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THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

17 Oct 2022

Re: International Council on Clean Transportation (ICCT) comments on the proposed Advanced Clean Fleets (ACF) regulation

The ICCT respectfully submits these comments to support the California Air Resources Board (CARB) in its finalization of the Advanced Clean Fleets regulation, first proposed on 30 August 2022.

The ICCT was established in 2001 as an independent source to provide unbiased research and technical and policy expertise for motor vehicle regulators working to improve the environmental performance and energy efficiency of road, marine, and air transportation, in order to benefit public health and mitigate climate change. Our work supports the development and implementation of advanced vehicle regulations in the world's largest markets. In the United States, the ICCT has been highly engaged with federal and state-level vehicle regulations, participating in expert working groups, submitting public comments on regulations' technical designs, and regularly publishing research on vehicle regulations and standards.

The ICCT welcomes the opportunity to provide comments on the proposed Advanced Clean Fleets regulation. We commend CARB on its continuing efforts to transition the commercial vehicle fleet to zero-emission technology that can deliver emissions reductions to the benefit of public health, particularly in disadvantaged communities, and achieve state climate targets. The comments below offer our support for the proposed regulation and specific recommendations for your consideration.

We would be glad to clarify or elaborate on any points made in the comments. CARB staff can feel free to contact Claire Buysse (c.buysse@theicct.org), Stephanie Searle (stephanie.searle@theicct.org), or Ray Minjares (ray@theicct.org) with any questions.

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Support for the proposed Advanced Clean Fleets regulation

Zero-emission vehicles (ZEVs) are the cornerstone of decarbonizing the transportation sector and meeting ambient air quality standards, particularly in disadvantaged communities. Heavy-duty vehicles specifically account for 21% of California's on-road transport greenhouse gas emissions and 76% of its NO_x emissions.[1] Overall, on-road heavy-duty vehicles are responsible for 8% of California's total greenhouse gas emissions and 30% of its total NO_x emissions. Additional federal and state policies are needed to spur swift adoption of ZEVs by heavy-duty vehicle fleets in line with the state's climate and air quality goals. The proposed Advanced Clean Fleets (ACF) regulation is necessary to assure and accelerate heavy-duty ZEV deployment to align with these goals.

We applaud CARB for continuing to develop leading regulations for heavy-duty ZEVs that target both market supply and demand. Fleet purchase requirements and phase-out targets are two effective policies we identified in our international work for accelerating the ZEV transition.[2] We strongly support the inclusion of large yard truck and light-duty delivery vehicle fleets, for which electrification is already technologically feasible and cost-saving, in the rulemaking. We emphasize that—given CARB's assessment of a favorable total cost of ownership for most segments in the 2025–2030 timeframe—fleet owners are projected to save money by transitioning to ZEVs, with a payback period of two to six years by 2030 without incentives.[3] We commend CARB for proposing to require a full transition to zero-emission drayage trucks by 2035 via the state drayage registry, which would serve as an important regulatory model for other states.

We strongly support setting a clear target year for 100% heavy-duty ZEV sales, as well as providing clear benchmarks for private fleet adoption of ZEVs. ICCT's modeling shows that limiting global warming to below 2°C as targeted in the Paris Agreement will require leading markets, including California and the broader United States market, to achieve 100% zero-emission new heavy-duty vehicle sales no later than 2040.[4] Many jurisdictions have followed California's leadership on heavy-duty ZEVs and, as of 17 Oct 2022, five states have already adopted California's Advanced Clean Trucks (ACT) regulation. California is also joined by 16 states, the District of Columbia, and the province of Québec in a multi-state memorandum of understanding to accelerate the deployment of heavy-duty ZEVs and strive toward 30% zero-emission sales of heavy-duty vehicles by 2030 and 100% by 2050.[5] California has additionally endorsed a global memorandum of understanding on medium- and heavy-duty ZEVs, which targets 30% zero-emission sales of trucks and buses by 2030 and 100% by 2040.[6] The ACF regulation would

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[1] Heavy-duty vehicles refers to Class 2b–8 vehicles; California Air Resources Board, "California Greenhouse Gas Emissions from 2000 to 2019: Trends of Emissions and Other Indicators" (Sacramento, CA, July 28, 2021), https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2019/ghg_inventory_trends_00-19.pdf; California Air Resources Board, "CEPAM2019v1.03 Emission Projection Data," accessed September 21, 2022, https://ww2.arb.ca.gov/applications/statewide-emissions.

[2] Dale Hall et al., "Decarbonizing Road Transport by 2050: Effective Policies to Accelerate the Transition to Zero-Emission Vehicles" (Washington, D.C.: ZEV Transition Council, December 27, 2021), https://theicct.org/publication/zevtc-effective-policies-dec2021/.

[3] California Air Resources Board, "Appendix G: Total Cost of Ownership Discussion Document," August 30, 2022, https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/appg.pdf.

