affect the organization, noting that more internalized motivations help promote organizational effectiveness. They note that extrinsic motivation may be the strongest motivator for effective change within the workplace. This theory was chosen for its ability to describe the motivations of the individual within the context of the larger organization as they are the ones making the purchase decisions [6]–[8]. Gagné and Deci [5] report that Self-Determination Theory, "provides a fuller and more useful approach to understanding the motivational bases for effective organizational behavior."

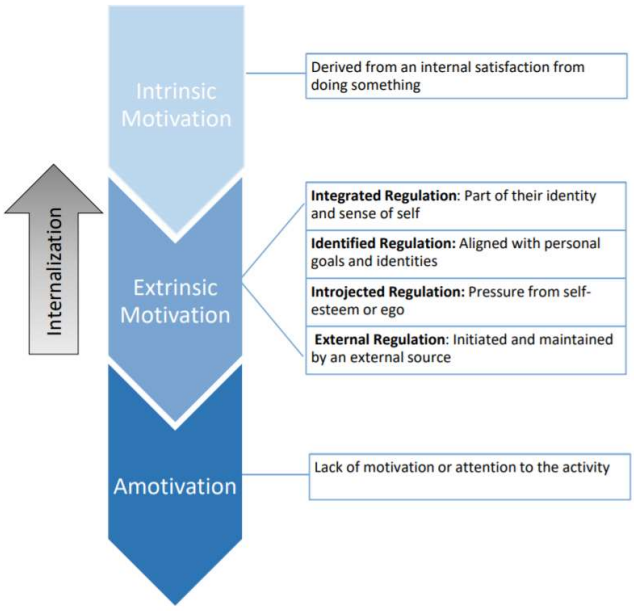

Figure 1: Overview of Self-Determination Theory (Adapted from [5])

2 Methods

2.1 Sample

Data for this paper comes from 23 semi-structured hour-long interviews conducted with fleet managers in California in 2019. The research examined purchasing of both conventional and plug-in vehicles, with one interview excluded from the PEV analysis as the fleet only purchased conventionally fueled vehicles. We classified fleets into small (under 500 vehicles), medium (501-2,000 vehicles), and large (over 2,000 vehicles). The sample contained 6 small, 7 medium, and 9 large fleets. Interviews focused mostly on public organizations such as cities and counties. All fleets included light, medium, and heavy-duty vehicles, but were composed mostly of light and medium duty vehicles. Most light duty vehicles were passenger cars used for administrative work, police vehicles, and pool vehicles for employees to use on an hourly or daily basis.

Interviews explored how fleet managers make vehicle purchase decisions, how fleets are managed, user experiences with PEVs, fleet manager perceptions of how PEVs could fit into their fleet, and how the decision to purchase PEVs was made (if the fleet had PEVs).

2.2 Analysis

Interviews were audio recorded and transcribed, transcripts were reviewed for accuracy and coded by one of the interviewers using the software program NVIVO. The dataset was analyzed using thematic analysis as outlined in the paper "Thematic Coding and Categorizing" [9]. This process begins with a set of categories outlined by the researcher based on key themes that emerged in the interviews. These categories are then expanded and subcategories created. This helps identify and categorize information relevant to the research, providing patterns and themes. Codes were inductively derived from the data not from any preexisting codebook.

Once this initial coding process was completed, interviews were further evaluated and sub-coded according to SDT. This was done based on both what the fleet manager said about each factor (such as mentioning external regulations) and on the sentiment of the conversation. Electrification decisions were categorized based on the degree to which the motivation was internalized. For example, the presence of a formal sustainability goal

indicated the decision was motivated by an external regulation. Fleet managers who report being informally directed to purchase more environmentally friendly were categorized as introjected regulations. The next category is identified regulations which includes fleet managers who indicated that they perceived it was environmentally beneficial to purchase an electric vehicle but were not required to purchase this way. Integrated regulations are the most internalized and includes fleet managers who created sustainability goals themselves.

