What drives fleets? Organizations' perceptions of barriers and motivators for alternative-fuel vehicle adoption in British Columbia, Canada

by

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Declaration of Committee

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Abstract

Although it is important to transition all vehicles to zero-emission vehicles to meet net-zero climate targets, there is a relative dearth of research on adoption in fleets. Through semi-structured interviews with participants from 24 organizations in British Columbia (mostly adopters), I identify the barriers and motivators of alternative-fuel fleet vehicle adoption, including electric, hydrogen, and natural gas vehicles. Overall, participants mentioned more motivators than barriers. The most commonly mentioned motivators included: internal support for environmental sustainability, operations and maintenance savings, positive impact on reputation, vehicle purchase incentives, and a positive history of alternative fuel vehicle use. The most commonly mentioned barriers included: the high capital cost of vehicles, the limited market availability of AFVs, vehicle range concerns, and a lack of charging or fueling infrastructure. Results also suggest that the mentioned barriers and motivators tend to vary by fleet size, and organization type, namely private versus public.

Keywords: Zero Emission Vehicles; Alternative Fuel Vehicles; Electric Vehicles; Fleet; Barrier; Motivator.

Dedication

I would like to dedicate this paper to my husband Steve and to my family and friends who have patiently and enthusiastically supported me throughout this endeavour. Without your love and support I would never have made it this far. I am truly blessed and ever grateful to be surrounded by such amazing people.

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List of Acronyms

AFV	Alternative-Fuel Vehicle
BC	British Columbia
EV	Electric Vehicle
ICBC	Insurance Company of British Columbia
IEA	International Energy Agency
ZEV	Zero-Emission Vehicle

Chapter 1.

Introduction

Transportation accounted for approximately 25% of Canada's GHG emissions, and 37% of emissions in the province of British Columbia (BC) in 2019 (Environment and Climate Change Canada, 2021). Therefore decarbonizing transportation will play a key role in enabling Canada and BC to reach their 2050 net-zero GHG emissions targets and interim 2030 and 2040 targets (Government of Canada, 2021; Province of British Columbia, 2019). One of the mechanisms for doing so is to displace conventional gasoline and diesel fueled vehicles from the road with alternative fuel vehicles (AFVs). I define AFVs as any vehicle that does not use either gas or diesel as its primary fuel source. This definition includes zero-emission vehicles (ZEVs) that produce no tailpipe emissions for all or a portion of their operating time, namely battery electric vehicles, plug-in hybrid electric vehicles, and hydrogen fuel cell vehicles. The term AFV also includes vehicles that use lower-carbon fossil fuel alternatives such as compressed natural gas or propane as their primary fuel source.

Given how integral vehicles have become both to our economy and our personal lives the transition to AFVs is complex. Numerous research studies have been conducted on personal vehicle purchasing behaviour and personal vehicle use. However, far less research has focussed on organizations that own and operate fleet vehicles for business purposes (Biresselioglu et al., 2018; Kaplan et al., 2016). This paper seeks to add to the existing body of knowledge by exploring the barriers and motivators of AFV adoption in fleets.

1.1. Literature Review

I begin with a review of existing literature which examines the factors influencing AFV adoption in fleets. In Table 1.1 I summarize insights from this literature including fleet stakeholders' perceptions of barriers, motivators and neutral factors. The barriers and motivators listed are those that past authors classified as barriers or motivators and the neutral factors listed are those past authors identified as having little or no impact on AFV adoption. For this review (and my research) I divide these factors into five thematic

areas: financial considerations, organizational context, functional considerations, organizational dynamics, and knowledge. Each thematic area has three to six associated factors which I summarize below. At the end of this section I also briefly describe AFV fleet literature references related to organization type (namely references to private sector or public sector fleets) and fleet size.

The first thematic area is financial considerations which includes financial factors that may impact an organization's ability or desire to adopt AFVs. This thematic area includes references to the capital cost of vehicles, vehicle purchase incentives, the capital cost of installing charging or fueling infrastructure, infrastructure installation incentives, operations and maintenance costs, and lifecycle costs. The relatively high capital cost of AFVs compared to conventional vehicles is a financial barrier mentioned in many of the studies I reviewed. For example, Biresselioglu et al.'s (2018) comprehensive literature review found that purchase price was a barrier to ZEV adoption across all three of the decision-making groups studied including fleets. Two more recent studies yielded similar results. The International Energy Agency (IEA) found purchase price to be one of the major barriers of ZEV adoption worldwide across all potential ZEV adopters despite widespread recognition that ZEVs would have lower operations and maintenance costs over the life of the vehicle (IEA, 2021). Similarly, Sugihara & Hardman (2022) found purchase price to be one of the major barriers of ZEV adoption in fleets during their interviews with 23 fleet managers in California, most of whom were ZEV adopters.

Also within this financial category, Sugihara & Hardman (2022) found that many fleet participants mentioned using vehicle purchase incentives and infrastructure incentives, particularly those provided by the state of California, to bring the cost of adopting ZEVs down to an acceptable level. This echoed the results of an earlier study conducted by Morganti & Browne (2018) whose interviews with 23 fleet van operators and policy makers in Paris and London found that purchase incentives were critical to fostering ZEV adoption.

Other financial factors mentioned in the fleet AFV adoption literature include the negative impact of high ZEV infrastructure installation costs (Skippon & Chappell, 2019), the positive influence of ZEV related tax incentives (Di Foggia, 2021) and lower fueling costs (Hutchins & Delmonte, 2012), and the varied influence of vehicle lifecycle cost

Table 1.1. Summary of Factors and Associated Literature by Thematic Area

Thematic area	Factors	Associated Literature		
		Barrier	**Motivator**	**Neutral**
Financial Considerations	Capital cost of vehicles	(Biresselioglu et al., 2018; Boutueil, 2016; Demeulenaere, 2019; IEA, 2021; Quak et al., 2016; Sugihara & Hardman, 2022)	(Mau & Woisetschläger, 2018)	-
	Vehicle incentives	(Biresselioglu et al., 2018; Skippon & Chappell, 2019)	(Di Foggia, 2021; Morganti & Browne, 2018; Sugihara & Hardman, 2022)	(Sierzchula, 2014)
	Capital cost of Infrastructure	(Skippon & Chappell, 2019)	-	-
	Infrastructure incentives	-	(Sierzchula, 2014; Sugihara & Hardman, 2022)	-
	Carbon offset credits	-	-	-
	Operations and maintenance costs	(Skippon & Chappell, 2019)	(Biresselioglu et al., 2018; Boutueil, 2016; Di Foggia, 2021; Hutchins & Delmonte, 2012; Sugihara & Hardman, 2022)	-
	Lifecycle cost	(Figenbaum, 2018; Mau & Woisetschläger, 2018)	(Boutueil, 2016)	-
Organizational Context	Partnership opportunities	-	(Di Foggia, 2021)	-
	External reputation of the organization	-	(Biresselioglu et al., 2018; Boutueil, 2016; Di Foggia, 2021; Mau & Woisetschläger, 2018; Sierzchula, 2014)	-
	Market availability of AFVs	(Biresselioglu et al., 2018; IEA, 2021; Quak et al., 2016; Skippon & Chappell, 2019; Sugihara & Hardman, 2022)	-	(IEA, 2021)
Functional Considerations	Range	(Figenbaum, 2018; Hutchins & Delmonte, 2012; Morganti & Browne, 2018; Skippon & Chappell, 2019; Sugihara & Hardman, 2022)	(Mau & Woisetschläger, 2018)	(Wikström et al., 2016)
	Availability of charging or fueling	(Biresselioglu et al., 2018; Boutueil, 2016; Demeulenaere, 2019; Hutchins & Delmonte, 2012; IEA, 2021; Morganti & Browne, 2018; Skippon & Chappell, 2019; Sugihara & Hardman, 2022; Yavuz & Çapar, 2017)	-	(Quak et al., 2016)
	Vehicle Comfort or Style		(Boutueil, 2016; Hutchins & Delmonte, 2012)	-
	Vehicle suitability to the organization's tasks	(Demeulenaere, 2019; Figenbaum, 2018; Morganti & Browne, 2018; Skippon & Chappell, 2019)	(Biresselioglu et al., 2018)	(Quak et al., 2016)
Organizational Dynamics	Internal support for environmental sustainability	(Biresselioglu et al., 2018)	(Biresselioglu et al., 2018; Demeulenaere, 2019; Hutchins & Delmonte, 2012; Quak et al., 2016; Sierzchula, 2014; Sugihara & Hardman, 2022)	-
	Internal support for innovation or new technology	(Boutueil, 2016; Mohamed et al., 2018)	(Sierzchula, 2014; Sugihara & Hardman, 2022)	-
	Purchasing practices	(Skippon & Chappell, 2019)	-	-
	History of AFV use	(Boutueil, 2016; Wikström et al., 2014)	-	(Hutchins & Delmonte, 2012)
Knowledge	Maintenance capacity	(Boutueil, 2016; Quak et al., 2016)	-	-
	Vehicle user training		-	- (Wikström et al., 2016)
	Peer-to-peer information sharing	(Boutueil, 2016)	-	-
	Policy awareness or understanding (regs, mandates)	(Demeulenaere, 2019)	-	-
	Internal AFV technical or market expertise	(Boutueil, 2016; Di Foggia, 2021; Hutchins & Delmonte, 2012; Mohamed et al., 2018)	-	-

calculations on ZEV adoption in fleets (Boutueil, 2016; Figenbaum, 2018; Mau & Woisetschläger, 2018).

Second is the thematic area of organizational context, which includes factors that are largely influenced by external forces and over which an organization is likely to have only a limited degree of control. This thematic area includes references to the availability of partnership opportunities, the external reputation of the organization, and the market availability of vehicles. For instance, a recent survey of Italian fleet managers conducted by Di Foggia (2021) investigated ZEV fleet vehicle integration and procurement decisions. Di Foggia found that 80% of fleet managers perceived partnerships with organizations that specialized in recharging infrastructure as a motivator for ZEV adoption. In addition, Di Foggia found another perceived motivator to be the positive impact ZEVs could have on the organization's corporate image. Similarly, Boutueil (2016) found the positive impact that ZEV's could have on corporate image to be a perceived motivator for several of the 44 fleet decision makers they interviewed near Paris. Bouteil expanded upon this to say that ZEV adoption could have a positive impact on brand image amongst customers by highlighting the organization's environmental performance and amongst employees by demonstrating and helping to embed a culture of environmental sustainability in the organization.