[4] Arijit Sen and Josh Miller, "Emissions Reduction Benefits of a Faster, Global Transition to Zero-Emission Vehicles," Working Paper (Washington, D.C.: The International Council on Clean Transportation, March 2022).

[5] "Multi-State Medium and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding," March 29, 2022, https://www.nescaum.org/documents/mhdv-zev-mou-20220329.pdf/.

[6] "Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles," accessed September 22, 2022, https://globaldrivetozero.org/site/wp-content/uploads/2021/12/Global-MOU-ZE-MHDVs-signed-20-Dec-21.pdf.

formalize this 100% ZEV sales target and pair it with demand-side requirements for trucking fleets, setting a new bar for heavy-duty ZEV regulations in the United States and around the world.

Summary of recommendations

Recommendation 1: Consider an earlier 100% ZEV sales target

We strongly encourage CARB to consider requiring 100% zero-emission heavy-duty vehicle sales by 2036. An earlier target would prioritize climate and health benefits, particularly in disadvantaged communities, while retaining cost-effectiveness and feasibility. Other countries have set phaseout dates earlier than 2040 for all heavy-duty vehicles and especially for buses and trucks with a gross vehicle weight rating below 40,000 lbs. Several major manufacturers have also set 100% ZEV sales targets by or before 2040. A 2036 target would align California more closely with these leading markets. In addition, an earlier target would better align manufacturer supply with fleet demand for ZEVs and assure competitive pricing of the vehicles.

Recommendation 2: Consider more stringent ZEV requirements for tractors

We strongly encourage CARB to consider accelerating the ZEV transition timeline and expanding the number of fleets subject to high priority fleet requirements for tractors. Specifically, we recommend moving sleeper cab tractors to group 2 to harmonize ZEV fleet composition milestones for all tractors. This would ensure alignment in ZEV deployment across day cabs and sleeper cabs, which is important given the overlap in operations between these two vehicle types. We also recommend setting a lower threshold for the tractor fleet size subject to the ZEV requirement, such as 10, or 20, which is the threshold used by CARB in the HVIP Innovative Small e-Fleets set-aside.[7] This would prioritize near-term benefits to communities disproportionately harmed by diesel exhaust and its associated health impacts. With current state and new federal incentives under the Inflation Reduction Act, the upfront cost burden for ZEV adoption would be smaller than projected in the Initial Statement of Reasons (ISOR) and more accessible to mid-sized fleets that represent a larger business investment than other mid-sized fleets.

Support for recommendations

Air quality, health, and climate benefits

CARB's proposed target for 100% ZEV sales by 2040 would deliver critical air quality and health benefits to the state, and would be even more beneficial if moved up to 2036. Manufacturer sales requirements are a key lever for transitioning California to a zero-emission vehicle fleet. As proposed, the ACF public and high priority fleet requirements only regulate 28% of existing Class 2b–8 trucks in California (Table 10 in ISOR). Manufacturer sales requirements have broader reach, however, accounting for 84%–91% of new Class 4-8 vehicles registered in California (Table 29 in ISOR).

Modeling by both ERM shows that accelerating the 100% ZEV sales requirement to 2036 would nearly double the cumulative number of heavy-duty ZEVs spurred by the regulation in 2040 compared to the

[7] "Innovative Small e-Fleets Update", accessed October 13, 2022, https://californiahvip.org/news/innovative-small-e-fleet-update/

baseline (Figure 2 in ERM study).[8] ERM further projects that accelerating the 100% sales requirement to 2036 would reduce cumulative fleet NO_x emissions from 2020 to 2050 by an additional 9% compared to the proposed 2040 phaseout; cumulative $PM_{2.5}$ emissions would be reduced by an additional 13%. ERM translates this to a 10% increase in the value of avoided health outcomes. Cumulative greenhouse gas emissions from 2020 to 2050 are projected to be reduced by roughly 12% more with a 2036 phaseout than a 2040 phaseout. ERM translates this to a 13% decrease in the social cost of greenhouse gas emissions. ERM projects net societal benefits, including the social cost of greenhouse gas emissions, would be 14% greater with an accelerated sales requirement.

CARB's proposed high priority fleet requirements would also provide greater benefits to disadvantaged communities if ZEV requirements for tractors were accelerated and expanded to include mid-sized fleets. Class 7-8 tractors contribute disproportionately to statewide NO_x emissions, accounting for four times the share of NO_x as their share of the heavy-duty vehicle population (Figures 36 and 37 in ISOR). Transitioning tractors to zero-emission technology is particularly important for reducing disproportionate health impacts and achieving air quality targets in disadvantaged communities. As proposed, the ACF public and high priority fleet requirements regulate 68% of existing Class 7-8 tractors in California (Table 10 in ISOR). Expanding the number of regulated tractor fleets to those with at least 10 tractors would increase this number by 15%–20%. Analysis by the Union of Concerned Scientists suggests that lowering the minimum fleet size to 10 for tractors would regulate 23% more of statewide tractor NO_x and $PM_{2.5}$ emissions and 17% more of greenhouse gas emissions.[9]

