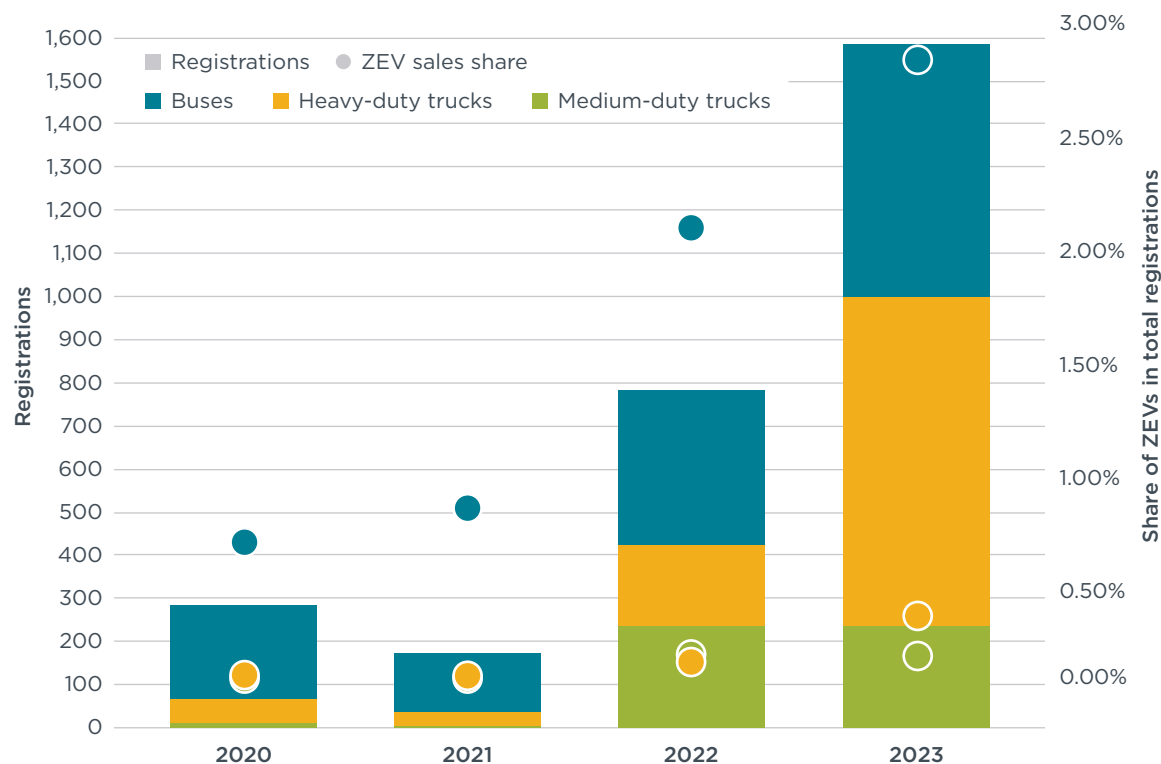


ZERO-EMISSION BUS AND TRUCK MARKET IN THE UNITED STATES: A 2022-2023 UPDATE

Yihao Xie

FIGURE 1

Number and share of zero-emission heavy-duty vehicle registrations in the United States by vehicle type



OVERVIEW

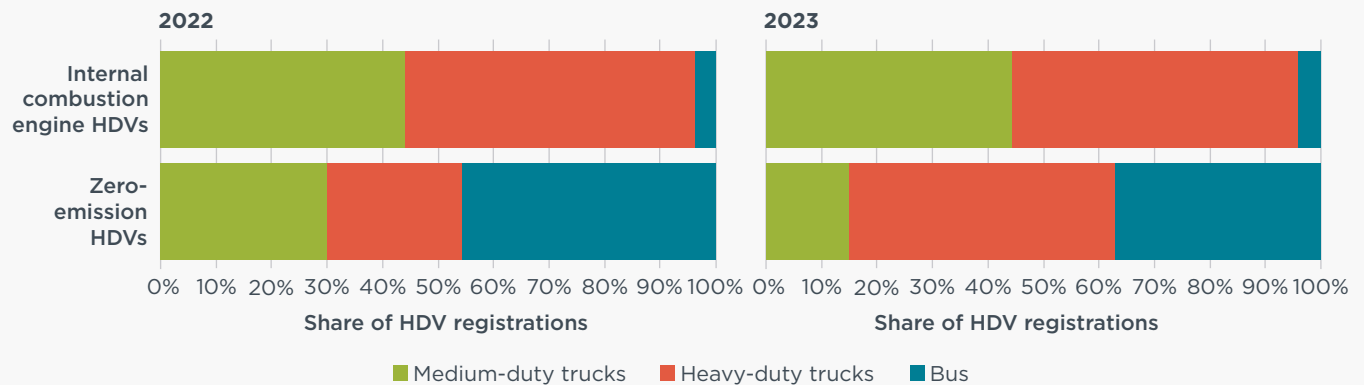
Registrations of new zero-emission heavy-duty vehicles (ZE-HDVs) in the United States rose from 200 in 2021 to 1,600 in 2023.