Also within this thematic area is the market availability of AFVs which was mentioned as a barrier in several fleet studies. One study by Quak et al. (2016) explored the opportunities and barriers for using ZEV's in city logistics fleets by reviewing the results of several urban electric freight vehicle demonstration projects in Europe. Specifically, Quak et al. found that the absence of large auto manufacturers engaged in producing ZEVs and the limited availability of electric versions of commonly used fleet vehicles (such as vans and larger trucks) were barriers to ZEV adoption in European city logistics fleets. Relatedly, a recent paper by Sugihara & Hardman (2022) found that a lack of available vehicle options, particularly in the medium- and heavy-duty vehicle classes, continues to be a barrier to fleet ZEV adoption in California. Further, the IEA (2021) identified that this same barrier is having an impact globally on all potential ZEV adopters (as opposed to only on fleet ZEV adopters).

The third thematic area is functional considerations of AFVs. Here I placed references to factors that have the potential to impact the organization's operations and

over which they have some influence or control (in contrast to the second theme of organizational context). This thematic area includes references to vehicle range, the availability of charging or fueling infrastructure, vehicle comfort or style, and a vehicle's suitability to the organization's tasks. ZEV range (I.e., how far a ZEV with a full battery can go before needing to stop and recharge) was the perceived barrier cited most frequently amongst the 22 fleet managers Hutchins & Delmonte (2012) interviewed in the UK. It was also a barrier that interviewees often connected to the availability of charging infrastructure. More recently, Demeulenaere (2019) found a lack of refuelling infrastructure was one of the main barriers of fleet AFV adoption mentioned across the breadth of the automotive AFV fleet documents they selected and assessed in their systematic literature review.

Other functional considerations mentioned in the fleet related literature include improved driving experiences associated with ZEVs (Boutueil, 2016; Hutchins & Delmonte, 2012) and various suitability considerations that impacted if AFVs could meet an organization's operational needs (Biresselioglu et al., 2018; Demeulenaere, 2019; Figenbaum, 2018; Morganti & Browne, 2018; Quak et al., 2016; Skippon & Chappell, 2019).

Fourth is the thematic area of organizational dynamics which encompasses factors internal to the organization that could impact AFV adoption particularly those related to an organization's culture, values, or internal processes. This thematic area includes references to an organization's internal support for environmental sustainability, their internal support for innovative or new technology, AFV related fleet purchasing practices, and fleets' historical experiences with AFV use. I found several studies that referenced the GHG emissions reduction potential and environmental benefits associated with AFV adoption. For example, Hutchins & Delmonte (2012) found that amongst the 22 UK fleet managers they interviewed ZEVs were valued for their ability to reduce carbon emissions so that organizations could meet their corporate emissions reduction targets and that sometimes this was considered the most important attribute of ZEVs. Similarly, Sugihara & Hardman (2022) found that amongst the 23 Californian public fleet managers they interviewed (most of whom were ZEV adopters) ZEV adoption was often motivated primarily by the organization's sustainability goals. Further, Sugihara found that although these goals were internal to the organization they were often precipitated by a need to comply with government mandates.

There were also several references within the fleet literature to an organization's internal support (or lack of support) for innovative or new technology. Two studies mentioned the hesitancy of fleets to adopt relatively new, and possibly risky, electric vehicles (Boutueil, 2016; Mohamed et al., 2018) and two mentioned organizations' desire play a leadership role when it comes to testing out new ZEV technologies for fleets (Sierzchula, 2014; Sugihara & Hardman, 2022).

Other factors mentioned in this thematic area include the negative impact that restrictive government purchasing practices could have on ZEV adoption in fleets (Skippon & Chappell, 2019) and the positive impact that a history of using ZEVs could have on fleet purchase decisions or user perceptions (Boutueil, 2016; Wikström et al., 2016).

Knowledge is the fifth and final thematic area. Here I placed references related to an organization's existing knowledge base or their ability to access, acquire or impart knowledge about AFVs. This includes references to maintenance capacity, vehicle user training, peer to peer information sharing, policy awareness or understanding, and internal AFV technical or market expertise. For instance, under maintenance capacity I placed references to the organization's access to trained maintenance staff such as the finding of Quak et al. (2016) and Boutueil (2016). In their review of several urban electric freight vehicle demonstration projects in Europe, Quak et al. (2016) found that a lack of economical, qualified after sales service support was a challenge for city logistics fleets. Similarly, Boutueil (2016) found that a lack of technical knowledge related to vehicle maintenance was a barrier for the adoption of innovative automotive technologies, such as ZEVs, for the fleet decision makers they interviewed near Paris.

This theme also includes AFV user training and how AFVs were introduced to the organization. For instance, Wikström et al. (2016) analyzed a mix of vehicle logbooks and driver survey data from a Swedish ZEV demonstration project to better understand the barriers of ZEV adoption in fleets. The authors found that the way ZEVs were introduced and the amount of information provided to new users could positively or negatively influence the internal acceptance of these vehicles and consequently ZEV usage rates.

Other factors referenced in this thematic area include barriers caused by a lack of information sharing amongst organizations (Boutueil, 2016), a lack of understanding or certainty about political or regulator environments (Demeulenaere, 2019) and a lack of information or knowledge about available AFV technologies and their functionality (Boutueil, 2016; Demeulenaere, 2019; Hutchins & Delmonte, 2012; Mohamed et al., 2018, 2018).

As a final consideration in this literature review, I reference two studies on fleet AFV adoption that differentiate between the barriers and motivators found in public sector versus private sector fleets and two studies that differentiate their findings in relation to fleet size. Demeulenaere (2019) found that high acquisition cost was identified as a key perceived barrier for public sector fleets in some (but not all) of the documents assessed in their systematic review of AFV fleet literature. Demeulenaere found greater consistency when it came to the perceived motivators of AFV fleet adoption in public sector organizations. The key motivators mentioned were policy goals, the need to comply with legislative directives, and public scrutiny. One of these motivators was also mentioned by Sierzchula (2014) who found that legislation specific to public sector entities (I.e., that did not apply to private sector entities) was a motivator for some of the public firms in their study.

The referenced motivators for private sector fleets follow a different pattern. Demeulenaere (2019) found that amongst private organizations the main drivers for AFV fleet adoption were using these vehicles to foster an environmentally friendly, innovative brand image and adopting AFVs as a way of increasing their knowledge and experience with these new technologies. Sierzchula (2014) found that private firms were motivated by public image, first-mover advantage and profit opportunities associated with fleet ZEV adoption.

With regards to fleet size, both Sierzchula (2014) and Sugihara & Hardman (2022) found that organization size could impact ZEV purchase decisions. Specifically, Sierzchula found that the greater financial resources of larger US and Dutch organizations (compared to small ones) allowed them to more easily absorb the financial losses associated with being an early adopter of ZEVs. Sugihara & Hardman (2022) found that amongst the Californian fleet managers they interviewed, those from smaller

fleets appeared more hesitant to experiment with new ZEV technologies than those with larger fleets.

1.2. Research Objectives and Provincial Context

Using BC as a case study, my research seeks to add to the existing body of knowledge and address some of the knowledge gaps. My central research questions are: what are the perceived barriers and motivators for AFV adoption in fleets in BC? And do these perceptions differ between public and private organizations or between organizations with different fleet sizes? My specific research objectives are to:

1. Conduct semi-structured interviews with organization employees who directly influence vehicle purchasing decisions in BC fleets to better understand their views about AFV adoption;
2. Identify the common barriers and motivators mentioned by participants, using thematic content analysis guided by my conceptual framework; and
3. Compare the barriers and motivators mentioned by participants from different organizations, notably public versus private organizations and organizations with different fleet sizes.

I define the public sector as including publicly run organizations and crown corporations. In Canada, Crown corporations are entities that the government owns, in this case the provincial government, but that operate as independent companies (Tupper & Smith, 2021). I define the private sector as including all privately-owned companies and corporations. Further, I created three fleet size categories (as I could not find any consistently pre-defined size categories in the literature) defined as follows:

- small fleets:100 vehicles or less,
- medium fleets: between 101-400 vehicles, and
- large fleets: greater than 401 vehicles or more.

As further background, in BC the number of vehicles registered under fleet plans was equivalent to about 8% (~320,000) of the 4 million vehicle policies issued in 2020. Further, approximately 1.8% of the 320,000 fleet vehicles registered in BC were AFVs (0.7% ZEVs and 1.1% low-carbon fossil fuel vehicles such as propane, compressed

natural gas) rather than conventional vehicles. This is slightly higher than the percentage of AFVs found amongst non-fleet vehicles which is 1.2% of 3.6 million (1.1% ZEVs and 0.1% low-carbon fossil fuel vehicles). These statistics provide a snapshot of 2020 AFV adoption rates in fleet and non-fleet contexts. A comparison of new AFV fleet vehicle sales compared to new AFV non-fleet vehicle sales would provide additional insight into adoption rate trends. Unfortunately, this data was not publicly available at the time this study was conducted.

Chapter 2.

Methods

This study used semi-structured interviews to document the experiences and opinions of participants regarding AFV adoption in fleets in BC. All participants were individuals who directly influenced their organization's decisions regarding the adoption of AFVs. They all held positions as either fleet managers, energy managers, or senior company leaders. I used semi-structured interviews for this study because they are particularly suited to exploring real-world problems in-depth (Korstjens & Moser, 2017). This interview-style uses a series of pre-determined questions and prompts to elicit participant feedback while allowing space for participants to express themselves in their own words and for the researcher to ask follow-up questions if needed (McCracken, 1988). Being exploratory by design, this study aimed not to prove a theory but rather to gather qualitative data that could be used for hypothesis generation. Further investigation will be needed to prove or disprove any hypotheses generated by this study such as quantitative analyses of data collected from a large representative sample. Therefore, the results should not be considered definitive or generalizable and should be interpreted with care.

2.1. Data Collection

Data collection for this study took place in BC between October 2020 and June 2021. Participants were drawn from public and private sector organizations throughout the province using a mix of purposive and snowball sampling methods to select a relatively diverse sample. Purposive sampling involves intentionally recruiting participants that are likely to have a rich depth of information to share related to the research topic and questions. I chose to purposefully select a diverse sample to help identify barriers and motivators that appear to span multiple economic sectors, regions, and organization types. This diversity also provided the organizational spread needed to explore my third research objective which was to compare the responses given by participants from different organization categories (by fleet size and public versus private). I emailed recruitment letters to select contacts within the energy management industry and to the presidents or administrators of several fleet management

associations for dissemination to their members. The fleet management organizations I contacted include: the Western Canadian Chapter of the NAFA Fleet Management Association, the Canadian Association of Municipal Fleet Managers, the Canadian Association of Fleet Supervisors, West Coast Electric Fleets, the Association of School Transportation Services of BC, and the Municipal Fleet Managers Association of BC.

Snowball sampling involves asking knowledgeable individuals to nominate people who might be able to provide insight into the research topic (Emmel, 2014). I asked all interviewees if there was anyone else that they would recommend I talk to. This provided me with additional interview candidates that I would not have had access to otherwise. From the names provided I then purposefully selected candidates who would help improve the diversity of my sample and worked to recruit them.

