
Accelerating ZEV adoption in fleets to decarbonize road transportation

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The Zero Emission Vehicles Transition Council is an international forum focused on enhancing political cooperation on the transition to zero emission vehicles (ZEVs).

It brings together Ministers that represent over 50% of the global car market. Council members have agreed to collectively address some of the key challenges in the transition to ZEVs, enabling the transition to be faster, cheaper, and easier for all.

The Council will convene on a regular basis to discuss how to accelerate the pace of the global transition to ZEVs, to reduce emissions and help the global economy meet our goals under the Paris Agreement.

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Executive Summary

Attention on vehicle fleets is critical in the early part of the transition to zero-emission vehicles (ZEVs) and accelerating fleet transition could do much to support the decarbonization of road transport globally. We define fleets quite broadly here to include a variety of vehicles used for commercial and public purposes—company cars, taxis, vans, delivery and ride-hailing vehicles, two- and three-wheelers, trucks, and buses—that are owned or operated by either governments, businesses, or individuals. Under this definition, vehicle fleets currently make up a quarter of vehicles on the road and almost two-thirds of greenhouse gas emissions from road transport globally.

The Zero Emission Vehicles Transition Council (ZEVTC) has identified fleet electrification as a key area of focus. This paper reviews the latest literature on the benefits of and opportunities for faster ZEV transitions within fleets and highlights the role of governments in supporting these transitions. We focus on technology cost and readiness, actions needed for charging infrastructure deployment, effective policy approaches, and emerging business models. The primary takeaways are:

An accelerated transition to zero-emission fleet vehicles can dramatically reduce global greenhouse gas emissions from road transport. ZEVs in heavy-duty fleets could provide half of the emissions reduction required to align with Paris Agreement goals and save approximately 47.5 billion tonnes of CO₂ emissions from 2020 to 2050.

ZEVs are already at or are quickly reaching technology readiness and commercial viability in ZEVTC member jurisdictions. Fleet consumers in ZEVTC jurisdictions can already choose from a number of commercially mature and competitive zero-emission light-duty vehicles (LDVs), and the number of available zero-emission heavy-duty vehicles (HDVs) is quickly growing, especially for buses, delivery vans, short-haul straight trucks, and tractor trucks. For zero-emission HDVs, though, certain regions and segments are at an earlier stage of technology readiness and product availability.

Most ZEVs will soon be cheaper to own than internal combustion engine (ICE) vehicles, and some are already cheaper. The total cost of ownership (TCO) outlook favors zero-emission fleet vehicles due to their lower cost of operations and maintenance. Battery-electric LDVs, including two- and three-wheelers, are expected to reach TCO parity with their ICE counterparts between today and 2030, depending on the region, even in the absence of incentives. Battery-electric transit buses and urban delivery trucks have achieved TCO parity today, and short-haul tractor trucks are expected to close the gap with their ICE counterparts before 2030 and even sooner with incentives.

Fleet transition could catalyze the global ZEV transition. Seven ZEVTC members have ZEV fleet purchase requirements in place today, and a growing number of corporate fleet owners and operators have voluntarily committed to 100% ZEV fleets as early as 2030 in leading markets and no later than 2035 globally. These first-movers are expected to help drive down ZEV costs to a tipping point where they reach price parity with ICE vehicles for other vehicle consumers, including smaller fleets. Additionally, leased vehicles like company cars could spur the secondhand market after the end of their lease periods and increase the affordability of private car ZEVs.

Effective policy approaches could enable both faster fleet transition to ZEVs and faster charging infrastructure deployment. ZEVTC governments have adopted such supportive policies and measures to influence the pace of ZEV transition in five key areas:

Phase-out targets and ZEV regulations: ICE vehicle phase-out targets and ZEV regulations send strong signals to fleet owners to electrify their vehicles and to manufacturers to invest in ZEV development. A growing number of countries have set target dates to end the sale of new ICE cars and vans between 2025 and 2040. For HDVs, 13% of new bus sales and 15% of new truck sales globally are now covered by ICE phase-out targets by 2050.

Fleet purchase requirements: These mandate a minimum share of ZEVs in fleet purchases specifically. ZEVTC governments can set ambitious purchase requirements for their own fleets in different vehicle segments that align with the pace of phase-out targets first and then initiate broader zero-emission purchase requirements for large private fleets.

Fiscal incentives: Governments can offer things like tax rebates and purchase subsidies to support commercial fleet customers who buy ZEVs and install charging infrastructure. These incentives lower the cost gap between ICE vehicles and ZEVs and lessen the burden on small and individual fleet owners who might have limited access to capital. Access to low-cost financing and new business models can also help small fleet owners overcome purchase barriers.

Charging infrastructure: Ensuring timely charging infrastructure build-out requires ensuring long-term planning and coordination between fleets, utilities, and regional transport and energy departments. Governments can empower electricity utilities to be proactive, create joint energy and transport government agencies, incentivize upfront planning from the utility and the fleet operator sides, and provide subsidies and tax rebates in the early stages of the market for charger purchase and installation and potential grid upgrades. They can also offer regulatory certainty regarding charging infrastructure, provide public land along important travel corridors and in dense cities, and encourage emerging business models.

Emerging business models: Alternative business models like Charging as a Service and Vehicle as a Service will be needed to help fleet owners manage the high upfront costs and technology risks and reduce the need to develop their own expertise. These models are essential for small fleet owners and for fleets in emerging markets and developing economies at the early stages of ZEV adoption. Governments can encourage these and foster private-sector involvement by designing flexible subsidy schemes and de-risking investments by transferring a portion of the risk to third parties or providing financial guarantees themselves.

Introduction

Faster deployment of zero-emission fleet vehicles could stimulate broader decarbonization of road transport.¹ Previous ICCT research demonstrated that Zero Emission Vehicles Transition Council (ZEVTC) countries, which are responsible for half of new vehicle sales globally and are home to the largest fleet owners, are well positioned to influence the pace of zero-emission vehicle (ZEV) transition.² This paper focuses on opportunities for accelerating the adoption of zero-emission commercial and public fleet vehicles in ZEVTC countries and the role that governments can play in supporting it.

This paper is divided into four parts. First, we present some of the benefits of accelerated fleet ZEV transitions. After that, we focus on key considerations for fleet electrification, and then the third part summarizes key policies and measures adopted by governments to support ZEV transitions. In the fourth section, we present emerging business models to facilitate zero-emission fleet vehicle operations and charging infrastructure installation.

Benefits of accelerated fleet ZEV transition

Fleet transitions to ZEVs are already underway. Growing commitments from governments and businesses showcase the momentum and the potential to increase ZEV uptake in fleets in the coming years. Such acceleration is not only possible but could bring about significant climate and health benefits for society and economic advantages for fleet operators. It could also improve public confidence in ZEVs and increase their visibility.

Climate

Although fleet vehicles are only about a quarter of the vehicles on the road today, they emit almost two-thirds of global greenhouse gas (GHG) emissions from road transport because they drive longer distances and carry heavier loads than private-use vehicles.³ Studies show that the climate impacts of fleet vehicles are already high, and their share of emissions from road transport is expected to increase in the absence of further policy action. For example, fleet vehicles in Europe travel more than 40% of total vehicle kilometers while making up just 20% of the vehicles on the road.⁴ These vehicles are responsible for half of the GHG emissions from road transport in Europe.

1 In this paper, we broadly define fleets as commercial vehicles owned or operated by governments, businesses, or individuals. Our primary focus is on fleet vehicle use, but we also cover ownership patterns for small fleets. We categorize fleet vehicles into the following segments based on vehicle gross weight: two- and three-wheelers, light commercial cars and vans, buses, and medium- and heavy-duty trucks (See Appendix A). Examples of light-duty commercial vehicles include company cars, ride-hailing vehicles, taxis, and urban delivery vans. Heavy-duty vehicles (HDVs) include transit buses, delivery vans, drayage trucks operating from seaports, and heavy-goods vehicles, and these are all used almost exclusively for business or public purposes. We therefore treat most HDVs as fleet vehicles.

2 Yihao Xie, Tim Dallmann, Rachel Muncrief, "Heavy-duty Zero-emission Vehicles: Pace and Opportunities for a Rapid Global Transition, (ICCT: Washington, DC, 2022), <https://theicct.org/publication/hdv-zevtc-global-may22/>

3 Climate Group, "Fleets First: How Accelerating Fleet Electrification Can Unlock the Shift to Clean Road Transport," (July 2021), <https://www.theclimategroup.org/fleetsfirst>

4 Serge Colle et al., "Accelerating Fleet Electrification in Europe: When Does Reinventing the Wheel Make Perfect Sense?" (EY, 2021), https://assets.ey.com/content/dam/ey-sites/ey-com/en_gl/topics/energy/ey-accelerating-fleet-electrification-in-europe-28012021-v2.pdf.

Heavy-duty vehicles (HDVs), primarily buses and commercial trucks, are responsible for more than a quarter of the road transport GHG emissions in the European Union.⁵

A rapid transition to zero-emission HDV fleets is needed to align with Paris Agreement goals. For ZEVTC members, our modeling shows that HDV fleets need to be decarbonized faster from 2030 onward, and emissions from HDV fleets need to fall by 70% through 2050 to align with a pathway that could keep global temperature rise below 2 °C.⁶ Approximately 47.5 billion tonnes of carbon dioxide (CO₂) emissions could be saved from 2020 to 2050 if zero-emission HDVs globally reach at least 45% of new sales by 2030 and almost 100% by 2040.⁷

Economies of scale

Fleets are composed of multiple vehicles, and it is typically easier to negotiate discounted rates when purchasing more than one vehicle. These discounts can decrease the upfront cost gap between ZEVs and their internal combustion engine (ICE) counterparts. Additionally, by increasing demand for ZEVs, fleets can help bring forward the point at which ZEVs will reach upfront cost parity with their ICE counterparts.

For light-duty vehicles (LDVs), public and private fleets can help convince private-use vehicle owners to switch to ZEVs because they assist in bringing affordable zero-emission options to the market more quickly. Faster electrification of fleet vehicles like company cars can inspire this transformation at scale. Moreover, company cars are often leased for up to 3 years and then they enter the secondhand market as private vehicles; this provides more options for cheaper ZEVs.

