

No fleet left behind: Barriers and opportunities for small fleet zero-emission trucking

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Introduction

This paper focuses on small truck fleets in the context of the transition to a zero-emission heavy-duty trucking sector in the United States and Canada. While many facets of zero-emission trucking have been explored, small fleets have not been comprehensively addressed in the existing literature on this technology transition. This report aims to fill the knowledge gap by presenting a literature review and results of an online survey and stakeholder interviews to evaluate the barriers to adopting zero-emission trucks (ZETs) for small fleets. Although medium- and heavy-duty vehicles (MHDV) of Class 2b to 8 are often discussed together, this paper focuses primarily on Class 7 and 8 vehicles.

The United States and Canada share a highly integrated manufacturing supply chain and a cross-border transportation and logistics network. Regulatory actions at the federal and state or provincial levels on both sides of the border exert similar pressure to transition to ZETs within the next 20-25 years. Hence, while there are notable differences between the trucking sectors in the United States and Canada, the general conditions of the transition toward zero-emission trucking are comparable in both countries. Barriers and policy priorities identified are likewise equally applicable to both.

In 2019, transportation accounted for 37% and 34% of greenhouse gas emissions in the United States and Canada, respectively (International Energy Agency, 2021). Both countries have committed to drastically reducing their greenhouse gas emissions: the United States' current target is a 50%-52% reduction compared to 2005 levels by 2030, while Canada's target is a 40% reduction along the same time horizon (The White House, 2021; Environment and Climate Change Canada, 2022). Meeting such ambitious targets will require drastic reductions in the transportation sector. In the United States, the Environmental Protection Agency (EPA) estimates that heavy-duty vehicles account

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for 23% of transportation-related greenhouse gas emissions (U.S. Environmental Protection Agency, 2021). In Canada, heavy-duty vehicles account for approximately half of all transportation emissions, a proportion projected to increase in the next 40 years if current policies stay in place (Environment and Climate Change Canada, 2021). This is due in part to the growth of the heavy-duty sector, and the slower projected uptake of zero-emission heavy-duty vehicles compared to light-duty vehicles.

The heavy-duty sector also contributes to air pollutants that lead to poor air quality and respiratory illness. The EPA's 2017 National Emissions Inventory shows that heavy-duty vehicles emit 42% of on-road nitrogen oxide (NO_x) emissions, 69% of on-road black carbon (BC) emissions, and 51% of on-road emissions of particulate matter smaller than 2.5 microns (PM_{2.5}) in the United States (U.S. Environmental Protection Agency, 2020). This elevates the pollution burden on communities along transportation corridors. Diesel pollution also harms truck drivers, who face elevated health risks from long periods of ambient exposure and the accumulation of diesel emissions in the driver's cabin (Bailey et al., 2007).

Fortunately, zero-emission trucks are beginning to enter the market, and experts expect adoption to accelerate as they decrease in cost over time (Sharpe et al., 2020). Recent studies have indicated that many battery-electric trucks are either nearing cost parity or already cheaper than diesel trucks when measured by the total cost of ownership (TCO), which accounts for the purchase, fuel, maintenance, permit costs, and in some cases, costs associated with charging or fueling infrastructure. The National Renewable Energy Laboratory (2021) estimates that electric trucks will reach parity by 2025, while Lawrence Berkeley National Laboratories and the Goldman School of Public Policy (2021) indicate that they are already cheaper than conventional diesel trucks in specific applications.

Yet, adopting ZETs can be challenging, particularly for small trucking fleets. General barriers include high upfront costs, technology and policy uncertainty, and a lack of zero-emission fueling and charging infrastructure. Small fleet operators, including independent owner-operators, face greater financial and institutional barriers to procuring zero-emission trucks. Furthermore, they likely have less access to informational resources and technicians specialized in zero-emission vehicles. A recent survey conducted by Dream Corps indicated that small fleets have surface-level knowledge of ZETs but lack deeper knowledge of aspects such as costs, financing, and technology (Wong, 2022). Dream Corps found that small fleet owners lacked the time and capacity to research aspects such as ZET range, charging needs, and compatibility with duty cycle needs.

Black, Indigenous, and people of color (BIPOC) operators comprise a steadily increasing fraction of both owner-operators and truck drivers as a whole (Zippia, 2022). BIPOC-owned businesses have been shown to be more susceptible to financial shocks such as the economic downturn caused by the COVID-19 pandemic (Battisto et al., 2021). As such, this technology transition bears racial equity considerations simply due to its high costs.

Currently, a typical zero-emission truck's upfront cost is much greater than a diesel equivalent's upfront cost, representing an insurmountable green premium for many operators (Sharpe & Basma, 2022). However, as noted above, the TCO for a zero-emission truck in some applications is at or near cost parity with diesel and declining over time. Hence, companies that can successfully bear the upfront capital costs can reap long-term financial and environmental benefits, while those with less capital are left behind. Financing can be challenging to obtain from third-party lenders who may not provide loans for a less-established technology (Propulsion Quebec, 2020).

While various government agencies provide financial support, small fleet operators can face additional barriers in accessing such support. Grant application programs are challenging and time-consuming to navigate for those who lack familiarity with government processes. In addition, there may be a language barrier for BIPOC and immigrant operators. Hence, there is an opportunity for government program managers to create programs that specifically target small operators.

Failing to support small fleets would put them at risk of being unable to transition towards zero-emission fleets, in turn putting jurisdictions at risk of failing to achieve emissions reduction targets.

Scope of the problem

The U.S. Department of Transportation's Federal Motor Carrier Safety Administration (2022) maintains a registry of trucks based in North America that carry cargo interstate, hazardous materials intrastate, or cargo intrastate in a state that requires trucks to acquire a Department of Transportation number. Therefore, the registry provides a valuable snapshot of the trucking sector, albeit missing carriers operating solely in Canada and those exclusively carrying non-hazardous materials within certain states.

In both countries, 90% of registered trucking companies operate ten or fewer trucks. The left side of Figure 1 shows the distribution of registered fleets in the United States and Canada organized by the size of their fleets. Over 60% of U.S.-based fleets and over 40% of Canada-based fleets operate a single truck. Most of these single truck fleets are classified as “for hire,” also known as owner-operators. These operators own and drive their own trucks, contracting their services to larger logistics companies. This equates to approximately 600,000 owner-operators in the United States and Canada who are solely responsible for the operation and maintenance of their single truck. The right side of Figure 1 shows the distribution of Class 7 and 8 trucks in the United States and Canada organized by the size of the fleet to which they belong. Although larger fleets make up most of the trucks on the road, fleets with up to ten trucks still contribute 44% of trucks in the United States and 24% of trucks in Canada.

