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# RACE TO ZERO

## How manufacturers are positioned for zero emission commercial trucks and buses in North America

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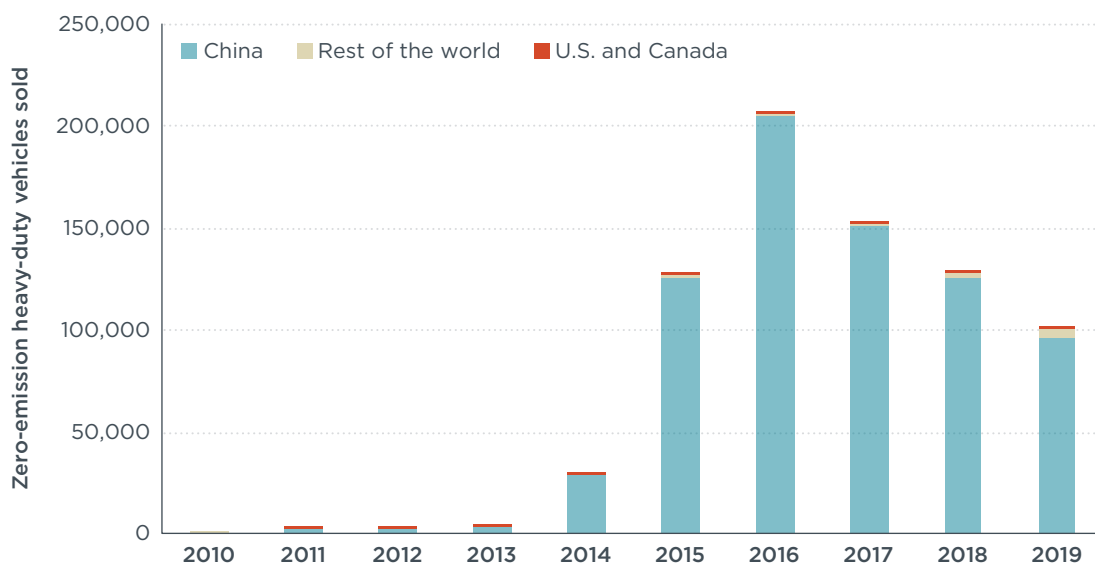
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## INTRODUCTION

While passenger cars have led the way on the vehicle electrification front, commercial trucks and buses are the next wave in the global transition to electric mobility. With a growing number of governments and corporations committing to fully decarbonize the economy by midcentury, the race to bring zero-emission heavy-duty vehicles (HDVs) to market is quickly heating up.

As shown in Figure 1, international production and sales of zero-emission HDVs is dominated by China. Data in the figure are sourced from EV-Volumes.com and include on-road trucks and buses with a gross vehicle weight rating of 3,500 kg (7,716 lbs.) or more.<sup>1</sup> Globally, zero-emission HDV sales were less than 3,000 units per year through 2013, before growing to nearly 30,000 in 2014, and quickly jumping to over 200,000 in 2016. After peaking in 2016, sales decreased in 2017 and 2018. In 2019, there were just over 100,000 zero-emission HDVs sold worldwide, and roughly 95% of these were delivered in China by Chinese manufacturers. Since 2010, 82% of the approximately 760,000 cumulative zero-emission HDVs sold through 2019 have been buses and shuttles, with trucks representing the remaining 18%. Over that same time period, battery-electric HDVs accounted for 99.7% of zero-emission sales, with fuel cell vehicles making up the remaining 0.3%.



**Figure 1.** Global zero-emission heavy-duty vehicle sales, 2010 to 2019.

In the United States and Canada, the market for zero-emission HDVs is nascent, with nearly 600 units sold in 2019—up from under 100 units in 2015. As shown in Figure 1, the combined sales in the United States and Canada (shown in red) have made up a small portion of the global market through the end of 2019. However, over the past 5 years, commercial activity in HDV electrification in North America has surged, as dozens of manufacturers across the industry have made significant investments to bring zero-emission products to market.

<sup>1</sup> EV-Volumes.com (Zero-emission commercial vehicle sales, acquired February 27, 2020), <http://www.ev-volumes.com>.