For HDVs, scale can happen when governments lead by example. Electrification that starts with government-owned or contracted fleets, mostly transit buses, can give confidence to large private fleets owners and operators to adopt ZEVs. Fleet electrification by public and large private fleets can lay the groundwork for infrastructure availability, expanded product offering, and lowered prices for smaller fleets.

Fleet owners are driving the demand for ZEVs in jurisdictions where there is strong policy support and, in some cases, they have pushed for more ambitious targets. Just over 400 companies in 36 countries signed the Climate Pledge, a commitment to reach net-zero carbon emissions by 2040, 10 years earlier than stated in the Paris Agreement.⁸ Thirty global businesses, including Ikea, Uber, and Coca Cola, jointly signed an open letter asking the European Commission to set binding zero-emission purchase targets for corporate fleets.⁹ They called for all new sales of corporate cars and vans to be zero-emission by 2030 and then widening the scope to include heavy commercial vehicles no later than 2035. The Climate Group's EV100 Initiative, a global initiative of companies committed to electrifying their fleets, has reached 127 members and they have collectively committed to 5.75 million electric vehicles (battery electric

5 Adrian O'Connell et al., "A Comparison of the Life-Cycle Greenhouse Gas Emissions of European Heavy-Duty Vehicles and Fuels," (ICCT: Washington, DC, 2023), <https://theicct.org/publication/lca-ghg-emissions-hdv-fuels-europe-feb23/>.

6 Xie et al., "Heavy-duty Zero-emission Vehicles: Pace and Opportunities."

7 Ibid.

8 "About The Climate Pledge," The Climate Pledge, accessed May 9, 2023, <https://www.theclimatepledge.com>.

9 Transport & Environment, "Open Letter Regarding the European Commission Greening Corporate Fleets Initiative: Accelerate the Electrification of Fleets in Europe," (February 15, 2023), https://www.transportenvironment.org/wp-content/uploads/2023/02/Open-letter_-_Accelerate-the-electrification-of-fleets-in-Europe1-3.pdf.

and plug-in hybrid electric) by 2030, up from 400,000 EVs operating on the road today.¹⁰

Economic benefits

Fleet owners and operators benefit from ZEVs because they are more energy efficient and require less frequent maintenance, and in the long run, these features can save their owners and operators money because of reduced labor and fueling costs. With more zero-emission vehicles in their fleets, fleet owners and operators also attract drivers who prefer driving the environmentally friendly vehicles. The economic advantages offered by ZEVs in all classes and segments provide extra motivation to an increasing number of corporations to voluntarily pledge to transition their fleets to ZEVs.¹¹ At the aggregate level, a Geotab analysis found that in 17 European countries, electrifying 46,000 passenger and light-duty commercial vehicles in 1,300 fleets could save €261 million over the next 7 years.¹² The California Air Resources Board has estimated that the Advanced Clean Fleets regulation, which would see California transition to a fully zero-emission medium- and heavy-duty vehicle fleet by 2036, will save \$26.5 billion in health costs and \$48 billion in vehicle ownership costs.¹³

Health

Zero-emission fleet vehicles can reduce air pollution and premature deaths in urban areas. Previous research showed that older diesel trucks contribute up to 83% of tailpipe particulate matter (PM_{2.5}) emissions in New York City and these disproportionately impact people of color living around major freight corridors in the Bronx and Queens.¹⁴ Shifting to zero-emission truck options would help clean up the air and improve health outcomes in the City's heavily burdened "environmental justice areas."

Diesel taxis are a significant source of tailpipe emissions in central London and produced 20% of nitrogen oxides (NO_x) emissions in 2020.¹⁵ Air pollution from road transportation has been linked to 1,500 premature deaths annually in London, many of these in low-income and ethnic minority neighborhoods in outer boroughs where there are higher nitrogen dioxide (NO₂) concentrations.¹⁶ Globally, electrifying fleet vehicles could potentially avoid approximately 120,000 premature deaths by 2030 and benefit highly polluted cities of the Global South.¹⁷

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- 10 Climate Group, "EV100 Progress and Insights Report 2023," (New York, NY, 2023), <https://www.theclimategroup.org/our-work/press/ev100-progress-and-insights-report-2023>.
- 11 IKEA, "IKEA Commits to Zero-Emission on Heavy-Duty Vehicles," news release, September 20, 2022, <https://about.ikea.com/en/newsroom/2022/09/20/ikea-commits-to-zero-emission-on-heavy-duty-vehicles>.
- 12 Geotab, "Profitable Sustainability: The Potential of European Fleet Electrification," (2022), <https://www.geotab.com/white-paper/european-fleet-electrification/>
- 13 "Advanced Clean Fleets Regulation Summary," California Air Resources Board, April 13, 2023, <https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-fleets-regulation-summary>.
- 14 Michelle Meyer and Tim Dallmann, "Exposure to Air Pollution from Diesel Trucks in New York City," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/fs-true-diesel-trucks-nyc-apr22/>.
- 15 The Real Urban Emissions Initiative, "New London Vehicle Policy Based on TRUE Findings (blog)," January 11, 2019, <https://www.trueinitiative.org/blog/2019/january/new-london-vehicle-policy-based-on-true-findings>.
- 16 Mayor of London, "Mayor Publishes First Data from Breathe London Network," news release, July 24, 2019, <https://www.london.gov.uk/press-releases/mayoral/first-breathe-london-data-published>.
- 17 Climate Group, "Fleets First: How Accelerating Fleet Electrification Can Unlock the Shift."

Key considerations for fleet electrification

Fleets face significant challenges in transitioning to ZEVs within the time frame required to align with Paris Agreement goals. This section discusses a number of important areas—charging infrastructure, total cost of ownership (TCO) considerations when designing subsidies, technological readiness, and financing issues facing small fleets—where additional action will be critical in supporting accelerated fleet ZEV transitions.

Charging infrastructure

Recent surveys of European and North American fleet operators identified private charging infrastructure installation and the lack of public charging infrastructure dedicated to fleets as primary roadblocks to fleet electrification.¹⁸ There are four critical areas related to charging infrastructure for fleets. These are presented in Table 1, and they apply to all vehicle segments.

Table 1. Four key considerations related to charging infrastructure for fleets

Planning ahead & Grid challenges
<ul style="list-style-type: none"> While battery electric vehicle (BEV) orders can often be fulfilled within a few months, charging infrastructure setup can take months or even years. It is thus important that fleet operators consider charging infrastructure before or at least at the same time as vehicle procurement. Grid upgrades take time and can take up to 10 years if transmission upgrades are needed. Electricity utilities thus need to be proactive in upgrading the grid instead of reacting to demand from fleets; this will prevent utilities from being a bottleneck in the process.¹⁹ Most of the time, challenges appear at the distribution stage rather than at the generation or transmission stages, and alternative solutions should be envisaged that would allow BEVs to operate while existing electricity is brought to the right place (see the government action section below).²⁰
Collaboration & Expertise
<ul style="list-style-type: none"> Collaboration is needed between transport, environment, economics, and energy departments in government to develop long-term plans, design policies and incentives, and enable new opportunities such as vehicle-to-grid (V2G). Fleet operators are historically more knowledgeable about transport than they are about the energy sector and often lack capacity to develop this expertise. They can struggle with unclear or non-existent permitting procedures for grid connection or charger installation. Conversely, electricity utilities are historically less knowledgeable about transportation and fleet needs for charging infrastructure.
Public charging infrastructure
<ul style="list-style-type: none"> Small fleets generally lack the resources to build a centralized private charging infrastructure hub and thus depend on public charging infrastructure. Long-haul trucks that do not return to the same location every night need reliable charging infrastructure along freight corridors. Regional fast-charging hubs give confidence to fleet operators to switch to ZEVs. Deploying public charging infrastructure requires land.
Cost
<ul style="list-style-type: none"> Charging infrastructure deployment is capital intensive. Due to high upfront costs and their own lack of expertise, many fleet owners are adding a few BEVs to their fleet at a time and installing a small number of chargers at a time. This is the most expensive way to electrify a fleet and install the charging infrastructure needed.²¹

18 Pierre-Louis Ragon and Felipe Rodríguez, “Road Freight Decarbonization in Europe: Readiness of the European Fleets for Zero-Emission Trucking,” (ICCT: Washington, DC, 2022), <https://theicct.org/publication/road-freight-decarbonization-europe-sep22/>; Jerold Brito, No Fleet Left Behind: Barriers and Opportunities for Small Fleet Zero-emission Trucking, (ICCT: Washington, DC, 2022), <https://theicct.org/publication/small-fleet-ze-trucking-oct22/>; Lynn Daniels, Chris Nelder, “Steep Climb Ahead,” (Rocky Mountain Institute: 2021), <https://rmi.org/insight/steep-climb-ahead/>.

19 Marie Rajon Bernard et al., “Charging Solutions for Battery-Electric Trucks,” (ICCT: Washington, DC, 2022), <https://theicct.org/publication/charging-infrastructure-trucks-zeva-dec22/>.

20 Ibid.

21 Daniels and Nelder, “Steep Climb Ahead.”

Cost

ZEVs are typically more expensive to purchase than conventional vehicles. In the United States, battery electric passenger vehicles in 2022 were about \$3,000 to \$25,000 more expensive to purchase than their gasoline counterparts.²² In India, battery-electric two-wheelers (2Ws) are not expected to reach purchase price parity with gasoline 2Ws until 2035 without government incentives.²³ The higher prices mean that fleet owners might need help in making a ZEV purchase. In emerging markets and developing economies (EMDEs), the price gap between ZEVs and low-cost ICE vehicles is a top barrier, especially for individuals or small fleet owners with limited access to financing.²⁴

An important consideration for fleet owners is the TCO, which refers to the overall cost of vehicle operations over a vehicle's entire useful life, including purchase, maintenance, refueling, and resale/residual values. By this metric, ZEVs, and especially BEVs, are more economically attractive. With BEVs there are operating-cost savings over time because of cheaper energy and reduced maintenance needs. In India, most battery-electric 2Ws will be significantly cheaper in TCO terms than conventional 2Ws before 2025, even without incentives; additionally, battery-electric cars used for ride-hailing services are cheaper today, with current incentives, compared to comparable diesel and gasoline cars over a 5-year ownership period.²⁵

Transit buses are the first HDV segment in which there has been mass adoption of BEVs, and with these TCO is often favorable compared to ICE buses.²⁶ Research by ICCT and others found that TCO parity between BEVs and ICE vehicles in truck segments, including urban delivery and regional and long-haul freight transport, is expected in the United States and Europe in the next decade, and even as early as today when incentives are provided.²⁷ Declining material and manufacturing costs mean the upfront cost gap would diminish to a point where the TCO premium for BEVs could be eliminated by the late 2020s or early 2030s for most truck segments (not for

22 Peter Slowik et al., "Assessment of Light-Duty Electric Vehicle Costs and Consumer Benefits in the United States in the 2022-2035 Time Frame," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/ev-cost-benefits-2035-oct22/>.