Over the same 2-year period, total new HDV registrations grew from around 490,000 to 520,000, or 5.8%. The share of ZE-HDVs in all HDV registrations remained low but rose from less than 0.10% in 2021 to 0.16% in 2022, and then to 0.30% in 2023. The heavy-duty truck segment contributed the most to the increase in the number of new ZE-HDV registrations. Despite this recent growth, the United States is still far behind the markets in China and the European Union: In 2023, there were 11,000 new ZE-HDVs sold in the 27 EU Member States and more than 110,000 sold in China.

In 2022 and 2023, medium- and heavy-duty trucks were 96% of the total internal combustion engine (ICE) HDV market in the United States. In the total ZE-HDV market, trucks are not as large a share and were 54% of the market in 2022 and 63% in 2023. That there are more buses in the ZE-HDV market shows that zero-emission trucks are in an earlier stage of development. While the registrations data we accessed for this analysis showed that all new ZE-HDVs registered in 2022 and 2023 were battery electric, sales data we obtained from separate sources shows that sales of hydrogen fuel-cell trucks occurred in 2023. That these are not in the registration data we accessed could reflect the limits of collection methods and scope. Another explanation is that sales data are not directly comparable with registration data; vehicles produced and sold are not always immediately registered and put in operation.

FIGURE 2

New heavy-duty vehicle registrations in the United States by vehicle type and powertrain



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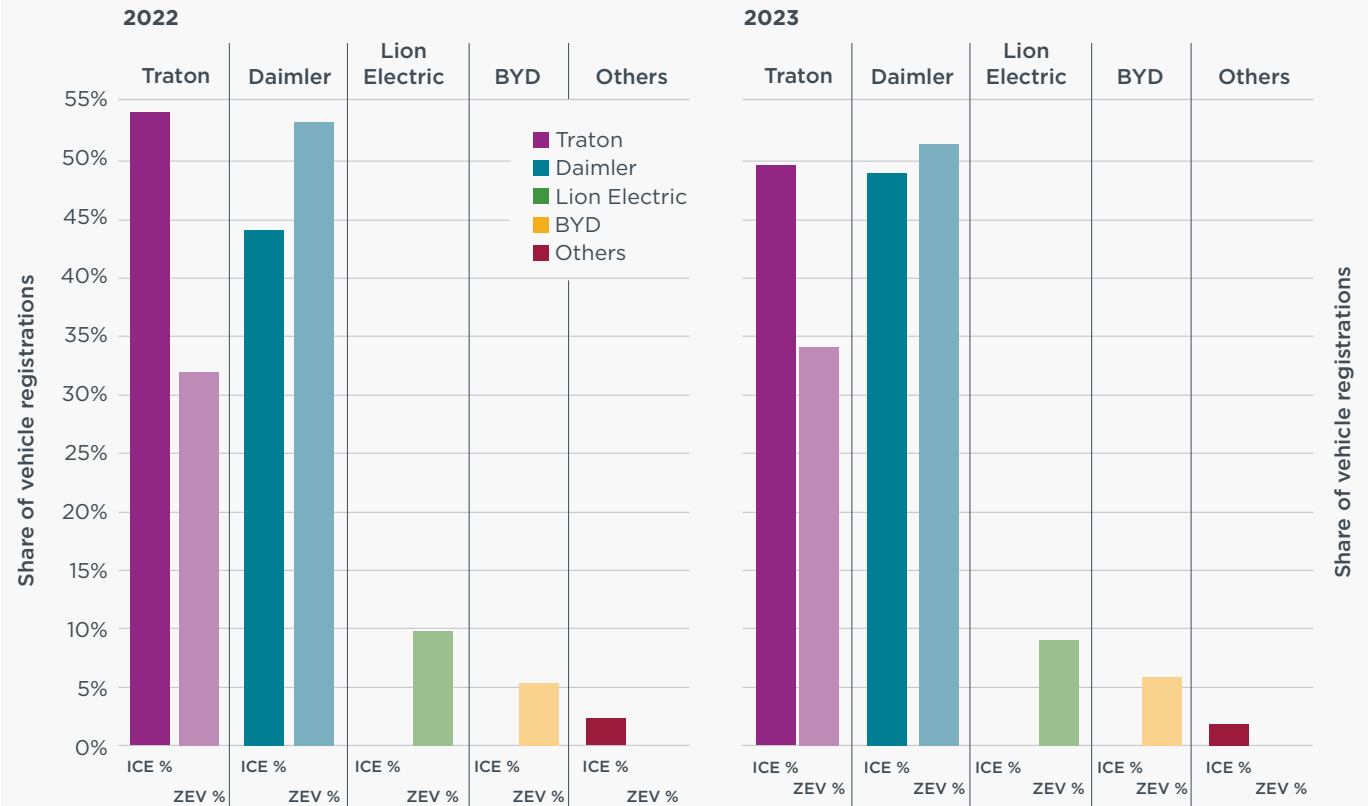
BUSES