3 RESULTS

First, to add context, we briefly describe the process through which fleets purchase their vehicles, then we explore fleet's vehicle purchase motivations for all vehicles, followed by an in-depth look at fleet electric vehicle purchase motivations. The same 23 interviews were used for the conventional and electric vehicle purchases, except for one fleet who only purchased conventionally fueled vehicles. This allows for a comparison of the differences in purchase behaviors within the fleet, controlling for differences between fleets that are outside of the management decisions. These are distinct sections since the way in which all vehicles and electric vehicles are selected differs. Finally, we mention barriers to electrification among the fleets sampled, this is included since while most fleets have electric vehicles, barriers to the widespread electrification of fleets still exist.

3.1 Fleet Vehicle Purchase Process

Fleet managers indicated two main avenues they used to purchase new vehicles: competitive bidding and cooperative purchasing. A competitive bid process was used by most fleets and requires the fleet to obtain several bids (typically 3 or more) to find the lowest purchase price for a vehicle that meets the criteria outlined in the bid request. Fleets often select the vehicle with the lowest purchase cost, although they can restrict vehicles based on previous experiences with them. For example, if vehicles from a certain manufacturer have historically been unreliable, they can exclude these vehicles, regardless of their lower upfront costs. At a larger scale, vehicles are purchased through cooperative purchasing contracts. These contracts are made by conducting competitive solicitations (amongst dealers or manufacturers) at a larger level than fleets can do on their own, creating a large scale leveraging of fleet purchasing power. Because these vehicles are already competitively bid, fleets can order vehicles on these contracts without having to create a bid themselves. Interviewees reported purchasing through two major contracts. At the state level, fleets can procure vehicles through the California State Contract managed by the California Department of General Services (DGS). Fleets also reported using Sourcewell, a nationwide cooperative purchasing contract. Each of these were used by approximately half of the sample.

3.2 Fleet Vehicle Purchase Decision

Table 1 shows the primary purchase considerations of fleet managers classified according to SDT. Ensuring the vehicle was fit for its purpose and could meet the requirements of the application it was intended for (compatibility of use) was the most mentioned motivation. This was often the first consideration to be mentioned by fleet managers which may indicate a high level of importance. For all fleets, this was an integrated regulation as there was no indication of an external rule directing fleet managers to purchase this way and all fleet managers internalized this factor.

Standardization was the second most mentioned purchase consideration. This is primarily focused on purchasing vehicles from a small number of manufacturers, lessening the number of parts the fleet needs to carry, reducing maintenance costs, and enabling fleets to become warranty certified. The need for standardization is more applicable to larger fleets who do much of their own maintenance while smaller fleets who outsource maintenance to dealerships and other facilities and therefore may have less need to standardize. While this was largely driven

by integrated regulations, some fleets standardized for reasons more external in nature. These include fleets with a specific rule requiring them to purchase vehicles from the same manufacturer, making the motivation an external regulation. Most fleet managers had begun to internalize this purchase consideration.

Fleet managers also indicated they were compelled to purchase the lowest cost vehicle that met their needs. This was largely driven by external regulations that are in place to help ensure "fiscal responsibility". This purchase motivation was one of the most externally influenced with some fleets reporting that city regulations mandated them to purchase the vehicle with the lowest purchase price.

Another commonly mentioned purchase consideration was to be more sustainable. This covered all four levels of extrinsic motivations. Some fleet managers reported making sustainable decisions to comply with their organization's regulations or to follow the California reputation for being "green", while others commented that it is just the right thing to do. Many fleet managers did not mention this as a purchase motivation which may be due to other challenges in vehicle purchasing such as requirements for compatibility of use, standardization, and purchase price, which often must be met to keep the fleet running. Three fleet managers had integrated this into their own motivations and did not mention external regulations directing them to purchase sustainable vehicles.

Fleet managers also mentioned purchasing vehicles to help reduce maintenance costs. These motivations were split between being a part of the required TCO calculation (making it an external regulation) and being used to ensure fiscal responsibility (which are integrated and identified regulations). For example, Fleet 20 reported using TCO because it is, "*the right thing to do from a financial perspective*," but they were not mandated to use it. This shows an integrated decision as the fleet manager sees it as their responsibility to limit expenses.