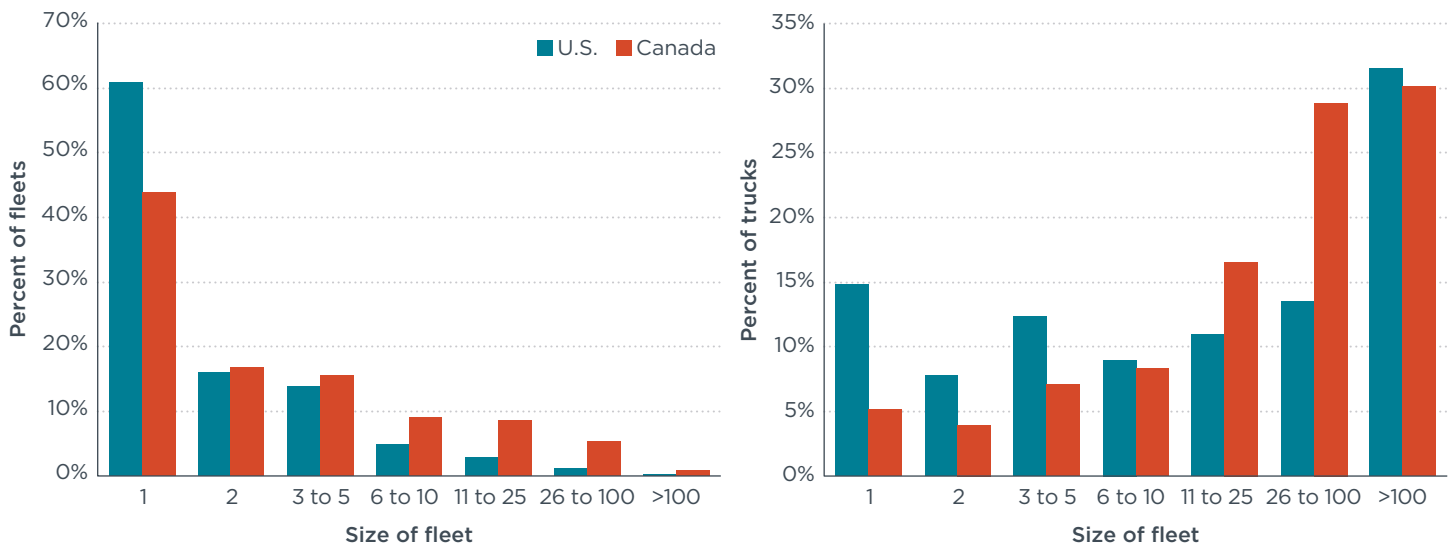


Figure 1. Distribution of fleets (left) and trucks (right) registered in the Department of Transportation Motor Carrier Management Information System, shown by the size of the fleet.

Quantified another way, the U.S. trucking industry generates over \$700 billion in revenue annually. One author estimated that \$350 billion of this market is attributable to for-hire services, of which 90% is comprised of fleets with six or fewer trucks (Bokher, 2019). This makes small fleets responsible for roughly 45% of the U.S. trucking industry, bringing in around \$315 billion annually.

The following section describes the ZET policy landscape in the United States and Canada. We then outline the methods used to collect and analyze data from truck operators and other stakeholders in the industry. Finally, we present recommendations on the policy areas that must be prioritized to support small fleets.

Review of current ZET policy landscape

California

California has enacted the Advanced Clean Trucks (ACT) rule that requires manufacturers to make increasing percentages of Class 7 and 8 truck sales zero-emission, starting at 5% in 2024 and reaching 40% by 2035 (Buysse & Sharpe, 2020). California's Advanced Clean Fleets (ACF) rule is under development and would require fleets to achieve 100% zero-emission drayage trucks by 2035 and 100% of other medium and heavy-duty ZEVs by 2045 (California Air Resources Board, 2022c). Paired together, the ACT and ACF rules will stimulate zero-emission supply and demand, both of which are critical in the early stages of market development (Mission Possible Partnership, 2022). Proposed ACF language indicates that the rule would apply to government, public agency fleets, all fleets performing drayage operations, and other high-priority fleets. Fleets deemed high priority are those with \$50 million or more in revenue or those that own or operate 50 or more vehicles. The exclusion of small, non-drayage fleets in the proposed ACF language notwithstanding, there are large populations of small fleets that perform drayage. For example, owner-operators make up 90% of truck operations at the Port of Oakland (Lockridge, 2022).

Zero-emission trucking is also supported by increasingly stringent emission standards such as California's Low NO_x Omnibus regulation and the EPA's proposed rulemaking to set stronger NO_x and greenhouse gas (GHG) standards for heavy-duty vehicles starting in the model year 2027 (Kelly & Sharpe, 2022; U.S. Environmental Protection Agency, 2022).

To facilitate the adoption of zero-emission MHDVs, CARB administers the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), which received a total allocation of \$569.5 million for FY 2021-22 (California Air Resources Board, 2021). HVIP provides vouchers to purchasers of zero-emission and plug-in hybrid trucks and buses on a first-come, first-served basis. Vehicles operated in small fleets and registered to addresses in disadvantaged communities are eligible for a 15% voucher enhancement. For FY 2021-22, CARB is also implementing an Innovative Small e-Fleets funding set aside through HVIP, which would reserve \$25 million out of the total allocation for programs geared towards small fleets and independent owner-operators of on-road vehicles (California Air Resources Board, 2021). Through this initiative, CARB plans to pilot a handful of innovative mechanisms, including open-ended leases, trucks as a service, assistance with infrastructure, and individual owner planning assistance. These provisions are indeed innovative, as very few incentive programs have specific carveouts for small fleets.

In California, regional air districts also administer local and state incentive programs. For example, the Bay Area Air Quality Management District (BAAQMD) administers three incentive programs that include funding for Class 7 and 8 ZETs: the local Transportation Fund for Clean Air, the state Goods Movement Program, and the state Carl Moyer Program (Bay Area Air Quality Management District, 2022). Incentives from local funding can be combined with HVIP vouchers but cannot be combined with other state programs.

Other U.S. states

Under the federal Clean Air Act, states wishing to adopt vehicle emission standards more stringent than federal standards may adopt measures identical to California. As of August 2022, Washington, Oregon, New York, New Jersey, and Massachusetts have adopted the ACT regulation. Connecticut, Maine, and Maryland have rulemakings underway to adopt the ACT regulation (Electric Trucks Now, 2022). An additional eight states and the District of Columbia have signed a Memorandum of Understanding pledging to ensure that 100% of new MHDV sales are zero emission by 2050, with an interim goal of 30% zero-emission MHDV sales by 2030 (NESCAUM, 2020). Together, these 17 states and the District of Columbia form the Multi-State ZEV Task Force. When California finalizes rulemaking for the ACF, these parties may adopt similar fleet-facing regulations.

Several of these states have existing incentive programs for zero-emission trucks. For example, the New York State Energy Research and Development Authority administers the New York Truck Voucher Incentive Program, which covers up to 95% of the cost difference between an eligible zero-emission vehicle and a comparable diesel vehicle, including Class 7 and 8 trucks (NYSERDA, 2022).

Canada

Canada has committed to developing regulation requiring 100% of MHDV sales to be zero-emissions by 2040 for specific vehicle types based on feasibility, with interim requirements for 2030 and the mid-2020s (Environment and Climate Change Canada, 2022). Canada is also one of fifteen countries that signed a Memorandum of Understanding as part of CALSTART's Global Commercial Vehicle Drive to Zero (Global Commercial Vehicle Drive to Zero, 2021). The Drive to Zero signatories have committed to achieving 30% zero-emission truck and bus sales by 2030 and 100% zero-emission sales by 2040.