23 Shikha Rokadiya, Anup Bandivadekar, and Aaron Isenstadt, "Estimating Electric Two-wheeler Costs in India to 2030 and Beyond," (ICCT: Washington DC, 2021), <https://theicct.org/publication/estimating-electric-two-wheeler-costs-in-india-to-2030-and-beyond/>

24 Tanzila Khan et al., "A Critical Review of ZEV Deployment in Emerging Markets," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/zev-market-review-global-feb22/>

25 Nibedita Dash, Sandra Wappelhorst, and Anup Bandivadekar, "Updated Analysis of Incentives for Electrifying India's Four-wheeler Ride-hailing Fleet," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/updated-analysis-of-incentives-for-electrifying-indias-four-wheeler-ride-hailing-fleet/>; Rokadiya et al., "Estimating Electric Two-wheeler Costs."

26 For India, see Aparna Vijaykumar et al., "Procurement of Electric Buses: Insights from Total Cost of Ownership (TCO) Analysis," (World Resources Institute India: New Delhi, 2021), https://wri-india.org/sites/default/files/WRI_EBus_Procurement_Commentary_FINAL_0.pdf; in the U.S., see Caley Johnson et al., "Financial Analysis of Battery Electric Transit Buses," (National Renewable Energy Lab: Golden, CO, 2020), <https://doi.org/10.2172/1659784>

27 For delivery vans in Europe, see Hussein Basma et al., "Electrifying Last-mile Delivery: A Total Cost of Ownership Comparison of Battery-electric and Diesel Trucks in Europe," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/tco-battery-diesel-delivery-trucks-jun2022/>; for commercial vans and pickup trucks in the U.S., see Eamonn Mulholland, "Cost of Electric Commercial Vans and Pickup Trucks in the United States Through 2040," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/cost-ev-vans-pickups-us-2040-jan22/>; for long-haul tractor-trailers in Europe, Hussein Basma, Arash Saboori, and Felipe Rodríguez, "Total Cost of Ownership for Tractor-trailers in Europe: Battery Electric Versus Diesel," (ICCT: Washington, DC, 2021), <https://theicct.org/publication/total-cost-of-ownership-for-tractor-trailers-in-europe-battery-electric-versus-diesel/>.

tractor trucks in some regions).²⁸ Figure 1 summarizes ICCT analyses of TCO in ZEVTC member countries for different fleet vehicle segments.

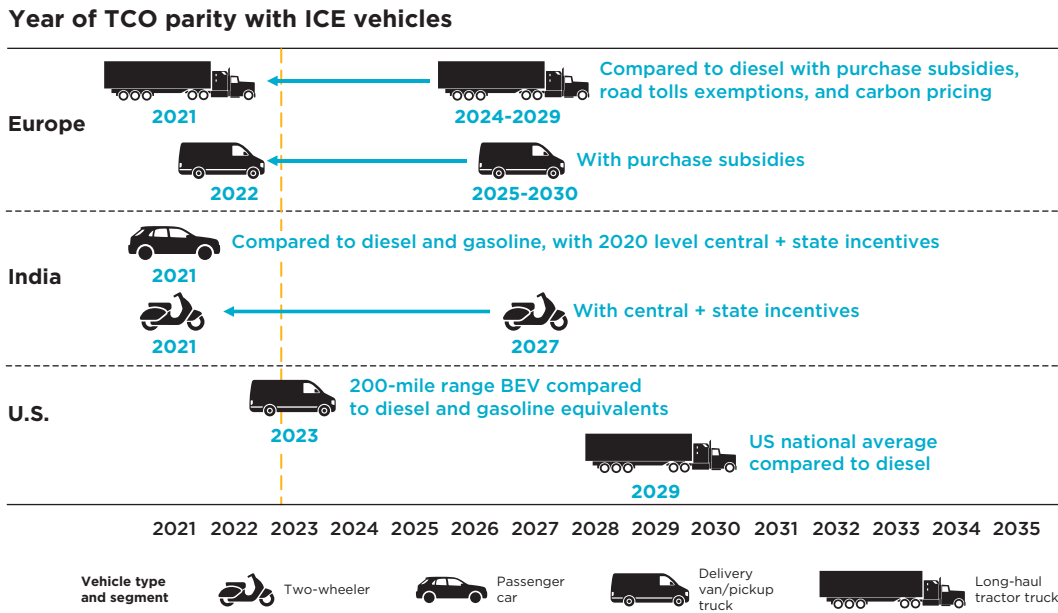


Figure 1. Summary of total cost of ownership analysis of battery electric vehicles from the ICCT.

Technological readiness and commercial availability

Zero-emission product offerings have proliferated in recent years, for both LDVs and HDVs. The technological readiness for zero-emission LDVs is demonstrated by their rising absolute sales and market penetration rates worldwide.²⁹ From delivery 2W/3Ws to taxi cars and logistics minivans, zero-emission LDVs can perform competently and meet the needs of fleet customers. Most zero-emission commercial products today are battery-electric powered.

For HDVs, ZEVs are at various stages of technological readiness. Urban buses, last-mile urban delivery vehicles, short-haul straight trucks, and short-haul tractor-trailers have predictable daily range and payload, return-to-base operations, and reliable and dedicated parking; they also lend themselves to innovative business models.³⁰ Zero-emission products in the market today can meet the duty cycle needs of fleets operating these vehicles. HDVs with the highest range and payload requirements, in other words, long-haul tractor-trailers, are at an earlier stage of zero-emission transition. Investments in the battery pack and fuel cell research and development, charging and refueling infrastructure build-out, and alternative solutions like battery-swapping are being explored to overcome the technological barriers currently facing the segment. Further, advances in heavy-duty ZEVs in one segment are likely to catalyze the adoption of ZEV technologies in the broader market because key ZEV components are typically transferrable. Like LDVs, battery-electric power trains

²⁸ Yihao Xie, Hussein Basma, Felipe Rodríguez, “Purchase Costs of Zero-emission Trucks in the United States to Meet Future Phase 3 GHG Standards,” (ICCT: Washington, DC, 2023), <https://theicct.org/publication/cost-zero-emission-trucks-us-phase-3-mar23/>

²⁹ BloombergNEF, “Electric Vehicle Outlook 2022,” (2022), <https://about.bnef.com/electric-vehicle-outlook/>

³⁰ Xie et al., “Heavy-duty Zero-emission Vehicles: Pace and Opportunities.”

dominate the market, while fuel-cell electric products are in an earlier stage of commercial maturity and technological readiness.³¹

Note that the technological readiness and commercial availability of ZEVs differs by region, and there are more technologically and commercially mature zero-emission passenger vehicles in higher-income countries.³² China leads the world in the number of heavy-duty bus and truck manufacturers and products, and the United States and Europe are distant runners-up.³³ Fleet customers in India have a wide selection of zero-emission 2Ws and 3Ws and battery-electric transit buses to choose from, but there is a smaller selection of zero-emission passenger cars and trucks.³⁴ In EMDEs, the introduction of zero-emission 2Ws and 3Ws and transit buses is beginning, and the availability of passenger vehicles and medium- and heavy-duty trucks is far more limited.

Small fleets

Transitioning to ZEVs can be difficult for small businesses with five or fewer vehicles, including light-duty commercial car, van, and truck owners. This is because they typically face several additional challenges such as limited access to financing, lack of technical knowledge and dedicated staff to support ZEV transitions, and insufficient public charging options combined with an inability to invest in high-cost private charging infrastructure.

In the United States and Canada, small truck fleet operators face greater financial barriers in procuring zero-emission trucks because they need more in-depth technical knowledge about costs, financing, and available technologies.³⁵ As seen in Figure 2, more than 90% of U.S.-based truck fleets and over 75% of Canada-based truck fleets have registered five or fewer trucks.

31 Hussein Basma and Felipe Rodríguez, "Fuel Cell Electric Tractor-trailers: Technology Overview and Fuel Economy," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/fuel-cell-tractor-trailer-tech-fuel-jul22/>.

32 Ilma Fadhill, Yidan Chu, and Lingzhi Jin, "Electric Vehicles Market Monitor for Light-Duty Vehicles: China, Europe, United States, and India, 2020 and 2021," (ICCT: Washington, DC, 2023), <https://theicct.org/publication/ev-ldv-major-markets-monitor-jan23/>.

33 Hussein Basma and Felipe Rodríguez, "Race to Zero: How Manufacturers are Positioned for Zero-emission Commercial Trucks and Buses in Europe," (ICCT: Washington, DC, 2021), <https://theicct.org/publication/race-to-zero-ze-hdv-eu-dec21/>; Shiyue Mao and Felipe Rodríguez, "Race to Zero: How Manufacturers are Positioned for Zero-emission Commercial Trucks and Buses in China," (ICCT: Washington, DC, 2021), <https://theicct.org/publication/race-to-zero-how-manufacturers-are-positioned-for-zero-emission-commercial-trucks-and-buses-in-china/>; Claire Buysse, "Zero-emission Bus and Truck Market in the United States and Canada: A 2021 Update," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/update-ze-truck-bus-market-us-can-sept22/>.