This paper summarizes the new vehicle sales market for Class 2 through Class 8 heavy-duty truck and buses in the United States and Canada.<sup>2</sup> In addition, we profile the early market for zero-emission HDVs by providing a snapshot of the various battery-electric and hydrogen fuel cell products available across different truck and bus segments.

Summaries of the overall sales market for new HDVs with are broken down by original equipment manufacturer (OEM) and fuel/technology type. Sales are for the combined U.S. and Canada market, and data for this section are for model year (MY) 2019 and sourced from IHS Markit.<sup>3</sup> As the emerging zero-emission truck and bus market is very dynamic with new zero-emission products being announced on nearly a weekly basis, we aim to summarize the current set of models that are being prototyped or deployed commercially as of July 2020. Appendices A (Class 4 to 8 trucks), B (Class 2B and 3 trucks), and C (buses)<sup>4</sup>, provide brief synopses of the leading legacy OEMs in the North American market, and Appendix D profiles several zero-emission HDV manufacturers who are currently offering commercial products on the market.

Appendices A, B, and C capture each of the OEMs with a combined U.S. and Canada market share of 3% or more across all fuel and technology types in the respective vehicle groupings. Appendix D includes all of the zero-emission manufacturers that sold at least 10 units in 2019 per data from EV-Volumes.com. Finally, the two tables in Appendix E list the zero-emission truck (Table E1) and bus (Table E2) models that are currently available or have been announced by manufacturers as coming to market in the next 1 to 2 years.

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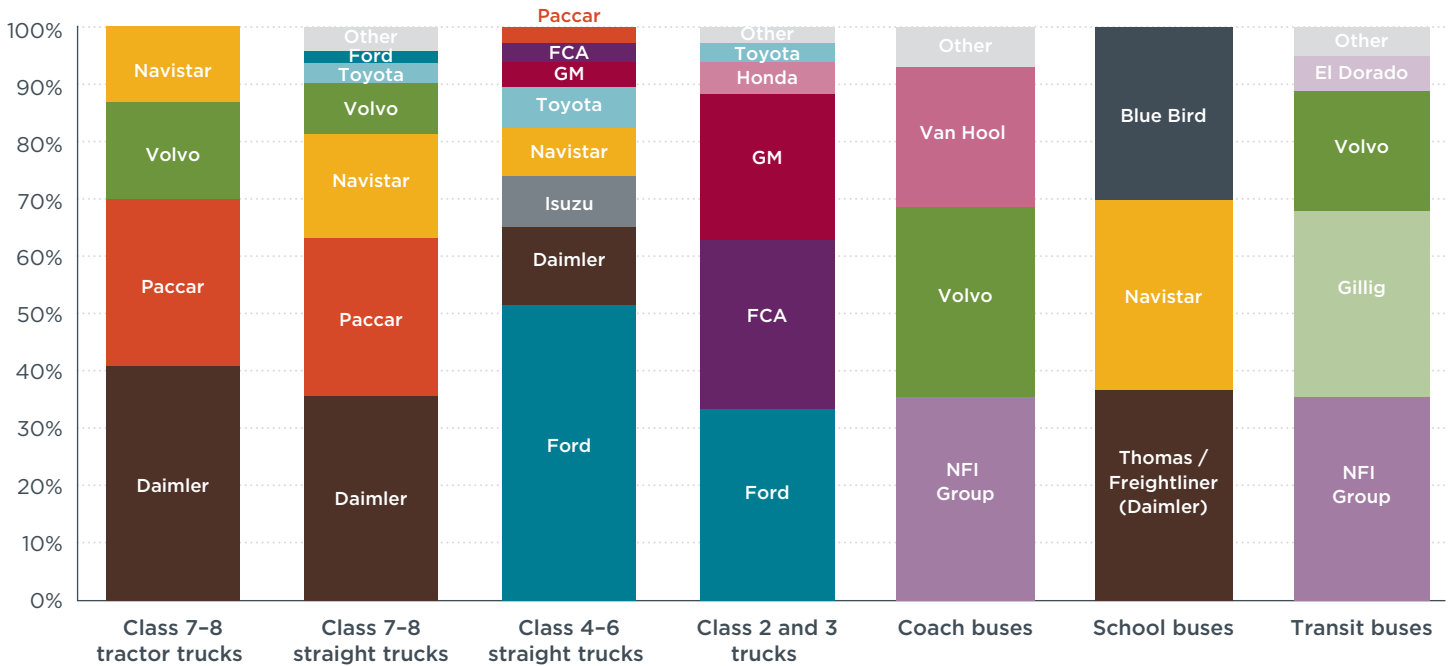
2 The IHS-Markit data does not break out Class 2A (6,001 to 8,500 lbs. gross vehicle weight rating (GVWR)) from Class 2B (8,501 to 10,000 GVWR) vehicles. However, sport utility vehicles (“SUVs”) are designated in the data and are excluded from this analysis.