At the provincial level, Quebec and British Columbia have been leading efforts for light-duty electrification and are developing regulations for heavy-duty vehicles. Quebec joined the Multi-State ZEV Task Force discussed above, becoming the only Canadian province to do so (NESCAUM, 2021). Quebec and British Columbia have endorsed the Global Commercial Vehicle Drive to Zero separately from the Canadian federal government (Global Commercial Vehicle Drive to Zero, 2022). British Columbia has signaled the intent to set standards for medium and heavy-duty vehicles "aligned with California" and will release a Clean Transportation Action Plan in 2023 (Environment and Climate Change Canada, 2022).

Alberta is notably focusing on hydrogen fuel cell technology through the Alberta Zero Emissions Truck Electrification Collaboration, which will conduct a pilot study with two fuel cell trucks to operate between Edmonton and Calgary (Emissions Reduction Alberta, 2022).

Survey and interview methodology

The following methodology aims to gather data that qualify and quantify the ZET adoption barriers faced by small fleets. Broad trends are explored quantitatively through survey data and complemented by qualitative interview data that adds nuance not captured in the online survey responses.

Online stakeholder surveys

Online surveys were developed for four trucking stakeholder groups:

- » Truck drivers/operators
- » Trucking associations
- » Manufacturers
- » Government and NGOs

The questions were formulated to characterize each stakeholder group's unique perspective on zero emission trucking. For example, trucking associations were asked whether they provided their members with ZEV programming (e.g., informational sessions, ride-and-drives), and manufacturers were asked about the scope of their sales and whether they offer specialized support for small fleet clients. Complete surveys are available in the Appendix.

Truck driver responses were solicited via social media and other online means. For the other stakeholder groups, surveys were distributed according to the snowball method, in which contacts were asked for other potential respondents to contact. Surveys were not intended to provide a representative sample of each stakeholder group within the trucking industry. Instead, surveys were implemented to garner interest, gather initial data, and develop talking points for follow-up interviews. Contacts were sorted into the four stakeholder groups and were sent the corresponding surveys.

Follow-up interviews

All surveys included a question asking if respondents were willing to be contacted further to speak in more detail about small fleets. Interviews with this subset of survey takers consisted of guided discussions that prompted interviewees to elaborate on what was answered in the surveys.

Data analysis

To analyze survey results from the truck driver stakeholder group, we focused on the distinctions between small and large fleet drivers. Due to a small number of respondents, survey results in the other stakeholder groups were not analyzed quantitatively (see results section).

Interview data were transcribed and synthesized into key thematic areas. Qualitative interview data was cross-referenced with survey results and findings in the broader literature.

Survey and interview results

Survey summary

A total of 49 survey responses were recorded, with 39 from the trucker stakeholder group. Table 1 below breaks down the sample into the four stakeholder groups. As noted above, the trucking association, manufacturer, and government and non-governmental organization (NGO) surveys were used primarily to garner initial opinions for further discussion in interviews. Hence, the quantitative analysis focuses on the truck driver stakeholder group.

Table 1. Tabulation of survey respondents by stakeholder group.

Stakeholder group	Number	Represented subgroups
Truckers	39	Independent contractors, company drivers
Trucking associations	2	-
Manufacturers	1*	E-truck manufacturers
Government and NGOs	7	State government, think tanks, environmental NGOs

* Two manufacturer representatives participated but one preferred to discuss the survey questions qualitatively via phone call

Truck operator survey results

Truck operators reported working in fleets of various sizes (Figure 2). Comparisons between “small fleets” and “large fleets” in this survey results section are made with 25 trucks as the threshold, with the understanding that survey results may not accurately reflect a large amount of heterogeneity among fleets with 25 or fewer trucks. The opinions expressed in the survey belong solely to respondents and do not necessarily reflect the views of others in their companies.

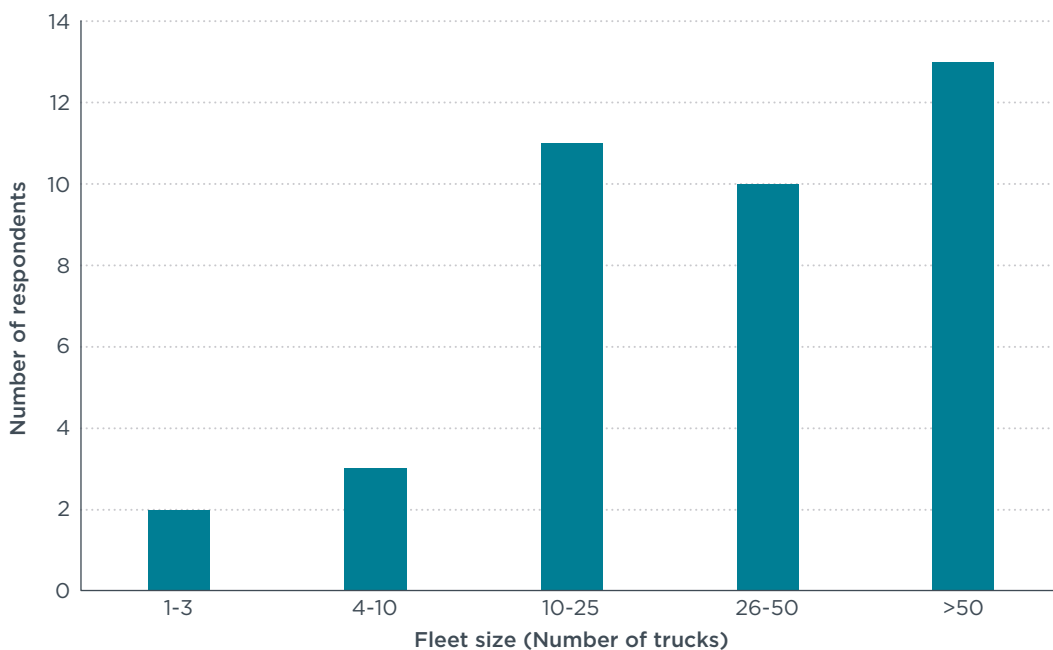


Figure 2. Distribution of truck operator survey by fleet size.

Figure 3 and Figure 4 show that respondents in small fleets differ from those in large fleets in which barriers they consider to be the most concerning. The top three barriers of greatest concern for those in smaller fleets were the total cost of ownership, insufficient government support, and upfront cost. Meanwhile, the top three barriers of greatest concern for those in larger fleets were insufficient government support, lack of ZET availability, and lack of fuel and other infrastructure. Drivers in smaller fleets were more concerned about a lack of technical support, with almost 70% very much or somewhat concerned, compared to approximately 50% for drivers in larger fleets. Performance of ZETs also ranked as a top concern for smaller fleets, with 56% very much or somewhat concerned, although they were overall less concerned than drivers in large fleets, at 65%.