In the ISOR, CARB projected that accelerated manufacturer sales requirements—combined with accelerated fleet composition milestones and a 10-truck minimum fleet size for tractor fleets in the Alternative 2 scenario—would reduce statewide annual NO_x, $PM_{2.5}$, and greenhouse gas emissions by roughly 50% more in 2040 than the current ACF proposal (Figures 81–83 in ISOR). The annual benefit of avoided health impacts in 2035 is more than doubled under Alternative 2 compared to the current proposal and is 58% greater in 2040 (Tables 21 and 83 in ISOR). We show a comparison of health outcomes in 2035 in Table 1 to emphasize the importance of early regulatory action to achieve near-term health and climate benefits that may not be prioritized by anticipated policies such as the Zero-Emission Truck Measure.

[8] ERM, "California Clean Trucks Program," 2022, https://www.erm.com/public-information-sites/clean-truck-regulations-analysis-nrdc-ucs/; California Air Resources Board, "Proposed Advanced Clean Fleets Regulation Staff Report: Initial Statement of Reasons," August 30, 2022, https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2022/acf22/isor2.pdf.

[9] Sam Wilson, "Changes to California's Electric Truck Proposal Could Reap Huge Climate and Air Quality Gains", Union of Concerned Scientists, October 13, 2022, https://blog.ucsusa.org/sam-wilson/changes-to-californias-electric-truck-proposal-could-reap-huge-climate-gains/

Table 1. CARB's statewide valuation from annual avoided health outcomes in 2035 (million 2021$) under the ACF proposal compared to Alternative 2.

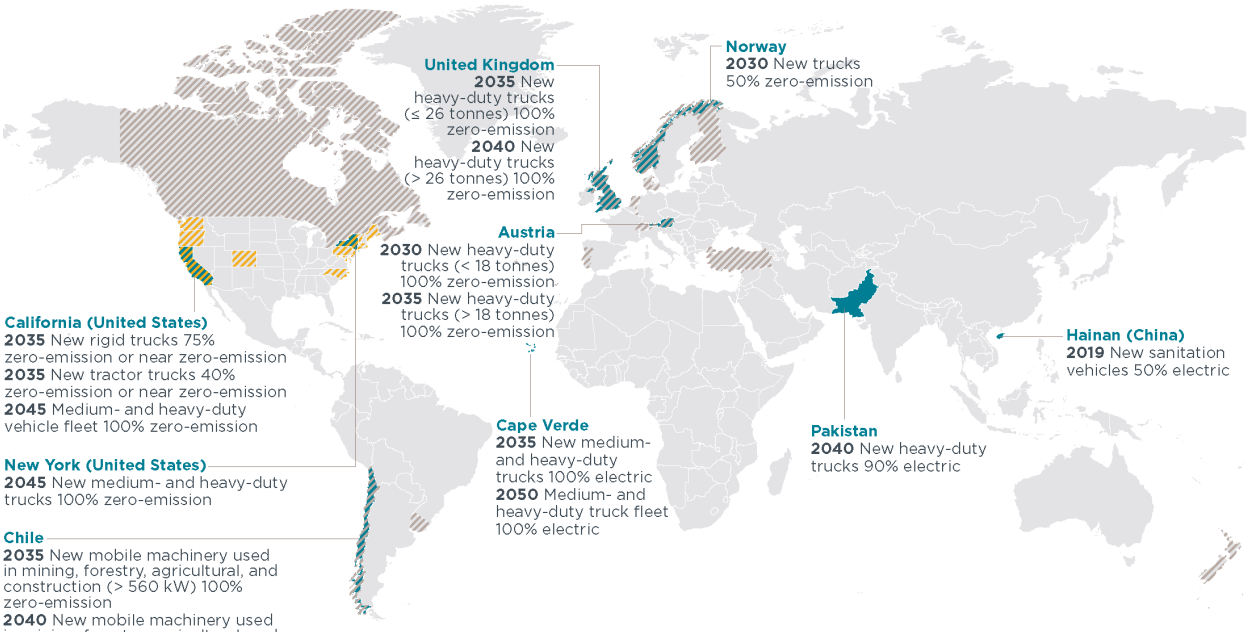
Scenario	Avoided cardiopulmonary mortality	Avoided hospitalization for cardiovascular illness	Avoided hospitalizations for respiratory illness	Avoided ER visits	Total annual valuation
Proposal	156	24	30	73	$1,633.92
Alternative 2	315	48	58	148	$3,299.20
Percent difference	+102%	+100%	+93%	+103%	+102%

The Alternative 2 scenario has a benefit-cost ratio of 1.5 compared to the current proposal's 1.7 (Table 81 in ISOR). Given both CARB and ERM's assessments determine that an accelerated sales requirement is cost-effective, we consider the achievement of the state's climate and air quality targets—particularly for disproportionately impacted communities in the near-term—to take precedent.

