

Zeroing in on Zero-Emission Trucks

May 2023
Market Update



Key Takeaways

- MHD ZET deployments in the United States continue to increase, exhibiting strong market growth. Since January 2017, annual MHD ZET deployments increased year-over-year by 104% in 2018, 23% in 2019, 60% in 2020, 397% in 2021, and 163% in 2022. As of December 2022, 136 non-pickup truck models are now available for purchase across over 41 manufacturers.
- The cumulative number of U.S. MHD ZET deployments has grown to 5,483 (from January 2017 to December 2022).³
- Of the cumulative U.S. MHD ZET deployments (for which deployment locations are known), 59% were in states that—as of December 2022—have adopted the Advanced Clean Trucks (ACT) rule,⁴ 7% were in states that have signed the Multi-State Medium- and Heavy-Duty Zero Emission Vehicle Memorandum of Understanding (MOU), and 34% were in non-MOU states.⁵
- In 2022 alone, 3,510 MHD ZETs were deployed, surpassing deployments of the previous five years (2017–2021) combined and representing breakthrough growth. Pickup trucks, which became available in 2022, represented nearly one-fourth (831) of these deployments.
- Of these 2022 deployments (for which deployment locations are known), 44% were in states that have adopted the ACT rule, 10% were in MOU states, and 46% were in non-MOU states.

About

This market update is the third publication in CALSTART's Zeroing in on Zero-Emission Trucks series. Providing a concise and current snapshot of the dynamic U.S. medium- and heavy-duty (MHD) truck market (Class 2b–8), it presents deployment statistics for on-road zero-emission trucks (ZETs)¹ and characterizes the existing U.S. MHD truck market. "Deployments" or "deployed sales" are defined as trucks that have been sold, delivered, and placed into service on U.S. roads. This update includes data on deployments from January 2017 through December 2022² and highlights key takeaways that can help guide future ZET deployments through insights into state-specific markets. These findings can be an essential component in the informed decision-making process of policymakers, original equipment manufacturers (OEMs), and fleet owners.

¹ CALSTART's definition of ZETs are those that do not emit exhaust gas or other pollutants from their onboard power source. This definition includes battery-electric and hydrogen fuel-cell vehicles and excludes low-emission technologies like natural gas (compressed, liquid, or renewable), hybrid-electric, and biodiesel vehicles. Trucks in this report are segmented according to the Zero-Emission Technology Inventory (ZETI) tool's categorization scheme, which divides Class 2b–8 trucks into seven distinct segments: pickup trucks, cargo vans, medium-duty (MD) step vans, MD trucks, heavy-duty (HD) trucks, refuse trucks, and on-road yard tractors. For more information on the definition and segmentation of commercial ZETs in this analysis, please refer to <https://calstart.org/zeroing-in-on-zero-emission-trucks/> for the first version of this report released in January 2022.

² This document is based on MHD ZET information and MHD truck data (S&P Global (Polk)) as of December 2022.

³ The total number of cumulative MHD ZET deployed sales since 2010 has grown to 6,211 units.

⁴ States that have adopted the ACT rule as of December 2022 include California, Massachusetts, New Jersey, New York, Oregon, Vermont, and Washington. Colorado has since become the eighth state to adopt the ACT rule in April 2023, though for the purposes of this update, which includes data through 2022, Colorado is not considered an ACT state. Similarly, Maryland and Rhode Island, which in April and May 2023, respectively, directed their states to adopt the ACT rule, are not considered ACT states for the purposes of this update.

⁵ For more information on the MOU, please visit <https://www.nescaum.org/initiatives/mhd-zev-initiative>.

- The growth of key zero-emission HD segments in the United States, like yard tractors⁶ (1,541% growth in deployments from January 2017 to December 2022) and HD trucks (7,167% growth from January 2020 to December 2022), reflects the increasing ability of zero-emission technologies to meet and exceed fleets' demanding operational requirements that have historically been served by internal combustion engine vehicles.
- The growth in the zero-emission cargo van segment (which experienced a 315-fold increase in deployments from 2017 to 2022) reflects the popularity of the new models on the market (e.g., Amazon's Custom Electric Delivery Vehicle from Rivian, BrightDrop's Zevo 600, Ford's E-Transit, etc.) and their relatively low-price premium compared to gasoline-powered vans. This market is expected to grow quickly, thanks in part to the new Commercial Clean Vehicle Credit, which provides up to \$7,500 in tax credits to mitigate the incremental cost.⁷
- From 2011 through 2022, redeemed and unredeemed vouchers from California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) for MHD ZETs totaled \$315 million over 3,149 units, an average of ~\$100,000 per MHD ZET or ~41% of the average original retail price for a deployed MHD ZET.
- California's strong ZET policy ecosystem is a major factor that has enabled the state to lead in deployments, representing 47% of total U.S. MHD ZET deployed sales from January 2017 to December 2022. Each dollar invested in MHD ZETs through California's HVIP program has unlocked \$1.42 in private industry investment.
- Seven states deployed their first ZET since CALSTART's Zeroing in on ZETs: June 2022 Market Update. Those states were Arkansas, Delaware, Montana, Nebraska, Oklahoma, Rhode Island, and Wyoming. The District of Columbia (DC) has also since deployed its first ZET.

Overall U.S. MHD Truck Market

- In 2022, total U.S. MHD truck deployed sales (Class 2b–8) increased to 1,186,966 units. Of this total, Class 4–8 deployed sales comprised 334,683 units. California leads the nation in U.S. MHD truck deployed sales, with 78,272 Class 2b–8 units sold in 2022. (California's Class 4–8 deployed sales were 23,642 units.)
- As of 2022, diesel-powered trucks constitute 38% of registered Class 2b vehicles, increasing to 97% of registered Class 8 vehicles. Class 2b–3 vehicles are composed of 44% gasoline-powered, 46% diesel-powered, and 10% flexible fuel-powered trucks.⁸ Class 4–8 vehicles are composed of 9% gasoline-powered, 89% diesel-powered, and 0.7% electric- and hybrid diesel-powered trucks. As MHD ZET deployments cut into these market shares, the numerous benefits these vehicles offer over their gasoline- and diesel-powered counterparts, such as improved air quality, mitigated effects of climate change, and operational savings, will increase.