Many fleets indicated that they were unable to use TCO due to its conflict with the competitive bid process and because of a disconnect between vehicle purchase price, maintenance costs, and fuel costs. In many fleets the vehicle was purchased by the fleet department, but fuel is paid for by the using department. This makes purchasing a more fuel-efficient vehicle with a higher purchase price less favorable to the fleet department as they do not receive benefits from the lower fuel expenditure. Similar to maintenance costs, interviewees reported either using TCO due to organizational regulations or due to understanding they need to be fiscally responsible.

The availability of parts was mentioned by fleet managers who reported purchasing based on their understanding that they need to keep the vehicle running. These were categorized as either integrated or identified regulations based on the degree to which fleet managers expressed its importance. They stressed how critical it was for them to maintain good parts supply avoid downtime, these managers had substantially internalized this motivation.

A preference for alternative fuel vehicles (AFVs) was often motivated by external regulations as they mentioned using these vehicles to meet their organization's sustainability goals. Conversely, the manager for Fleet 19 had begun to internalize this consideration, discussing their self-motivating in procuring PEVs for their fleet.

Lesser mentioned considerations from fleet managers include proximity to dealerships, purchasing vehicles that their maintenance team is trained to work on, maintenance time, fuel costs, and purchasing based on the interviewee's previous experience. Each of these motivations were primarily categorized as being an introjected regulation as fleets were not required to purchase in this way, but it was not a part of their identity. Other purchase considerations were mentioned by one or two fleets as being primary factors in their purchase decisions including vehicle warranties, right sizing, safety, and resale value.

Table 1: Overview of primary vehicle purchase decisions by fleet.

Purchase Decisions													
Interview Number	**Compatibility of Use**	**Standardization**	**Purchase Price**	**Sustainability**	**Maintenance Costs**	**TCO**	**Availability of Parts**	**Preference for AFV**	**Proximity to Dealer**	**Maintenance Trained on**	**Maintenance Time**	**Fleet Manager Experience**	**Fuel Costs**
1					Undetermined	Undetermined*							
2		Integrated*					Integrated						
3	Integrated*	Integrated		Identified			Integrated	External	Identified				External
4	Integrated*	Introjected			Integrated	Integrated					Identified		
5	Integrated	Identified				External*	Integrated						
6	Integrated*		Introjected	Introjected	Integrated							Identified	
7	Integrated		External*										
8	Integrated	Integrated	External		Undetermined*					Identified			
9	Integrated								Identified		Identified*		
10	Integrated*	Integrated		Integrated			Identified			Identified			
11	Integrated		External*		Integrated		Identified			Integrated			
12	Integrated		External	External	Undetermined			External*					
13			External*			Integrated							
14	Integrated*		External	Identified								Identified	
15	Integrated*		External										Identified
16	Integrated	Undetermined*		Integrated					Identified				
17	Integrated*		Introjected	Introjected		Identified					Identified		
18	Integrated*	Integrated	External				Identified			Identified	Identified		
19	Integrated	Integrated		Identified*	Introjected		Integrated	Identified	Identified				
20	Integrated*	Integrated		Integrated	Integrated	Integrated			Identified	Identified			Identified
21	Integrated		External					External*					
22	Integrated	Integrated			Undetermined	External*		External			Identified	Identified	
23	Integrated*	Integrated	Introjected	Identified				External					

Legend	
External	Purchase motivation is classified as an external regulation (initiated and maintained by an external source)
Introjected	Purchase motivation is classified as an introjected regulation (pressure from self-esteem or ego)
Identified	Purchase motivation is classified as an identified regulation (aligned with personal goals or identities)
Integrated	Purchase motivation is classified as an integrated regulation (part of their identity or true sense of self)
Undetermined	Purchase motivation type could not be classified in terms of SDT
*	Indicates this consideration was the first to be mentioned by the fleet manager

3.3 Electric Vehicle Purchase Motivations

Out of the 23 fleets in this study, 22 have adopted at least one PEV, 18 fleet managers have conventional hybrid vehicles, and seven have hydrogen vehicles. In this paper we focus on only on PEV purchase considerations.

Table 2 shows that the most commonly mentioned motivation for purchasing PEVs was to meet sustainability and climate goals set by the organization and a classification of fleet managers motivations using SDT. Fleet managers also mentioned the following motivations: being more sustainable, striving to be a "green leader", utilizing available incentives, reducing costs, and external influences outside of the fleet.

Table 2: Overview of reported motivations for vehicle electrification decisions by fleet.