Registrations of zero-emission buses grew from around 140 in 2021 to 360 in 2022, and then to around 590 in 2023. In 2023, zero-emission buses were 2.8% of all new bus registrations in the United States—the highest market penetration among HDV segments.

The two largest manufacturer groups of ICE-powered buses in the United States are Traton and Daimler, and these two groups are also becoming dominant players in the zero-emission bus market. Traton subsidiary Navistar manufactures battery electric school buses under the IC Bus brand and Daimler subsidiary Thomas Built manufactures battery electric Saf-T-Liner C2 Jouley school buses. Registrations of electric school buses have propelled Traton and Daimler past all-electric bus manufacturers Lion Electric and BYD, which took third and fourth place, respectively, in the U.S. zero-emission bus market in both 2022 and 2023.

FIGURE 3

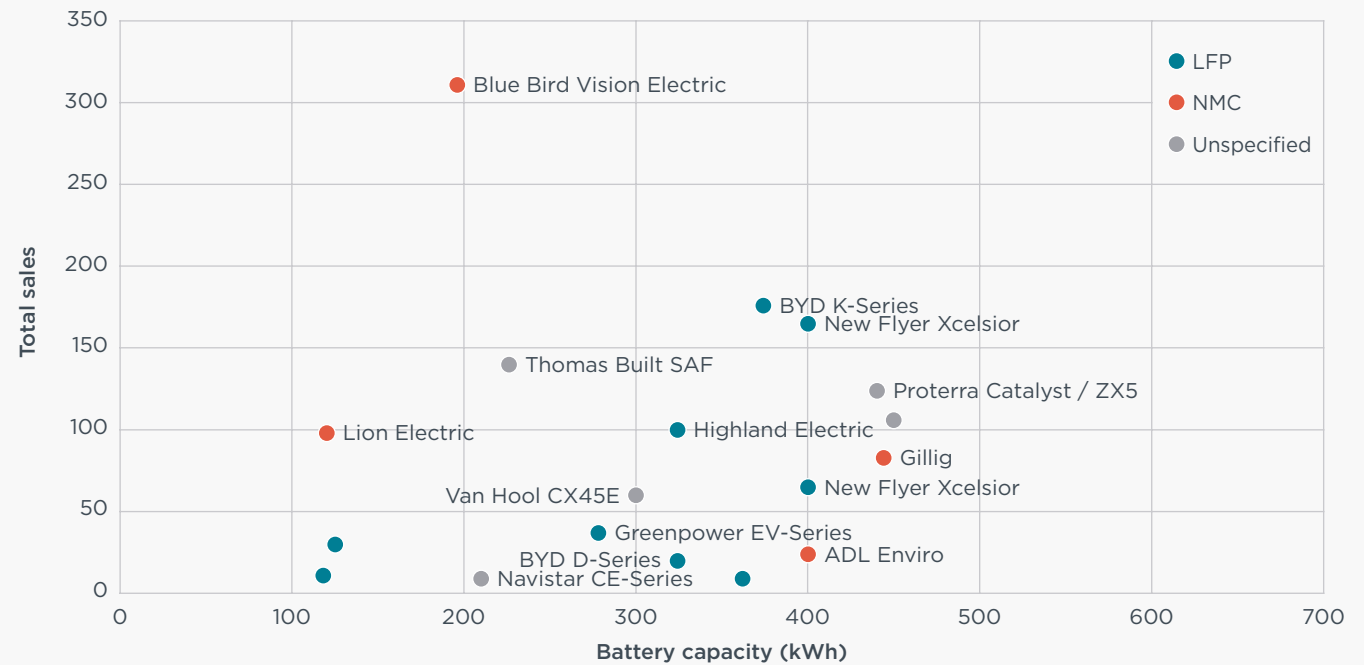
Internal combustion engine and zero-emission bus registration shares in the United States by manufacturer group



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New zero-emission buses sold in the United States in 2022 and 2023 have a mix of lithium nickel manganese cobalt oxide (NMC) and lithium iron phosphate (LFP) battery chemistries. BYD relies solely on LFP, while Blue Bird/Lion Electric uses NMC batteries. Proterra uses a mix of NMC and lithium titanate oxide, a less common battery chemistry. Battery capacities range from just above 100 kWh for short-distance shuttle buses to over 400 kWh for urban transit bus models.