3 IHS Markit (On-road commercial truck and bus sales in model year 2019, acquired June 10, 2020), <http://www.ihsmarket.com>.

4 Buses in the “BUS NON SCHOOL” category in the IHS Markit dataset are designated as transit or coach bus models based on information available from manufacturers’ websites.

## HEAVY-DUTY VEHICLE MARKET IN THE UNITED STATES AND CANADA

Figure 2 shows the manufacturer market shares for the combined United States and Canada market for various model year 2019 truck and bus segments. In each bar in the figure, HDV sales are aggregated by the corporate parent. Table 1 lists all the corporations that serve the North American market and the brands or subsidiary companies that are active within each vehicle segment. This table only includes legacy OEMs—not the startups that focus on zero-emission products. Note that this table does not include Ford, Isuzu, Blue Bird, Gillig, and Van Hool, as none of these OEMs have subsidiary companies that make up a significant portion of their sales in the HDV market.



**Figure 2:** Corporate parent market shares of heavy-duty truck and bus manufacturers in the United States and Canada in model year 2019. Market share data is based on IHS Markit TIPNet U.S. and Canada new registrations for model year 2019 trucks and buses through calendar year 2019.<sup>5</sup>

<sup>5</sup> Buses in the “BUS NON SCHOOL” category in the IHS Markit dataset are designated as transit or coach bus models based on information available from manufacturers’ websites.

**Table 1:** Corporate parents and their subsidiary brands and companies by vehicle segment

Corporate parent	Class 7-8 tractor trucks	Class 6 – 8 refuse trucks	Class 4 – 6 trucks	Class 2 & 3 trucks	Coach buses	School buses	Transit buses
Daimler		Freightliner Western Star				Thomas Built Buses	
Paccar		Kenworth Peterbilt					
Navistar		International				IC Bus	
Volvo Group	Volvo Trucks Mack Trucks				Volvo Bus; Prevost		Nova Bus
General Motors				Chevrolet GMC			
Fiat Chrysler Automobiles				Ram			
Toyota Group				Hino			
NFI Group					Motor Coach Industries		New Flyer

In terms of units sold in 2019 for the entire HDV market, including trucks and buses, Ford is the largest OEM, with a 31% market share, followed by Daimler (21%), Paccar (12%), GM (10%), Navistar (9%), and Volvo (6%). The far-left column in Figure 2 summarizes the market shares for Class 7 and 8 tractor trucks. Daimler is the market leader for tractor truck sales with just over 40% of the market, followed Paccar (29%), Volvo (17%), and Navistar (13%). For Class 7 and 8 straight (i.e., non-tractor or “rigid”) trucks, Daimler (36%), Paccar (28%), Navistar (18%), and Volvo (9%) account for 90% of the market, with Toyota, Ford, and several other companies accounting for 3% or less of sales. Representing over half of the market, Ford is the dominant OEM in the Class 4 – 6 truck segment. Daimler (14%) holds the second spot in this segment, and Isuzu, Navistar, Toyota, GM, FCA, and Paccar each account for between 3% and 9% of sales.