Electrification Decisions				
	Sustainability and Environmental Goals	**Be a Leader**	**Grants/ Incentives**	**Reduced Costs**
Interview 1	External*			
Interview 2	Integrated*			
Interview 3	External*		External	
Interview 4		Integrated*		
Interview 5	Introjected*	Introjected		External
Interview 6	NA	NA	NA	NA
Interview 7	External*			
Interview 8	External*			External
Interview 9	External*			
Interview 10	External*			External
Interview 11	External*			
Interview 12	External	External*		
Interview 13	Integrated	Introjected*	External	
Interview 14	Identified*			
Interview 15	Introjected*	Introjected		
Interview 16				
Interview 17				
Interview 18				
Interview 19	External*			
Interview 20	External	Integrated*		
Interview 21	Integrated	Identified	External*	
Interview 22	External*			
Interview 23	External*			

Legend	
External	Purchase motivation is classified as an external regulation (initiated and maintained by an external source)
Introjected	Purchase motivation is classified as an introjected regulation (pressure from self-esteem or ego)
Identified	Purchase motivation is classified as an identified regulation (aligned with personal goals or identities)
Integrated	Purchase motivation is classified as an integrated regulation (part of their identity or true sense of self)
*	Indicates this consideration was the first to be mentioned by the fleet manager

3.3.1 Sustainability and Environmental Goals

Sustainability goals were often the first electric vehicle purchase motivation to be mentioned by fleets. These were most commonly a result of external regulations made within the organization in which the fleet resided (e.g. the City or County), and not from external sources (such as federal or state regulations). In some cases, these goals came as specific mandates, such as those for buying 50% alternative fuel vehicles each year (Fleet 2, City), while in other cases, they were more general, including one calling for the fleet to buy 'green' vehicles where

possible (Fleet 10, City). For most fleets, these goals were set by those in higher administrative levels within the organization, such as by the Board of Advisors, City Council, or Mayor's office, making them an external regulation. While these motivations are externally based, most interviewees reported being supportive of the goals, indicating they have begun to internalize them, and are likely to continue to implement them. These general directives were given to the fleet managers, who created more structured plans to meet these goals through electrification.

"We have a formal directive that we should buy green whenever possible, that's in a city regulation, and there's a tradition, I've been here for about 5 years, and there's a tradition of buying as green as we could anyway, so we aggressively go out and look for the green options." (Fleet 10, City)

In some cases, the electrification decision came from an entirely separate entity, such as a utility company or a car manufacturer. Interviewees mentioned that they purchased an electric vehicle because they felt pressure or received help from these sources beyond what was in their formal sustainability plans. The manager for Fleet 13 noted that they first began looking into electric vehicles after their local electric utility suggested that they consider them and offered their support in the conversion process.

"We have our own electric utility here… and uh obviously they want to promote electric vehicles so they approached me and said, you know, what can we do, what's available out there for electric vehicles?" (Fleet 13, City)

Three interviewees mentioned developing their own sustainability goals, making the decision an integrated regulation as the decision results from an internal motivation of the fleet manager to transition to 'greener' vehicles in the fleet. Fleets in this category are demonstrating their personal commitment to sustainability and environmental issues by taking it upon themselves to create additional regulations for their department.

"We wrote it, it's gone through some, you know, a couple revisions but it's going through the process of getting finalized right now, talks about right sizing the fleet so you know, really understanding are we getting the most usage out of the fleet?" (Fleet 13, City)

Fleet managers mentioned purchasing PEVs to be more sustainable or environmentally friendly but did not have formal sustainability goals. They noted purchasing PEVs and performing other environmentally friendly practices because they felt this was the right thing to do, not from a requirement. Depending on the degree to which these attitudes were influenced by their organization, responses fell into either introjected or identified regulation. The manager for Fleet 5 reported that while there were no formal goals requiring them to purchase environmentally friendly vehicles, they felt compelled to purchase this way because their CEO was such a strong advocate.