FIGURE 4
Sales of zero-emission buses in the United States by model in 2022 and 2023 (combined) and by battery capacity



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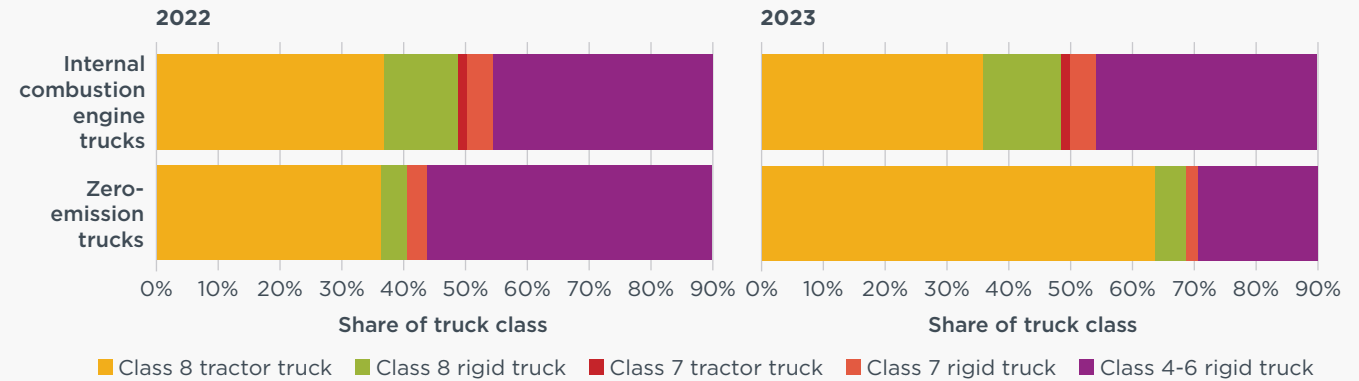
TRUCKS

From 2021 to 2022, new zero-emission heavy-duty truck registrations grew from 33 to 190, and new zero-emission medium-duty truck registrations surged from the single digits to 240. From 2022 to 2023, zero-emission heavy-duty truck registrations quadrupled to 760 and zero-emission medium-duty truck registrations remained about the same as in 2022. As a result of the recent market growth, zero-emission heavy-duty trucks were 0.28% all new heavy-duty truck registrations and zero-emission medium-duty trucks were 0.10% of all new medium-duty truck registrations in 2023.

The composition of classes in the ICE truck market remained largely the same between 2022 and 2023, but the makeup of the zero-emission market changed. Class 8 tractor trucks and Class 4–6 rigid trucks had the highest share of both ICE and zero-emission registrations. More than 70% of zero-emission trucks registered in 2023 were Class 8 tractors. Class 7 and Class 8 rigid trucks together were 18% (2022) and 19% (2023) of ICE truck registrations but only 8% (2022) and 9% (2023) of zero-emission truck registrations. There were no zero-emission Class 7 tractor trucks registered in 2022 or 2023.