In most organizations (n=21) I only interviewed one participant. However, I interviewed three people in one organization and two people each in two other organizations. This occurred by the organization's choice when they felt that more than one individual was needed to tell the full story of their organization's AFV adoption experiences and opinions. In these cases I either interviewed participants simultaneously or combined their interview transcripts during data analysis to ensure that no double counting of organizations occurred.

I designed a pre-interview questionnaire and an interview guide based on my conceptual framework, my study of the literature, and my research questions. Before their interview I sent each participant a copy of the pre-interview questionnaire to collect demographic information about the organization as well as numerical data about fleet size and composition (number of vehicles, fuel types etc.) and about charging and fueling infrastructure.

During the 1.5hr online interviews I used my interview guide to ask participants a series of questions divided into the following five sections:

1. Participants' knowledge of their organization's existing purchasing practices and any differences in how the organization had approached purchasing AFVs as opposed to conventional vehicles in the past.

2. Details about the organization's future AFV purchasing plans and what, if anything, the organization was doing to prepare for or help facilitate AFV adoption.

3. The organization's policies and culture.

4. How participants viewed their organization's past AFV adoption experiences.

5. Logistical questions related to vehicle maintenance capacity and the organization's charging infrastructure.

The interview guide also included a list of planned prompts to help ensure that all thematic areas were addressed during the interviews. As recommended by McCracken (1988), I only used the prompts if participants failed to spontaneously bring up a given topic in response to open-ended interview questions. In keeping with standard practice for semi-structured interviews, I also occasionally asked participants follow-up questions if their answers were unclear or incomplete or if they brought up novel findings that seemed to warrant additional investigation (Brinkmann, 2013; Moser & Korstjens, 2018). Further, I took notes and digitally recorded the interviews for later transcription and analysis.

2.2. Data Analysis Methods

I analyzed my data using a combination of thematic and comparative content analysis. The purpose of thematic content analysis is to categorize data to help identify patterns, such as which barriers were mentioned by a higher proportion of participants than others (Bazeley, 2013). During this analysis stage I methodically reviewed interview transcripts and notes and used a qualitative analysis software called NVivo to code participant mentions to the factors identified in my initial coding framework. I also identified each participant mention as either a barrier, motivator, neutral or mixed factor. I classified a factor as a barrier if participants identified it as having the potential to negatively impact AFV adoption across some or all vehicle classes and operational departments within their organization. I classified a factor as a motivator if participants identified it as having the potential to encourage or speed up AFV adoption in their organization. I classified a factor as neutral if participants inferred or stated that it was a

factor that would have little or no impact on their decisions to adopt AFVs. I classified a factor as mixed if a participant mentioned that its influence on their decision to adopt an AFV varied on a case-by-case basis becoming a barrier in some circumstances and a motivator in others. To avoid double counting mentions if I classified a factor as mixed for a participant I did not count it as a motivator nor did I count it as a barrier for that participant.

Throughout the thematic content analysis stage I iteratively refined my coding framework in NVivo by adding in emergent (not previously identified) factors and eliminating factors that had little or no data associated with them. Once I finalized my coding framework I double-checked to ensure I had not missed any participant mentions by using targeted search queries and by rereading interview transcripts and notes. I also reviewed my coding results factor by factor to ensure that I had not double-coded (and therefore double-counted) any participant mentions. Finally, I counted the number of participants that mentioned a factor at least once during their interview to arrive at the final counts of mentions shown in Table 3.3 (Section 3.2, pg.20).

I then used comparative analysis to examine the similarities and differences between the types of barriers, motivators, neutral and mixed factors mentioned by participants across organizational categories. I compared across two different categories: organization type (public sector versus private sector), and fleet size (small versus medium versus large). I used Nvivo to classify participants based on these categories then used the crosstab query function to compare the number of participants from different organization types and fleet sizes that mentioned a given barrier, motivator, neutral or mixed factor.

In the results section, I summarize the number of participants who mentioned a factor at least once as either a barrier, motivator, neutral or mixed factor and show when this varies across organization type and fleet size. I also explore the most commonly mentioned factors (which I classify as those mentioned at least once by at least one-third of participants) in more depth and provide quotes to illustrate the nuances of my results.

Chapter 3.

Results

I have organized my results into four sections. The first section is an overview of my realized sample to provide context for my results. The following three sections summarize the barriers, motivators and neutral or mixed factors that participants mentioned during their interviews and how organization type and fleet size appear to have impacted the results. I present my results using a mix of participant counts and quotes. As described in my methods section I use participant counts to show the total number of participants that mentioned a factor at least once during their interview, and I use quotes to provide examples and additional detail. I use percentage graphs to depict how participant counts for different factors vary by organization type and fleet size. Given the sample size of n=24 participants in this study and the smaller sample size of each subcategory (e.g., there were nine private fleets), the variation in participant counts shown by organization type and fleet size should be interpreted with additional care. I did not conduct any statistical tests of significance.

3.1. Realized Sample

I interviewed 27 people from 24 organizations for a study sample size of n=24 participants for this study. As described in Section 2.1, in three cases I interviewed more than one person from the same organization simultaneously. In those cases, I grouped their interview transcripts under one participant number to ensure that each organization would only be counted once regardless of how many individuals in that organization were interviewed. Through a mix of purposive and snowball sampling I recruited participants from various economic sectors, operational regions, organization types and fleet sizes within the Province of BC (Table 3.1). Twenty-two out of 24 participants (92%) were from organizations that are AFV adopters, and two (8%) were from organizations

Table 3.1. Demographic Breakdown of Study Participants

Demographic Category	# of organizations
Sample Size	24 (100%)
AFV adoption*	

Gas and/or diesel vehicle users	24 (100%)
AFV adopters	22 (92%)
ZEV adopters (electric vehicles or hydrogen fuel cell vehicles)	22 (92%)
Low-carbon fossil fuel vehicle adopters (propane, or compressed natural gas)	6 (25%)
Adopted no AFVs	2 (8%)
Vehicle after-hours storage location	
Central storage area (e.g., maintenance yard parking lot)	22 (92%)
Vehicle operator's residence	16 (67%)
Economic Sector	
Local Government	6 (25%)
Educational Services	5 (21%)
Professional Service (e.g., tradespeople, insurance etc.)	4 (17%)
Transportation and Warehousing	3 (13%)
Energy & Natural Resource Use (e.g., mining, utilities)	3 (13%)
Healthcare and Social Assistance	2 (8%)
Consumer Goods (e.g., retail or warehousing)	1 (4%)
Fleet vehicle use(s)*	
Service or maintenance work (e.g., trades work)	21 (88%)
Administrative work (e.g., going to meetings, completing inspections)	16 (67%)
Local or regional deliveries	6 (25%)
Public transportation (school buses)	3 (13%)
Shared mobility (car shares)	2 (8%)
Other (e.g., industrial use, security, field research, community service)	4 (17%)
Operational Region*	
Southwest BC (Southwest coast and Islands, pop. 4,000,000) **	18 (75%)
Southeast BC (Thompson-Okanagan & Kootenay regions, pop. 770,000) **	9 (38%)
North BC (North coast, Nechako and Northeastern regions, pop. 170,000) **	5 (21%)
East Central BC (Cariboo region, pop. 170,000) **	5 (21%)
Organization Type	
Public	15 (63%)
Private	9 (38%)
Fleet Size	
Small (1-100 vehicles, purchase on average 2 vehicles per year)	10 (42%)
Medium (101- 400 vehicles, purchase on average 20 vehicles per year)	8(33%)
Large (401+ vehicles, purchase on average 150 vehicles per year)	6 (25%)

* These demographic breakdowns do not add to n=24 because some organizations operate in multiple regions, have a variety of vehicle uses or have multiple vehicle types in their fleet.

** population data for these regions was drawn from the Province of BC's population estimates for 2020 (Provincial Government of British Columbia 2021)

that have not adopted any AFVs. I classified adopters as any organization that currently owns or has very recently owned (within the last 12 months) at least one AFV and non-adopters as those that did not meet these criteria. Of the 22 participants that were AFV

adopters, all 22 had at least one ZEV (22 had at least one battery electric or plug-in hybrid electric and two also had at least one hydrogen fuel cell vehicle) and six also had at least one low-carbon fossil fuel vehicle. All participants also owned some gas- or diesel-powered vehicles. Most participants (n=22) stored some (or all) vehicles in a fleet storage yard afterhours though many (n=16) also had some vehicles return to the operator's residence when not being used for work.

In addition, I classified each organization by economic sector, vehicle use, operational region, organization type and fleet size. I based the organization's economic classification on what I believed to be each organization's primary economic purpose. As examples, universities were placed under educational services, and tradespeople were placed under professional services. The economic classifications I use are based on the 20 classifications found in the Canadian publication of the *North American Industry Classification System (NAICS) 3.0* (Government of Canada, 2018), which I condensed into eight simplified ones (Table 3.2). I recruited participants from all sectors except service and entertainment and the subsector of long-haul freight. My realized sample contains organizations spanning seven economic sectors with the highest number of participants coming from local government (n=6), followed by educational services (n=5), professional services (n=4), transportation and warehousing (n=3), energy and natural resource use (n=3), healthcare and social assistance (n=2), and consumer goods (n=1).

Further, although my participants were from a variety of economic sectors in many cases their fleet vehicles were used for similar purposes. The most common use for fleet vehicles identified by participants was service or maintenance work (n=21), followed by administrative work (n=16), local or regional deliveries (n=6), public transportation (n=3), and shared mobility (n=2). There were also four participants that mentioned using some of their fleet vehicles for other tasks such as industrial use, security, field research or community service work.

Table 3.2. Economic sectors for participant classification

Consolidated Economic Sectors for this study	NAICS 3.0 classifications
Educational Services	Educational Services
Healthcare and Social Assistance	Healthcare and Social Assistance
Local Government	Public Administration

Professional Services	Construction Finance and Insurance Real estate and rental and leasing Professional, scientific and technical services Management of companies and enterprises Administrative Support, Waste management and remediation
Consumer Goods	Manufacturing Wholesale Trade Retail Trade
Transportation and Warehousing	Transportation and Warehousing
Energy & Natural Resource Use	Agriculture, forestry, fishing and hunting Mining, quarrying and oil & gas extraction Utilities
Service & Entertainment	Information and cultural industries Arts, entertainment and recreation Accommodation and food services Other Services (except public administration)

I also combined BC's eight economic development regions (Province of British Columbia, 2021a) into four simplified geographic ones, namely: Southwest, Southeast, North and East Central (which is essentially the middle of the province). The Southwestern region encompasses both the South Coast of BC and Vancouver Island and is the most densely population region housing approximately four out of the five million people living in BC. The Southeastern region is the second most densely populated with approximately 770,000 people. The Northern and East Central regions are the least densely populated with approximately 170,000 people each. Participants were asked to self-identify which regions they operate in during the pre-interview survey. Some participants (n=6) indicated that they operate in multiple regions while the rest (n=18) indicated that they operate in only one region. My realized sample contains organizations that operate in all four regions of the province at least some of the time. A higher percentage of them work in the more densely populated regions of Southwestern BC (n=18) and Southeastern BC (n=9) while a smaller percentage of them work in the more sparsely populated regions of Northern BC (n=5) and East Central BC (n=5).