⁶ Data includes deployed on-road yard tractors but not off-road yard tractors, which are not registered with the Department of Motor Vehicles.

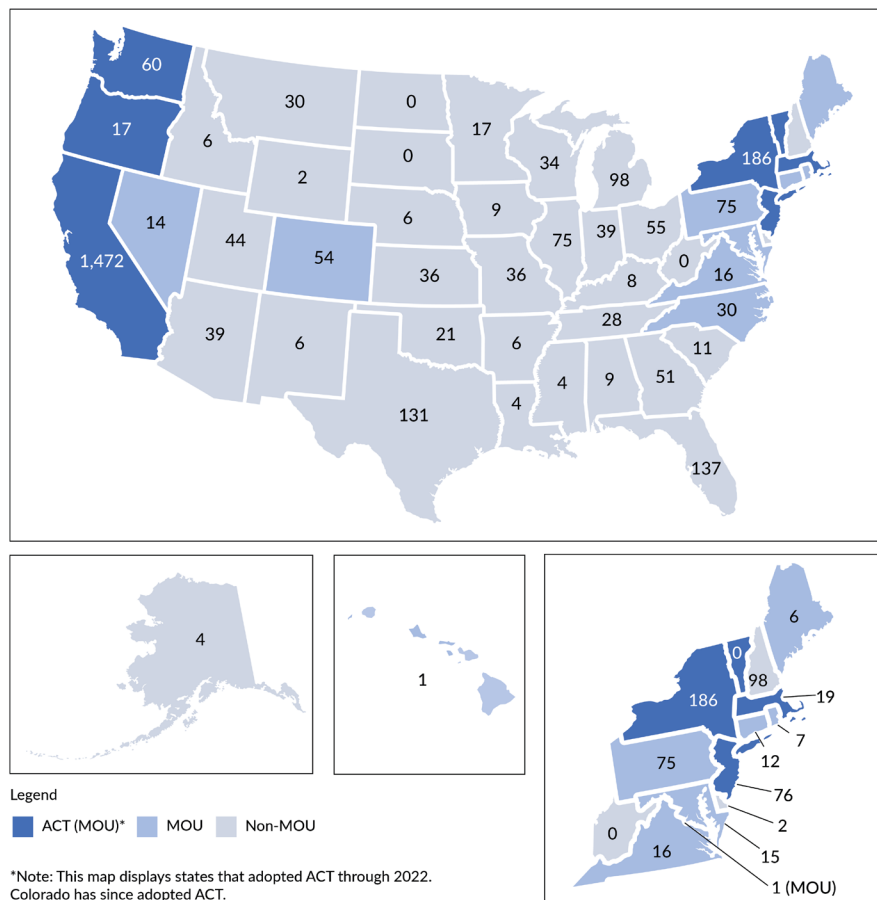
⁷ For more information on the Commercial Clean Vehicle Credit, please visit <https://www.irs.gov/pub/taxpros/fs-2023-08.pdf>.

⁸ Flexible fuel-powered vehicles are internal combustion engine vehicles capable of operating on gasoline and any blend of gasoline with up to 83% ethanol.

U.S. MHD ZET Deployments by State

U.S. MHD ZETs deployed since January 2017 reached a total of 5,483 units as of year-end 2022. Deployment locations (by state) are known for 3,107 of these ZETs, about half of which (46%) were deployed in California. Figure 1 presents the number of deployed MHD ZETs by state and identifies major state-level ZET sales regulations and commitments.⁹ Categories include states with the highest level of ZET policy ambition that, as of December 2022, have adopted California’s ACT rule (dark blue), states that have signed a memorandum of understanding (MOU) indicating intent to follow the ACT rule (light blue), and non-MOU states that do not have an aligned policy on ZETs (gray). Figure 2 breaks down cumulative U.S. MHD ZET deployed sales by segment for the same period.¹⁰

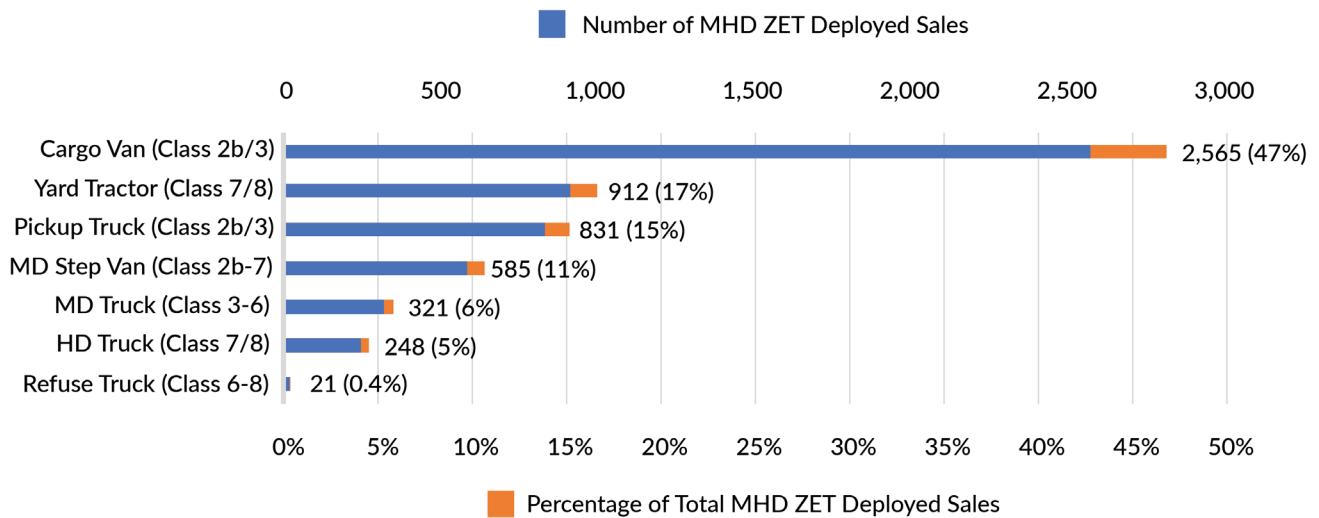
Figure 1: Cumulative U.S. MHD ZET Deployed Sales by State (2017–2022)



⁹ Figure 1 represents only the 3,107 ZETs for which deployment locations are known. Some deployment numbers may differ slightly from the previous market update due to corrections in the data provided by OEMs. State totals do not equal total deployments because deployment locations are not known for all ZETs.