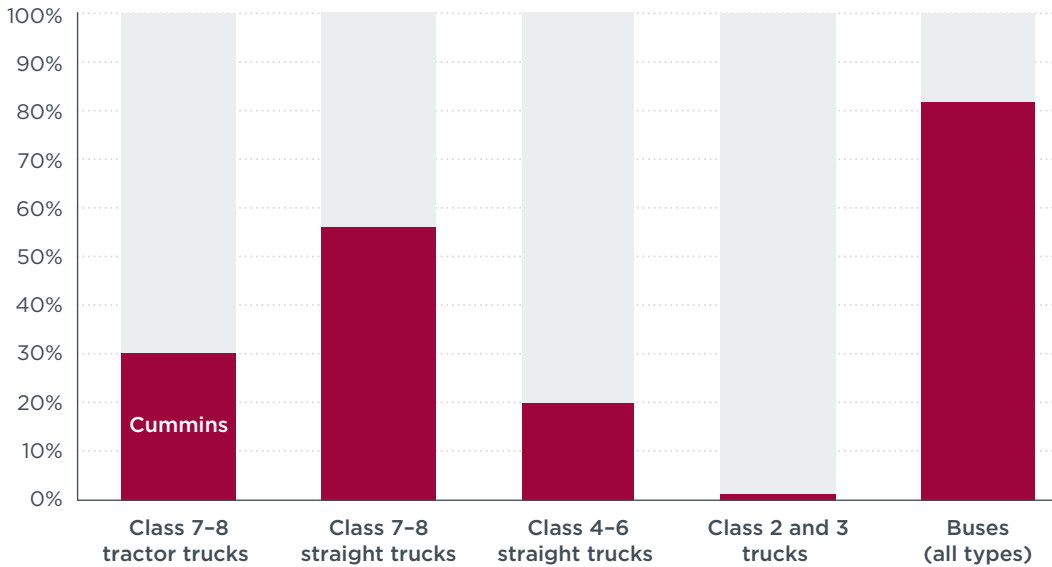
The Class 2 and 3 market is dominated by Ford, FCA, and GM, who each account for about 30% of sales.<sup>6</sup> Three subsegments of buses included in this analysis—coaches, school, and transit—are summarized on the right three bars. For coaches, NFI Group (36%), Volvo (33%), and Van Hool (24%) together make up over 90% of the market. The school bus market is primarily comprised of three companies—Daimler, Navistar, and Blue Bird—who each represent about one-third of total sales. In the transit market, NFI Group (36%), Gillig (32%), and Volvo (21%) are the largest manufacturers, combining to account for nearly 90% of bus sales.<sup>7</sup>

Cummins, an independent engine and powertrain manufacturer, has a significant presence in the commercial truck and bus markets in the United States and Canada. In general, there is a great deal of customization in the HDV market in North America, and end users are typically able to specify a wide range of vehicle features and subsystems. Particularly for Class 4 through 8 trucks, as well as with buses, fleet customers can select the engine manufacturer—generally this is a choice between a Cummins engine

6 Note that the IHS Markit data referenced in this section do not make the distinction between Class 2A (less than 8,500 lbs. gross vehicle weight) and Class 2B (greater than 8,500 lbs. GVW) trucks, so a significant portion of the Class 2 vehicles are technically light-duty vehicles. This analysis does not include sport utility vehicles (SUVs).

7 Buses in the “BUS NON SCHOOL” category in the IHS Markit dataset are designated as transit or coach bus models based on information available from manufacturers’ websites.