International public and private sector commitments

National and sub-national governments have endorsed various heavy-duty ZEV sales targets over the past several years. These targets as of June 2022 are shown in Figures 1 (trucks) and 2 (buses). A few governments have set official targets for 100% zero-emission sales of heavy-duty trucks, including Austria, Chile, Cape Verde, New York (United States), and the United Kingdom. Several more governments have set official targets for 100% zero-emission sales of buses, including Austria, Cape Verde, Chile, Colombia, Costa Rica, Ireland, the Netherlands, and New Zealand.[10] Of these, both Austria and Cape Verde have targeted 2035 or sooner for both trucks and buses. In addition, twelve other national governments—Canada, Denmark, Finland, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Switzerland, Turkey, the United Kingdom, and Uruguay—do not have official targets but have signed a global memorandum of understanding endorsing a 2040 target for 100% zero-emission truck and bus sales and manufacturing.[11] Both Scania, a major European manufacturer, and DHL, a major delivery fleet, have endorsed the global memorandum of understanding and its 100% ZEV sales target by 2040. More details about these government phaseout targets can be found on our website, which is updated regularly.[12]

[10] Denmark and Israel have also set official targets, though only for urban buses.
[11] "Memorandum of Understanding on Zero-Emission Medium- and Heavy-Duty Vehicles."
[12] ICCT, "Internal Combustion Engine Phase-Outs," *International Council on Clean Transportation* (blog), 2022, https://theicct.org/ice-phase-outs/.



Note: Governments with an at least 40% new truck sales target.
* Not necessarily yet reflected in an official national/state policy document such as a climate or transport strategy/plan, in a law, or in a similar framework.

Figure 1. Governments with targets toward phasing out sales of internal combustion engine trucks through June 2022.

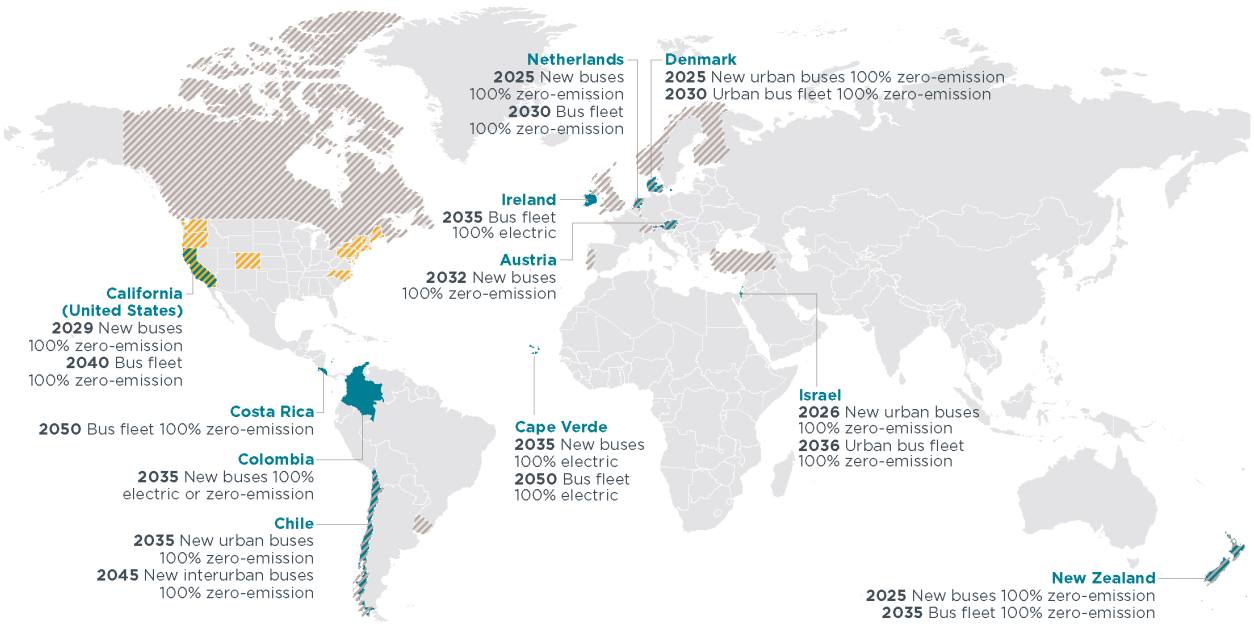


Figure 2. Governments with targets toward phasing out sales of internal combustion engine buses through June 2022.