"It is definitely for the reduction in emissions 'cause it's the right thing to do environmentally. The overarching reason is what our CEO describes as demonstrating leadership in environmental sustainability." (Fleet 5, Utility)

3.3.2 Be a Leader

Interviewees noted their organizations are encouraging consumers to switch to electric vehicles, so they felt like they needed to show they are also committed to the transition. In some cases, leadership goals came as a directive from people in higher positions within the organization, while some of these goals came from within the fleet manager's office. Some fleet managers reported they were willing to purchase vehicles that use new technologies, even if they are not the most cost effective, because they want to show the public and other fleets they are feasible. A few interviewees discussed how their experiences with new technologies has allowed them to inform other

fleets and automakers about their experiences with the vehicles. These motivations came from the fleet managers themselves rather than from external sources.

"We have been committed to being on the bleeding edge of some technologies meaning that we're okay if we're going to make some mistakes, we're gonna learn from those, share information with other fleets from making the same mistakes." (Fleet 20, County)

Not all interviewees shared the same desire to try new technologies. Managers of smaller fleets appeared to be more conservative in their adoption of new technologies, perhaps due to their smaller operating budgets and lesser resources (to conduct research on new vehicle technologies, apply for rebates, install infrastructure etc.).

"As a county, we like being first on the second wave, we let the big guys try stuff out and then we'll come in… You know so that's the other thing we try not to jump into things too quickly." (Fleet 3, County)

3.3.3 Incentives and Grants

The next most mentioned motivation was the availability of external grant and incentive programs. Fleet managers indicated they began converting their fleet to electric when they heard about the availability of these programs. For example, when asked about how they made the decision to purchase electric vehicles, the manager for Fleet 21 described their experience when attending workshops on PEV grants offered through the air district.

"So I went to a couple of those and I was like 'hey they're giving money away, let's get this free money and go buy a car,' and it's like, wow it worked, we got a car, let's do it again." (Fleet 21, County)

Other fleets offered similar sentiments, stating, *"almost everything that we've done with our charging stations or electric vehicles there has been some sort of grant or other voucher program that we use."* (Fleet 20, County).

Most fleets mentioned using incentives to purchase their vehicles, with many interviewees indicating that the availability of these lowered PEV costs allowed them to purchase the vehicles. The most used incentive is from the State of California, which offers both vehicle and charging station incentives. Incentives at the federal level had low participation rates, with just two fleets reporting having used funds from the federal government. One fleet noted that they were restricted from using these federal grants as public fleets are not eligible to directly receive this incentive because government agencies have no federal tax liability.

3.3.4 Reduced Costs

Few fleet managers mentioned economic drivers as a primary motivation in their decisions to purchase PEVs, despite nearly all of them reporting economic benefits from using PEVs. This is likely because an understanding of these benefits (low fuel costs, low maintenance costs) emerged after taking ownership of PEVs. This encouraged fleet managers to continue purchasing these vehicles in the future but was not commonly reported as an initial motivation for PEV purchase. This motivation was characterized as being an external regulation as fleet managers were required to purchase vehicles with the lowest overall costs to ensure fiscal responsibility.

3.4 Barriers to Fleet Electrification

Fleet managers mentioned seven main barriers to electrification: lack of access to charging infrastructure, lack of model availability, limited vehicle range, upfront purchase costs, limited employee buy-in, difficulties electrifying emergency response vehicles, and public perceptions.

3.4.1 Charging Infrastructure Access

Fleet managers reported their ability to purchase PEVs was limited by the time and capital investment required to install charging stations for these vehicles. Fleet managers reported vehicles being located in different fleet

parking locations meaning infrastructure would need to be installed in several locations. Difficulties in commissioning work and the cost of work to install infrastructure was also mentioned. In organizations where charging stations were already in place, there was no mention of issues with installing infrastructure. This may mean that infrastructure installation is not an insurmountable barrier.

"The only negative thing is the ability to get to charging stations, so the infrastructure and trying to coordinate because a lot of the vehicles are parked at downtown city garages, the City doesn't own the garages so coordinating with the building owner to be able to install charging stations, and then do you make them public or private, and so if you make them public then you may not be able to get to it and so the infrastructure is the biggest challenge and coordinating efforts." (Fleet 19, City)

3.4.2 Lack of Model Options

Despite fleet manger desires to electrify their fleet, they were limited in their ability to do so because of the lack of vehicle options. They found that while they would be able to electrify nearly all their passenger vehicles, there are little to no options for electrification of pickup trucks, as well as medium and heavy-duty vehicles. This was especially restricting for fleets with a large proportion of medium and heavy-duty vehicles in their fleet.