34 Sustainable Bus, "The E-bus Market in India Has Grown 65% in 2022," February 2, 2023, <https://www.sustainable-bus.com/electric-bus/electric-bus-market-india-2022/>

35 Brito, "No Fleet Left Behind."

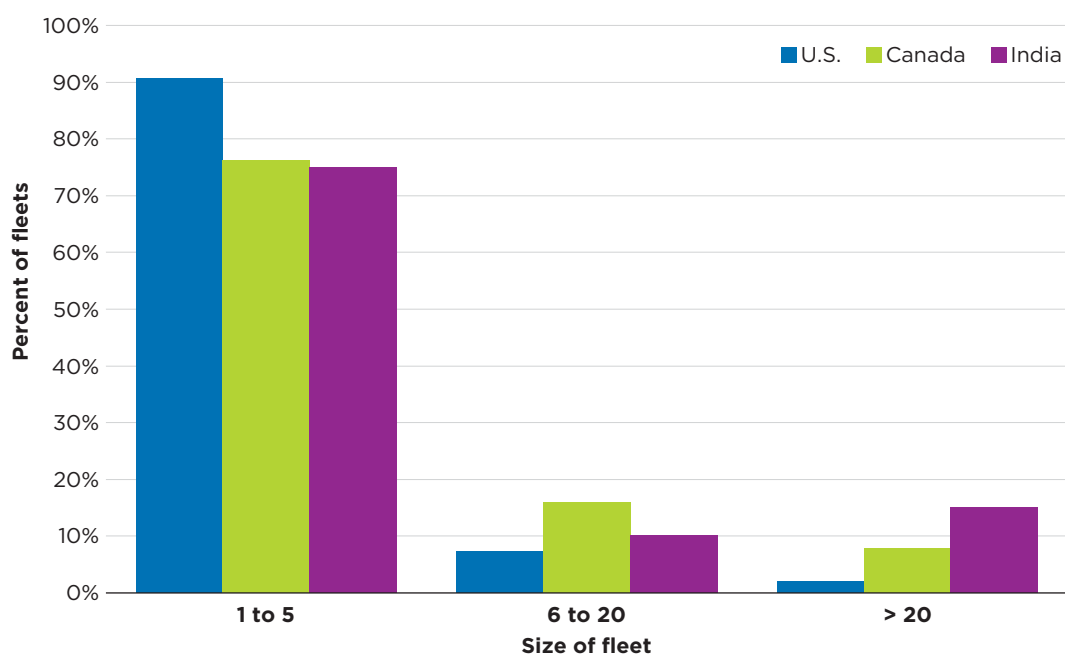


Figure 2. Distribution of truck fleets shown by the size of the fleet. Data for the United States and Canada is from the Department of Transportation Motor Carrier Management Information System (April 2022) and for India, from Raghuram (2015).

In India, the trucking business is predominately owned by small operators with five or fewer trucks, and these operators own 75% of the truck fleet.³⁶ The majority of these are cash-strapped operators who own older trucks and lack access to loans to make the switch to ZEVs. Additionally, the fragmented and competitive freight market leads to unsustainably low revenues; lending to them is thus unattractive to financiers, due to perceived risk of default.³⁷ Commercial fleet operators tend to borrow from unorganized money lenders who usually provide high-interest loans and drive the market toward low-cost business models.

The role of government in supporting faster fleet ZEV transitions

Supportive legislative frameworks are critical for bolstering the supply of and demand for ZEV fleet vehicles. There is growing policy momentum for fleet electrification at the national, subnational, and supranational levels. This section reviews measures that leading ZEVTC governments are taking to address key barriers facing fleets and support faster transitions to ZEVs.

ICE vehicle phase-outs and ZEV regulations

Governments and businesses in the largest auto markets have set voluntary target dates for phasing out sales of ICE vehicles and transitioning all new vehicle sales to ZEVs. Over 200 governments, automotive manufacturers, fleet owners and operators, and other stakeholders have signed the ZEV Declaration committing to work toward

³⁶ G. Raghuram, "An Overview of the Trucking Sector in India: Significance and Structure," (working paper, Indian Institute of Management, Ahmedabad, 2015), <https://www.iima.ac.in/sites/default/files/rnpfiles/12319057932015-12-02.pdf>

³⁷ Daniels and Nelder, "Steep Climb Ahead."

all new car and van sales being zero-emission by 2035 in leading markets and by 2040 globally.³⁸ Twenty-seven countries, including six ZEVTC members, have signed the Global Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles, which sets a goal of 30% new zero-emission truck, delivery vehicle, and bus sales by 2030 and 100% by 2040.³⁹

A growing number of governments have backed ICE vehicle phase-out targets with binding regulations for light-duty vehicles. These binding targets will positively impact the ZEV supply-and-demand dynamics, giving clarity to fleet owners about the pace of the ZEV transition and making it easier for them to invest in ZEVs. California's Advanced Clean Cars rule (ACCII) mandates that all new cars and light trucks sold in California be zero-emission by 2035.⁴⁰ The U.S. Environmental Protection Agency has proposed new GHG emission standards for light- and medium-duty vehicles that is projected to lead to 54% ZEV sales by 2030 and 67% by 2032.⁴¹ The European Union introduced a legally binding regulation requiring that 100% of new LDVs sold have zero CO₂ emissions by 2035, as a part of the Fit-for-55 package. The European Union is the world's third-largest vehicle market and is progressively imposing stringent emission standards: at least a 55% reduction in CO₂ emissions for new passenger cars and a 50% reduction for light-commercial vans is required by 2030.⁴² In March 2023, the United Kingdom proposed a new ZEV mandate for cars and vans that would require a growing share of new car and van sales to be zero-emission beginning in 2024, in alignment with the U.K. Government's commitment that all new cars and vans will be fully zero-emission at the tailpipe by 2035.⁴³ Canada has also proposed a zero-emission LDV sales mandate; it sets requirements that increase annually starting in 2026 and culminates with 100% zero-emission LDV sales by 2035.⁴⁴

Many national and subnational governments have committed to decarbonizing HDVs, starting with bus fleets.⁴⁵ Countries with official phase-out targets to end ICE buses by 2050 now cover 13% of new bus sales globally. The European Commission recently proposed new CO₂ standards for HDVs that includes a 100% ZEV sales target for city

38 A2Z Coalition, "Accelerating to Zero Coalition Launches at COP27 to Drive Global Transition to Zero-emission Vehicles," news release, November 16, 2022, <https://acceleratingtozero.org/accelerating-to-zero-a2z-coalition-launches-at-cop27-to-drive-global-transition-to-zero-emission-vehicles/>

39 "Global Memorandum of Understanding on Zero-emission Medium- and Heavy-duty Vehicles," Global Commercial Vehicle Drive to Zero, November 2022, <https://globaldrivetozero.org/mou-nations/>

40 California Air Resources Board, "California Moves to Accelerate 100% New Zero-emission Vehicle Sales by 2035," news release no. 22-30, August 25, 2022, <https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035#:~:text=In%202040%2C%20greenhouse%20gas%20emissions,of%20395%20million%20metric%20tons.>

41 "Proposed Rule: Multi-pollutant Emissions Standards for Model Years 2027 and Later Light-duty and Medium-duty Vehicles," U.S. Environmental Protection Agency, updated May 12, 2023, <https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-multi-pollutant-emissions-standards-model>

42 Jan Dornoff et al., "Fit for 55: A Review and Evaluation of the European Commission Proposal for Amending the CO₂ Targets for New Cars and Vans," (ICCT: Washington, DC, 2021), <https://theicct.org/publication/fit-for-55-a-review-and-evaluation-of-the-european-commission-proposal-for-amending-the-co2-targets-for-new-cars-and-vans/>.

43 "Government Response and Outcome to Technical Consultation on Zero Emission Vehicle Mandate Policy Design," UK Department for Transport, updated March 30, 2023, <https://www.gov.uk/government/consultations/policy-design-features-for-the-car-and-van-zero-emission-vehicle-zev-mandate/outcome/government-response-and-outcome-to-technical-consultation-on-zero-emission-vehicle-mandate-policy-design#:~:text=From%201%20January%202024%2C%20ZEV,until%20reaching%20100%25%20in%202035.>

44 Canada Gazette, Part I Vol. 156, No. 53, December 31, 2022, <https://canadagazette.gc.ca/rp-pr/p1/2022/2022-12-31/pdf/g1-15653.pdf>

45 Sandra Wappelhorst and Felipe Rodriguez, "Decarbonizing Bus Fleets: Global Overview of Targets for Phasing Out Combustion Engine Vehicles (blog)," December 9, 2021, <https://theicct.org/decarbonizing-bus-fleets-global-overview-of-targets-for-phasing-out-combustion-engine-vehicles/>

buses by 2030.⁴⁶ Chile aims to have all new urban buses be zero-emission by 2035 and freight transportation and intercity buses be zero-emission by 2045.⁴⁷ Colombia aims to reach 100% zero-emission or electric new urban bus sales for the bus rapid transit system by 2035.⁴⁸ California's Advanced Clean Trucks (ACT) regulation, the first ZEV regulation for heavy-duty trucks in the world, will take effect in 2024 and require manufacturers to sell increasing percentages of zero-emission trucks in the state.⁴⁹ With the approval of the Advanced Clean Fleets (ACF) regulation in April 2023, California extended ZEV requirements to fleets; it requires manufacturers to sell only ZEV medium- and heavy-duty vehicles by 2036.⁵⁰ According to the California Air Resources Board, almost 94% of the medium and heavy vehicle stock in the state will be zero-emission by 2050 due to the ACT and ACF requirements.⁵¹ Finally, the U.S. Environmental Protection Agency has issued a proposed rule to set new GHG emission standards for HDVs sold between 2027 and 2032; it would accelerate ZEV uptake in U.S. fleets and, for the first time, require manufacturers to sell zero-emission trucks and buses.