Major heavy-duty vehicle manufacturers have committed to 100% heavy-duty ZEV sales targets. Traton Group, the parent company of brands including MAN, Scania, and Navistar, aims to reduce conventional engines to just one-fifth of all product development by 2025.[13] Daimler Trucks has announced its ambition to sell only CO_2-neutral (tank-to-wheel) vehicles by 2039 in North America. Volvo Trucks has also targeted 50% zero-emission truck sales globally and stated that the transition is being "led by Europe and North America where targets are even higher."[14] Select manufacturer commitments are shown in Table 2. In addition to legacy manufacturers, a considerable number of zero-emission products are expected to be produced by new all-electric manufacturers. Both major and new all-electric manufacturers currently have ZEV manufacturing plants located in North America, as shown in Figure 3.[15]

[13] Traton Group, "Traton Group Boosts Investment in Electric Mobility," TRATON, March 22, 2021, https://traton.com/en/newsroom/press-releases/press-release-22032021.html.
[14] Volvo Trucks, "New report - High pressure on the transport industry to shift to electric," accessed October 11, 2022, https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/sep/New-report-high-pressure-on-the-transport-industry-to-shift-to-electric.html.
[15] Claire Buysse, "Zero-Emission Bus and Truck Market in the United States and Canada: A 2021 Update" (Washington, D.C.: International Council on Clean Transportation, September 26, 2022), https://theicct.org/publication/update-ze-truck-bus-market-us-can-sept22/.

Table 2. Select manufacturer commitments to heavy-duty ZEV sales.

Manufacturer	Commitment
Daimler Trucks[a]	100% sales of CO_2-neutral vehicles in driving operation (tank-to-wheel) in Europe, North America and Japan by 2039
Ford[b]	67% zero-emission commercial vehicle sales by 2030 in Europe, 100% by 2035
Navistar[c]	50% zero-emission sales by 2030, 100% by 2040
Traton Group[d]	50% zero-emission sales of Scania trucks by 2030, 100% by 2040 60% zero-emission sales of MAN delivery trucks by 2030 40% zero-emission sales of MAN long-haul trucks by 2030
Volvo Trucks[e]	50% sales of electric trucks by 2030 globally, 70% in Europe 100% fossil fuel free vehicles by 2040

[a] "Environment," Daimler Trucks, accessed Sept 27, 2022, https://www.daimlertruck.com/sustainability/e-environment/
[b] Ford Motor Company, "Helping Build a Better World: Integrated Sustainability and Financial Report 2022" (Dearborn, MI, n.d.), https://corporate.ford.com/content/dam/corporate/us/en-us/documents/reports/integrated-sustainability-and-financial-report-2022.pdf
[c] "Navistar launches new truck with its 'last' internal combustion engine", Bulk Transporter, August 16, 2022, https://www.bulktransporter.com/equipment/trucks/article/21248846/navistar-launches-new-truck-last-ice-powertrain
[d] Traton Group, "Traton Group Boosts Investment in Electric Mobility"; Matthias Rathmann, "CEO Levin zur Antriebswende: Warum Traton auf Batterien setzt," Eurotransport, September 7, 2022, https://www.eurotransport.de/artikel/ceo-levin-zur-antriebswende-warum-traton-auf-batterien-setzt-11213350.html
[e] Volvo Trucks, "New report - High pressure on the transport industry to shift to electric," accessed October 11, 2022, https://www.volvotrucks.com/en-en/news-stories/press-releases/2022/sep/New-report-high-pressure-on-the-transport-industry-to-shift-to-electric.html; "Towards Fossil Free Transport," Volvo, accessed September 27, 2022, https://www.volvogroup.com/en/future-of-transportation/going-fossil-free.html