In terms of organization type, my realized sample includes 15 participants from the public sector and nine from the private sector. In terms of fleet size, my sample includes 10 participants from organizations with small fleets ($\leq$100 vehicles), eight from

organizations with medium fleets (101- 400 vehicles), and six from organizations with large fleets (401+).

One final demographic not included in Table 3.1 is vehicle weight class. I excluded it from the table for two reasons. First, not all participants were able to provide information about the types of vehicles they owned in terms of vehicle weight classes. Second, during interviews, a few participants mentioned that the numbers they had provided were rough estimates as they did not normally track and classify their vehicles in this way. However, to provide an approximation of the types of vehicles included in this study I provide the following fleet composition ranges based on the available data. The percentage of light duty vehicles (GVWR ≤ 3856 kg) in participants fleets ranged from 10% to 100%. The percentage of medium duty vehicles (GVWR 3,857 kg to 4,536 kg) ranged from 1% to 60% and the percentage of heavy-duty vehicles (>GVWR 4,537 kg) ranged from 0% to 40%.

3.2. Overview of Results

Table 3.3 summarizes the factors of AFV adoption mentioned by participants organized by thematic area. In total, participants mentioned 19 different types of motivators, 14 types of barriers, 12 neutral factors, and 12 mixed factors. Some factors were mentioned by most participants as barriers (e.g., the capital cost of vehicles, n=18) while others were mentioned by most as motivators (e.g., the external reputation of the organization, n=15) or neutral factors (e.g., maintenance capacity, n=10). There are also some factors I classified as mixed factors for some participants. I classified a factor as mixed if a participant mentioned that its influence on their decision to adopt an AFV varied on a case-by-case basis becoming a barrier in some circumstances and a motivator in others. To avoid double counting mentions, if I classified a factor as mixed for a participant I did not count it as a motivator nor did I count it as a barrier for that participant.

In the proceeding subsections, I use participant counts and quotes to explore the barriers, motivators, neutral, and mixed factors mentioned by participants. Each quote will be labelled with an indication of the participant who said it that includes their organization type (public versus private) and fleet size (small, medium or large) in brackets. For example, “Participant 6 (public, small)” indicates that this participant is

from a public sector organization with a small-sized fleet. I will go into more depth for those factors mentioned by at least one-third of participants and touch more briefly on the others. I will also graphically represent and briefly discuss how participant counts for these factors appear to be impacted by organization type and fleet size.

3.3. Barriers

This section explores which barriers were mentioned by the highest number of participants. Recall that the counts of participants shown in Table 3.3. are based on the total number of participants that mentioned a factor at least once during their interview, organized by thematic area. I also use percentage graphs to depict how participant counts vary by organization type and fleet size (Figure 3.1). I classify barriers as factors that participants identified as having the potential to negatively impact AFV adoption across some or all vehicle classes and operational departments within their organization. Using my conceptual framework, I identify 14 barrier categories (Table 3.3) which span all five thematic areas. The four most commonly mentioned barriers are the capital cost of vehicles (n=18), market availability of vehicles (n=15), the availability of charging and/or fueling infrastructure (n=14) and range (n=10). These fit within three thematic areas: financial considerations, organizational context, and functional considerations.

The barrier mentioned by the highest count of participants is the capital cost of vehicles. It was mentioned by 18 out of 24 participants (75%). This was typically mentioned as the relatively high purchase price of AFVs compared to conventional vehicles and was sometimes mentioned in conjunction with vehicle purchase incentives. As Participant 9 (public, medium) explained: “it usually comes down to the purchase price because of finance’s focus on upfront capital costs.” (Recall that the terms public and medium in brackets above mean that Participant 9 was from a public sector

Table 3.3. Motivators, Barriers, Neutral and Mixed Factors of AFV adoption (Total number of participants with at least one mention of each factor organized by thematic area)

		Number of participants that mentioned this factor as a			
Thematic Area	**Factor**	**Barrier**	**Motivator**	**Neutral**	**Mixed factor**
Financial Considerations	Capital cost of vehicles	18	-	3	-
	Vehicle incentives	-	13	2	3
	Capital cost of infrastructure	7	-	6	-
	Infrastructure incentives	-	5	6	2
	Carbon offset credits	-	3	-	-
	Operations and maintenance costs	2	18	6	-
	Lifecycle cost	1	5	-	10
Organizational Context	Partnership opportunities	-	7	-	-
	External reputation of the organization	-	15	2	-
	Market availability of AFVs	15	1	-	2
Functional Considerations	Range	10	1	2	3
	Availability of charging or fueling	14	1	3	1
	Vehicle comfort or style	3	3	-	-
	Vehicle suitability to the organization's tasks	5	6	-	9
Organizational Dynamics	Internal support for environmental sustainability	-	24	-	-
	Internal support for innovation or new technology	7	8	-	-
	Purchasing practices	-	9	-	1
	History of AFV use	4	12	3	-
Knowledge	Maintenance capacity	3	-	10	2
	Vehicle user training	3	-	9	2
	Peer-to-peer information sharing	-	6	-	3
	Policy awareness or understanding (regs, mandates)	-	8	2	2
	Internal AFV technical or market expertise	2	5	-	-

organization with a medium-sized fleet.) Similarly, Participant 18 (private, small) said: "[ZEVs are] expensive right now. That's part of why I hope that [the commercial vehicle purchase incentive] program kicks in." Looking across organization categories, this barrier was more frequently mentioned among public-sector participants (in comparison to private-sector participants), and among participants with small or medium fleets (as opposed to large fleets).

The market availability of AFVs is the barrier with the second highest count of participants. It was mentioned by 15 out of 24 participants (63%). Specifically, participants mentioned that some of the types of fleet vehicles they typically use aren't currently available for sale as AFVs in Canada. In addition, some participants mentioned either that the vehicles available are not suitable to meet the needs of certain departments (n=5) or that some classes of vehicles are not technologically mature

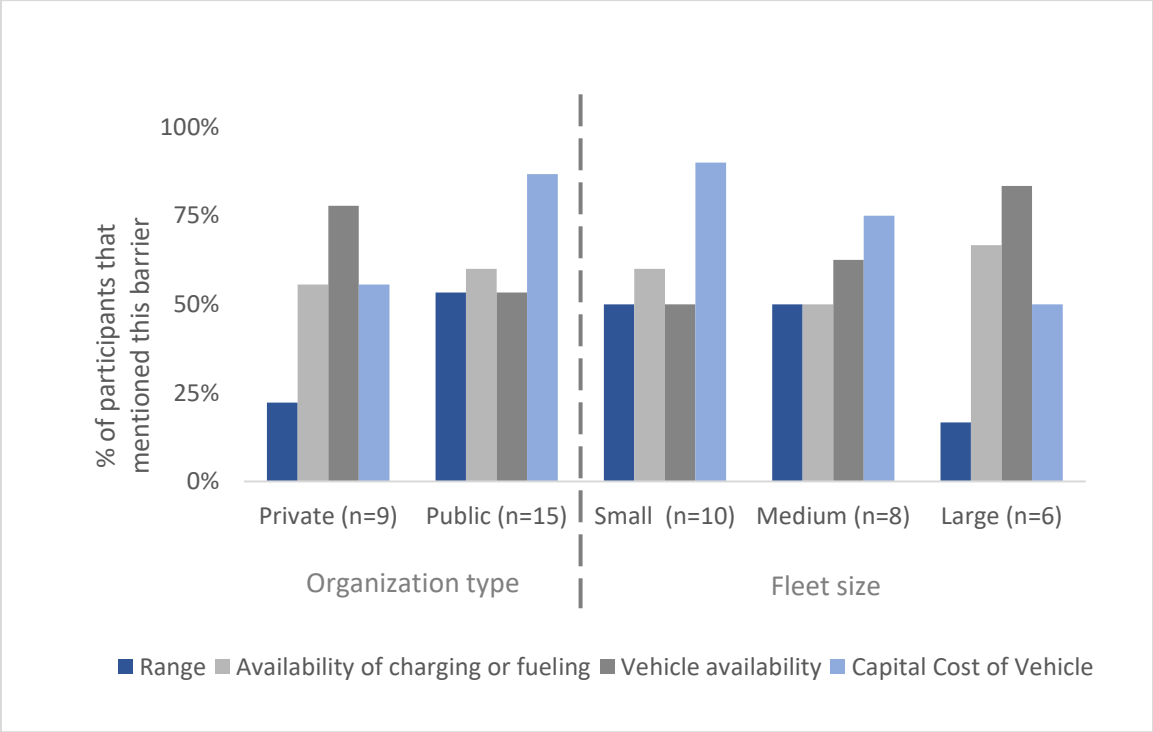

Figure 3.1. The most commonly mentioned barriers across organization type and fleet size categories.

enough for them to be willing to buy them (n=3). When asked why they decided not to purchase an AFV, Participant 11 (public, medium) responded: "At this point in time, the electric technology for those vehicles is still what I would call a beta prototype… we are waiting for them to become production ready before [we purchase] them." Many

participants (n=11) identified cargo vans or pick-up trucks as a potential area of AFV adoption that is being held up by a lack of market ready AFVs available for purchase in BC. As Participant 16 (private, small) declared: “what we think is going to make the biggest difference is if we can start seeing smaller cargo vans and service vehicles [available for sale in North America].” Some organizations have already established an electric vehicle purchasing plan with the necessary financial approvals to back it up. However, they identify the lack of availability as a key barrier. As Participant 15 (public, large) explained:

> “The hardest part is that the units are not available… even the Ford F-150; nothing is going to be available to me till mid next year. I’ll be lucky if I get the first one in mid-next year. The transit vans; I can’t order – I want to order some transit vans, fully electric transit vans, that order desk is not open yet. They are behind. So it’s not the money or being able to charge [that] is the issue; the issue is [a lack of] supply for those units.” (Participant 15, public, large)

Looking across organization categories, this barrier was mentioned more frequently by private-sector participants (compared to public-sector ones) and by participants with large fleets (as opposed to small or medium fleets).