Fleet purchase requirements and fleet emission targets

Fleet purchase requirements create demand for ZEVs by mandating a minimum share of ZEVs in fleet purchases. Ambitious purchase requirements for government fleets can inject confidence into the whole industry. These requirements typically start with publicly owned fleets that the government controls directly, and several ZEVTC members already have programs. For example, the U.S. federal government targets 100% zero-emission LDV procurements by 2027 and 100% zero-emission procurements for other vehicle classes by 2035 for its fleet of more than 600,000 vehicles.⁵² South Korea has legislated that purchases of new publicly owned passenger vehicles must be at least 80% battery-electric or hydrogen fuel-cell electric beginning in 2022.⁵³ The U.K. Government has committed to making new purchases for the central government's car and van fleet fully zero-emission at the tailpipe by the end of 2027.⁵⁴ In addition, as of November 2022, nine governments had signed the Zero-Emission Government Fleet Declaration; with this, they committed to procuring 100% zero-emission LDVs

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- 46 European Commission, "Proposal for a Regulation Regarding Strengthening the CO2 Emissions Performance Standards for New Heavy-duty Vehicles and Integrating Reporting Obligations and Repealing Regulation (EU) 2018/956," February 14, 2023, https://climate.ec.europa.eu/system/files/2023-02/policy_transport_hdv_20230214_proposal_en_0.pdf
- 47 Government of Chile, "Estrategia Nacional de Electro-Movilidad [National Strategy of Electromobility]." (Santiago, 2021), https://energia.gob.cl/sites/default/files/estrategia-nacional-electromovilidad_ministerio-de-energia.pdf.
- 48 "National Law on Electromobility," The Congress of Colombia, Law 1964/2019, July 11, 2019, <https://www.runt.com.co/sites/default/files/normas/Ley%201964%20de%202019%20En%20virtud%20de%20la%20cual%20se%20promueve%20el%20uso%20de%20veh%C3%ADculos%20el%C3%A9ctricos%20en%20Colombia.pdf>
- 49 Claire Buysse and Ben Sharpe, "California's Advanced Clean Trucks Regulation: Sales Requirements for Zero-emission Heavy-duty trucks, (ICCT: Washington, DC, 2020), <https://theicct.org/publication/californias-advanced-clean-trucks-regulation-sales-requirements-for-zero-emission-heavy-duty-trucks/>
- 50 International Council on Clean Transportation, "California Sets Global Precedent with First-ever 100 Percent Sales Requirement for Zero-emission Trucks, Paves the Way with Zero-emission Fleet Requirements," press statement, April 28, 2023, <https://theicct.org/california-sets-global-precedent-with-first-ever-100-percent-sales-requirement-for-zero-emission-trucks-paves-the-way-with-zero-emission-fleet-requirements/>
- 51 California Air Resources Board, "Advanced Clean Fleets Regulation Summary."
- 52 Exec. Order No. 14057, 86 C.F.R. 236, (2021), <https://www.govinfo.gov/content/pkg/FR-2021-12-13/pdf/2021-27114.pdf>
- 53 Enforcement Decree of the Act on Promotion of Development and Distribution of Environment-Friendly Motor Vehicles, Pub. L. No. Presidential Decree No. 32361, (2022), https://elaw.klri.re.kr/eng_service/lawView.do?hseq=60393&lang=ENG
- 54 The UK Department for Transport, "Government Charges Ahead in Car Fleet Transition to Electric Vehicles," January 19, 2023, <https://www.gov.uk/government/news/government-charges-ahead-in-car-fleet-transition-to-electric-vehicles>

for government-owned or operated fleets and working toward 100% zero-emission medium- and heavy-duty vehicles by 2035.⁵⁵

Fleet purchase requirements for HDVs today mostly apply to transit buses. California implemented the Innovative Clean Transit rule for transit agencies statewide in 2018 and it requires that 25% of new bus purchases be zero-emission from 2023, and that 100% be zero-emission by 2030.⁵⁶ In Europe, the Netherlands has pledged to procure 100% zero-emission transit buses by 2025 and to achieve a 100% zero-emission fleet by 2030 through its Climate Agreement.⁵⁷

Public fleet purchase requirements can further pave the way for future requirements that target non-government fleets. California's aforementioned ACF regulation is the first comprehensive fleet purchase requirement that targets both public and private trucks in the state. The ACF regulation requires drayage, government, and large private fleets with more than 50 trucks or that generate over \$50 million in total gross annual revenue to purchase only zero-emission trucks as early as 2024.⁵⁸ The new regulation also targets the most polluting trucks, with 67% of all Class 7-8 tractors (gross vehicle weight rating > 11,794 kg) covered by its scope.

An alternative method of regulation is through emissions targets that promote or even mandate electrification for fleet owners, operators, and contractors. California's Clean Miles Standard will require the electrification of ride-hailing-company fleets starting in 2023, with annual targets requiring zero grams of CO₂ emissions per passenger mile and that 90% of total annual miles be driven by ZEVs by 2030.⁵⁹ Companies can earn credits by connecting riders to public transit or investing in active mobility infrastructure like sidewalks and bike lanes.⁶⁰ Both Uber and Lyft support the legislation and have pledged to electrify their vehicles by 2030.⁶¹

Financial incentives

Governments can provide financial incentives like tax rebates and cash subsidies to ZEV fleet customers to overcome the upfront cost premium. Table 2 lists select incentive programs in ZEVTC member countries.

55 Clean Energy Ministerial, "Zero-Emission Government Fleet Declaration," September 13, 2022, <https://www.cleanenergyministerial.org/content/uploads/2022/09/evi-zero-emission-government-fleet-declaration-final.pdf>; The White House, "CEQ Announces New Countries Committing to the Zero-Emission Government Fleet Declaration," news release, November 16, 2022, <https://www.whitehouse.gov/ceq/news-updates/2022/11/16/ceq-announces-new-countries-committing-to-the-zero-emission-government-fleet-declaration/>

56 California Air Resources Board, "Innovative Clean Transit (ICT) Regulation Fact Sheet," May 16, 2019, <https://ww2.arb.ca.gov/resources/fact-sheets/innovative-clean-transit-ict-regulation-fact-sheet>

57 The Government of the Netherlands, "Climate Agreement," (The Hague: 2019), <https://www.klimaataakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands>

58 California Air Resources Board, "Advanced Clean Fleets Regulation Summary."

59 "Clean Miles Standard," California Public Utilities Commission, accessed February 25, 2023, <https://www.cpuc.ca.gov/regulatory-services/licensing/transportation-licensing-and-analysis-branch/clean-miles-standard>.

60 California Air Resources Board, "Clean Miles Standard Regulation: Passengers and Communities to Benefit from Lower Emissions with Actions by Transportation Network Companies," October 18, 2022, <https://ww2.arb.ca.gov/resources/fact-sheets/clean-miles-standard-regulation-passengers-and-communities-benefit-lower>.

61 Emily C. Dooley, "California Sets Green Goals for Ride-Hailers Like Lyft, Uber," *Bloomberg Law*, May 20, 2021, <https://news.bloomberglaw.com/environment-and-energy/california-sets-green-car-goals-for-ride-hailers-like-lyft-uber>.

Table 2. Examples of financial incentives for ZEVs in ZEVTC member countries

ZEVTC member	Incentive program	Applicable vehicle type	Notes
California	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) ⁶²	Zero-emission medium- and heavy-duty buses and trucks	Point-of-sale purchase subsidy, amount depends on vehicle size and cost; program has issued more than 5,900 vouchers for battery-electric and fuel cell-electric vehicles
Canada	Incentives for Medium- and Heavy-Duty Zero-Emission Vehicles (iMHZEV) Program ⁶³	Battery-electric, plug-in electric and hydrogen fuel-cell electric medium- and heavy-duty buses and trucks	Program launched in July 2022 to provide C\$547.5 million over 4 years to Canadian fleet consumers for the purchase/lease of medium- and heavy-duty ZEVs
France	Ecological bonus ⁶⁴	Battery-electric and fuel-cell electric passenger cars, vans, and 2Ws/3Ws below 2.4 tonnes and less than €60,000	Up to €3,000 for electric cars and up to €4,000 for electric vans purchased by businesses
India	Faster Adoption and Manufacturing of (Hybrid and) Electric Vehicles (FAME) Scheme – Phase II ⁶⁵	Battery-electric and plug-in hybrid electric 2Ws and 3Ws, passenger vehicles, and buses	The program has run since 2019 and supported the sale of more than 1 million 2Ws and 3Ws and over 8,700 cars and buses; the allocated budget for financial year 2024 is INR 51.72 billion
Korea	Electric Vehicle Subsidy Program ⁶⁶	Battery-electric and hydrogen fuel-cell electric light- and heavy-duty vehicles for individual and corporate consumers	Amount of subsidy determined by vehicle class, size, range, and manufacturer customer service capability
Netherlands	Subsidy scheme for zero-emission commercial vehicles (SEBA) ⁶⁷	Zero-emission commercial vehicle for entrepreneurial and commercial activities	Up to €5,000 per vehicle
United States	Commercial Clean Vehicles Credit ⁶⁸	Light-, medium- and heavy-duty battery-electric and fuel-cell electric commercial vehicles for business use	Tax credits of up to \$7,500 for light-duty commercial vehicles and up to \$40,000 for medium- and heavy-duty commercial vehicles, available until the end of 2032
United Kingdom	Zero-Emission Buses Regional Area ⁶⁹	Zero-emission transit buses	£270 million in financial year 2021 to 2022 for local transport authorities to bid for funding to purchase up to 1,000 zero-emission buses

62 California Air Resources Board, “Proposed Fiscal Year 2022-23 Funding Plan for Clean Transportation Incentives,” October 22, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-10/proposed_fy2022_23_funding_plan_final.pdf

63 “Medium and Heavy-Duty Zero-Emission Vehicles,” Transport Canada, last modified August 30, 2022, <https://tc.canada.ca/en/road-transportation/innovative-technologies/zero-emission-vehicles/medium-heavy-duty-zero-emission-vehicles>.