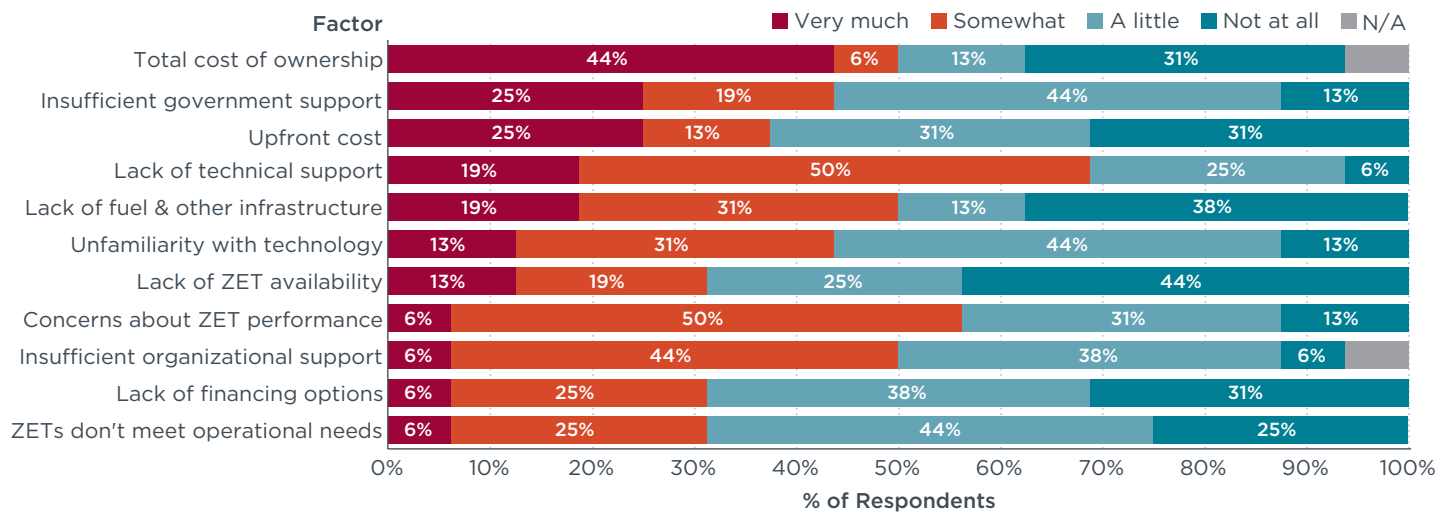


Figure 3. Barriers to ZET adoption ranked by the highest proportion of respondents indicating “very much” concern among fleets with 25 or fewer trucks.

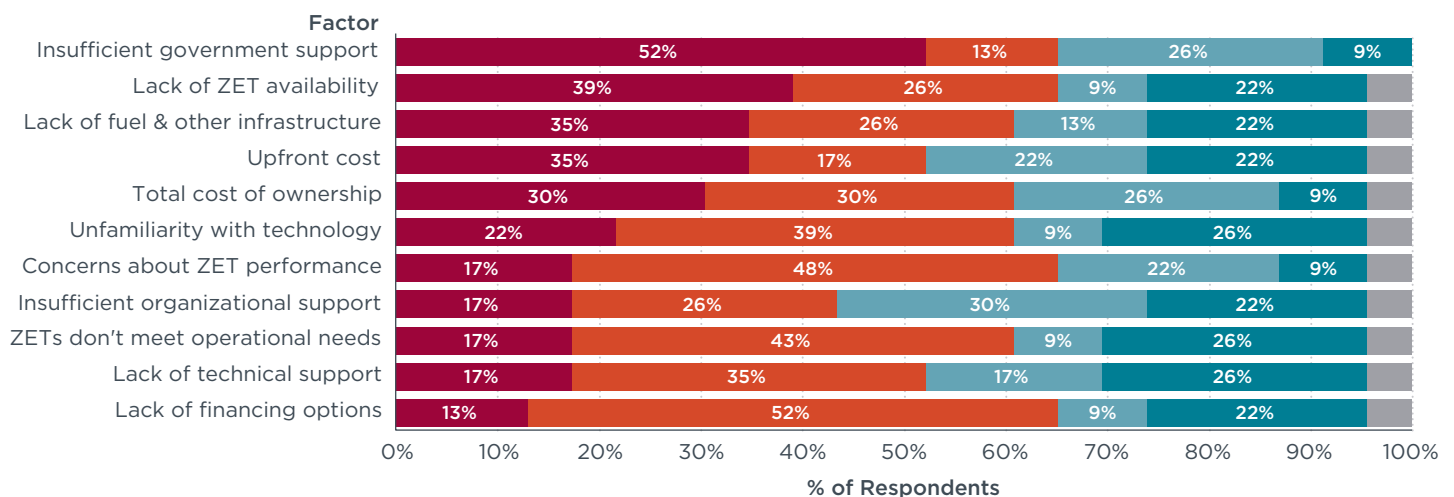


Figure 4. Barriers to ZET adoption ranked by the highest proportion of respondents indicating “very much” concern among fleets with 25 or more trucks.

Regarding openness to acquiring a zero-emission truck for their next purchase and plans to transition to full zero-emission fleets, operators of larger fleets showed markedly more receptiveness. Figure 5 shows that while all larger fleets indicated considering a zero-emission truck for their next purchase, only 63% of smaller fleets surveyed were considering them. Similarly, Figure 6 shows that 91% of larger fleets had plans for full zero-emission fleets, compared to 44% of smaller fleets. Smaller fleets were also much more likely to only have such plans if required by regulations. However, as respondents were all drivers for their respective companies, it is difficult to determine how much weight their preferences are given in the procurement process.

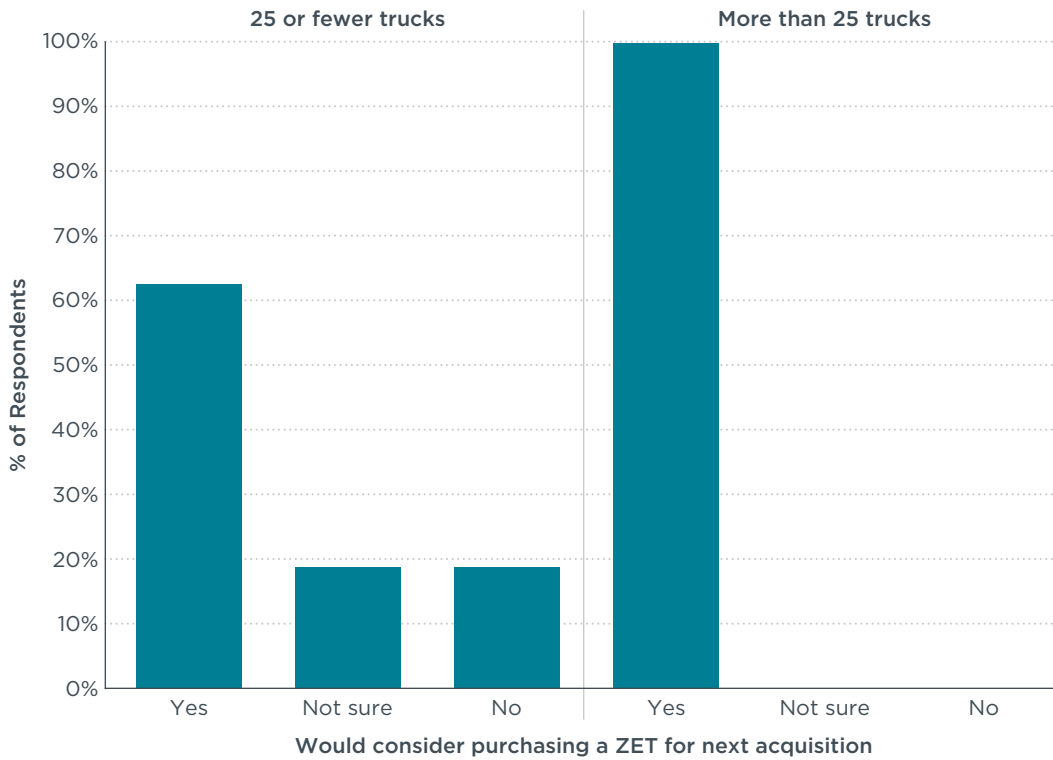


Figure 5. Survey responses for operator intentions to make their next purchase a ZET.