The third most commonly mentioned barrier is the availability of charging and/or fueling. It was mentioned by fourteen out of 24 (58%) participants. The concerns they mentioned primarily related to a lack of works-site or public electric vehicle charging stations and the difficulties associated with installing more of them. When asked what would stop them from purchasing an AFV, Participant 6 (public, small) replied: “[it’s] the infrastructure. These vehicles have to go across the province, and we’re not confident that the [current] infrastructure [is sufficient to enable] our employees to [effectively] work their hours.” The degree of participant concern appeared to be associated with how vehicles were used and where they finished at the end of the day. Some mentioned concerns related to public charging while others mentioned concerns about a lack of sufficient ZEV chargers at fleet storage yards, or at operators’ homes. While most organizations (n=22) have most vehicles return to a fleet parking area for afterhours storage, many (n=16) also allow some operators to take their vehicles home at the end of the day and a few(n=3) allow most of their operators to do so. For example, Participant 19 (private, small) said:

> "Our biggest issue is that [all of the vehicles are independantly owned by their operators and] many of them don't have a home that they can [install a ZEV] charger in. If they live in an apartment or if they're renting a house or a basement suite, a lot of times, [it's] not even an option. So, really, you can market ZEVs to only a small percentage of [our fleet vehicle] operators" (Participant 19, private, small)

Of the 14 organizations that mentioned this barrier, three mentioned that it is difficult to convince landlords to install ZEV chargers in leased spaces. Another five flagged site electrical capacity constraints as an issue inhibiting them from installing sufficient ZEV charging. As Participant 12 (public, medium) pointed out: "one consideration is whether or not [building owners] have room on their panel to put in chargers. And if they don't, then that becomes a more challenging hurdle." Looking across organization categories, this barrier was mentioned with about equal frequency by participants from private- and public-sector organizations and slightly more frequently by participants with small or large fleets (compared to medium fleets).

A lack of vehicle range is the fourth most commonly mentioned barrier. It was mentioned by 10 out of 24 (42%) participants.Vehicle range concerns were predominately mentioned in relation to ZEVs and by organizations that expected to have to travel long distances some (or all) of the time. For example, Participant 7 (public, medium) said: "The feedback we've had [from one department is ZEV] range is a concern because [their] vehicles travel thousands of kilometres over a [work] period." Some participants also mentioned that the combination of a lack of vehicle range and a lack of available of charging infrastructure could be a challenge. As Participant 6 (public, small) pointed out: "it's a combination of the range of certain vehicles with where there are charging stations and also how long charges take to complete." Looking across organization categories, this barrier was mentioned more frequently by public-sector participants (versus private-sector ones) and by participants with small or medium fleets (as opposed to large fleets).

Other barriers were mentioned less frequently and are not discussed in further detail here due to space constraints. These barriers include:

- the capital cost of installing new charging or fueling infrastructure (n=7),
- a lack of internal support for innovation or new technology (n=7),
- concerns about vehicle comfort or style (n=4),

- a history of AFV use that involved some negative experiences (n=4),
- concerns about the organization's AFV maintenance capacity(n=3),
- the time or effort needed for vehicle user training (n=3),
- the additional maintenance costs associated with the AFV's in their fleet(n=2) (this barrier was not associated with ZEVs),
- a lack of internal technical and market AFV awareness (n=2), and
- lifecycle costs that are higher than those of equivalent conventional vehicles (n=1).

3.4. Motivators

This section explores which motivators were mentioned by the highest number of participants. Recall that the counts of participants shown in Table 3.3. are based on the total number of participants that mentioned a factor at least once during their interview, organized by thematic area. I also use percentage graphs to depict how participant counts vary by organization type and fleet size (Figure 3.2). I classify motivators as those factors that participants identified as having the potential to encourage or speed up AFV adoption in their organization. Using my conceptual framework, I identify 19 motivator categories (Table 3.3) which span all five thematic areas. The five most commonly mentioned motivators were internal support for environmental sustainability (n=24), operations and maintenance costs (n=18), the external reputation of the organization (n=15), vehicle purchase incentives (n=13) and a history of AFV use (n=12). These fit within three thematic areas: financial considerations, organizational context, and organizational dynamics.

The motivator mentioned by the highest count of participants is internal support for environmental sustainability which was mentioned by all 24 participants (100%). This motivator encompasses participant comments about staff and senior leader support for GHG emissions reduction, pollution reduction, and environmental sustainability more generally. Participants mentioned two main aspects of this motivator. The first aspect was that their organization had established an official GHG emissions reduction plan, policy, or target which, (directly or indirectly) encouraged AFV adoption as a means of lowering GHG emissions. This was mentioned by 20 out of 24 participants (75%). As Participant 9 (public, medium) explained:

> "There are specific lines and goals within [our organization's five-year strategic plan] that essentially instruct us to align with the [provincial government's mandate…] that 10% of our light-duty vehicles [must be replaced with] a ZEV. [This] has been very helpful because any time I want to put a case together to … procure a [ZEV] that may not make sense in purely financial terms, … linking it to an explicit statement or explicit target within the strategic plan gives it a fairly high level of support." (Participant 9, public, medium)

The second aspect of this motivator mentioned by participants was that their organization has a pro-environmental culture that aligns with lowering GHG emissions through AFV adoption. This was mentioned by 16 out of 24 participants. For example, Participant 23 (private, large) said: "Sustainability is front and centre in terms of corporate values. It's highly communicated, and it's highly valued within the company…there is executive support for the decarbonization programs … and that's really helped drive these [ZEV] pilots." Some participants also mentioned that internal support for environmental sustainability has been increasing over time due, in part, to the pro-environmental values that younger workers are bringing with them to the workforce. As Participant 14 (public, large) declared:

> "It really just felt like the drive to go low-emissions, the understanding of being in a climate emergency, like just the general sense of a need to respond to what's going on around us is stronger now than it was five years ago, it's no longer a nice to have, I think people are really starting to understand it's something that they want to embed in their work, and as our workforce trends younger, [we're] also seeing [that for] more and more people this [is] top of mind." (Participant 14, public, large)

There were no differences in the frequency of mentions across organization categories for this motivator because all participants mentioned it.

The second most commonly mentioned motivator is operations and maintenance savings which was mentioned by 18 out of 24 participants (75%). Participants typically mentioned that they expected (or found) that their fuel costs and vehicle maintenance costs decreased when they switched from internal combustion engine vehicles to AFVs. As Participant 7 (public, medium) pointed out: "the reduction in cost associated with filling up a truck with fuel versus [charging] a Nissan Leaf was really well-received." Likewise, when talking about ZEVs Participant 23 (private, large) observed: "I'd say we've seen a good reduction in maintenance costs, [and] definitely a reduction in [the amount of time needed for] regularly planned maintenance events." There was also a

recognition among some participants of the time that could be saved by using ZEVs that were charged up overnight rather than vehicles that had to stop to fuel up during the workday. As Participant 18 (private, small) pointed out: “I don’t have to pay people to go to gas stations anymore.” This motivator was mentioned with near equal frequency by participants from all organization categories.

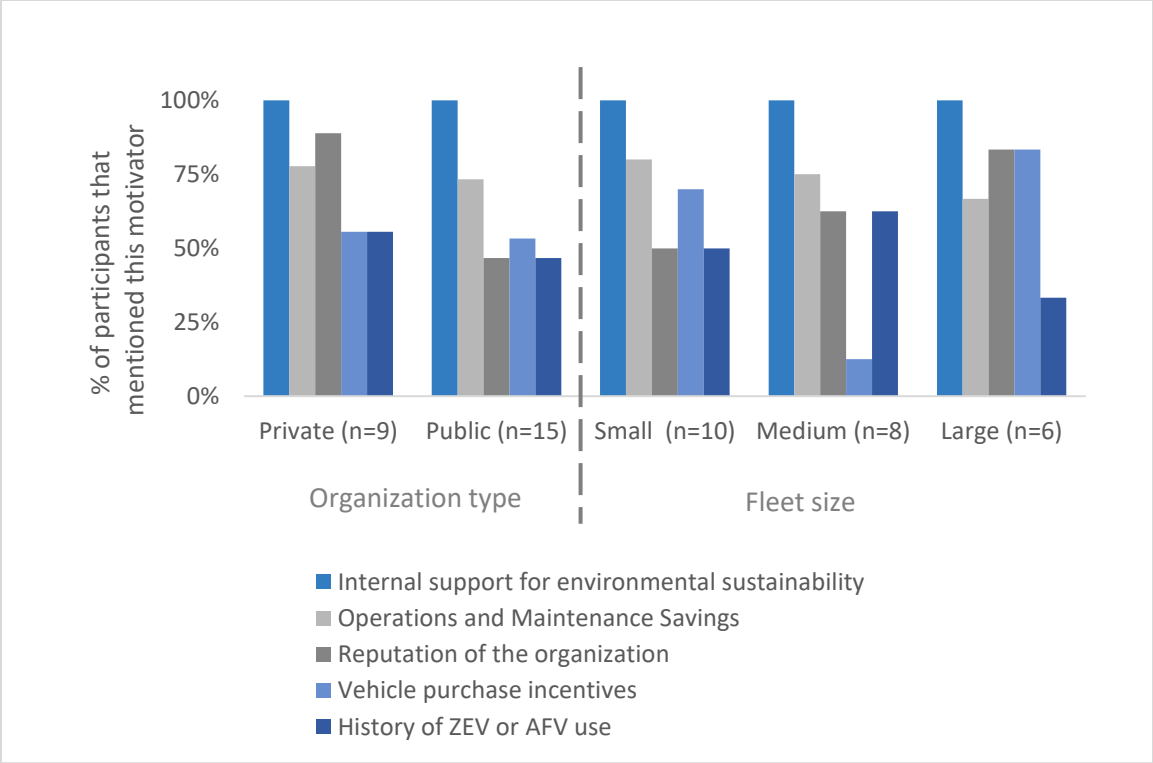

Figure 3.2. The most commonly mentioned motivators across organization type and fleet size categories

The external reputation of the organization is the motivator mentioned by the third-highest count of participants. It was mentioned by 15 out of 24 participants (63%). Participant statements related to this motivator often tied back to GHG reduction and/or positive environmental impact but were more concerned with how AFV adoption would be viewed by external stakeholders rather than internal ones. As Participant 7 (public, medium) explained: “We are always looking to raise… our reputation in the sustainability field… one of the drivers in starting [to purchase ZEVs] was the fact that we wanted to raise our profile [as] leaders in sustainability.” Other organizations saw AFV adoption as an opportunity to strengthen their brand image. For example, Participant 22 (private, large) said: “we publicized a lot the fact [that we have ZEVs], through social media, and this is around brand building, if you like, creating awareness and brand building.”

Looking across organization categories, this motivator was mentioned more frequently by private-sector participants (as opposed to public-sector ones) and by participants with large fleets (versus small or medium fleets).

Vehicle purchase incentives is the fourth most commonly mentioned motivator. It was mentioned by 13 out of 24 participants (54%). In all cases, the vehicle purchase incentives discussed were those provided by either the federal or provincial government and referred to either point-of-sale, post-purchase rebate or, tax-break incentive programs. For some organizations vehicle purchase incentives helped to bring the capital costs of vehicle acquisition down to an acceptable level. Such was the case for Participant 13 (public, large) who said: “The [ZEV] we just purchased, [cost] substantially more than an [internal combustion engine vehicle], and it’d be a tough sell… [but] with the [vehicle purchase] incentive, it’s a little easier to justify.” Other participants, such as Participant 9 (public, medium), said: “[vehicle purchase incentives] only make a small difference in the overall cost.” For them this small difference was not enough to offset the higher capital costs of AFVs. Looking across organization categories, this motivator was mentioned with equal frequency by private- and public-sector participants but more frequently by participants with either small or large fleets (as opposed to medium fleets).