¹⁰ Due to rounding, the sum of the percentages in this figure is slightly higher than 100%.

Figure 2: Cumulative U.S. MHD ZET Deployed Sales by Segment (2017–2022)

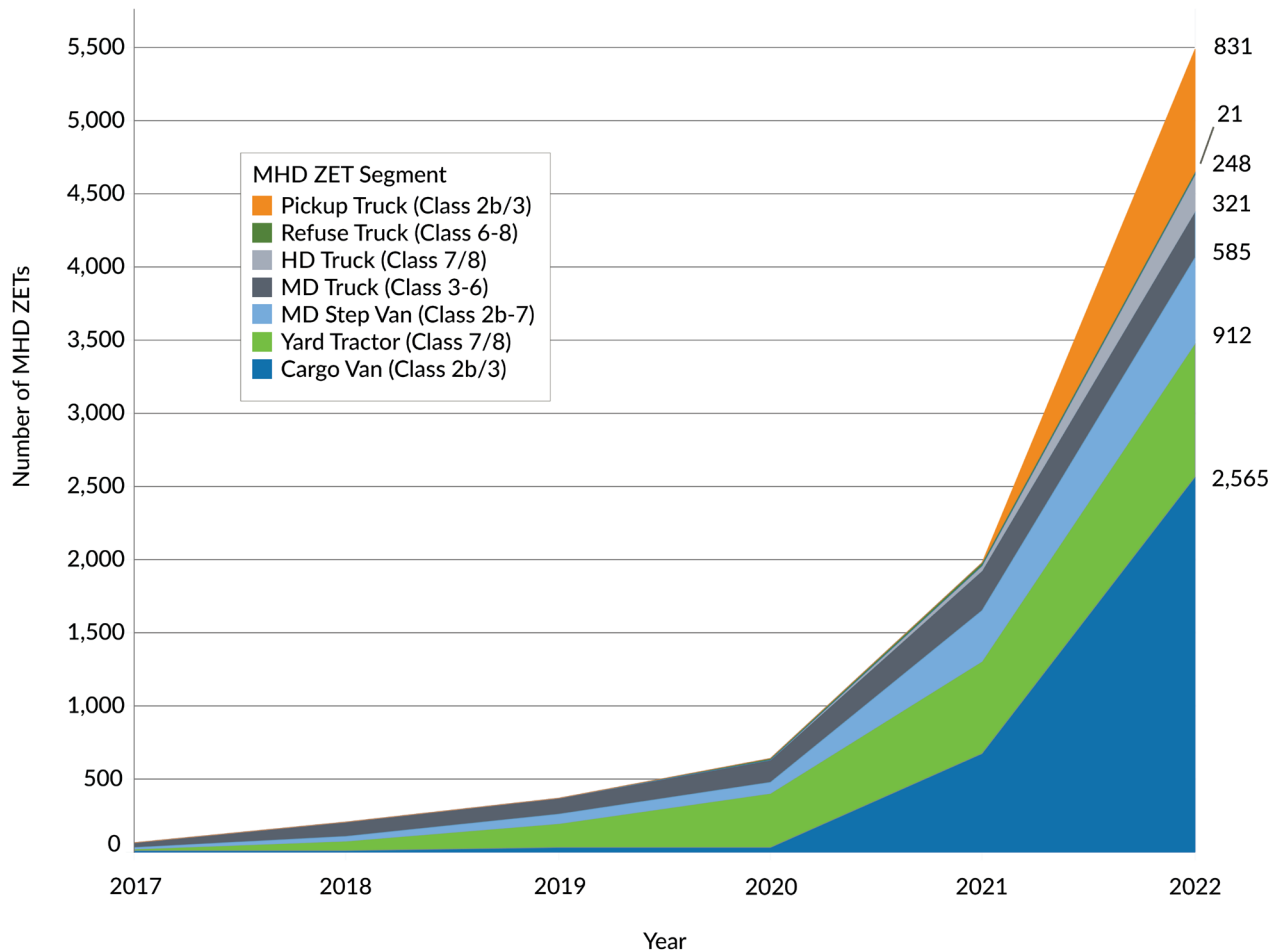


- Three OEMs dominate zero-emission yard tractor deployments in California, all of which have deployed models outside of California. Since January 2017, California has accounted for 65% of zero-emission yard tractor deployments, followed by New York (5%) and Colorado (4%).
- Two OEMs lead zero-emission MD step van deployments in California, both of which have deployed models outside of California. Since January 2017, California has accounted for 49% of zero-emission MD step van deployments, followed by New Hampshire (16%) and New York (10%).
- Eleven OEMs prevail over MD ZET deployments, eight of which have deployed models in California and nine of which have deployed models outside of California. Since January 2017, California has accounted for 63% of MD ZET deployments, followed by New York (6%) and Pennsylvania (5%).
- Ten OEMs currently command the HD ZET market, seven of which have deployed models outside of California. Since January 2017, California has accounted for 50% of HD ZET deployments, followed by New Jersey (8%) and Pennsylvania (8%).

U.S. MHD ZET Deployments by Segment

Figure 3 represents the cumulative growth of the seven MHD ZET segments in this analysis over the past six years. More than 136 models are now available for purchase across over 41 manufacturers (as of December 2022).