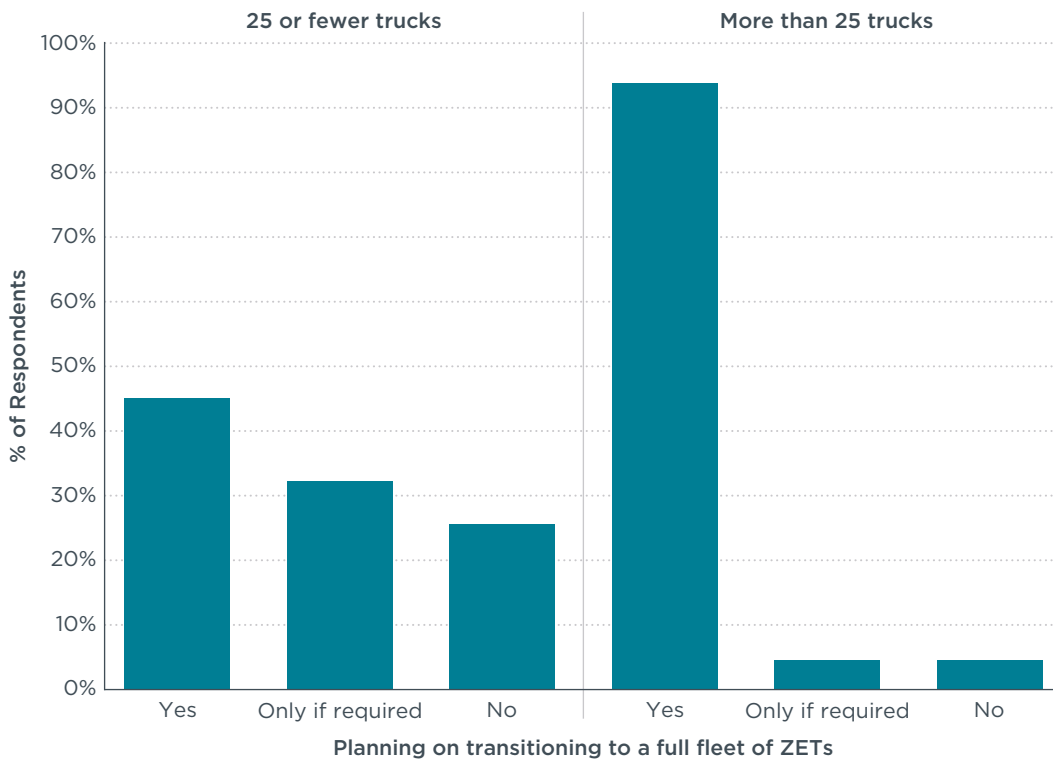


Figure 6. Survey responses for operator intentions to fully transition to ZETs.

Survey limitations

The robustness of the truck driver survey was limited by the lack of respondents and the lack of geographic diversity. Most respondents operate trucks for companies based in California, which means that the survey results may not reflect other localities. Although a small financial incentive was provided to compensate participants in the survey for their time, this stakeholder group was difficult to contact and more difficult yet to retain. Our difficulty in reaching small fleets is indicative of the challenge facing government agencies that may want to engage with these companies and individuals. One NGO interviewee echoed these difficulties, saying that small fleet truckers are particularly hard to convene. Many of these truck drivers and owner-operators do not have or want to share their email addresses, which leaves phone and text as the main methods of outreach.

Key themes from interviews

This section summarizes the key themes that arose from stakeholder interviews. The discussion below is cross-referenced with findings from the online survey and the literature review. Eight individuals surveyed agreed to be interviewed; five interviewees were government or NGO representatives, and one interviewee each represented the other three stakeholder groups. While the themes below were generated from interview discussions, this should not be viewed as an exhaustive list of issues faced by small fleets.

Incentives are crucial for small fleets but have different applications in the new and used markets

There are several state and provincial incentive programs for purchasing heavy-duty electric vehicles. Except for minor allowances made by California, most existing

programs do not consider fleet size and thus are deficient in serving small fleets. Nonetheless, six out of seven government and NGO respondents to the online survey ranked incentive programs as the number one priority for supporting small fleets. The seventh survey respondent ranked it as the number two priority. Interviewees indicated that the form of incentive is one factor that determines a program's suitability for a small fleet. For a small business with lower available capital and a slim operating margin, an upfront cash incentive would be optimal, followed by a purchase rebate. Less preferable forms include loans and tax credits.

One interviewee indicated that some grants serve a maximum number of trucks per fleet, which means that small fleets might be better poised to take advantage of such programs. However, this assumes equal access to information and resources. Larger fleets that have greater staffing capacity have the knowledge and means to apply for funding almost immediately. Indeed, funds for California's HVIP program have historically been exhausted within several hours, or even minutes, of each round's release (Green Car Congress, 2021).

While existing programs such as California's HVIP focus on new electric trucks, the used market deserves some consideration. Currently, small fleets rely almost exclusively on the used market for diesel trucks. One industry stakeholder suggested that agencies should focus on the adoption of new vehicles by large companies, as the cost gap between a used diesel truck and a new electric truck would be insurmountable for small fleets, even with reasonable incentives applied. For example, a used diesel truck costs approximately \$50,000, and new electric trucks retail from \$200,000 to \$950,000 (Sharpe & Basma, 2022). Large companies can more easily overcome these initial cost barriers and benefit from decreased operating costs of electric trucks, but small fleets cannot easily increase their capital expenditures severalfold while remaining financially solvent. This approach to incentive programs would focus on large fleets, effectively ignoring small fleets with the goal of increasing the market penetration of zero-emission trucks and achieving better economies of scale. Small fleets would then buy zero-emission trucks in the secondary market, reducing their required capital expenditure.

However, this strategy presents a serious equity issue, where small fleets are priced out of the transition. A secondary zero-emission truck market will likely take many years to develop, as the first used trucks will only begin to be available in the next five to ten years. It is unwise to allow such a significant delay for a quarter to half of the heavy-duty sector to begin adopting zero-emission trucks. By effectively preventing this large group from participating in the transition for approximately a decade, we would greatly impede the ability to reach vehicle electrification and transportation sector emissions reduction goals.

Moreover, the state of long-term battery performance and degradation for zero-emission trucks is yet unknown. Battery degradation is well-recognized as a major factor influencing the viability of used passenger electric vehicles. An NGO interviewee expressed concern that because electric trucks are only beginning to see adoption, it is unclear how they will perform after significant use by their first owners, or how replacement battery costs would affect the used market. With this significant uncertainty, it is unclear whether the used electric truck market will be as reliable as the current used market for diesel trucks.