The fifth most commonly mentioned motivator is a history of AFV use. It was mentioned by 12 out of 24 participants (50%). Specifically, participants mentioned organizing vehicle demonstrations, undertaking pilot projects, and strategically placing vehicles in common-use vehicle pools as means of allowing drivers to try out AFV technologies in real-world operations. They often mentioned using short-term vehicle demonstrations to test the functional considerations of an AFV. For example, Participant 11 (public medium) said: “We did a trial period as well, with one of our incumbent electric vehicles. The staff members actually really enjoyed it, and they found that it wasn’t as much of an operational impact as they originally thought it might be.” Likewise, Participant 21 (private, large) mentioned: “we actually ran a piece of [ZEV] equipment on trial to see if it would perform and based on the trial we then decided to purchase [it].” Participants also mentioned purposefully creating opportunities for drivers to develop a personal history of AFV use to help increase their comfort levels with these technologies. This was done either through pilot projects, or through adding them to vehicle pools where multiple drivers could use them if they wished to. As Participant 20 (public, medium) explained:

> "[The ZEVs] went into the common use [pool] first. [As a result,] utilization amounts weren't super high, but it provided a good, safe opportunity for people to get exposure to and test the technology…which worked really well."

Some organizations mentioned that over time the combination of proving the operational fit of the equipment and increasing driver familiarity helped improve internal acceptance of AFVs. As Participant 13 (public, large) explained:

> "[When I introduced the first ZEV] I had some issues convincing user groups that it was a good thing and that they should try it…now, because most people know we've had ZEV's for [a few] years… there are no rumblings about how they aren't workable and doable … in fact, the user groups now think it's pretty cool if they're being considered for a ZEV." (Participant 13, public, large)

Looking across organization categories, this motivator was mentioned slightly more frequently by private-sector participants (compared to public-sector ones) and by participants with small or medium fleets (as opposed to large fleets).

Participants mentioned many other motivators less frequently. These are not discussed in further detail here due to space constraints but include:

- purchasing practices that favored AFV adoption (n=9),
- internal support for innovation or new technology (n=8),
- an awareness of current provincial government policies (mandates, GHG emission reduction targets or regulations),
- an intention or desire to align their organization with those policies (n=8)
- partnership opportunities with utility companies, local governments or universities that facilitated adoption (n=7),
- internal or external peer-to-peer knowledge sharing about AFVs (n=6),
- the suitability of AFVs to the organization's tasks (n=6),
- a high level of internal AFV technical or market expertise (n=5),
- charging or fueling infrastructure incentives that encouraged the installation of these resources (n=5),
- lower lifecycle costs that improved the business case for adoption(n=5),

- the opportunity to earn carbon offset credits from alternative vehicle fuel production and use or from industrial electrification (n=3),
- a perceived level of increased vehicle comfort or style associated with AFVs (n=3),
- new vehicles coming onto the market that increase the availability of vehicles suitable to the organizations needs (n=1),
- increases in vehicle driving range (n=1),
- and the increasing availability of charging or fueling infrastructure (n=1).

3.5. Neutral and Mixed Factors

This section explores the neutral and mixed factors mentioned by the highest number of participants. I count a factor mention as neutral if participants inferred or stated that it was a factor that would have little or no impact on their decisions to adopt AFVs. Sometimes these are logistical considerations that participants mentioned as part of their business-as-usual routines. In other neutral cases, when prompted for their opinion, a participant simply stated were not an impactful factor for their organization. There are two commonly mentioned neutral factors, namely, maintenance capacity (n=10) and vehicle user training (n=9). Both these factors fit within the thematic area of knowledge.

I classified a factor as mixed if a participant mentioned that its influence on their decision to adopt an AFV varied on a case-by-case basis becoming a barrier in some circumstances and a motivator in others. The two most commonly mentioned mixed factors are lifecycle cost (n=10) and a vehicle's suitability to the organization's tasks (n=9). These factors fit within the thematic areas of financial considerations, and functional considerations.

The neutral factor mentioned by the highest count of participants is maintenance capacity. It was mentioned as a neutral factor by 10 out of 24 participants (42%). Typically, participant comments centered around either their organization's ability to service AFVs in-house, or their access to local service centers that could do this work. Some participants (n=9) mentioned the availability of local dealerships who could help with repairs, some (n=7) mentioned that they had trained, or planned to train, their in-house staff to do this work and some mentioned both (n=4). For electric vehicles in particular, a few participants (n=4) mentioned that they have few concerns about

maintenance because they expected (or found) that electric vehicles do not require much. As Participant 15 (public, large) explained: “We’ve done basic electric vehicle training for our staff but to date, there’s [been] very little maintenance [to do] on those electric vehicles.”

Vehicle user training is the second most commonly mentioned neutral factor. It was mentioned as a neutral factor by nine out of 24 participants (38%). Specifically, participants mentioned the need to provide users with vehicle orientation sessions, show them how to plug-in and charge ZEVs, or place written vehicle use instructions in the glove box. Some participants (n=4) mentioned that the amount of additional vehicle user training needed for ZEVs (compared to that needed for conventional vehicles) was minimal, or not needed at all. As Participant 12 (public, medium) said:

> “this was our first go so we didn’t [provide a lot of training or user manuals] … we followed up and said, ‘Do you need any of this stuff?’ and the response we got was, ‘No it’s pretty self-explanatory, we’ve got it figured out’ and so we didn’t bother to create a whole bunch of accompanying change documentation because it just didn’t seem necessary.” (Participant 12, public, medium)

Others (n=5) mentioned vehicle user training as one part of a typical change management process that their organization would undertake regardless of what new technology or vehicle was being introduced suggesting this was viewed as a routine logistical consideration rather than a barrier or motivator.

The most commonly mentioned mixed factor is lifecycle cost which I classified as a mixed factor for 10 out of 24 participants (42%). Lifecycle costing is an accounting practice used to inform vehicle purchasing decisions. It brings vehicle capital cost, operations and maintenance costs, length of ownership and other financial considerations together to calculate a single aggregate lifecycle cost. I classify this as a mixed factor because its positive or negative influence on a participant’s vehicle purchasing decisions appears to vary on a case-by-case basis depending on whether the lifecycle cost of the proposed AFV is higher or lower than the cost of an equivalent conventional vehicle. Further, the application of this costing methodology to inform vehicle purchasing decisions appears to be varied. Some (n=2) organizations mentioned that they only applied this practice to AFVs but did not use it for conventional vehicle purchases. Others (n=5) mentioned that they are still in the process of developing (or

collecting data to inform) a lifecycle costing method for evaluating AFVs. For example, Participant 7 (public, medium) said: “we’re developing [a] life cycle analysis, to [compare] the long-term operational [costs] of a vehicle…and the upfront purchase price [to find out] when we reach a break-even point.” In addition, some (n=6) mentioned that lifecycle cost is one part of a larger vehicle purchase analysis that gives equal (or sometimes more) importance to other factors such as the vehicle’s impact on the environment, the cost of installing charging infrastructure, or leasing options. As P16 (private, small) explained: “if [the lifecycle cost] is going to be close or on par, we’d rather go with the choice that’s environmentally friendly and that makes a positive impact.”

The second most commonly mentioned mixed factor is the vehicle’s suitability to the organization’s tasks (n=9, 38%). Participant mentions typically pertained to a vehicle’s functional aspects such as payload and horsepower or its ability to meet drivers needs under adverse conditions such as off-road, winter driving, or long operating hours. I classified this as a mixed factor if it was mentioned as both a barrier and a motivator by the same participant depending on the class of vehicle or the use case they were talking about. For example, Participant 9 (public, medium) said:

> “For smaller sedans, the default would be you will get [a ZEV] unless there’s a good reason why not… [such as, the user is] in a remote location, or they’re travelling long distances in rural areas where they don’t have easy access to a charging point… but certainly within the city… the expectation would be that you will get a ZEV.” (Participant 9, public, medium)

To help counteract this variability in user needs, some organizations(n=11) have implemented vehicle right-sizing processes that seek to match each vehicle to the operational needs of the department or operating region it will be placed in. As Participant 14 (public, large) explained:

“Rather than starting with an approach where we’re just doing a like-for-like replacement, we start by understanding how the vehicle is being used and what the requirements are for that vehicle or equipment to meet the operational needs… [our team] turn those requirements into specifications… that results in a purchase order.” Participant 14 (public, large)

Several other factors were mentioned as neutral or mixed factors by some participants. They are not discussed in detail here due to space constraints but include:

- the capital cost of installing new charging or fueling infrastructure (neutral, n=6),
- the availability of infrastructure incentives (neutral, n=6; mixed, n=2),
- operations and maintenance costs (neutral, n=6),
- the capital cost of vehicles (neutral, n=3),
- the availability of charging or fulling infrastructure (neutral, n=3; mixed, n=1),
- a history of AFV use (neutral, n=3),
- vehicle purchase incentives (neutral, n=2; mixed, n=3),
- the external reputation of the organization (neutral, n=2),
- vehicle range (neutral, n=2; mixed, n=3),
- policy awareness or understanding (neutral, n=2; mixed, n=2),
- peer to peer information sharing (mixed, n=3),
- the market availability of AFVs (mixed, n=2),
- purchasing practices (mixed, n=1).

Chapter 4.

Discussion and Conclusion

I conducted a series of semi-structured interviews with participants from 24 organizations to explore the barriers and motivators of AFV adoption in fleets in BC, Canada. The study design includes inductive data collection and qualitative analysis intended to explore this topic in depth, uncover new data, identify themes and patterns and generate hypotheses rather than test them. Below I discuss the limitations of this study, summarize my key results by thematic area, and explore how they compare to previous studies of AFV fleet adoption.

4.1. Limitations and Opportunities for Future Research

Although this study seeks to add to the body of knowledge on AFV adoption in fleets, I first acknowledge that it has several limitations and that given these limitations its results must be interpreted with care. In this section I describe five limitations, how they may have impacted my results and how future research could improve upon them.

The first limitation of this study is that the realized sample contains a disproportionate number of AFV adopters (n=22) compared to non-adopters (n=2). This was likely caused by self selection bias wherein individuals more aware and supportive of AFV adoption in fleets chose to participate and those more resistant to, or disinterested in, AFVs chose not to. Regardless, the disproportionate number of AFV adopters in this study likely led to an overemphasis of the number and strength of motivators and an under emphasis of firm barriers. A similar study aimed at non-adopters, or a larger study with a broader range of participants that includes a more even distribution of adopters and non-adopters, could facilitate additional comparative analysis to verify or contradict these results and counteract this bias.