Figure 3: Cumulative U.S. MHD ZET Deployed Sales by Segment (2017–2022)



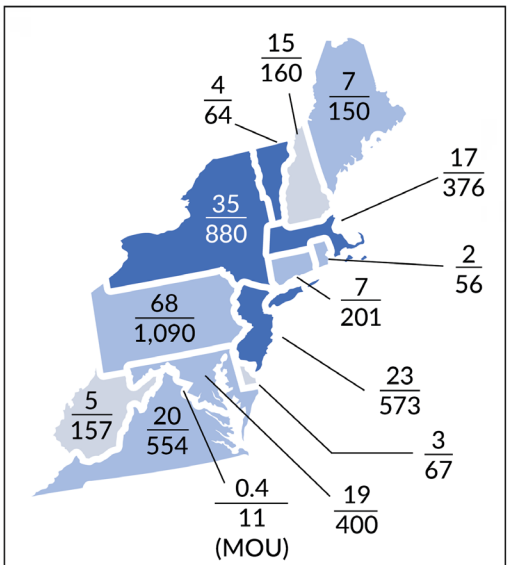
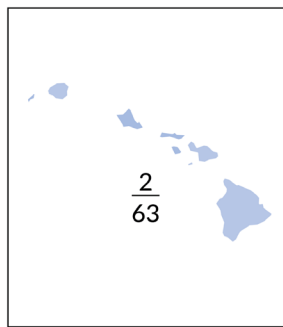
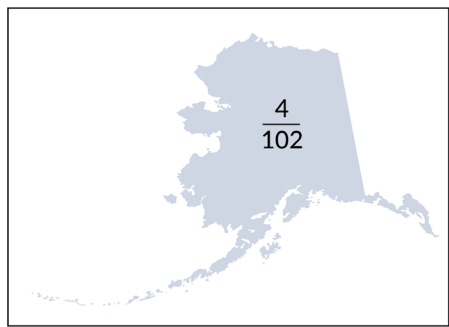
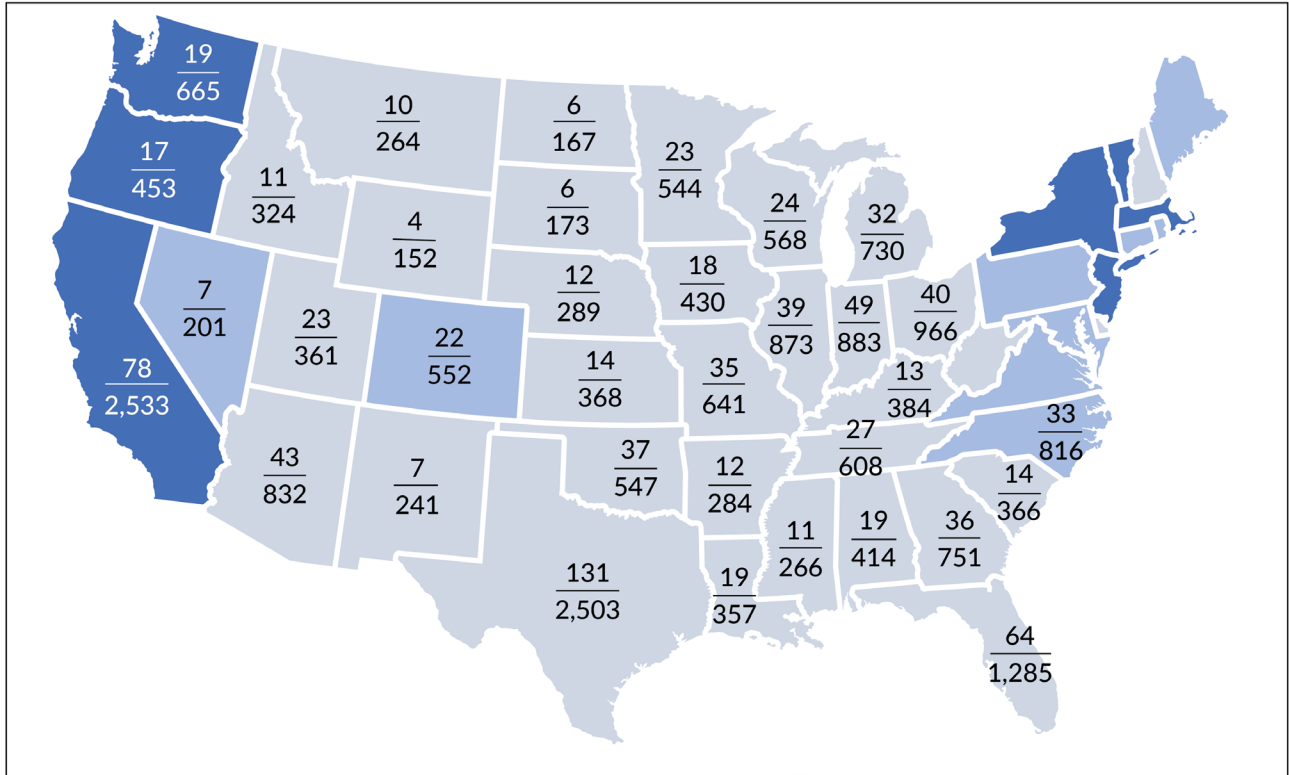
- In 2022, MHD ZET deployments grew by 163%. The average annual growth rate over the past six years (2017–2022) was 149%. This growth rate is expected to continue its aggressive upward trend as more OEMs enter the market, established OEMs expand their offerings, and fleets become more comfortable with the technology. Over the same period, zero-emission cargo vans have experienced an average annual growth rate of 2,571%, followed by HD ZETs (754%), zero-emission MD step vans (87%), zero-emission refuse trucks (147%), zero-emission yard tractors (85%), and MD ZETs (49%).

- Zero-emission cargo vans and on-road yard tractors are achieving a significant market share (i.e., share of sales as a proportion of total MHD ZET sales). For example, zero-emission cargo vans account for 47%, while on-road yard tractors account for 17% of all new MHD ZET registrations, followed by zero-emission pickup trucks (which have been available for purchase since 2022) at 15%, zero-emission MD step vans at 11%, MD ZETs at 6%, HD ZETs at 5%, and zero-emission refuse trucks at 1%.