With proper oversight, third-party facilitators can make ZETs more accessible for small fleets

Several NGO interviewees emphasized the importance of third parties in facilitating access to incentive programs. Third parties commonly provide consulting services for fleet operators and managers eligible for credits under California's Low Carbon Fuel Standards (LCFS) regulation. These consultants are certified by CARB and provide verification services to ensure monitoring and reporting are carried out in compliance with LCFS requirements (California Air Resources Board, 2022a).

Third parties can specialize in navigating the available programs and ensuring that fleets receive all funding for which they are eligible. This benefits small fleets by filling important gaps in staffing capacity or institutional knowledge. In addition to incentive funding, third parties may also assist with financing. They can aggregate the demand of many small fleets, allowing for flexible financing options more akin to those available to large fleets. With accumulated expertise in zero-emission trucking, these third parties may also offer ancillary technical resources to small fleets, such as servicing and maintenance support.

Truck dealers currently provide these services to their customers, in addition to leasing and financing options. However, dealers are obligated to represent their respective vehicle manufacturers and are financially incentivized to sell their vehicles to earn a commission. Third-party facilitators outside the dealership model would increase competition between dealers and could help to drive down the purchase price of ZETs.

However, government agencies administering incentive programs must oversee third parties and hold them to high standards. Without proper oversight, third parties may engage in predatory activities while purporting to get the best deal for their clients. One interviewee reported concerns about third parties skimming an unreasonable percentage of the cash value of LCFS credits. In recent years, contractors have reportedly used the Property Assessed Clean Energy (PACE) program to defraud homeowners by leading them to unknowingly sign up for large loans that were not commensurate with the clean energy and energy efficiency services provided. In some cases, the total repayable amount (including interest) amounted to more than their home's appraisal value (Krawczyk, 2021). Hence, third parties serving small fleets must be diligently overseen to avoid the proliferation of fraudulent contractors.

Public charging and fueling infrastructure are more beneficial for small fleets

One NGO interviewee highlighted the difficulty that small fleet operators experience in installing and accessing charging infrastructure. Small fleets primarily rely on street parking or rental spaces within a larger yard. As small fleets generally lack the resources to build centralized electric charging or hydrogen fuel depots, they will be required to seek out publicly available stations. It is also unlikely that small businesses will have the financial capacity to install the electric vehicle supply equipment (EVSE) required to have their own charging stations. Public hydrogen fueling stations serving freight trucks are virtually non-existent at present and would be extremely challenging for individual small fleets to install.

Without information sharing, ZET demonstration projects concentrate information among large fleets

A focus on large fleets to conduct ZET pilot projects creates an information asymmetry between small fleets and large fleets. Stakeholder feedback noted that zero-emission pilot projects are almost exclusively conducted in partnerships with large fleets or

other large stakeholder organizations. For example, the Port of Oakland partnered with Shippers Transport Express (STE), which operates over 100 trucks at four West Coast ports, to conduct a pilot study of ten zero-emission drayage trucks under CARB's Zero and Near-Zero Emission Freight Facilities (ZANZEFF) program (Shippers Transport Express, 2022; Sandifur, 2021). Like other large companies participating in pilot projects, it will have firsthand experience and access to cost and operational data that is not available to other fleets. Hence, companies participating in pilots such as these can build familiarity, confidence, and workflow capabilities that pertain specifically to ZETs. If this information is not shared, small fleets are at risk of being several years behind in their understanding of zero-emission trucking.

California leads ZET policy nationally and internationally; Canadian provinces lag behind

While the trucker survey only captured respondents from companies headquartered in the United States, interviewees from other stakeholder groups noted national differences in the overall policy landscape. Interviewees from Canada indicated that while emissions reductions are a top policy priority, most policymaking on heavy-duty vehicles to date has been centered around retrofits for aerodynamics and fuel efficiency. Quebec and British Columbia have been policy leaders in the electrification of the passenger car segment but are only beginning to act on medium- and heavy-duty vehicles. In the United States, California has the most robust regulations for adopting zero-emission heavy-duty vehicles and serves as a national and international leader in this sector. As noted in a previous section, California is also unique in piloting certain considerations for small fleets in clean fleet regulations and funding provisions.

Recommendations

The following recommendations draw on findings from the survey, interviews, and literature review and address the key themes discussed in the previous sections.

Provide proportional incentive funding for small fleets

Incentive funding should ideally reflect the proportion of trucks in small fleets within a particular jurisdiction rather than disproportionately favoring large fleets, which already have greater financial, staffing, and technical resources. For example, CARB's HVIP program reserves \$25 million out of a total \$569.5 million funding pool for small fleets, representing 4% of total funding. While the Innovative Small e-Fleets (ISEF) program is experimental and designed to explore novel types of small fleet programs, policymakers should consider increasing support in order to address the scale of the problem at hand. As 44% of trucks on the road are operated by small fleets in the U.S., we estimate that a proportional increase would bring ISEF funding up to approximately \$250 million.

Lay the groundwork for a used ZET market with data transparency and funding

Used zero-emission trucks may not be available for the next five to ten years. While the first ZETs are still being deployed, uncertainties regarding battery health, future market prices, and the availability of used trucks may be partially addressed by policy today. As part of its Advance Clean Cars II, CARB is proposing regulations that would require (light-duty) electric car manufacturers to include a dashboard displaying the "state of health" of the battery, showing its level of deterioration (California Air Resources Board, 2022b). Data transparency requirements such as this would also be highly valuable for

ZETs and would reduce uncertainty during the market's early stages. As the used market develops, incentive funding for used vehicles should also be considered.

Support third parties who facilitate access to financing and incentives

Third-party services can aggregate ZET demand among small fleets and facilitate access to incentive programs, financing, and technical knowledge. Demand aggregation can take the form of bulk purchases on behalf of many small fleets, which eases the administrative burden on individual fleets. One approach being piloted in the private sector is trucking-as-a-service, in which a company buys a large fleet of vehicles and leases them out to drivers. While this would effectively remove the burden of purchasing, applying for incentives, and recordkeeping from small fleets, this approach also reduces the level of ownership for small fleets.

Outside of bulk purchasing, third parties can offer information to small fleets who want to purchase ZETs. Currently, CALSTART operates the Transforming Trucks Transforming Communities initiative, which provides information on ZET incentives and technical aspects of ZETs to small fleets seeking to electrify (CALSTART, 2022). Such a knowledge-sharing initiative can be combined with the demand aggregation and bulk purchasing services described above. In addition, accreditation of third-party services similar to CARB's existing LCFS verification process would prevent these parties from misrepresenting available incentives, programs, and technologies.

Increase focus on public heavy-duty charging and fuel infrastructure

Charging and hydrogen fueling infrastructure is crucial for enabling the viability of zero-emission trucking. A recent ICCT study estimates that by 2030, the U.S. will need 40,000 publicly accessible fast chargers (350 kW or greater) for zero-emission tractors (Minjares et al., 2021). Public charging and fueling infrastructure will benefit zero-emission truckers overall but will be particularly beneficial to small fleets as they depend more heavily on public amenities and infrastructure. In February 2022, the U.S. Department of Transportation announced that \$5 billion will be made available to build out a national charging network for all classes of vehicles (U.S. Department of Transportation Federal Highway Administration, 2022b). This network will be built along Alternative Fuel Corridors, with the goal of having a charger every 50 miles (U.S. Department of Transportation Federal Highway Administration, 2022a). Efforts to keep electricity rates for publicly accessible heavy-duty chargers competitive with those at large-scale depots could avoid financially disadvantaging small fleets.