Second is social desirability bias which is the tendency for research participants to say what they think the researcher wants to hear, or what they believe to be a socially desirable answer rather than one that accurately reflects their reality (Bergen & Labonté, 2020). Although I did my best during interviews to appear as a “benign, accepting, curious (but not inquisitive) individual who [was] prepared and eager to listen to virtually

any testimony with interest" (McCracken, 1988,p.38), it is possible I was unsuccessful and that my own pro-AFV sentiments influenced participant responses. This may have prompted participants to express more pro-AFV sentiments than they normally would have or to stay silent about topics they thought I might disapprove of. Additional research using an alternative data collection method such as surveys which reduce researcher – participant interaction could be used to verify these results and reduce the potential impacts of this bias.

Third is the short duration of this study which provides a single snapshot of a participant's opinions taken during a point in time when the automobile industry is at a transformative juncture in its history and when both federal and provincial government policies are supportive of AFV adoption. If AFV market offerings, government policies, or any number of other political, social, or economic drivers change so too might participant opinions about AFV fleet adoption potentially rendering the results of this study less applicable. A repetition of this study at a later date (particularly following a significant change) could reveal what, if anything, has changed.

The regionality of this study is its fourth limitation. This study took place in British Columbia (BC), Canada and as such its results are most applicable to this geographic location and political and social context. Given that most participants had some vehicles that they used for service and maintenance work (n=21) or administrative work (n=16) and that these tasks largely took place in concentrated urban areas, it could be argued that many of the challenges and opportunities they face when trying to use AFVs are likely to be similar to those found in other urban areas throughout the world. However, it is also important to note that when operating outside these concentrated urban areas long travel distances and the relatively low population densities found in other parts of the province may exacerbate some barriers (e.g., vehicle range) for fleets in BC more so than for fleets in other jurisdictions.

Lastly, this study's sample size of 24 participants limits its generalizability. The selected sample is not large or diverse enough to be statistically representative of fleets in BC. Additional research such as a survey of a broader number of organizations could be used to verify the results of this study with a higher degree of statistical significance thus making them more generalizable.

4.2. Main Findings

Many factors have the potential to impact AFV adoption in organizations. In this section I briefly summarize the barriers, motivators, neutral, and mixed factors mentioned by the highest numbers of participants organized into my five thematic areas, namely: financial considerations, organizational context, functional considerations, organizational dynamics, and knowledge. I also discuss how these results relate to the existing literature and how they may impact policy and industry.

4.2.1. Financial Considerations

The first thematic area is financial considerations which includes capital costs (or purchase price), cost savings, and incentives. I found four commonly mentioned factors in this thematic area including one barrier, three motivators and one mixed factor. I found that many participants mentioned high capital costs as a barrier (n=18). Participant mentions about capital cost typically related to the relatively high purchase price of AFVs compared to conventional vehicles and how this could discourage adoption. Similarly, Sugihara and Hardman (2022) found purchase price to be a major barrier of ZEV adoption mentioned during their interviews with Californian fleet managers. Further, a recent study by the International Energy Agency (2021) found that the purchase price of ZEV's remains a key barrier for all potential ZEV adopters (fleet and non-fleet).

The most commonly mentioned financial motivator was operations and maintenance cost savings (n=18). Specifically, participants mentioned expectations that operating costs (particularly fuel costs) and maintenance costs would be less for AFVs than for conventional vehicles. This is in keeping with the results of Boutueil (2016) and Hutchins & Delmonte (2012). Boutueil (2016) found that many of the 22 organizations they interviewed in Paris mentioned lower operating costs (mainly fuel and maintenance costs) as motivators for ZEV adoption. Hutchins & Delmonte (2012) found that lower operations and maintenance costs, particularly lower fuel costs, were a motivator for ZEV adoption amongst the UK fleet managers they interviewed.

Vehicle purchase incentives were the second most commonly mentioned financial motivator (n=13). Participants generally mentioned how vehicle purchase incentives help increase the chances of AFV adoption by helping to lower upfront capital

costs and improve the overall business case for purchasing AFVs. A recent study by Sugihara and Hardman (2022) showed comparable results stating that during interviews fleet managers in California (mostly ZEV adopters) mentioned using vehicle purchase incentives to lower capital costs down to a level that made ZEVs financially justifiable purchases. Similarly, Morganti and Browne (2018) found that during interviews in Paris and London fleet operators mentioned high retail prices as a major barrier and vehicle purchase incentives as crucial for fostering a transition from diesel vehicles to AFVs.

I also found one financial motivator that appears to be unique to this study. Three participants mentioned carbon offset credits as a motivator for AFV adoption. While only a small number of participants mentioned this motivator it is one that may have wider relevance for fleet AFV adoption, decarbonization targets, and climate policy and thus may warrant additional study.

The one mixed factor in this thematic area was lifecycle costs. I classified this as a mixed factor for many participants (n=10) because they primarily mentioned it as a decision-making tool the results of which could become either a barrier or a motivator on a case-by-case basis. This differs from the findings of Mau and Woisetschläger (2018) who found that the 39 fleet industry experts they interviewed in Germany all stated that ZEVs were still not cost-competitive in terms of lifecycle cost.

4.2.2. Organizational Context

Organizational context is the second thematic area. It includes factors that are largely impacted by forces external to the organization but that may nevertheless impact AFV adoption in fleets. I found two commonly mentioned factors in this thematic area including one barrier, and one motivator.

The barrier mentioned by the highest count of participants in this thematic area was the market availability of AFVs (n=15). Participants mentioned that market ready electric vans or trucks and medium-duty, heavy-duty, or special purpose AFVs were unavailable for purchase or difficult to obtain in BC. Participant mentions about the market availability of AFVs typically classified this as a short-term barrier that they expected to decrease with time and technological advancement. The availability of light-duty passenger vehicles was generally not mentioned as a barrier. Similarly, Quak et al.

(2016) found that a lack of ZEV availability (specifically large vans and trucks) was a barrier for adoption amongst the city logistics fleets studied during their review of several European electric freight vehicle demonstration projects. More recently, Sugihara & Hardman (2022) completed a study that used interviews to explore fleet vehicle decision making processes and identify the motivators and barriers of ZEV adoption in Californian public and semi-public fleets. Their results closely align with mine. Specifically, Sugihara & Hardman found their participants mentioned that their ability to electrify their fleets was limited by a lack of available vehicle options (particularly for pick-up trucks and medium- and heavy-duty vehicles) but that this was not considered a barrier for passenger vehicles. Taken together, the results of this study and the literature seem to indicate that there may be some pent-up demand for fleet AFVs in some vehicle classes, although it is unclear how much.

The most commonly mentioned motivator in this thematic area was the positive impact AFV adoption could have on the external reputation of the organization (n=15). Participant comments were often tied to GHG emissions reduction or the positive environmental impact of AFV adoption and how it would be favourably viewed by external stakeholders. Similarly, Boutueil (2016) found that during a round of 22 interviews with fleet decision makers in the Paris region (about fifty percent of whom were ZEV adopters) many participants mentioned that adopting ZEVs was expected to have a positive impact on their brand image with both customers and employees. With customers it was expected to improve their image as an environmentally sustainable organization and with employees it was expected to help embed sustainability and innovative into their corporate culture.

4.2.3. Functional Considerations

Functional considerations is the third thematic area. It encompasses the technical and operational aspects of AFVs and how they can be used in organizations. I found three commonly mentioned factors in this thematic area including two barriers, and one mixed factor.

The availability of charging or fueling infrastructure (n=14) and range anxiety (n=10) were the two most commonly mentioned barriers and both are barriers frequently mentioned in the literature as well (Table 1.1, Section 1.1, pg.3). Charging and fueling

concerns mentioned by participants primarily related to a lack of electric vehicle chargers and the difficulties associated with installing more of them. Participants mentioned concerns about a lack of publicly available chargers, as well as a lack of chargers at fleet storage yards or at peoples' homes (for those organizations that allowed drivers to take fleet vehicles home after hours). The challenges associated with installing additional chargers mentioned by participants include high installation costs, electrical capacity constraints, employee living conditions not conducive to ZEV charger installation (e.g., employees living in condos or rental suites as opposed to self-owned single-family houses), and landlord hesitancy to install chargers in leased spaces. Similarly, a recent study by the International Energy Agency (2021) found that the members of EV100 (a group of 100 companies committed to advancing electric transportation in 80 markets worldwide) mentioned a lack of charging infrastructure as the top barrier of ZEV adoption in fleets.

Closely linked to the availability of infrastructure is the barrier of low vehicle driving range which is the second most commonly mentioned barrier in this thematic area (n=10). Participants predominately mentioned range concerns related to ZEVs and this barrier was most often mentioned by organizations that expected to have to travel long distances some (or all) of the time. Hutchins & Delmonte (2012) also found that range was one of the most commonly mentioned barriers during their interviews with 22 fleet managers in the UK. Further, the authors found that participant comments about range were almost always linked to the availability of charging infrastructure. The fact that these two barriers were mentioned by participants of this study and that they appear in the existing literature, seems to indicate that a lack of charging infrastructure and vehicle range concerns may be persistent barriers. They also appear to be barriers that continue to impact fleet manager's willingness to adopt AFVs (particularly ZEVs) in BC despite recent advances in AFV technology to increase range and recent expansions of ZEV charging and low-carbon fueling infrastructure in BC and Canada (Natural Resources Canada, 2022; Province of British Columbia, 2021b, 2021c).

The most commonly mentioned mixed factor in this thematic area was vehicle suitability to the organization's tasks (n=9). I classified it as a mixed factor when a participant mentioned that AFVs were seen as suitable for some departments, operational uses, or vehicle classes within their organization but not yet for others. In contrast, Demeulenaere's systematic review of AFV fleet literature found that the

inadequacy of AFVs to meet the operational requirements of organizations was a commonly identified barrier to the adoption of these technologies(Demeulenaere, 2019). Likewise, Figenbaum (2018) found that ZEVs (specifically battery electric vehicles) were perceived to be incompatible with many of the transportation needs identified by the Norwegian craftsmen and service fleet owners they interviewed.

4.2.4. Organizational Dynamics

The fourth thematic area is organizational dynamics which encompasses attitudinal, experiential, or administrative factors internal to the organization that could impact AFV adoption in fleets. I found two commonly mentioned factors in this thematic area, namely, internal support for environmental sustainability (n=24) and a history of AFV use (n=12) both of which were motivators.