Total U.S. MHD Truck Registrations and 2022 Deployed Sales

The United States has the largest number of registered trucks globally with 26.7 million units reported in 2022. Pickup trucks (Class 2b/3) dominate with around 14 million registrations. Figure 4 presents the total number of registered MHD trucks (i.e., stock) and annual deployed sales for 2022 by state in thousands and highlights states with major ZET policies in the same manner as Figure 1. Juxtaposing overall U.S. MHD truck market statistics with ZET sales regulations can help inform market and policy opportunities for ZETs at the state level. Figure 5 illustrates total MHD truck registrations and 2022 deployed sales by segment.

Figure 4: U.S. MHD Truck Total Registrations and 2022 Deployed Sales by State (Thousands)



Legend

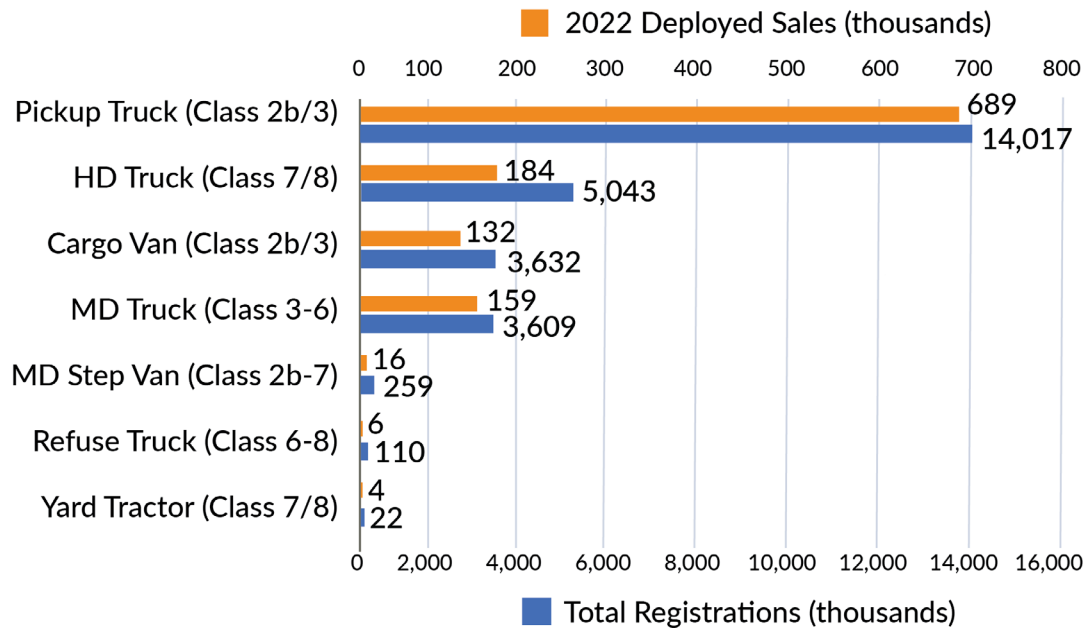
- ACT (MOU)*
- MOU
- Non-MOU

2022 Deployed Sales (thousands)
Total Registrations (thousands)

*Note: This map displays states that adopted ACT through 2022. Colorado has since adopted ACT.



Figure 5: U.S. MHD Truck Total Registrations and 2022 Deployed Sales by Segment (Thousands)



- The majority of the registered U.S. MHD truck market—as of 2022—is comprised of pickup trucks (52.5%); when pickup trucks are not considered, HD (Class 7–8) trucks lead in registrations (40%), followed by Class 2b/3 cargo vans (29%) and Class 3–6 MD trucks (28%).
- Five states represent 31% of registered U.S. MHD trucks: California (9.5%), Texas (9.4%), Florida (4.8%), Pennsylvania (4.1%), and New York (3.3%). All other states each comprise 4% or less of registered vehicles.
- States that have adopted the ACT rule—as of 2022—represent 21% of national MHD truck registrations and 16% of national 2022 MHD truck deployed sales.
- States that have signed the MOU (including ACT states) represent 36% of national MHD truck registrations and 32% of national 2022 MHD truck deployed sales.
- Five states represent 33% of 2022 U.S. MHD truck deployed sales: Texas (11%), California (7%), Pennsylvania (6%), Florida (5%), and Indiana (4%). All other states each comprise 4% or less of deployed sales.
- Over half (53%) of registered U.S. MHD trucks are owned by individuals. Of these individually owned trucks, 74% are Class 2b/3 pickup trucks, 11% are cargo vans, 7% are HD trucks, and 7% are MD trucks.

- Eight vocations represent 85% of MHD truck registrations: individual (53%), construction (7%), service (7%), general freight (7%), lease/rental (4%), wholesale/retail (3%), government/miscellaneous (~2%), and manufacturing (~2%).
- Internal combustion engine vehicles, which are primarily fueled by gasoline or diesel, represent 93% of MHD trucks registered in the United States. Diesel accounts for 59%, gasoline for 34%, flexible fuel for 7%, and all other fuel types (i.e., natural gas, propane, hybrid, and electric) represent less than 1% of registered trucks.
- MHD trucks (including pickup trucks) represent 86% of registered U.S. MHD vehicles (Sport utility vehicles represent 2%, and buses, including transit buses, coach buses, school buses, passenger/shuttle vans, and motor homes, represent 11%.) The deployed-sales share of each of these segments is consistent with registrations, differing by a degree of only 1%.

Annual U.S. MHD truck deployed sales fluctuate from year to year due to several factors such as fleets' acquisition cycles, market economy, supply chain constraints, regulations, and anticipated models. As seen in Figures 6 and 7, deployed sales over the past four years have fluctuated based on the factors mentioned above. (Deployed sales in 2020 declined 18% year-over-year, followed by another decline of 23% in 2021, but deployed sales in 2022 increased by 23%.)