"There's no factory light duty truck electric vehicle option yet, I think when that happens, which I'm thinking it's probably not that far away, that's gonna be a complete game changer for fleets. Uh because again the majority of our fleets are light duty trucks so not having that option is huge." (Fleet 23, City)

3.4.3 Range

PEV driving range was noted as a barrier to adoption by nine interviewees. Fleet managers reported this barrier was about the perceived lack of range of BEVs, rather than the actual range of the vehicle. Additionally, many fleet managers noted that range was something they had experienced early on in their electrification process, but once they began adopting vehicles with over 200 miles of range, this barrier was eliminated. Fleet 20 noted that while they have electric vehicles in their fleet, driver concerns over range limited how they could use them.

"We placed 22 Ford Focus EVs in our fleet and the range was sold as 88 miles or 86 miles and then real-world fleet condition it was between 45 and 55 miles, significantly less. So when you're telling the customers [fleet vehicle drivers], plan on needing to recharge after 45-55 miles, they get range anxiety because in their minds they want to make sure they're only driving 30 miles so they don't get stuck someplace. So then the vehicle could go 70 miles but nobody is willing to drive it past 30..." (Fleet 20, County)

While range concerns were generally focused on BEVs, some interviewees also mentioned the limited electric range of PHEVs. The manager from Fleet 20 mentioned being disappointed that they were not able to electrify more miles, which decreased the cost and emissions savings associated with these vehicles.

"The range of just operating off the batteries varies from 13 miles up to about 32 miles, 36 miles, that's not quite long enough for a government fleet, it would be much better if we had a plug-in hybrid that gave us 100 miles from driving on the battery. That would meet a lot more of our duty cycles." (Fleet 20, County)

3.4.4 Vehicle Costs

The higher upfront cost of PEVs was mentioned by seven fleet managers as a barrier to adoption. Many of these interviewees noted that while they support the push towards electrification, and had sustainability goals in place, there was uncertainty over who would be paying for the increased costs of purchasing these vehicles. The manager from Fleet 4 noted that there was no room in their budget to cover the additional costs of these vehicles.

"The city has set specific goals, you know we have a kind of goal to have the most cost-effective type of vehicle that's most economical, the lowest emissions. But if it costs more, we're probably not gonna do it."
(Fleet 4, County)

3.4.5 Employee-Buy In

Lack of employee buy-in is tied to other barriers, as it is caused by issues such as lack of vehicle range, charging infrastructure, and model availability. Interviewees reported that when PEVs were first purchased, employees were hesitant to use them. In some organizations, fleet management teams addressed this through outreach and education. In other fleets, PEVs were assigned to certain people or departments to get used to driving them.

3.4.6 Other Barriers

Interviewees mentioned that while they were looking to electrify their fleet, they did not feel they would be able to purchase these vehicles for emergency response purposes, which seemed to be mainly rooted in PEVs longer charging times and limited range. These fleet managers reported that they did not think police cars would ever be converted to PEVs due to their operating requirements.

Some fleet managers found public perception of PEVs to be barrier to their adoption. In many cases, they were referring to purchasing higher end >200-mile range PEVs, which they claimed to be the only vehicles that would fit their operational needs. Fleet managers reported that even if they could afford the higher price, or if they utilized incentives to lower the price, the public would perceive the purchase as a misuse of government funds. Other barriers that were mentioned include a lack of fleet authority to buy a PEV, longer procurement times, fleet managers being too busy to evaluate PEVs, and lower resale value.

3.4.7 Institutional Barriers

Several barriers to PEV adoption were identified by the researchers. These were not specifically mentioned by interviewees as being barriers but may pose difficulties for PEV adoption.

First, the use of the competitive bid processes and higher purchase costs of PEVs may mean that fleet managers cannot purchase PEVs. Second, some interviewees reported a lack of time and resources for fleets to apply for incentives, which can reduce the purchase cost of PEVs below that of conventional vehicles.