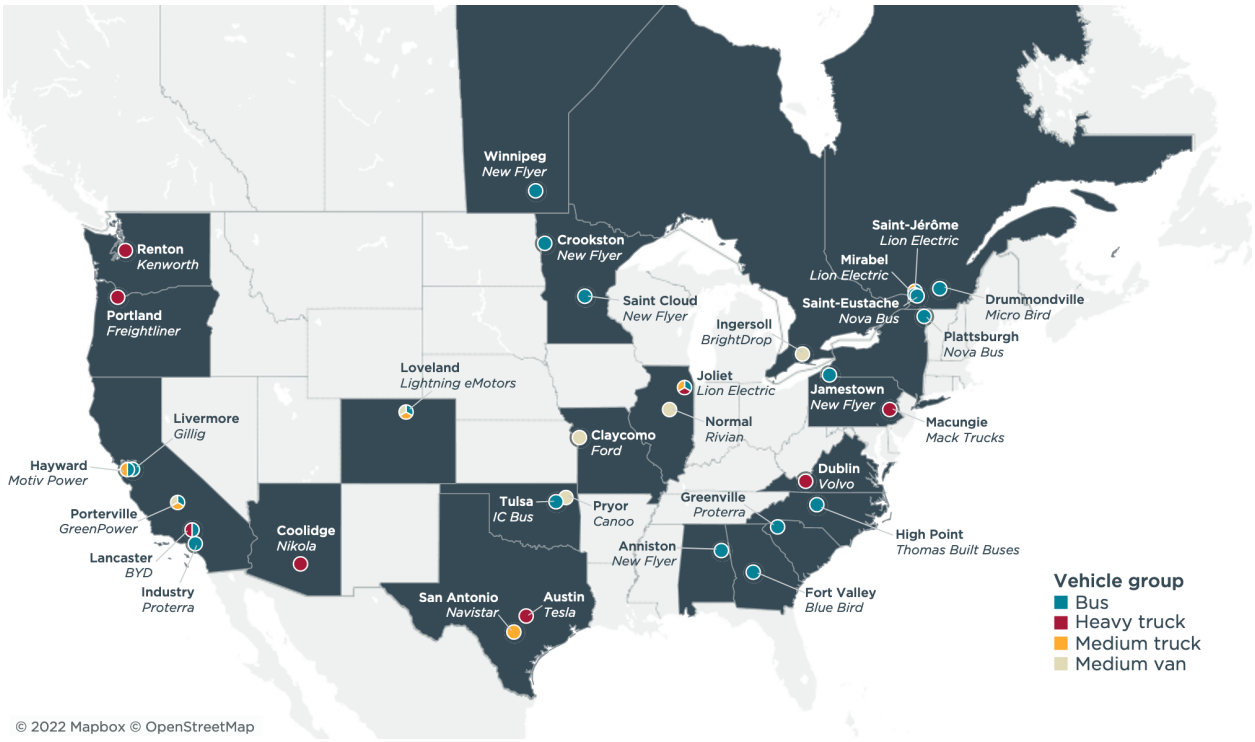


Figure 3. Current manufacturing plants for zero-emission heavy-duty vehicles in North America.

Manufacturer commitments to heavy-duty ZEVs are complemented by those of large private fleet owners. For example, Amazon aims to make 50% of shipments carbon neutral by 2030 and has pledged to be net-zero carbon by 2040.[16] The company recently announced an investment of nearly $1 billion in electric vans, trucks, and cargo bikes in Europe.[17] Several private fleet owner commitments are highlighted in Table 3. With numerous endorsements by both government and key industry players across the globe for 100% zero-emission sales by or before 2040, we encourage CARB to accelerate its own phaseout timeline.

Table 3. Select fleet owner commitments to heavy-duty ZEV deployment.

Fleet owner	Commitment
Amazon[a]	50% CO_2-neutral shipments by 2030 globally
DHL Group[b]	60% electric last-mile delivery fleet by 2030 globally
FedEx[c]	50% zero-emission parcel pickup and delivery vehicle purchase by 2025, 100% by 2030 100% zero-emission parcel pickup and delivery fleet by 2040 globally
Ingka Group[d]	100% zero-emission customer deliveries and services by 2025 globally
Walmart[e]	100% zero-emission vehicles including long-haul trucks by 2040 globally

[a] Amazon, "Delivering Shipment Zero, a vision for net zero carbon shipments," accessed October 11, 2022, https://www.aboutamazon.com/news/sustainability/delivering-shipment-zero-a-vision-for-net-zero-carbon-shipments
[b] Deutsche Post DHL Group, "Accelerated roadmap to decarbonization: Deutsche Post DHL Group decides on science based targets and invests EUR 7 billion in climate-neutral logistics until 2030," accessed 27 Sept 2022, https://www.dpdhl.com/en/media-relations/press-releases/2021/dpdhl-accelerated-roadmap-to-decarbonization.html
[c] "FedEx commits to carbon-neutral operations by 2040," FedEx, accessed 27 Sept 2022, https://newsroom.fedex.com/newsroom/sustainability2021/
[d] "Zero emissions for home deliveries," IKEA, accessed 27 Sept 2022, https://about.ikea.com/en/sustainability/becoming-climate-positive/zero-emissions-for-home-deliveries
[e] "Walmart's regenerative approach: Going beyond sustainability," Walmart, accessed 27 Sept 2022, https://corporate.walmart.com/newsroom/2020/09/21/walmarts-regenerative-approach-going-beyond-sustainability

ZEV supply and demand

Fleet requirements in the proposed ACF are not aligned with the ACT, with demand expected to exceed what manufacturers are required to supply under the ACT in some cases. This is particularly true for tractors. We estimate that ACF-driven demand for Class 7–8 tractors will consistently outpace manufacturer sales requirements, reducing the incentive for manufacturers to set competitive prices. The outpacing of ACT by ACF fleet requirements is supported by ERM's analysis for Class 4–8 vocational vehicles and Class 7–8 tractors (Figures A4 and A5).[18] This gap between supply and demand could increase upfront costs, which would be especially impactful for small drayage fleets with limited access to capital. The forthcoming Zero-Emission Truck Measure included in the 2022 State Implementation Plan

[16] Amazon, "Delivering Shipment Zero, a vision for net zero carbon shipments," accessed October 11, 2022, https://www.aboutamazon.com/news/sustainability/delivering-shipment-zero-a-vision-for-net-zero-carbon-shipments.
[17] Associated Press, "Amazon to Invest $972M for Electric Vans, Trucks in Europe," E&E News, October 12, 2022, https://subscriber.politicopro.com/article/eenews/2022/10/12/amazon-to-invest-972m-for-electric-vans-trucks-in-europe-00061269.
[18] ERM, "California Clean Trucks Program."