FIGURE 5

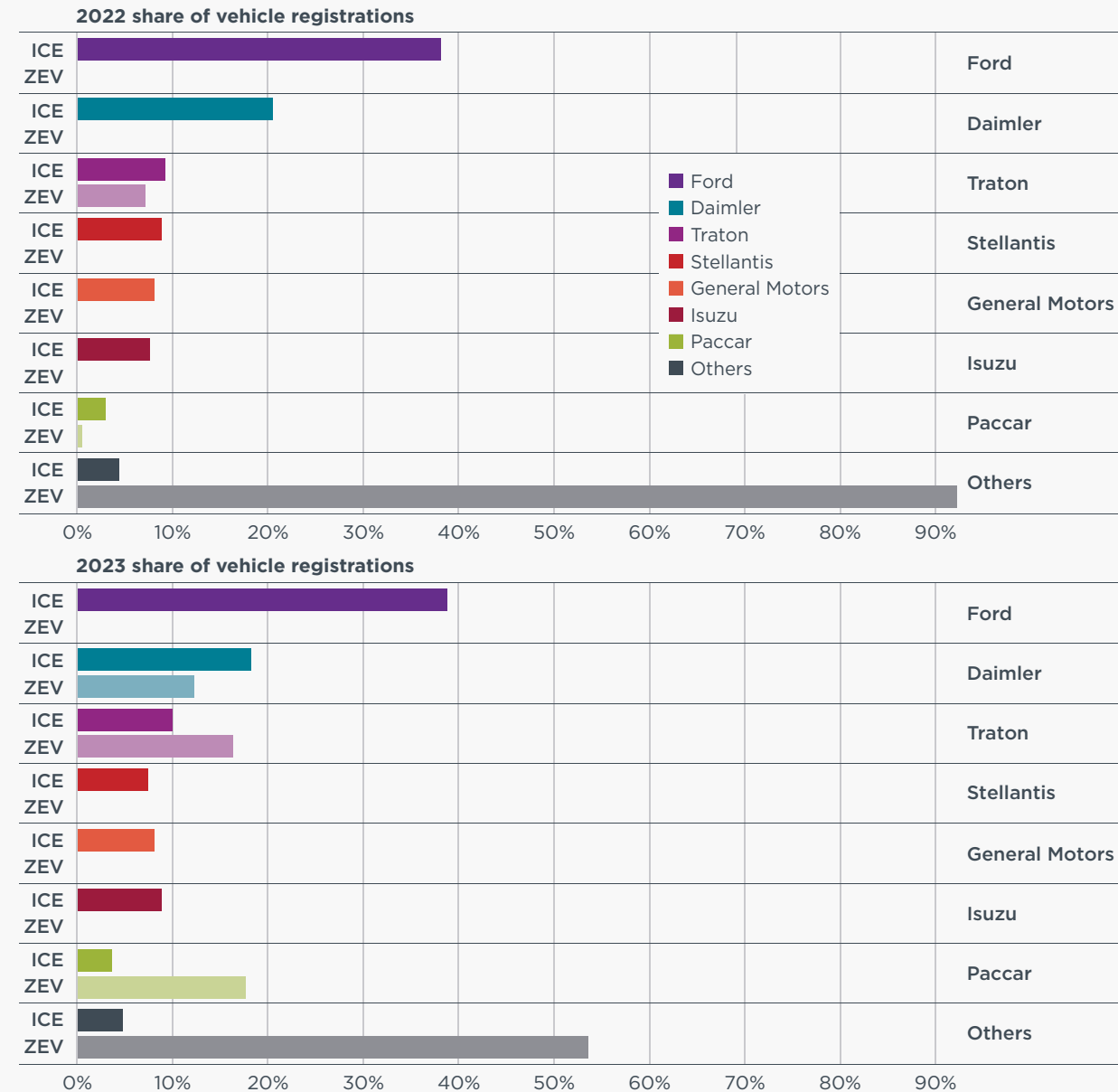
New medium- and heavy-duty truck registrations in the United States by vehicle class and powertrain



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More than 90% of zero-emission medium-duty truck registrations in 2022 had no manufacturer information listed in the data we accessed; ICE industry leaders Ford, Daimler, and Traton, which owns Navistar, were shown in this limited data to have low or nonexistent zero-emission registration shares. In 2023, more than half of registrations had no manufacturer information. Nonetheless, Daimler, Traton, and Paccar collectively accounted for 46% of the zero-emission medium-duty truck market, and all-electric manufacturer Lion Electric was responsible for 3% of registrations.

FIGURE 6
Internal combustion engine and zero-emission medium-duty truck registration shares in the United States by manufacturer group