64 Ministry of Finance, Economy and Industrial and Digital Sovereignty, “Achat d’un véhicule: Comment fonctionne le bonus écologique?,” February 9, 2023, <https://www.economie.gouv.fr/particuliers/bonus-ecologique> (In French)

65 Melissa Cyrill, “India’s FAME-II Scheme Gets 80% Jump in Budget Allocation,” *India Briefing News*, February 3, 2023, <https://www.india-briefing.com/news/indias-fame-ii-scheme-for-electric-vehicles-gets-80-bump-in-budget-allocation-27121.html/>; Government of India Ministry of Heavy Industries National Automotive Board, “FAME India Scheme Phase II Dashboard,” accessed March 13, 2023, <https://fame2.heavyindustries.gov.in/dashboard.aspx>

66 Kwon-Pil Cheon and Ha-Nee Shin, “Changes Soon to Come in Korea’s EV Subsidy Plan,” *Korea JoongAng Daily*, February 6, 2023, <https://koreajoongangdaily.joins.com/2023/02/06/business/industry/Korea-EV/20230206175724479.html>

67 “Subsidieregeling Emissieloze Bedrijfsauto’s (SEBA) [Subsidy Scheme for Zero-emission Commercial Vehicles],” Netherlands Enterprise Agency, last modified on November 13, 2020, <https://www.rvo.nl/subsidies-financiering/seba>

68 “Commercial Clean Vehicle Credit,” Internal Revenue Service, last modified on January 23, 2023, <https://www.irs.gov/credits-deductions/commercial-clean-vehicle-credit>

69 The UK Department for Transport, “UK on Track to Reach 4,000 Zero Emission Bus Pledge with £200 Million Boost,” March 26, 2022, <https://www.gov.uk/government/news/uk-on-track-to-reach-4000-zero-emission-bus-pledge-with-200-million-boost>

Most ZEVTC members have adjusted the financial incentives listed above to reflect the evolution of the market. The best-designed incentive programs for large and public fleets cover the TCO gaps between zero-emission and ICE technologies, account for technology improvements and cost reductions over time, and support targeted segments and consumers. For smaller fleets for which the capital investment needed for ZEVs is too high, support can be extended to offset the purchase price premium. Several incentive programs follow a revenue-neutral design, and these include bonus-malus programs and CO₂-based tolls that finance subsidies by increasing the cost of higher-emitting vehicles and activities. International financial support is often going to be needed for EMDEs to close the cost gap. Governments should explore alternative financing mechanisms and business models, and these are explained later in this briefing.

Charging infrastructure

Governments can support charging infrastructure deployment and enable faster fleet transition when business opportunities for charge point operators are less evident. There are multiple tools at their disposal and these policy options are described below. Examples for each option are provided in Table 3.

Incentivize planning from both the fleet and the electricity utility sides and ensure electricity utilities are proactive and engage deeply in the process. Electricity utilities, as critical stakeholders, should be proactive in making the necessary grid network available. For large charging infrastructure deployment, there might be some grid constraints, mostly at the distribution stage (the generation and transmission stages are expected to be less of a bottleneck). While an already constrained grid can mean a significantly longer wait time before those interested get a functioning charger, there are temporary mitigation measures and actions to increase the load factor of the existing grid that can be implemented so that companies can still electrify while the grid is being upgraded.⁷⁰ Last, taking a long-term view toward building charging infrastructure from the fleet, utility, and government sides is key to overcoming delays and capturing cost efficiencies.

Address the disconnect between the electricity and transportation sectors by ensuring collaboration between governing bodies and offering training programs to fleet operators. Developing charging infrastructure is inherently complex as it lies at the crossroads of multiple agencies that need to work together. Governments can create joint energy and transport agencies and dedicated steering groups to address this collaboration challenge. Fleet operators are historically more knowledgeable about transport than they are about the energy sector, and electricity utilities are historically less knowledgeable about the transport sector's needs regarding charging infrastructure. Government can create training programs and could restrict financial assistance to parties that have attended these programs.

Ensure a base level of public charging infrastructure network coverage, provide subsidies and financing options for private charging, and provide regulatory certainty to foster private investment. Ensuring basic coverage for the public charging infrastructure network is important for small fleets that might not have the financial

⁷⁰ Agora Energiewende, "Toolbox für die Stromnetze – Für die künftige Integration von Erneuerbaren Energien und für das Engpassmanagement [Toolbox for the power grids - For the future integration of renewable energies and for congestion management]," (Berlin: 2018), <https://www.agora-energiewende.de/veroeffentlichungen/toolbox-fuer-die-stromnetze/>; Pierre-Louis Ragon et al., "Near-term Infrastructure Deployment to Support Zero-emission Medium- and Heavy-duty Vehicles in the United States," (ICCT: Washington, DC, 2023), <https://theicct.org/publication/infrastructure-deployment-mhdv-may23/>

ability to install private chargers, for long-haul trucks that do not return to the same location every night, and to give confidence to fleet operators. However, private charging is likely to be the dominant form, especially for large commercial fleets that favor building and owning infrastructure dedicated to their fleet. Private charging subsidies can thus help kick-start the market. Financing options that align repayment with the level of charger use can also be provided to address the uncertainty of ZEV adoption rates faced by developers and investors, so they can invest in charging and refueling infrastructure with confidence. Finally, providing regulatory certainty is crucial to fostering private investment.

Table 3 summarizes recommended government actions and provides examples of how these policies have been implemented in ZEVTC jurisdictions.

Table 3. Key charging infrastructure considerations for fleet electrification with suggested government actions and examples.

Policy options	Examples
Planning ahead & Grid challenges	
<ul style="list-style-type: none"> • Incentivize planning from both the electricity utility and the fleet operators. • Ensure electricity utilities are proactive, engage early, have streamlined processes to quickly respond to demand, and provide alternative solutions to still operate ZEVs while the grid is being upgraded. • Allow third parties to design and construct distribution-level infrastructure according to utilities' specifications with payments for services over time. • Incorporate transportation electrification forecasts into grid planning and allow utilities to build grid capacity ahead of demand. 	<ul style="list-style-type: none"> • Canada provides funding for "Planning Projects" under its Zero Emission Transit Fund program. This includes studies, modeling, and feasibility analyses to support the development of future large-scale capital projects such as charging infrastructure deployment.⁷¹ • The Netherlands developed pilot projects to test mitigation measures to increase the load factor of the existing grid.⁷² • Tesla provided design and engineering services for chargers at two PepsiCo locations in the United States.⁷³ • California Assembly Bill 2700 takes a first step in allowing utilities to "pre-build" capacity and calls for California utilities to incorporate "fleet data" to ensure the distribution grid is ready for medium- and heavy-duty vehicle charging.⁷⁴
Collaboration & Expertise	
<ul style="list-style-type: none"> • Address the disconnect between the power and the transportation sector. • Offer training programs because fleet operators are historically more knowledgeable about transport than they are about the energy sector, and potentially condition financial assistance on fleet operators having attended these trainings. • Streamline permitting processes and make them consistent across jurisdictions. • Encourage emerging business models to attract private capital, de-risk investments, and avoid high capital expenditures. 	<ul style="list-style-type: none"> • The United States created a Joint Office of Energy and Transportation to foster collaboration and alignment between the Energy and Transport Departments. • Germany implemented the Interministerial Charging Infrastructure Steering Group (ISLa) to plan, coordinate, and monitor the implementation of the Charging Infrastructure Master Plan II and better link the charging network with the power grid.⁷⁵ • California enacted AB 1236 to ensure consistent state-wide permitting standards and timely and cost-effective installation of chargers.⁷⁶ • The United States created the Federal Energy Management Program's (FEMP) fleet management training courses.⁷⁷

71 "Zero Emission Transit Fund," Government of Canada, last modified May 30, 2022, <https://www.infrastructure.gc.ca/zero-emissions-trans-zero-emissions/index-eng.html>

72 Nationale Agenda Laadinfrastructuur, "Laden voor logistiek bij beperkte netcapaciteit [Charging for logistics at limited grid capacity]," (2022), <https://www.agendalaadinfrastructuur.nl/ondersteuning+gemeenten/documenten+en+links/documenten+in+bibliotheek/handlerdownloadfiles.ashx?idnv=2301859>

73 Ragon et al., "Near-term Infrastructure Deployment to Support Zero-emission Medium- and Heavy-duty Vehicles."

74 AB-2700 Transportation Electrification: Electrical Distribution Grid Upgrades, State of California Assembly Bill No. 2700, September 16, 2022, https://leginfo.ca.gov/faces/billPdf.xhtml?bill_id=20210220AB2700&version=20210AB270091CHP

75 "Charging Infrastructure Masterplan II," Germany Federal Government, January, 2023, https://nationale-leitstelle.de/wp-content/uploads/2023/01/Masterplan-Ladeinfrastruktur-II-der-Bundesregierung_Englisch_DIN_A4_barrierefrei.pdf

76 AB-1236 An act to add Section 65850.7 to the Government Code, relating to local ordinances, State of California Assembly Bill No. 1236, February 27, 2015, http://www.leginfo.ca.gov/pub/15-16/bill/asm/ab_1201-1250/ab_1236_bill_20150827_amended_sen_v95.htm

77 "Federal Energy Management Program: Electric Vehicle Training," U.S. Department of Energy, accessed March 13, 2023, <https://www.energy.gov/eere/femp/electric-vehicle-training>

Public charging infrastructure	
<ul style="list-style-type: none"> • Ensure basic network coverage (especially important for small fleets and long-haul trucks, to give confidence to fleet operators) through standards, deployment requirements, and by providing public land where available. • Foster private investment by providing regulatory certainty and encouraging emerging business models. • Provide access to public land along main traffic corridors and for regional lots. 	<ul style="list-style-type: none"> • The Alternative Fuels Infrastructure Regulation (AFIR) proposed by the European Commission helps meet the basic public charging infrastructure needs for fleets and private passenger cars and provides regulatory certainty and fosters private-sector investment.⁷⁸ • The U.S. Inflation Reduction Act (IRA) and Infrastructure Investment Jobs Act (IIJA) accelerated the ZEV transition and fostered private-sector investment.⁷⁹ • Germany is tendering the construction and operation of a fast charging network for sites along highways and for regional lots through its Deutschlandnetz program.
Cost	
<ul style="list-style-type: none"> • Provide private charging subsidies and develop a public network (especially important for small fleets). • Incentivize financing options that de-risk investments. • Encourage emerging business models. 	<ul style="list-style-type: none"> • France covers 60% of the cost of private depot chargers for heavy-duty fleets through a revenue-neutral program (Advenir). If the station has an installed power above 500 kVA, the subsidy scales up with power and includes all electricity equipment needed.⁸⁰ • Canada Infrastructure Bank invests \$500 million in large scale urban and commercial ZEV charging and refueling infrastructure.⁸¹ Financing is provided to the private sector and repayment is aligned with use levels to share risks and address utilization uncertainty. • The U.S. Clean Heavy-Duty Vehicle Program funded by the Inflation Reduction Act (IRA) offers grants to replace existing HDVs with clean zero-emission ones, plan activities, deploy the necessary charging infrastructure, and train the workforce.⁸²

Low- and zero-emission zones

Cities are introducing and exploring low-emission zones (LEZs) and zero-emission zones (ZEVs) to support their climate goals and improve air quality. National legal frameworks could empower cities to establish these zones and incentivize zero-emission fleet vehicle adoption. The Mobility Orientation Law of France requires that an LEZ be established in cities with more than 150,000 inhabitants, to meet air quality standards.⁸³ The Netherlands plans to establish zero-emission delivery zones in 30 to 40 of its largest cities by 2025.⁸⁴ Rotterdam already implements a zero-emission delivery zone on a 1.6 km long street, and only zero-emission trucks weighing 3.5 tonnes or more are allowed to access the zone.