Strategy is expected to further increase demand, widening the gap. Accelerating the 100% ZEV sales requirement to 2036 could compensate for some of the lag between ACT sales requirements and demand driven by both the proposed ACF fleet requirements and planned Zero-Emission Truck Measure.

Tractor operations

Functionally, day cab and sleeper cab tractors may be used interchangeably in return-to-base operations. While day cab tractors may be better suited for short- and regional-haul routes, fleets may opt for sleeper cabs to give them greater flexibility in their operations. Of Class 7–8 tractors surveyed under the large entity reporting requirements of the ACT, there is an overlap in average daily range: roughly 47% of day cabs and 23% of sleeper cabs logged between 100 and 300 daily miles (Figure 32 and 33 in ISOR).

In the proposed ACF, day cab tractors that opt-in to high priority and federal fleet composition milestones would be subject to the Group 2 ZEV phase-in schedule. Sleeper cab tractors would be subject to the Group 3 schedule, which lags Group 2 by three years. [19] However, the overlap between day and sleeper cab operations means that fleets could delay electrification by opting to maintain more sleeper cabs in their fleet.

Cost literature

The feasibility of ZEV deployment is affected by the purchase and ownership cost of the vehicle. Table 4 summarizes estimates of total cost-of-ownership (TCO) and upfront cost parity for heavy-duty ZEVs compared to conventional internal combustion engine (ICE) vehicles from recent studies in the United States.[20] In the table, upfront cost parity ratios lower than 1 indicate ZEVs will have lower purchase costs in 2027 than ICE vehicles, while ratios higher than 1 indicate ZEVs will have higher purchase costs in 2027.

This compilation of studies suggests that many vehicle segments will have achieved or be approaching upfront cost parity in the next several years, reducing the upfront cost burden and increasing ownership cost savings from electrification. For segments with higher upfront costs, the achievement of TCO parity in the next decade suggests that those fleets with sufficient access to capital to purchase ZEVs would see a return on their investment over time. We emphasize the need for sustained incentive funding and

[19] CARB staff assumed 100% of Group 3 vehicles would opt-in to the ZEV Milestones Option as an alternative to the Model Year Schedule and 75% of Group 2 vehicles for opt-in.

[20] Argonne National Laboratory, "BEAN," Vehicle & Mobility Systems Group - Argonne National Laboratory, June 30, 2021, https://vms.taps.anl.gov/tools/bean/; Vishnu Nair et al., "Technical Review of: Medium and Heavy-Duty Electrification Costs for MY 2027- 2030" (Roush Industries, February 2, 2022), https://www.edf.org/media/new-study-finds-rapidly-declining-costs-zero-emitting-freight-trucks-and-buses; Eamonn Mulholland, "Cost of Electric Commercial Vans and Pickup Trucks in the United States through 2040" (Washington, D.C.: International Council on Clean Transportation, January 11, 2022), https://theicct.org/publication/cost-ev-vans-pickups-us-2040-jan22/; Catherine Ledna et al., "Decarbonizing Medium- & Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis" (Golden, CO: National Renewable Energy Laboratory, March 7, 2022), https://doi.org/10.2172/1854583; Chad Hunter et al., "Spatial and Temporal Analysis of the Total Cost of Ownership for Class 8 Tractors and Class 4 Parcel Delivery Trucks" (Golden, CO: National Renewable Energy Laboratory, September 16, 2021), https://doi.org/10.2172/1821615; Andrew Burnham et al., "Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains," April 1, 2021, https://doi.org/10.2172/1780970; Dan Welch et al., "Moving Zero-Emission Freight toward Commercialization" (ZEV Alliance, October 2020), http://www.zevalliance.org/wp-content/uploads/2020/12/Zero-Emission-Freight-Commercialization-dec2020.pdf.

support for smaller fleets, particularly in the drayage industry, in order to provide more equitable access to these cost savings.

Table 4. Summary of recent literature on ZEV cost parity for key segments in the heavy-duty sector.

Vehicle segment	Year of ZEV:ICE TCO parity	ZEV:ICE upfront cost parity in 2027	Sources
Class 2b-3 pickups and vans	2022–2027 (vans) 2022–2029 (pickups)	1–1.3	a, b, c, d
Class 4-6 short-haul rigid trucks	2022–2028	0.9–1.4	a, b, d, e, f
Class 7-8 short-haul rigid trucks	2027–2028	0.9–1.6	a, b, g
Class 4-8 long-haul rigid trucks	2031–2032	No information	d
Class 7-8 short-haul tractors	2025–2034	1.3–1.8	a, e, f, g
Class 7-8 long-haul tractors	No consensus	2.1–2.4	a, d, c, f, g
Class 8 refuse trucks	<2025	0.9–1.1	a, b