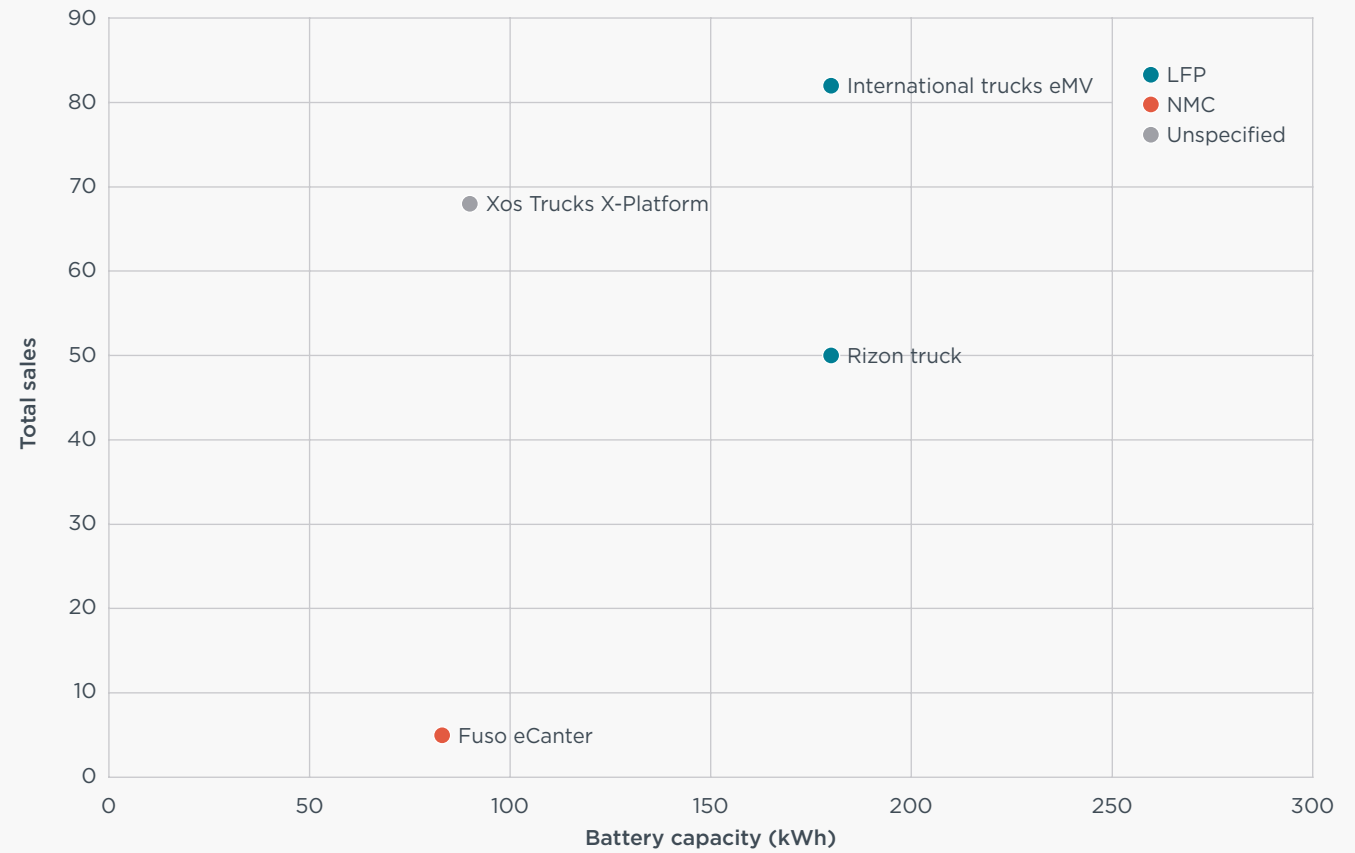


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Different manufacturers chose to use LFP and NMC batteries in their vehicles, with capacity ranging from under 100 kWh to 175 kWh.

FIGURE 7

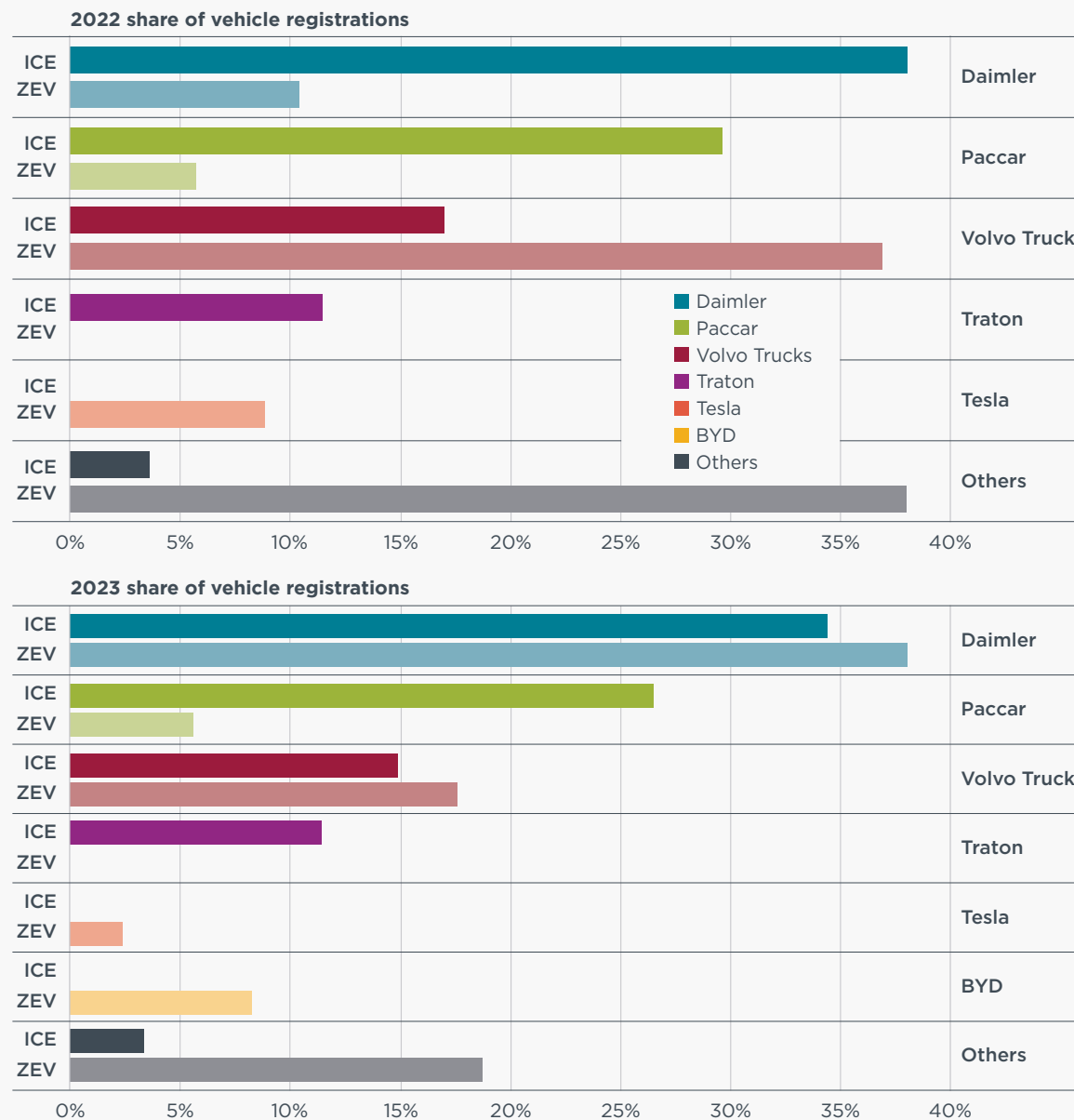
Sales of zero-emission medium-duty trucks in the United States by model in 2022 and 2023 (combined) and by battery capacity