Several European cities have put forward measures to prioritize electrifying taxis as a part of their LEZ and ZEV planning. That taxis have high visibility and drive many kilometers in the city makes them a good target for fleet electrification and for raising

78 Marie Rajon Bernard et al., "A Review of the Alternative Fuels Infrastructure Regulation (AFIR) Proposal," (ICCT: Washington, DC, 2022), <https://theicct.org/publication/review-afir-proposal-en-mar22/>

79 David Schlosberg, "The Inflation Reduction Act Will Accelerate Commercial Fleet Electrification," *TeraWatt Infrastructure*, August 26, 2022, <https://terawattinfrastructure.com/ideas/inflation-reduction-act/>.

80 "Une nouvelle prime à destination des flottes de véhicules poids lourds vient enrichir le programme ADVENIR," May 4, 2021, <https://advenir.mobi/2021/05/03/nouvelle-prime-flottes-poids-lourds/>

81 "Green Infrastructure", Canada Infrastructure Bank, accessed April 20, 2023, <https://cib-bic.ca/en/sectors/green-infrastructure/>

82 "Clean Heavy-duty Vehicle Program," U.S. Environmental Protection Agency, last modified on May 9, 2023, <https://www.epa.gov/inflation-reduction-act/clean-heavy-duty-vehicle-program#:~:text=The%20Inflation%20Reduction%20Act%20invests,vehicles%20between%20now%20and%202031>

83 Law 2019-1428 on The Orientation of Mobility, République Française, December 24, 2019, https://www.legifrance.gouv.fr/jorf/article_jo/JORFARTI000039666659

84 Rijksoverheid, "Kabinet Komt Ondernemers Tegemoet Bij Overstap Op Schone Bestelbus of Vrachtwagen [The Government Will Accommodate Entrepreneurs When They Switch to a Clean Delivery Van or Truck]," news release, October 5, 2020, <https://www.rijksoverheid.nl/actueel/nieuws/2020/10/05/kabinet-komt-ondernemers-tegemoet-bij-overstap-op-schone-bestelbus-of-vrachtwagen>.

public awareness about ZEVs. London's Taxi delicensing scheme fund removed 4,000 older black taxis by giving up to £10,000 to taxi drivers who traded in their older diesel vehicles early.⁸⁵ Amsterdam will permit only zero-emission taxis to enter the city center by 2025⁸⁶ and “clean” taxis have priority access to public fast-charging stations at strategic locations during peak times.⁸⁷

Emerging business models

ZEVs often create an economic opportunity for fleets, but transitioning to ZEVs still requires a high capital expenditure and entails various risks that some fleets, mostly small ones, can struggle to manage themselves. This creates an opportunity for alternative business models that convert initial high capital expenditures into manageable monthly or per-km payments and allocate the risk to stakeholders more ready to absorb it.

Vehicle as a Service and Electrification as a Service

Vehicle as a Service (VaaS) is a subscription-based fleet electrification package. The business model can range from solely leasing electric vehicles to providing a full package—also known as Electrification as a Service (EaaS)—that includes a fleet electrification assessment and plan, vehicle and charging infrastructure lease, incentives navigation, maintenance, insurance, and staff training. Most of the time fleet operators pay a monthly fee for the service, but there is also a pay-as-you-drive model in which customers are charged based on their use of the vehicle. As an example, Hyundai Hydrogen Mobility is renting its trucks exclusively through this pay-per-use model in Switzerland.⁸⁸ VaaS can be provided either directly by an auto manufacturer, Volta trucks in Europe is one example,⁸⁹ or by a third-party organization like WattEV in California.⁹⁰

The “as a Service” business models usually involve three parties, as shown Figure 3, and they are the fleet operator, the “as a Service” entity, and the financing institution.

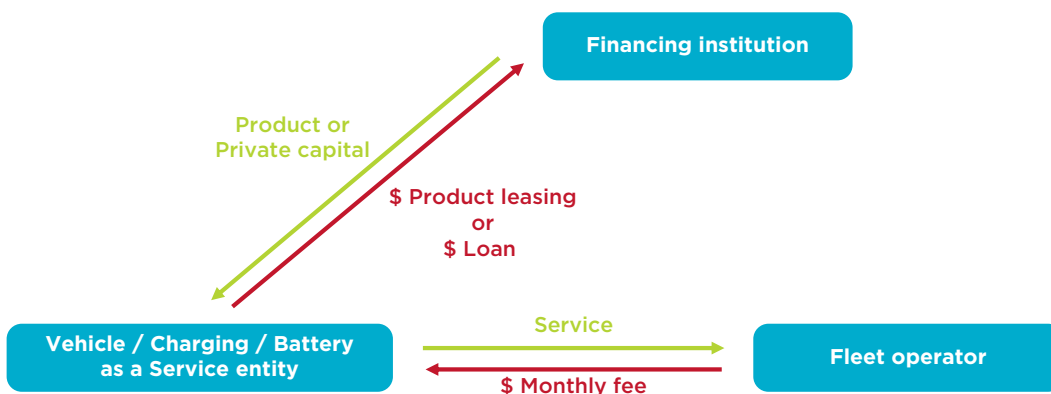


Figure 3. Typical “as a Service” business model.

85 “Taxi Delicensing,” Transport for London, accessed November 2, 2022, <https://tfl.gov.uk/info-for/taxis-and-private-hire/taxi-delicensing-scheme>.

86 “Policy: Taxis,” The City of Amsterdam, accessed February 25, 2023, <https://www.amsterdam.nl/en/policy/policy-traffic/policy-taxis/>

87 The City of Amsterdam, “Plan Amsterdam: The Electric City,” (2018), https://issuu.com/gemeenteamsterdam/docs/plan_amsterdam_4-2018_the_electric_.

88 “Pay Per Use Modell,” Hyundai Hydrogen Mobility Partnership with H2Energy, accessed March 27, 2023, <https://hyundai-hm.com/en/unser-angebot/>

89 “Truck as a Service,” Volta Trucks, accessed February 22, 2023, <https://voltatrucks.com/truck-as-a-service>

90 “Electrifying Heavy Duty Transport”, WattEV, accessed February 22, 2023, <https://www.wattev.com>

Beyond transforming high upfront costs into lower recurring costs, EaaS provides support and expertise throughout the vehicle lifetime. This model analyzes telematics data to find the best-suited vehicles and charging strategies, and provides both electrification plans and administrative support for obtaining government subsidies. VaaS also de-risks the investment for financial institutions and bears the stranded-asset risks for fleet operators.

A concession business model based on public-private partnership has been implemented for bus fleet electrification in Santiago de Chile and Bogota, and in both cases the local municipality acts as the “middle-entity” between the financing institutions and the bus operators.⁹¹ Manufacturers, utility companies, and other third parties (financing institutions) procure electric buses as fleet providers, establish a leasing contract with the operator, and offer technical expertise as needed. The local government bears the financial risk for the fleet provider and can manage the bus depot for operators. This model, illustrated in Figure 4 below, helps ease the high upfront cost burden of electric buses for operators and governments while de-risking the investment for financing institutions.

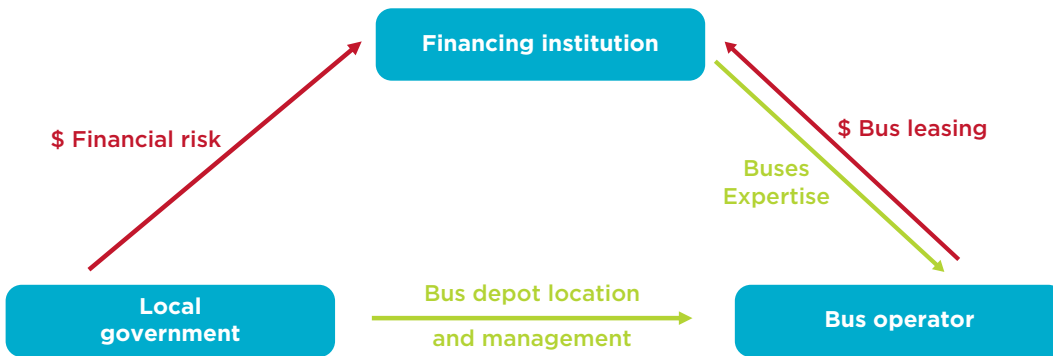


Figure 4. Public-private partnership-based concession business model for bus fleets.

Similarly, in India, thousands of electric buses are being procured through a gross cost contract (GCC) model. The aforementioned FAME II subsidy only provides electric bus subsidies under this model.⁹² Under this GCC model, public fleets are leasing electric buses from private bus operators. The private bus operators are usually in charge of installing and operating the charging infrastructure and maintaining the buses, and they often also provide the drivers. In return, public fleets pay a monthly fee based on the distance operated each month. The bus depot and upstream electric infrastructure are provided by the public fleet itself, and it also provides bus routes and schedules and collects revenue. In this model, the public fleet eliminates the revenue-collection risk for the private bus operator, while the operator eliminates the technology risk for the public fleet. This model also avoids the need to detail the technical specifications of the electric buses by public fleets, and they only need to specify practical needs such as the range requirement and the maximum time for full charging.