All 24 participants mentioned internal support for environmental sustainability as a motivator making it by far the most frequently mentioned motivator in this study. Many of the organizations who mentioned this motivator had established GHG reduction plans, policies or targets (n=20), had a pro-environmental organizational culture or values (n=16), or had both of these things (n=14). In similar a recent study, Sugihara and Hardman (2022) explored fleet vehicle decision making processes and the motivators and barriers of ZEV adoption in public and semi-public organizations in California. The authors found that sustainability and environmental goals were often the first motivators mentioned by the fleet managers they interviewed (most of whom were ZEV adopters). The consistency in participant mentions of this motivator and the fact that Sugihara and Hardman had similar findings may indicate that GHG reduction and environmental sustainability are driving AFV adoption in fleets with other motivators playing more of a supporting role. This hypothesis is further supported by the findings of Hutchins & Delmonte, (2012) who found that amongst UK fleet managers, the role ZEVs can play in helping fleet managers to meet their CO2 emissions reduction targets was the most frequently cited advantage and sometimes considered the most important attribute of these vehicles.

The other commonly mentioned motivator in this thematic area was having or developing a history of AFV use (n=12). Specifically, participants mentioned how running pilot projects (n=9) or having dealerships supply demonstration vehicles (n=6) could help

improve drivers' perceptions about vehicle usability and suitability by enabling them to test AFVs in real-world scenarios. This is in keeping the findings of Sierzchula (2014) who analyzed interviews and pilot project reports from 14 US and Dutch organizations (all ZEV adopters) to learn about what factors influenced their fleet ZEV purchasing decisions. Sierzchula found that ZEV adoption decisions in fleets were often influenced by a desire to test out new technologies so the organization could increase their knowledge about the practicality and usability of these vehicles. These results suggest that organizations considering AFV adoption may find it advantageous to either run their own pilot projects or approach automotive dealers to determine their willingness to supply vehicles on a trial basis.

4.2.5. Knowledge

Knowledge was the fifth thematic area. Here I explore organizations' existing knowledge bases or their ability to access, acquire or impart knowledge. I found two commonly mentioned factors in this thematic area, namely maintenance capacity (n=10) and the need to provide vehicle user training for AFVs (n=9). Both were mentioned by participants as neutral factors in the sense that they were logistical considerations expected to have little or no impact on their decision to adopt AFVs.

When speaking about the availability of vehicle maintenance capacity, participants generally expressed confidence in their ability to either find local dealerships who could assist them or to be able to train and use in-house staff. These results appear to be in contrast with the findings of Quak et al. (2016) who found that concerns such as a lack of qualified and economical after sales support were becoming a bigger focus for European city logistics fleets.

Vehicle user training was also mentioned as a neutral factor. Some participants mentioned that for ZEVs they anticipated needing to provide only a minimal amount of additional training, if any, compared to the amount they would already habitually provide for conventional vehicles. Add to this, the findings of Wikstrom, Hansson and Alvfors (2016) who spoke with 40 battery electric vehicle (BEVs) users from public and private organizations taking part in a ZEV demonstration project in Sweden. Their study results showed that users who are provided with sufficient information and preparation for ZEV use are likely to have positive or neutral attitudes towards ZEVs whereas those given no

assistance are likely to evidence low usage rates. Therefore, although vehicle user training may have little impact on initial AFV purchase decisions it may influence usage rates and user attitudes towards these technologies and thus remains an important logistical consideration in the transition to AFVs in fleets.

4.3. Organization Type and Fleet Size

I found that organization type (public versus private) and fleet size (small versus medium versus large) may impact the mentioned barriers and motivators of AFV adoption in fleets (Figure 3.1, pg. 21 and 3.2, pg. 26). This section provides examples of how results varied across these categories and links these findings with the literature.

4.3.1. Organization Type

The most commonly mentioned barriers and motivators varied by organization type with one notable exception. An organization's internal support for environmental sustainability was a universally mentioned motivator amongst participants. Leaving this factor aside, my results appear to indicate that public sector organizations may be more cost sensitive than private sector ones. The most commonly mentioned barrier and motivator for public sector participants were both financial considerations. Specially, their most commonly mentioned barrier was the high capital cost of AFVs and their most commonly mentioned motivator was operations and maintenance savings. These results are comparable to what Demeulenaere (2019) discovered during their systematic review of AFV fleet literature. Demeulenaere found that high capital costs may be a stronger barrier for public sector organizations than private sector ones because public fleets do not benefit from the tax rebates available to private sector organizations. Demeulenaere also found that the main drivers for public entities tended to be policy goals, mandates, and public scrutiny. Taken together, these results seem to indicate that public sector organizations may need greater financial support or may require the use of strong motivational levers such as GHG emissions reduction mandates to help advance AFV adoption in these fleets.

Conversely, the most commonly mentioned barrier and motivator for private sector participants were both non-financial considerations. The market availability of AFVs was their most commonly mentioned barrier and the external reputation of the

organization was their most commonly mentioned motivator. These findings are also in keeping with those of Demeulenaere who found that two of the main drivers of AFV adoption for private sector fleets tended to be enhancing their reputation as an environmentally friendly and innovative organization and demonstrating good citizenship.

4.3.2. Fleet Size

My results also varied by fleet size (again excluding the universal motivator of internal support for environmental sustainability). For small fleets of 100 vehicles or less, the most commonly mentioned barrier and the two most commonly mentioned motivators were all financial considerations indicating that small fleets (similar to public fleets) may be more price sensitive than larger fleets. The high capital cost of AFVs was the most commonly mentioned barrier for participants with small fleets whereas operations and maintenance savings and vehicle purchase incentives were their most commonly mentioned motivators. Likewise, Sugihara & Hardman (2022) found that in California smaller fleets appeared more hesitant to experiment with new ZEV technologies than larger fleets and the authors suggested that this may be due to the more limited resources small fleets have compared to larger fleets.

The results for medium fleets (101-400 vehicles) were very similar to those of small fleets. The most commonly mentioned barrier for participants with medium fleets was also the high capital cost of AFVs and their most commonly mentioned motivator was operations and maintenance savings just as it was for participants with small fleets. However, vehicle purchase incentives were not a commonly mentioned motivator amongst participants from medium fleets although there was not clear indication as to why that might be.

The results for large fleets differed from those for small and medium fleets. The most commonly mentioned barrier for participants with large fleets was the market availability of AFVs and their two most commonly mentioned motivators were the external reputation of the organization and vehicle purchase incentives. Interestingly, proportionally less participants from organizations with large fleets mentioned vehicle range as a barrier compared to participants with small or medium fleets. This difference may be due to the greater flexibility larger fleets are likely to have in terms of how and where they use AFVs compared to the level of flexibility small and medium fleets are

likely to have. This hypothesis is in keeping with the findings of Mau & Woisetschläger (2018) who stated that electric vehicles are suitable for fleets, in part, because they can be selectively placed on shorter-routes leaving longer routes to conventional vehicles.

4.4. Policy and Industry implications

My results hold four important policy and two important auto industry implications which I briefly discuss in this section.

4.4.1. Policy Implications

The first policy implication is that government vehicle purchase incentives appear to still be an important mechanism for encouraging AFV adoption in fleets. Many participants mentioned high capital costs as barriers (n=18) and vehicle purchase incentives as motivators (n=13). These finding are consistent with the existing literature as well which suggests that they may be persistent financial barriers and motivators. Therefore, it seems advisable for provincial and federal governments to continue providing vehicle purchase incentive programs until the market price of AFVs declines to a point where capital cost is no longer perceived to be significant barrier.

The second policy implication of this study is that government incentive programs may need to be redesigned to accommodate the high annual vehicle purchase volumes of larger fleets. When speaking about vehicle purchase incentives, one unexpected barrier mentioned by participants was the current incentive caps that the Provincial and Canadian government have included in their vehicle purchase incentive programs. While the intent of these incentive caps is likely to enable the distribution of the allocated funds across a broad range of organizations and individuals, they may have the unintended consequence of inhibiting the large-scale adoption of AFVs in larger fleets. In this study, participants with large fleets purchased approximately 150 vehicles per year on average. With the current caps in place, these organizations would only be eligible for vehicle purchase incentives for a small percentage of their annual vehicle purchases. For example, the Government of Canada's iZEV program has a cap of 10 light-duty vehicle incentives per organization per year (Transport Canada, 2021). So large fleets would only be eligible to receive incentives for approximately 6.5% (10 out of 150 vehicles) of their average annual vehicle purchases. Given that high capital costs remain a barrier for

AFV adoption in fleets and vehicle purchase incentive remain a motivator, policy makers may wish to consider raising the current caps of vehicle purchase incentive programs or designing new fleet specific vehicle incentive programs that take high vehicle purchase volumes into consideration.

Third is the implication that government policies that encourage and support charging and fueling infrastructure installation may still be needed. While the capital cost of infrastructure installation was not one of the barriers with a high participant count (n=7), the availability of charging or fueling infrastructure was. Twelve participants mentioned encountering ZEV charging infrastructure challenges and five mentioned difficulties related to obtaining low-carbon alternative fuels. Furthermore, as fleets move from small-scale AFV pilot projects to large-scale adoption they will require access to more charging and fueling stations. The need to install additional fueling and charging infrastructure can have significant financial implications. This is particularly true in the case of ZEV chargers where organizations may encounter additional costs related to increasing site electrical capacity as the number of chargers grows. Government policies which help reduce infrastructure installation costs or which facilitate electrical capacity upgrades could therefore be helpful for reducing these fleet AFV adoption barriers.

The fourth policy implication is that medium- and heavy-duty ZEV mandates may facilitate AFV adoption in fleets by helping to address barriers caused by a lack of market ready AFVs. Many participants mentioned that they were interested in purchasing AFVs (especially ZEVs) but could not find market ready AFVs available in BC in some of the vehicle classes they wished to purchase. Specifically, participants mentioned a lack of electric vans and trucks, medium- and heavy-duty vehicles and specialty use vehicles. ZEV mandates can be a cost effective way to help spur market transformation by signalling to the automotive industry that there will be future market demand for the types of ZEVs included in the mandate (Axsen et al., 2020; Greene et al., 2014; Melton et al., 2017; Wesseling et al., 2015). Thus, medium- and heavy-duty ZEV mandates could encourage auto manufacturers to further invest in the development and production of more medium- and heavy-duty AFV (particularly ZEV) options. Any increase in the market ready availability of AFVs in these vehicle classes would help to decrease this barrier for fleets and likely spur increased adoption of these technologies.

My results also have two industry implications. The first is that many participants (n=11) expressed an interest in purchasing electric vans or trucks. Therefore, fleets may represent a ready market for these technologies and one which auto manufacturers could potentially leverage to help them increase AFV sales. The second is that dealerships may be able to increase the likelihood of AFV adoption in fleets by facilitating vehicle demonstrations and pilot projects. Many participants (n=15) mentioned these types of activities helped their organizations to test out a vehicle's suitability to the organization's tasks, familiarize themselves with the technology and create a positive history of AFV use in their organization.

While significant barriers to AFV adoption in fleets in BC remain, there is reason to be hopeful. Current market trends related to technology improvements, declining costs and vehicle model availability may help to decrease the barriers mentioned by the highest number of participants, while GHG emissions reduction targets in both the public and private sector may help to drive adoption, particularly if public support for environmentally sustainability continues to rise.

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