Figure 6: U.S. Yard Tractor, Refuse Truck, and MD Step Van Deployed Sales (2019–2022)

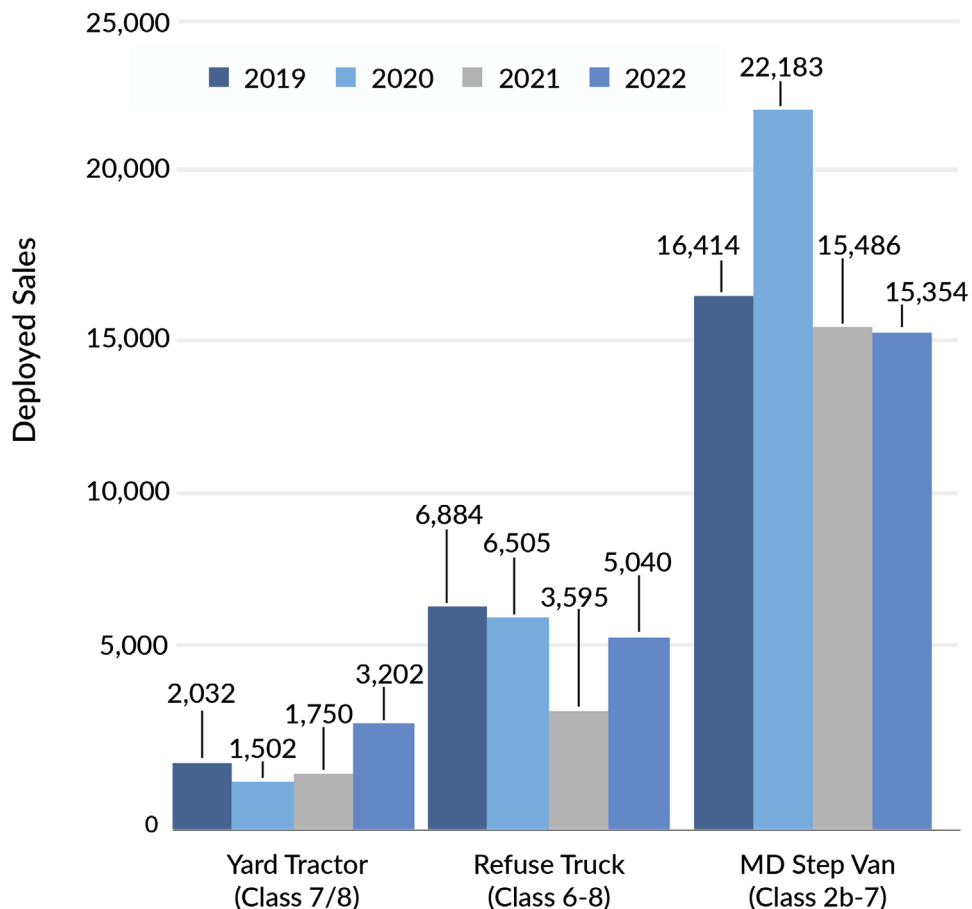
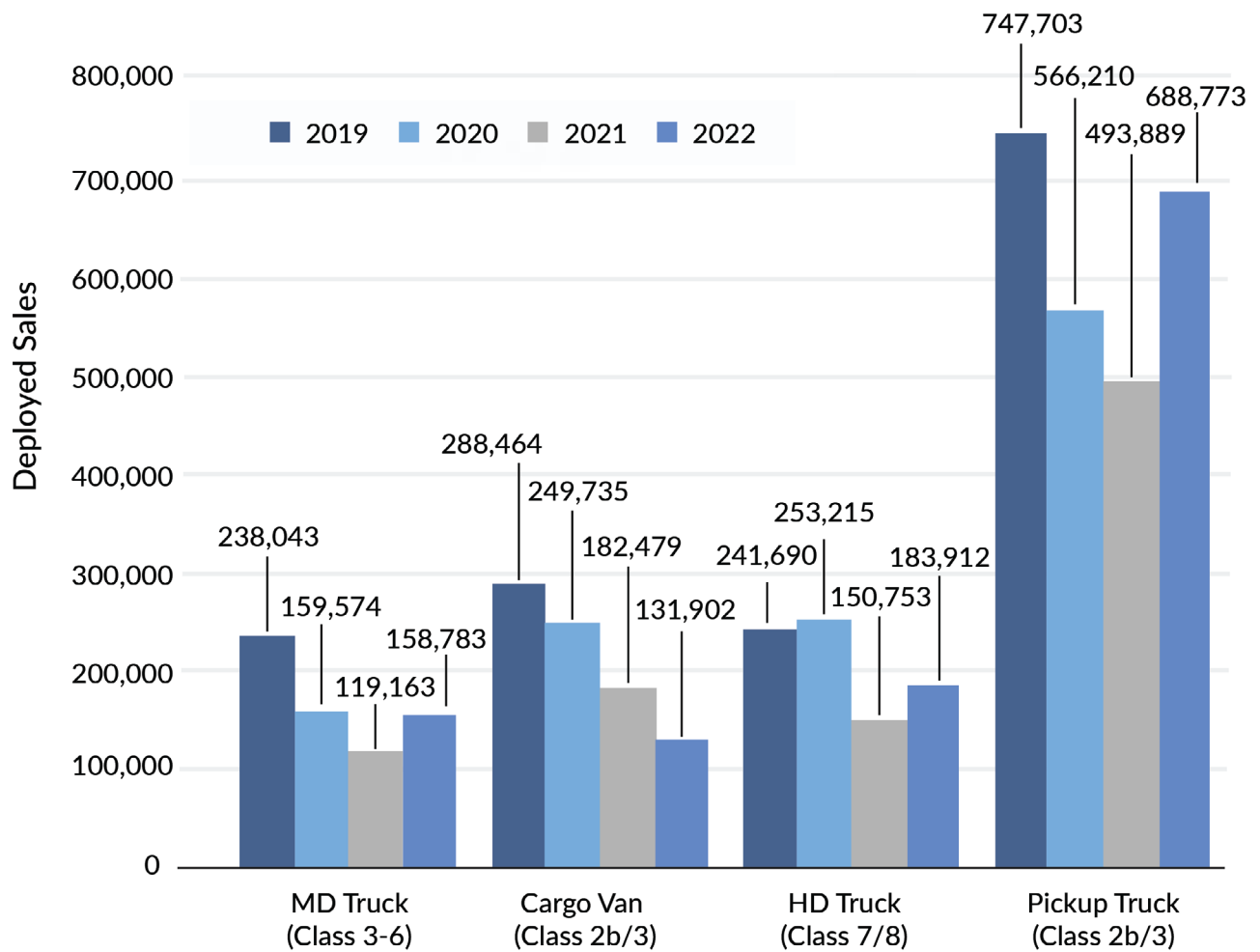
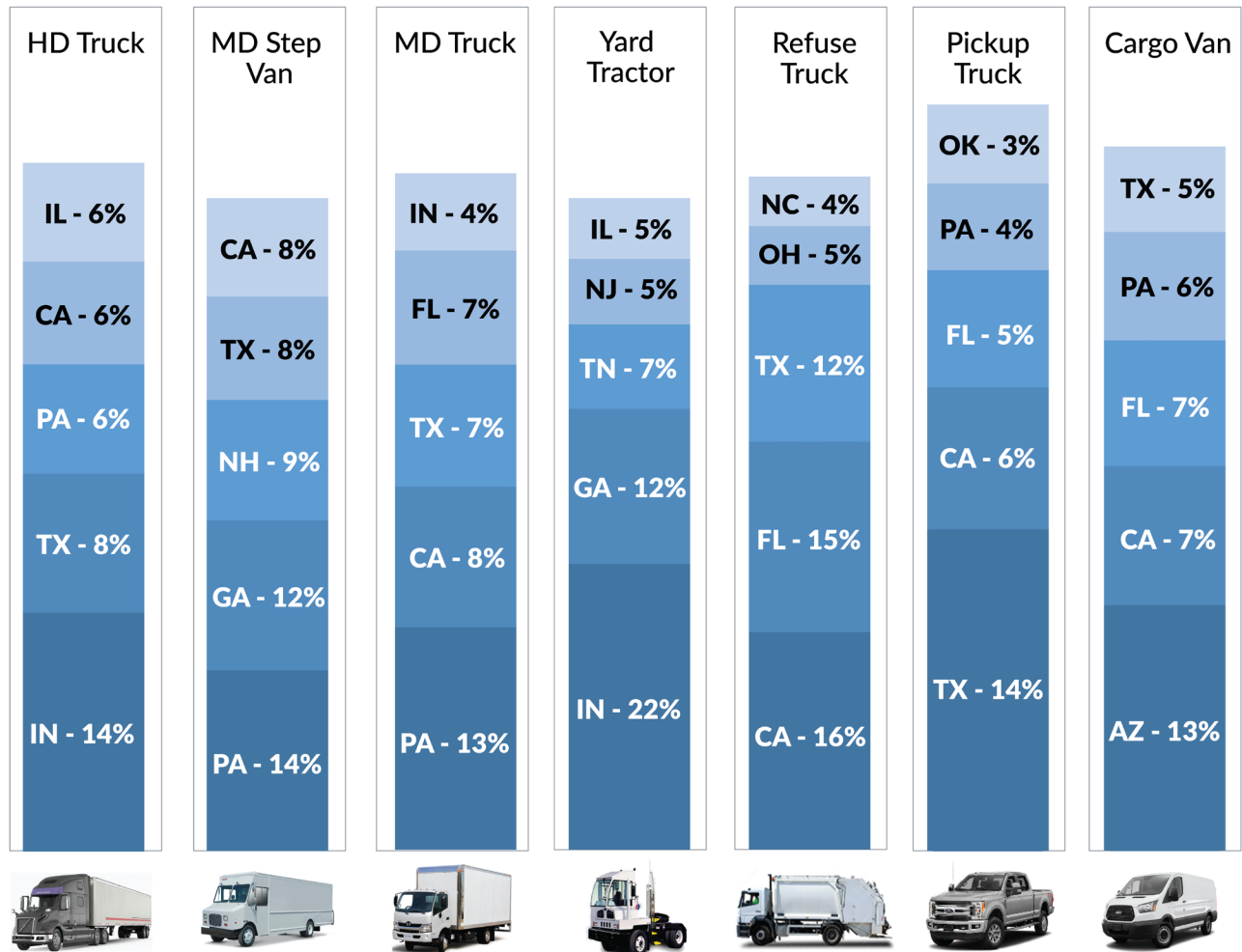