91 Tanzila Khan and Zifei Yang, “Electrification of heavy-duty vehicles in emerging markets,” (ICCT: Washington, DC, 2022), <https://theicct.org/publication/global-hvs-evs-zev-electrif-hdv-emerg-mkts-sep22/>; Dalberg, “Investing in Electric Bus Deployment in Latin America,” (2020), <https://theicct.org/publication/investing-in-electric-bus-deployment-in-latin-america/>

92 Department of Heavy Industry, Ministry of Heavy Industries & Public Enterprises, Government of India, “Expression of Interest Inviting Proposals for Availing Incentives under Fame India Scheme Phase II For Deployment of Electric Buses on Operational Cost Model Basis,” June 4, 2019, https://heavyindustries.gov.in/writereaddata/fame/famedepository/13-E__didm_WriteReadData_userfiles_Final%20EOI%2004%20June%202019%20Published.pdf

Charging as a Service

Charging as a Service (CaaS) is a subscription-based charging package that provides turnkey electric vehicle charging solutions that remove the burden of ownership and maintenance and provide expertise. The CaaS provider deploys, installs, operates, and maintains the charging infrastructure. Additionally, they can assist with planning for future system expansion, coordinate with the local utility, manage charging times to minimize the energy bill, and guarantee that the vehicles will be fully charged when they need to be operated. Fleet operators either pay a monthly fee for the service or can be charged based on their use of the infrastructure. CaaS can be provided by a truck manufacturer (e.g., Volta Trucks), utility provider (e.g., Hydro Québec's subsidiary Cléo), infrastructure operator (e.g., Spark Charge), or a third-party organization (e.g., EV connect).

Some businesses are beginning to look for CaaS providers to relieve the burden of planning, procuring, operating, and maintaining charging infrastructure. It shifts the technology and performance risk from the fleet operator onto the CaaS provider. As previously mentioned, CaaS can be combined with VaaS to offer full EaaS. Forum Mobility in California offers such a service for drayage trucks.⁹³ For EaaS, the financing entity can either build and own the charging infrastructure or sign contracts with existing charge point operators to allow the vehicles they lease to charge on their facilities. With EaaS, this “middle-entity” can assist in optimizing the entire system of vehicles and chargers.

Battery as a Service

The battery-swapping business is prevalent in China for passenger cars and HDVs and in India, it is common for 2Ws and 3Ws. Battery swapping is typically offered under a Battery as a Service (BaaS) business model whereby fleet owners only pay for the vehicle body without batteries when they purchase, and battery swapping station operators own and provide access to fully charged batteries. SUN Mobility is an example of electric 2W and 3W BaaS company in India.⁹⁴

The Chinese central government has expressed clear support for battery-swapping-enabled heavy-duty trucks for short-haul applications at ports and mining sites, and as part of urban logistics solutions.⁹⁵ In October 2021, China launched a two-year pilot program to promote the application of battery-swapping technology in 11 cities, including Beijing, Wuhan, Chongqing, and Baotou.⁹⁶

Similarly, the Government of India has also positioned itself in favor of battery swapping.⁹⁷ In April 2022, it released a draft battery swapping policy focusing on 2Ws and 3Ws. This policy aims at de-coupling vehicle and battery upfront costs, enabling interoperability of BEVs and batteries, fostering private-sector involvement,

93 “Charging Depot and Heavy-duty Electric Trucks for Zero-emission Drayage,” Forum Mobility, accessed March 7, 2023, <https://forummobility.com>

94 “Energy as a Service,” Sun Mobility, accessed February 24, 2023, <https://www.sunmobility.co.in/>

95 National Development and Reform Commission, “关于进一步提升电动汽车充电基础设施服务保障能力的实施意见 [Guidance on Further Improving Capacities to Guarantee EV Charging Service],” (2022), http://www.gov.cn/zhengce/zhengceku/2022-01/21/content_5669780.htm

96 Ministry of Industry and Information Technology of the People's Republic of China, “工业和信息化部启动新能源汽车换电模式应用试点工作 [Pilot Project for the Application of New Energy Vehicle Battery Replacement Model],” news release, October 28, 2021, https://www.miit.gov.cn/xwdt/gxdt/sjdt/art/2021/art_c73f1ade7759456fa18586114b555238.html

97 Pramoda Gode et al., “Battery Swapping for Electric Two-wheelers in India: Strategy Hinterlands,” (ICCT: Washington, DC, 2022), <https://theicct.org/publication/india-ev-battery-swapping-may22/>

encouraging partnerships along the value chain to deliver integrated services to end users, and promoting better life-cycle management of batteries.⁹⁸

How governments can enable emerging business models

Vehicle, Charging, and Battery as a Service are promising, innovative business models for small urban fleets that might not have the financial capacity and the expertise to buy and own their BEVs and charging infrastructure. Governments could help develop these business models in two primary ways:

Design flexible subsidy schemes to adapt to emerging business models.

Most government incentives to date have been provided to entities that own and operate vehicles or charging infrastructure and thus they do not suit these emerging business models. Governments could revise their incentive structures to add flexibility and adapt to these new business models. This would help foster private-sector involvement.

For example, California developed a flexible funding scheme that allows small fleets to benefit from the VaaS and CaaS business models.⁹⁹ Small fleets must work with an approved service provider to access the funding. This small e-fleets program is part of the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP), which funds small fleet owners with a fleet of 20 or fewer trucks and an annual revenue of less than \$15 million.

Encourage private-sector involvement by de-risking investments.

In its draft battery swapping policy, the Government of India highlighted the importance of designing financial schemes for both BaaS businesses and BEV users.¹⁰⁰ The policy also encourages the development of new business models by de-risking investment to encourage private-sector participation.

To de-risk investment and address the residual value risk, CALSTART proposed the development of a first-loss protection instrument.¹⁰¹ Institutions might be reluctant to purchase and lease BEVs due to uncertainty related to the vehicle's residual value as it ages. A first-loss protection financial product would insulate lenders from a pre-defined amount of financial loss due to a specific risk enhancing the creditworthiness of the loan transaction. This financial product would re-assure financial institutions or third parties like VaaS entities by transferring a portion of the risk to the sponsoring agency: a specific and credible financing party.

98 Government of India, "Battery Swapping Policy—Draft," (2022), https://www.niti.gov.in/sites/default/files/2022-04/20220420_Battery_Swapping_Policy_Draft.pdf

99 "Innovative Small E-fleet Update," California HVIP, last modified August 3, 2022, <https://californiahvip.org/news/innovative-small-e-fleet-update/>

100 Government of India, "Battery Swapping Policy—Draft."

101 Robert O. Gurman, "Drive To Zero—Taking Commercial Fleet Electrification to Scale: Financing Barriers and Solutions," (CALSTART: Pasadena, Calif., 2021), <https://globaldrivetozero.org/site/wp-content/uploads/2021/03/Taking-Commercial-Fleet-Electrification-to-Scale-White-Paper.pdf>

Appendix A

In this paper, we categorized fleet vehicles into three segments based on gross vehicle weight rating (GVWR).¹⁰² The categories are intentionally broad, and many countries have more detailed classification of fleet vehicles. We classified each vehicle segment as follows:

Motorized light-weight vehicles (MCs) consist of two- and three-wheelers that are motorized, often with a two- or four-stroke engine. Examples of fleet vehicle types are delivery and shared mopeds, auto rickshaw taxis, tempos, and tuk-tuks.¹⁰³

Light-duty vehicles (LDVs) refer to cars or light commercial vehicles with a GVWR of less than 3.5 tonnes. Fleet vehicles in this category include company cars, taxis, ride-hailing cars, urban delivery vans, and postal service vans.

Heavy-duty vehicles (HDVs) include medium and heavy commercial vehicles such as buses and trucks with a GVWR of over 3.5 tonnes. Fleet vehicle types in this category consist of urban and transit buses, delivery trucks, and tractor trailers. These vehicles are mostly used for commercial and public purposes, and therefore we treat all HDVs as fleet vehicles.

Table A1. Fleet vehicle categories based on GVWR and vehicle types covered

Vehicle categories	Description	Examples of fleet vehicle types covered
MCs	Two and three-wheelers	Delivery and shared mopeds, auto rickshaw taxis, tempos, tuk-tuks
LDVs	Passenger cars (GVWR < 3.5 tonnes) Light commercial vehicles (GVW < 3.5 tonnes)	Ride-hailing cars, taxis, company cars, urban delivery vans, postal service vans
HDVs	Buses (GVWR > 3.5 tonnes) Medium-duty trucks (GVW 3.5–15 tonnes) Heavy-duty trucks (GVW > 15 tonnes)	Urban and transit buses, urban delivery trucks, short-haul tractor trucks, long-haul tractor trucks

¹⁰² “Roadmap model,” International Council on Clean Transportation, accessed February 23, 2023, <https://theicct.github.io/roadmap-doc/versions/v1.9/>

¹⁰³ Fanta Kamakaté and Deborah Gordon, “Managing Motorcycles: Opportunities to Reduce Pollution and Fuel Use from Two- and Three-wheeled Vehicles,” (ICCT: Washington, DC, 2009), <https://theicct.org/publication/managing-motorcycles-opportunities-to-reduce-pollution-and-fuel-use-from-two-and-three-wheeled-vehicles/>.

Glossary

Battery electric vehicles (BEVs): Vehicles powered with a battery-electric motor and charged with an external charging station.

Battery as a Service (BaaS): Battery-swapping station operators own and provide access to fully charged batteries as a service to fleet operators.

Charging as a service (CaaS): Subscription-based electric vehicle charging package that provides turnkey charging solutions.

Electrification as a Service (EaaS): Turnkey electric vehicle and charging solutions for fleet operators, a combination of CaaS and VaaS.

Fleet purchase requirements: Government regulation that requires a minimum share of a fleet to be zero-emission.

Heavy-duty vehicles (HDVs): Medium and heavy commercial vehicles such as buses and trucks with a GVWR greater than 3,500 kg.

Light-duty vehicles (LDVs): Vehicles with less than 3,500 kg of gross vehicle weight, including commercial cars, vans, and two- and three-wheelers.

Private fleets: Vehicle fleets owned or operated by private entities or individuals, such as company cars, ride-hailing two- and three-wheelers and heavy goods delivery trucks.

Public fleets: Vehicle fleets owned, operated, or contracted by local, regional, and national government agencies.

Total cost of ownership (TCO): The cost of purchasing, using, and maintaining a vehicle over its term of ownership.

Vehicle as a service (VaaS): Subscription-based or pay-based on use vehicle fleet electrification package.

Zero-emission vehicles (ZEVs): Battery-electric and fuel-cell electric vehicles with zero exhaust emissions.

Zero-emission zones (ZEZs): Restricted areas in certain parts of cities, often urban centers, where no internal combustion engine vehicles are permitted for certain operating hours of the day or all the time.