[a] BEAN tool, https://vms.es.anl.gov/tools/bean/
[b] Roush Industries for the Environmental Defense Fund, "New Study Finds Rapidly Declining Costs for Zero-Emitting Freight Trucks and Buses [press release]," (2022, February 10), https://www.edf.org/media/new-study-finds-rapidly-declining-costs-zero-emitting-freight-trucks-and-buses
[c] Includes results for ZEVs with 200- and 300-mile range only. Eamonn Mulholland, "Cost of electric commercial vans and pickup trucks in the united states through 2040," (Washington, DC: ICCT, 2022), https://theicct.org/publication/cost-ev-vans-pickups-us-2040-jan22/
[d] Includes results for ZEVs with 150- and 300-mile range for short-haul and 500-mile range for long-haul. Catherine Ledna, Matteo Muratori, Arthur Yip, Paige Jadun, and Chris Hoehne, "Decarbonizing Medium- & Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis," (NREL, 2021), https://www.osti.gov/biblio/1854583
[e] Chad Hunter, Michael Penev, Evan Reznicek, Jason Lustbader, Alicia Birky, and Chen Zhang, "Spatial and Temporal Analysis of the Total Cost of Ownership for Class 8 Tractors and Class 4 Parcel Delivery Trucks" (NREL 2021), https://www.nrel.gov/docs/fy21osti/71796.pdf
[f] Andrew Burnham, David Gohlke, Luke Rush, Thomas Stephens, Yan Zhou, Mark A. Delucchi, Alicia Birky, Chad Hunter, Zhenhong Lin, Shiqi Ou, Fei Xie, Camron Proctor, Steven Wiryadinata, Nawei Liu, and Madhur Boloor, "Comprehensive Total Cost of Ownership Quantification for Vehicles with Different Size Classes and Powertrains," (ANL, 2021), https://publications.anl.gov/anlpubs/2021/05/167399.pdf
[g] CALSTART and FIER Automotive & Mobility, "Moving zero-emission freight toward commercialization," (International ZEV Alliance, 2020), http://www.zevalliance.org/zero-emission-freight-2020/

CARB's own analysis, summarized in Table 5, generally aligns with recent literature on ZEV upfront cost and TCO parity. Upfront cost estimates from CARB largely fall within the summarized literature range in 2027 for all segments except for sleeper cab tractors, for which CARB estimates lower costs. For Class 2b cargo vans and Class 8 refuse trucks, CARB estimates are just above the literature range. Total cost of ownership estimates in Appendix G of the ISOR also fall within the literature range, except for day cab and sleeper cab tractors, for which CARB estimates earlier TCO parity.

Table 5. Summary of CARB's ZEV cost results for key segments in the heavy-duty sector. Results are linearly interpolated to 2027 and are shown for battery-electric and diesel powertrains except when noted.

Vehicle segment	Year of ZEV:ICE TCO parity	ZEV:ICE upfront cost parity in 2027
Class 2b cargo van	<2025	1.4 (gasoline) 1.3 (diesel)
Class 5 walk-in van	<2025	1.1
Class 6 bucket truck	2025–2030	1.2
Class 8 day cab tractor	<2025	1.3
Class 8 sleeper cab tractor	2025–2030	1.5 (fuel cell) 1.7 (battery-electric)
Class 8 refuse truck	<2025	1.2

The cost analyses from CARB and the recent literature largely do not account for state and federal incentives, which further decrease upfront and ownership costs, and are expected to be in place for early adopters. At the state level, these include various grants and purchase incentives that reduce the upfront cost of ZEVs and their supporting infrastructure. The generation of credits from California's Low Carbon Fuel Standard could additionally offset much of the operational cost of charging or refueling. At the federal level, the recently passed Inflation Reduction Act provides funding for purchase incentives of $40,000 for Class 4–8 commercial vehicles and $7,500 for lighter commercial vehicles available through 2032.[21] ERM estimates that, with these new federal purchase incentives, upfront cost parity will be achieved five to twelve years earlier and by 2028 for all vehicle segments except sleeper cab tractors.[22] Under the same act, an IRS tax credit for charging infrastructure was extended through 2032 and could offset 30% of installation costs up to $100,000 per site.

Given projected ZEV costs, TCO parity, and state and federal incentives, fleets are poised to reap significant cost savings from electrification. We encourage CARB to consider the impact of state and federal incentives in lowering upfront costs and increasing overall cost savings for high priority and federal fleets.

[21] "Inflation Reduction Act of 2022," Pub. L. No. 117–169 (2022), https://www.congress.gov/bill/117th-congress/house-bill/5376/text/rh.

[22] ERM, "Investment Reduction Act Supplemental Assessment: Analysis of Alternative Medium- and Heavy-Duty Zero-Emission Vehicle Business-As-Usual Scenarios", August 19, 2022, https://www.erm.com/contentassets/154d08e0d0674752925cd82c66b3e2b1/edf-zev-baseline-technical-memo-addendum.pdf