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There was no manufacturer information available in the data for 38% of zero-emission heavy-duty truck registrations in 2022 and 19% of the registrations in 2023. Nikola began production and delivery of its Class 8 Tractor trucks in 2022, and registrations with missing manufacturer information may be attributable to this company. Nonetheless, in the heavy-duty truck market, the four largest ICE manufacturer groups in the data were Daimler, Paccar, Volvo Trucks, and Traton, and they collectively represented more than 95% of the market in both 2022 and 2023. The top three manufacturer groups were also active in the zero-emission market. In 2022, 37% of zero-emission heavy-duty truck registrations were Volvo Trucks products, 10% were Daimler, and 5% were Paccar. In 2023, the share of Daimler products increased to 42% of all zero-emission heavy-duty truck registrations; Volvo Trucks was in second place with 19%, and Paccar had the third-largest share with 6%. Tesla entered the zero-emission heavy-duty truck market with its Semi model, which accounted for 9% of registrations in 2022. Chinese manufacturer BYD had 9% registrations in 2023, outperforming both Paccar and Tesla.

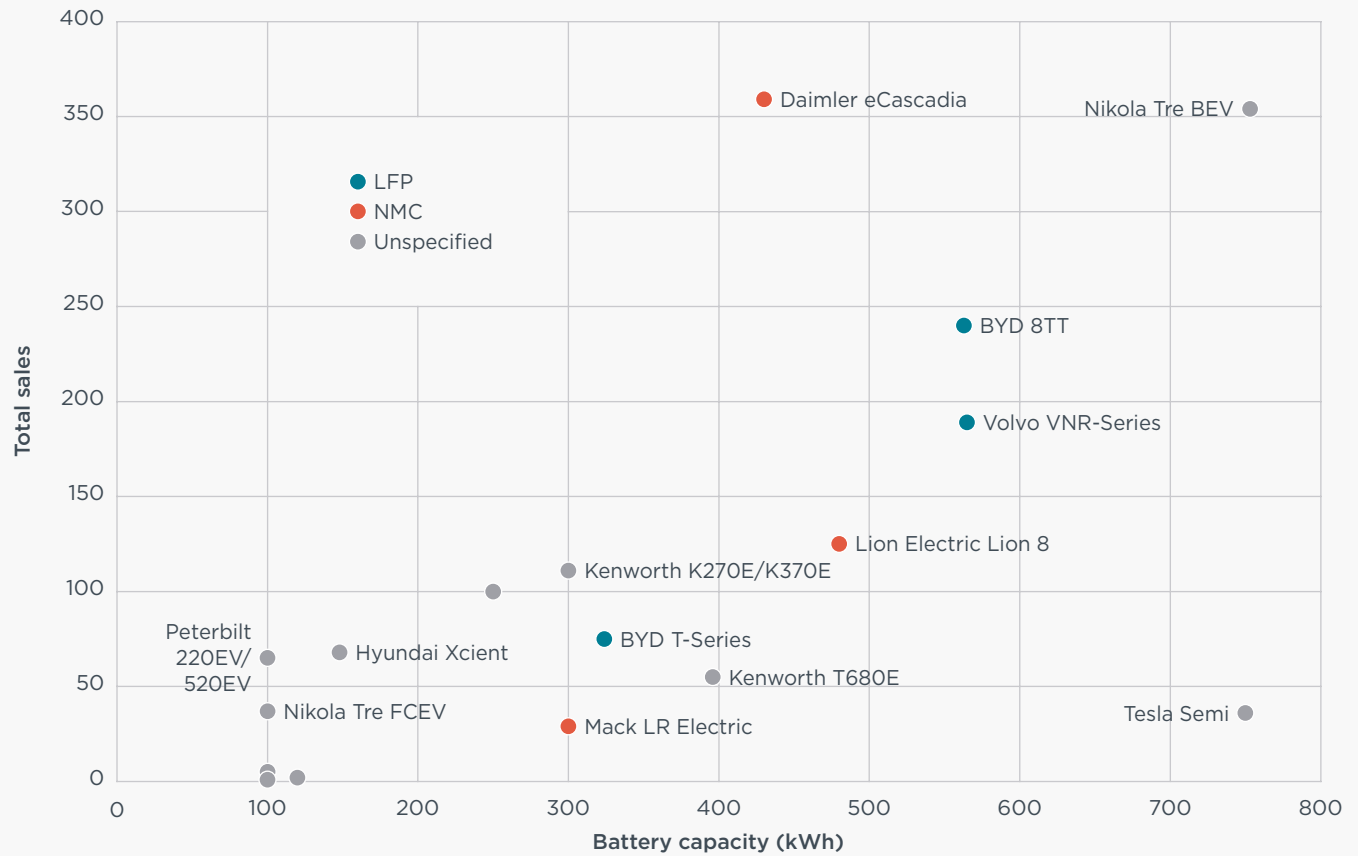
FIGURE 8
Internal combustion engine and zero-emission heavy-duty truck registrations share in the United States by manufacturer group