Foster knowledge sharing to and among small fleets

To close the information gap between small fleets and larger fleets, information garnered from ZET pilot studies should be shared widely. Efforts should be bolstered to target a variety of outreach channels that truckers already frequent. Independent owner-operators are particularly hard to reach as the individuals who make business decisions and would benefit from receiving information about ZETs are the same ones who are incentivized to maximize their time on the road. Interviewees noted that the most effective methods are those that can reach truck drivers while they are on the road, such as radio programs, phone, and text outreach. Interviewees also emphasized the importance of truck shows and "ride and drive" events where small fleet operators can gain firsthand experience with ZETs and speak to experienced ZET owners. Truckers already get a lot of information from each other—survey respondents indicated that information from other truck drivers was as trustworthy as that from trucking

associations or manufacturers. Existing organizations such as the American Trucking Associations and Owner-Operator Independent Drivers Association may be suitable for administering outreach efforts.

Summary

The heavy-duty sector is a major contributor of transportation-related greenhouse gas emissions in the U.S. and Canada. To curb emissions, California's Advanced Clean Trucks rule requires manufacturers to make 40% of truck sales zero-emission by 2035, and the proposed Advanced Clean Fleets rule requires truck fleets to be 100% zero-emission by 2035 or 2045. Many states and provinces are following California's leadership and either have adopted or are in the process of adopting similar standards. However, current policies and programs give insufficient consideration to fleet size and the heterogeneity in access to financial and institutional resources, charging and fueling infrastructure, and technical information. Through a literature review, online surveys, and interviews, this report examines the barriers faced by small fleets in adopting zero-emission trucks and offers policy recommendations to foster a more inclusive zero-emission heavy-duty transportation sector.

Recent studies indicate that zero-emission trucks can be competitive with conventional diesel trucks in performance and total cost of ownership, albeit at an upfront cost that can be significantly greater than that of a conventional truck. Meanwhile, small fleets and owner-operators typically have small operating margins, have low access to capital, and often purchase used diesel trucks. Incentive programs provide some support but tend to be far over-subscribed and funds are depleted by large companies that have the resources to quickly complete applications.

Interviewees highlighted that a well-functioning used ZET market will be vital for small businesses throughout this technological transition. Small fleets have limited access to infrastructure to support the acquisition of ZETs. Generally, owner-operators lack the resources to build out their own facilities and must instead take advantage of public amenities like parking, charging, and hydrogen fueling infrastructure.

Beyond access to physical resources, small fleets are typically not included in zero-emission truck pilot studies and only have surface-level knowledge of zero-emission trucks. Without information sharing and increased outreach efforts, crucial operational information about ZETs will remain concentrated within large companies.

The following actions would help to address these barriers for small fleets to transition to zero-emission:

- » Set aside small fleet ZET incentive funding proportional to the number of trucks belonging to small fleets in the industry. This will increase equitable access to funding and keep small fleets from having to compete with larger fleets with greater resources.
- » Lay the groundwork for a healthy used ZET market by creating data transparency requirements that will alleviate uncertainty about long-term battery and vehicle health. As the market develops, continue to support small fleets with incentives for used ZETs.
- » Support third parties who can aggregate demand, facilitate incentive access, provide financing options, and provide consulting services to small fleets. Aggregation creates efficiency and reduces the burden on individual small fleets to

navigate purchasing and accessing incentives separately. Oversight of third parties would ensure that economic benefits are passed down to small fleets.

- » Increase focus on the build-out of publicly accessible charging and refueling infrastructure. Small fleets have a greater reliance on public infrastructure and, hence, focusing on a robust public network will greatly enable small fleets to be confident in making ZET purchases.
- » Share information from ZET pilots and tailor outreach to channels already frequented by truck operators. Greater information sharing will reduce the information asymmetry between large fleets and small fleets.

Creating a more inclusive pathway forward will avoid environmental solutions from imposing financial hardships on those who already have limited financial and institutional resources. Rather, with proper support, zero-emission trucks can represent a great opportunity for small fleet operators to play an active role in the clean transportation transition and to reap the environmental and economic benefits of switching away from diesel trucks.

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Appendix: Survey Questions

The following are the survey questions asked of each stakeholder group.

Truck Drivers

1. Please enter information about the truck that you most frequently operate (Model year/Make/Model).
2. How many trucks does your fleet operate (including trucks operated by sub-contractors)? (Options: 1-3, 4-10, 11-25, 26-50, More than 50).
3. What option below best describes your employment and driving situation? (Options: Independent contractor or owner-operator, Employee who drives the same truck every day, Employee who may drive different trucks day-to-day.)
4. What percent of your trucks does your fleet plan on retiring in the next 5 years? (Options: 0-10%, 11-25%, 26-50%, More than 50%, I'm not sure.)
5. Where are your primary headquarters located?
6. What best describes your personal driving situation? (Options: Local and regional routes and I'm almost always home every night, Longer and unpredictable routes in different states and regions where I spend nights away from home on the road, A mix of local and longer-haul routes.)
7. How many hours per day is your truck parked and not in use during your work week? Please enter numerical digits only.
8. About how many miles did you drive over the past year? For numbers over 999, enter numerical digits only. For example, enter 1000, not 1,000.
9. About how much money do you spend out-of-pocket for diesel fuel in a typical week? Answer "0" if your company pays for fuel expenses. For numbers over 999, enter numerical digits only. For example, enter 1000, not 1,000.
10. About how much money do you spend out-of-pocket for truck maintenance and repair per month? Answer "0" if your company pays for maintenance and repair expenses. For numbers over 999, enter numerical digits only. For example, enter 1000, not 1,000.
11. About what is the total cost that you pay to own and operate your truck per month? Include things like fuel, maintenance, repairs, truck payments, permits, parking, etc. Enter "0" if your company pays for all of your operating expenses. For numbers over 999, enter numerical digits only. For example, enter 1000, not 1,000.
12. Do you pay for truck parking? (Options: Yes, No, Sometimes.)
13. Please tell us how you maintain your truck. (Options: I do most of my own repairs, I pay to have most of my maintenance done, My company or someone else pays to maintain the truck.)
14. When do you plan to acquire a new or used truck in the future? (Options: Within the next year, 1 to 2 years, 2 to 5 years, I'm not sure, N/A - my company makes this decision.)
15. Do you or your fleet acquire new or used trucks? (Options: New, Used, New and used.)