Figure 7: U.S. MD Truck, Cargo Van, HD Truck, and Pickup Truck Deployed Sales (2019–2022)



The share of deployed sales by truck segment varies by state. Figure 8 represents the top five states with the highest 2022 deployed sales for each truck segment. States with high 2022 deployed sales may appear to have large markets for certain vehicle segments, but to fully understand the current condition of these markets, registration of those truck segments must also be considered. Furthermore, depending on the market dynamics of each state, new trucks will either replace old trucks or expand existing fleets.

Figure 8: Top U.S. States with High 2022 Truck Deployed Sales by Type



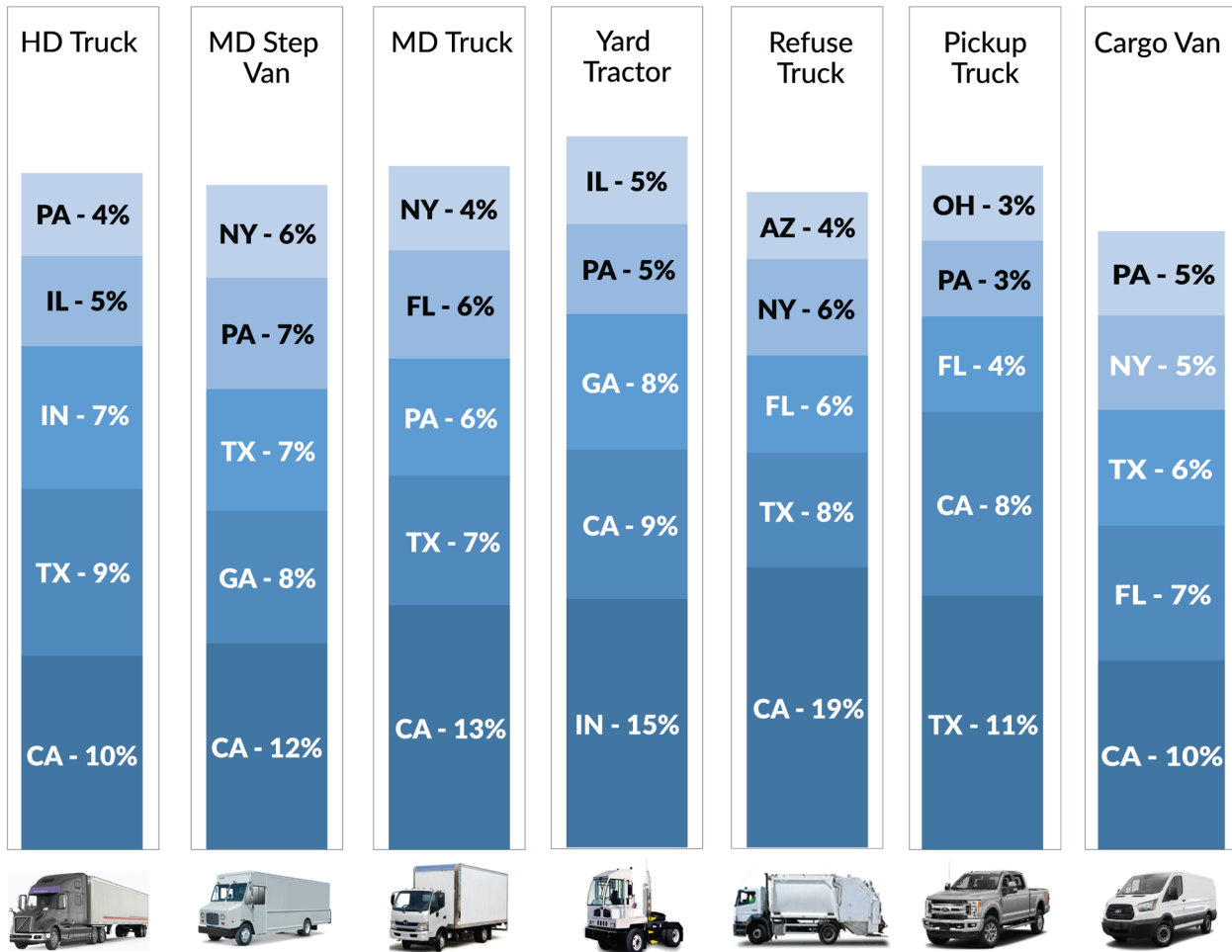
- The top five states per segment account for over one-third of the national deployed sales for each truck type: HD truck (40% or 73,322 units), MD step van (51% or 7,844 units), MD truck (38% or 61,019 units), yard tractor (51% or 1,636 units), refuse truck (51% or 2,595 units), pickup truck (33% or 225,378 units), and cargo van (38% or 50,075 units).¹¹
- Deployed sales are not distributed evenly across states due to several factors. Some states like Indiana, California, Georgia, Texas, and Pennsylvania serve as freight hubs and are home to large ports and shipping infrastructure. Financial elements such as fee reductions may also play a role in influencing where logistics companies establish operations and purchase vehicles. Indiana leads deployed sales of HD trucks and pickup trucks in 2022, in alignment with the state's current position in the U.S. freight and logistics chain.

¹¹ Due to rounding, the sum of the percentages in this insight differs slightly from the sum of the percentages provided in Figure 8.

- California's 2022 MHD truck deployed sales represent approximately 7% of total U.S. deployed sales.
- The breakdown of MHD truck deployed sales in each state is largely dependent on the dominant vocational needs specific to each state.

Figure 9 represents the top five states with the highest 2022 registrations under each truck segment. States with high deployed sales (i.e., market growth) do not necessarily have large markets for certain vehicle segments as of year-end 2022.

Figure 9: Top U.S. States with High 2022 MHD Truck Registrations by Type



- The top five states per segment account for around one-third of national registrations (i.e., stock) for each truck type: HD truck (35% or 1,778,253 units), MD step van (40% or 103,353 units), MD truck (35% or 1,263,416 units), yard tractor (43% or 9,253 units), refuse truck (43% or 47,828 units), pickup truck (30% or 4,224,595 units), and cargo van (34% or 1,230,317 units).¹²
- Similar to deployed sales, truck registration is not distributed across states evenly due to several factors. Some states like Indiana, California, Georgia, Texas, and Pennsylvania serve as freight hubs and are home to large ports and shipping infrastructure. Financial elements such as fee reductions may also play a role in influencing where logistics companies establish operations and purchase vehicles. Indiana leads yard tractor registrations in 2022, in alignment with Indiana's current position in the U.S. freight and logistics chain.
- California's registered MHD trucks in 2022 represent approximately 9% of total U.S. MHD truck registrations.
- The breakdown of MHD truck registrations in each state is largely dependent on the state population, economy, and location.

Conclusion

The U.S. ZET market has experienced significant growth over the last six years. More OEMs are entering the market and offering a greater number of models available in numerous states. Truck buyers are increasingly deploying zero-emission models for progressively demanding segments and duty cycles, including heavier-duty and longer-range applications. ZET deployments are growing not just within California but across the country. States that have adopted or signaled an intent to adopt the ACT rule account for over one-third of U.S. MHD truck registrations.

¹² Due to rounding, the sum of the percentages in this insight differs slightly from the sum of the percentages provided in Figure 9.

Acknowledgments

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