Some interviewees reported their organization having a system in which the central fleet purchases vehicles, but individual departments pay fuel costs. This can decrease the cost savings potential associated with the vehicle from the perspective of the central fleet manager and can impact vehicle operation cost calculations.

The lower operating costs of PEVs is not necessarily sufficient to persuade fleet managers to purchase them since the need to standardize the fleet, have the most compatible vehicle, and disconnect between the payment of the vehicle could override any cost considerations. These findings suggest that a lower TCO for PEVs may have less of an influence on their market share of fleet vehicles than previously thought [10], though their lower maintenance costs do align with fleet managers purchase decision making.

The interviews revealed that smaller fleets with less resources often lack the adequate time (due to them having fewer employees) and money needed to fully assess the integration of PEVs into their fleets, including understanding any barriers or benefits. Smaller fleets were frequently unaware of or did not utilize incentive programs for PEV purchase and did not consider TCO or vehicle running costs when making purchase decisions. Some fleets indicated purchasing vehicles based on the knowledge they had gained working in the industry and did not use any sophisticated calculations or criteria.

4 DISCUSSION & CONCLUSION

Results from these interviews show PEVs are not necessarily aligned with existing purchasing considerations of fleet managers. Fleet managers seek to purchase vehicles that are compatible with their use requirements, to standardize the make of vehicles, and often are required to purchase the cheapest vehicle available to them. Public fleets do not typically use TCO calculations as a primary purchase factor, therefore, lower operating costs of PEVs in comparison to ICEVs may not lead fleet managers to disregard existing considerations.

Fleet managers are purchasing PEVs despite their misalignment with fleet purchasing processes and barriers to PEV adoption. Their motivations for doing so are often outside of typical purchase considerations and include sustainability goals, environmental motivations, motivations to be a 'green' leader, grants, external influences, and a desire to reduce operating costs. Fleet managers overcome the barriers to PEV adoption by educating fleet vehicle users about PEVs and assigning the vehicles to more receptive drivers and departments. They are also working with utilities, using existing infrastructure, and researching new infrastructure installations. Range limitations are overcome through education, assigning vehicles to tasks that fit PEV driving range, and by introducing models with longer ranges. Higher purchase prices are overcome through grants and with sustainability goals that give waivers to the lowest bid purchase requirements.

We find it is most common for fleet purchase decisions to come from more internalized extrinsic motivations including integrated and identified regulations. This is perhaps because fleet managers are accustomed to purchasing conventional vehicles and have internalized these factors due to their alignment with managers own motivations. In contrast, electrification decisions primarily come from less internalized motivations that fall under external regulations. This disparity may be at least partially attributable to the relative novelty of electric vehicles, which require some level of external motivation to spur initial adoption. As fleet managers become more experienced with using and purchasing these vehicles, fleets may begin to internalize these motivations. Until this occurs, external regulations may be required to motivate electrification.

While fleets face many of the same barriers as private consumers, the way they manifest is often different. For example, while some consumers are willing to pay a premium for PEVs, some fleet managers would not be able to do this even if they wish to do so [15]. Additional fleet specific barriers, including issues with employee buy-in, procurement under the competitive bid process, the need for vehicle standardization, lack of vehicle options, difficulties in installing charging infrastructure, and ensuring drivers charge the vehicles. As in previous studies [16]–[18], fleets were found to be driven by their desire to try new technologies, lessen environmental impact, improve public image, and use grants. Unlike a prior study [19], TCO was not found to be one of the main drivers of electrification as other factors play a larger role in decision-making.

While this study focuses on the adoption of PEVs in California, the results may be applicable to other states in the United States, and internationally. Results reveal where the motivation to procure electric vehicles originated from, which in many cases was at higher administrative levels in city, county, and state governments. It may be possible for policymakers in other regions to set similar policies. Similarly, fleets in other regions may have procurement rules that direct them to purchase the lowest priced vehicles. Restructuring policies to prioritize the purchase of electric vehicles and allowing for the use of TCO rather than purchase price will help fleets across the world transition to electric vehicles. Barriers such as range, limited model availability, and lack of charging infrastructure have been shown to restrict fleet electrification across Europe [19], [22], [23].

Given the growing need for sustainability in both public and private organizations, more research is needed to create a broader understanding of how specific measures are influencing the adoption of PEVs in fleets around the world.

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