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There are a wide range of battery sizes in zero-emission heavy-duty trucks. Smaller batteries (100 kWh) were mostly found in hydrogen fuel cell truck models like Nikola’s hydrogen Tre model and Hyundai’s Xcient, as the primary energy for fuel-cell electric trucks comes from onboard hydrogen tanks. The largest-capacity batteries were found in battery electric long-haul tractor trucks like Nikola’s Tre model and Tesla’s Semi. Between the two extremes are drayage and regional-haul truck models, which use a mix of LFP and NMC battery chemistries.

FIGURE 9
Sales of zero-emission heavy-duty trucks in the United States by model in 2022 and 2023 (combined) and by battery capacity



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DEFINITIONS AND DATA SOURCES

Zero-emission vehicles: Any vehicle with a propulsion system that produces zero combustion emissions, such as a dedicated battery electric, fuel cell electric, or other motor that is not driven by combustion.

Heavy-duty vehicles: All vehicles with a gross vehicle weight rating above 14,001 lb, which correspond to Classes 4–8 in the National Highway Administration’s vehicle class definition.

Buses: All Class 4–8 buses and coaches.

Heavy-duty trucks: Class 8 trucks with a gross vehicle weight rating greater than 33,000 lb.

Medium-duty trucks and vans: Class 4–7 trucks and vans with a gross vehicle weight rating of 14,001–33,000 lb.

Class of truck	Gross vehicle weight rating (lb)	Gross vehicle weight rating (kg)	Classification in this Market Spotlight
4	14,001–16,000	6,350–7,257	Medium-duty trucks
5	16,001–19,500	7,258–8,845	
6	19,501–26,000	8,846–11,793	
7	26,001–33,000	11,794–14,968	
8	33,001+	14,968+	Heavy-duty trucks

DATA SOURCES

All zero-emission vehicle sales data and battery capacity data were sourced from EV-Volumes, <https://ev-volumes.com/>. Vehicle registration data were supplied by S&P Global Limited; Copyright © S&P Global Limited 2024. All rights reserved.

Individual vehicle model information was retrieved from the following:

Nikola Corporation, “Nikola Corporation Reports Fourth Quarter and Full Year 2023 Results,” <https://nikolamotor.com/nikola-corporation-reports-fourth-quarter-and-full-year-2023-results>

Jessica DiNapoli, “Tesla Semi Trucks in Short Supply for PepsiCo as Its Rivals Use Competing EV Big Rigs,” *Reuters*, April 19, 2024, <https://www.reuters.com/business/autos-transportation/tesla-semi-trucks-short-supply-pepsico-its-rivals-use-competing-ev-big-rigs-2024-04-19/>

Navistar, “The Next Generation IC Bus® CE Series Bus,” <https://www.icbus.com/buses/school/ceseries#;>

Thomas Built Buses, “Saf-T-Liner® C2 Jouley® Electric School Bus,” <https://thomasbuiltbuses.com/school-buses/saf-t-liner-c2-jouley/>



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