16. What is the most important reason why you acquire a new or used truck?
(Options: Maintenance costs of current trucks have become too high, Better power or performance, Better fuel economy, Local or state regulations.)
17. Other than cost, what is the most important factor in your truck purchase decision? (Options: Reliability, Warranty, Brand, Fuel Economy.)
18. Please rank these sources of information based on their trustworthiness for reliable truck and trucking technology information. '1' is the most trusted source of information; '6' is the least trusted source. (Sources: Trucking associations, Unions, Truckers/fleet operators, Other truck manufacturers, Government agencies, Media personalities.)
19. Please rank the following issues based on your level of concern/priority for them. '1' is your highest concern; '6' is your lowest concern. (Issues: Drivers' working conditions, Cost of trucks (upfront), Cost of truck operation and maintenance, Complying with regulations, Reducing diesel emissions, Job security.)
20. Do you or your fleet belong to a trucking association?
21. Are you currently operating zero-emission trucks?
22. Would you consider procuring a zero-emission truck in your next truck acquisition (whether or not you already operate some)?
23. Are you planning on transitioning to a fully zero-emission truck fleet? Are you regulated under a state/provincial or federal mandate to have a fully zero-emission truck fleet?
24. How much of a barrier do these factors present to your organization in adopting zero-emission trucks? (Factors: Upfront cost, Total cost of ownership (TCO), Difficulty with financing, Availability of zero-emission trucks, Zero-emission trucks do not meet operational needs, Lack of familiarity with the technology, Lack of technical support and maintenance availability for the technology, Lack of fuel or other infrastructure, Inadequate or inaccessible government support, Inadequate support within your own organization.)

Trucking Associations

1. What percent of your members operate small truck fleets (three or fewer trucks)?
2. What percent of your members are independent owner-operators?
3. Where are your primary headquarters located?
4. What activities does your organization engage in (check all that apply)?
(Options: Research, Advocacy, Policy development, Supporting political candidates, Coalition-building, Fundraising, Providing services to truckers.)
5. In your view, what is the most important factor in a company's truck purchase decision (other than cost)? (Options: Reliability, Warranty, Brand, Fuel Economy.)
6. Please rank these sources of information based on their trustworthiness for reliable truck and trucking technology information. '1' is the most trusted source of information; '6' is the least trusted source. (Sources: Trucking associations, Unions, Truckers/fleet operators, Other truck manufacturers, Government agencies, Media personalities.)
7. Please rank the following issues based on their level of concern/priority for TRUCK DRIVERS. (Issues: Drivers' working conditions, Cost of trucks (upfront),

Cost of truck operation and maintenance, Complying with regulations, Reducing diesel emissions, Job security.)

8. Please rank the following issues based on their level of concern/priority for TRUCKING ASSOCIATIONS. (Issues: Drivers' working conditions, Cost of trucks (upfront), Cost of truck operation and maintenance, Complying with regulations, Reducing diesel emissions, Job security.)
9. Are you currently providing your membership with the latest information on alternative fuel or zero-emission trucks?
10. Do you have any programs that support your members with procuring alternative fuel or zero-emission trucks?
11. Is your region under a state/provincial or federal regulation to transition to zero-emission truck fleets?
12. How much of a barrier do these factors present to your member companies in adopting zero-emission trucks? (Factors: Upfront cost, Total cost of ownership (TCO), Difficulty with financing, Availability of zero-emission trucks, Zero-emission trucks do not meet operational needs, Lack of familiarity with the technology, Lack of technical support and maintenance availability for the technology, Lack of fuel or other infrastructure, Inadequate or inaccessible government support, Inadequate support within your own organization.)
13. Please evaluate the following statement: Incentive funding should be made available for used zero-emission trucks. (Options: Strongly disagree, disagree, agree, strongly agree.)
14. Please evaluate the following statement: A certain percentage of funding should be set aside for small businesses. (Options: Strongly disagree, disagree, agree, strongly agree.)
15. Please rank the ways you think your member fleets would be interested in getting more information about zero-emission trucks. Choose '1' for your highest ranking and '5' for your lowest. (Information sources: Ride-n-drive events in your region, Trucking shows or conferences, Podcasts or radio programs, Online videos or articles, Word-of-mouth from other truckers.)

Manufacturers

1. What percent of your customers operate small truck fleets (three or fewer trucks)?
2. What percent of your customers are independent owner-operators?
3. Where are your primary headquarters located?
4. Describe the geographic scope of your sales and distributions.
5. Does your company specialize in manufacturing alternative fuel/zero-emission trucks, or equipment for such trucks?
6. Does your company have any zero-emission trucks or key components currently available for purchase?
7. Which part(s) of the transportation sector do you manufacture trucks/equipment for (check all that apply)? (Options: Medium-duty, Heavy-duty (short-haul transport or drayage), Heavy-duty (long-haul transport), Specialized equipment (e.g., cement trucks, garbage trucks).)

8. In your view, what is the most important factor in a company's truck purchase decision (other than cost)? (Options: Reliability, Warranty, Brand, Fuel Economy.)
9. Please take the perspective of a trucking fleet in answering this question. Rank these sources of information based on their trustworthiness for reliable truck and trucking technology information. '1' is the most trusted source of information; '6' is the least trusted source. (Sources: Trucking associations, Unions, Truckers/fleet operators, Other truck manufacturers, Government agencies, Media personalities.)
10. Do you have any programs that specifically target small fleets or owner-operators who are looking to procure alternative fuel or zero-emission trucks?
11. Do you sell trucks or equipment to customers under a state/provincial or federal regulation to transition to zero-emission truck fleets?
12. How much of a barrier do these factors present to your customers in adopting alternative fuel or zero-emission trucks? (Factors: Upfront cost, Total cost of ownership (TCO), Difficulty with financing, Availability of zero-emission trucks, Zero-emission trucks do not meet operational needs, Lack of familiarity with the technology, Lack of technical support and maintenance availability for the technology, Lack of fuel or other infrastructure, Inadequate or inaccessible government support, Inadequate support within your own organization.)
13. Please evaluate the following statement: Incentive funding should be made available for used zero-emission trucks. (Options: Strongly disagree, disagree, agree, strongly agree.)
14. Please evaluate the following statement: A certain percentage of funding should be set aside for small businesses. (Options: Strongly disagree, disagree, agree, strongly agree.)
15. Please rank these policy priorities for supporting small fleet operators in procuring alternative fuel or zero-emission trucks: Outreach and education, Purchase incentives for trucks and/or infrastructure, Supporting a network of ZET technicians, Preferential parking and loading zones.

Government and NGOs

1. Where are your primary headquarters located?
2. What activities does your organization engage in (check all that apply)? (Options: Research, Advocacy, Policy development, Supporting political candidates, Coalition-building, Fundraising, Providing services to truckers.)
3. Which of these parties do you work with (check all that apply)? (Options: Regional/national trucking associations, trucking labor unions, truck manufacturers, Government agencies.)
4. Do you work with partners who are regulated under a state/provincial or federal mandate to have a fully zero-emission truck fleet?
5. Do you have currently ongoing projects aimed at enabling fleets to transition to zero-emission trucks?
6. Does your project work differentiate large fleets from small fleets and independent owner-operators?
7. Are you involved in work on the California Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP), or developing a similar program for another jurisdiction?

8. Are you involved in work on the California Advanced Clean Trucks (ACT) Rule, or developing a similar regulation for another jurisdiction?
9. Please rank these policy priorities for supporting small fleet operators in procuring zero-emission trucks: Outreach and education, Purchase incentives for trucks and/or infrastructure, Supporting a network of ZET technicians, Preferential parking and loading zones.
10. Please evaluate the following statement: Incentive funding should be made available for used zero-emission trucks. (Options: Strongly disagree, disagree, agree, strongly agree.)
11. Please evaluate the following statement: A certain percentage of funding should be set aside for small businesses. (Options: Strongly disagree, disagree, agree, strongly agree.)