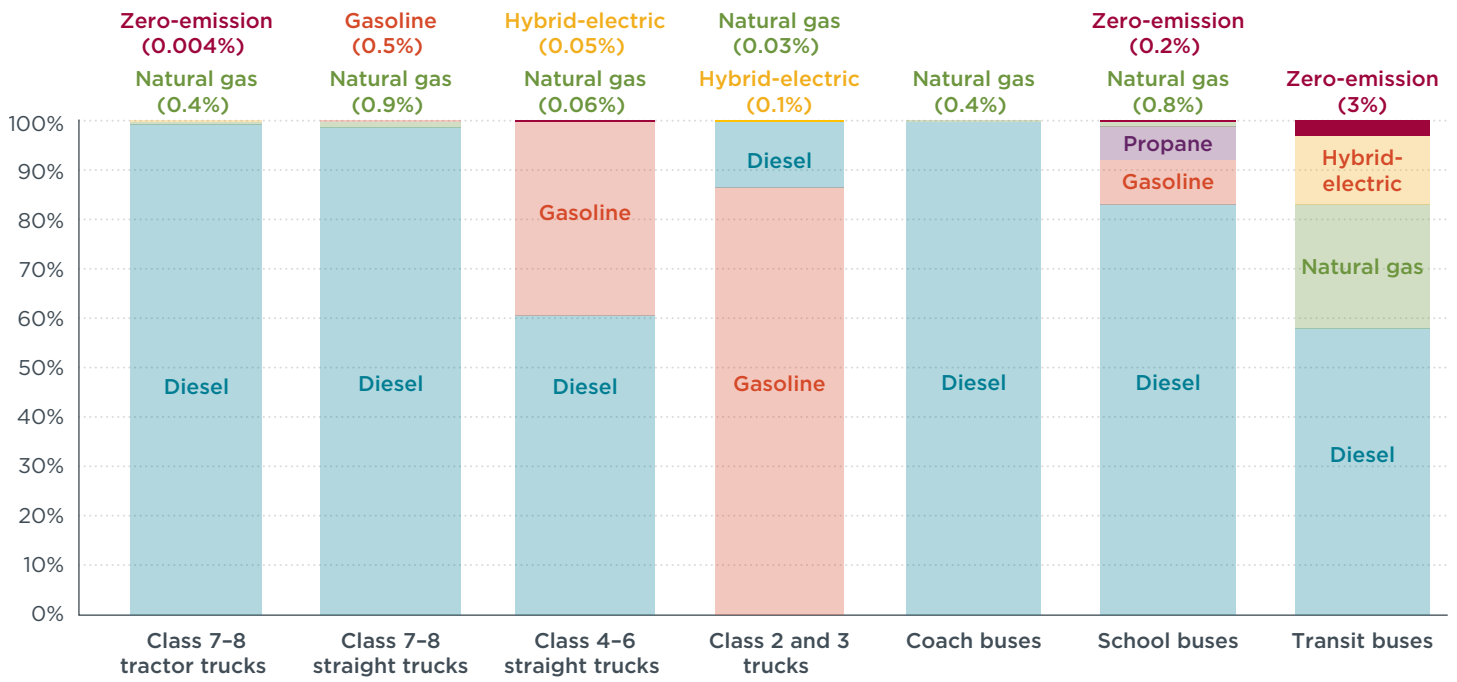
and an engine from the OEM that makes the vehicle or chassis. Figure 3 summarizes Cummins' market share across several truck and bus segments. Cummins accounts for roughly 30%, 55%, and 20% of the Class 7 and 8 tractor, Class 7 and 8 straight truck, and Class 4 through 6 engine sales, respectively. Commercial buses are the segment where Cummins has its largest market share, as they represent over 80% of total engine sales.



**Figure 3:** Cummins' share of the engine manufacturing market in various truck and bus segments in the United States and Canada in model year 2019. Market share data is based on IHS Markit TIPNet U.S. and Canada new registrations for model year 2019 trucks and buses through calendar year 2019.

Figure 4 shows the breakdown of fuel and technology types for the HDV segment. Conventional diesel and gasoline vehicles dominate the commercial truck market, together accounting for over 99% of sales. Alternative fuel, hybrid-electric, and zero-emission HDVs each make up a small fraction of a percentage, with the exception being natural gas trucks, which account for nearly 1% of Class 4 through 8 sales. Coach and school buses are also almost exclusively powered by fossil fuel internal combustion engines, though propane is the leading alternative fuel for school buses, with a 7% market share. In 2019, there were no zero-emission coaches sold in the United States and Canada. The roughly 70 battery-electric school buses sold in 2019 represent 0.2% of total sales. In contrast, alternative fuels and advanced technologies make up a significant portion of transit bus sales—over 40% of the market. Natural gas (25%) and diesel hybrid-electric (14%) buses have a stronghold in the transit market, and zero-emission buses made up 3% of 2019 sales.



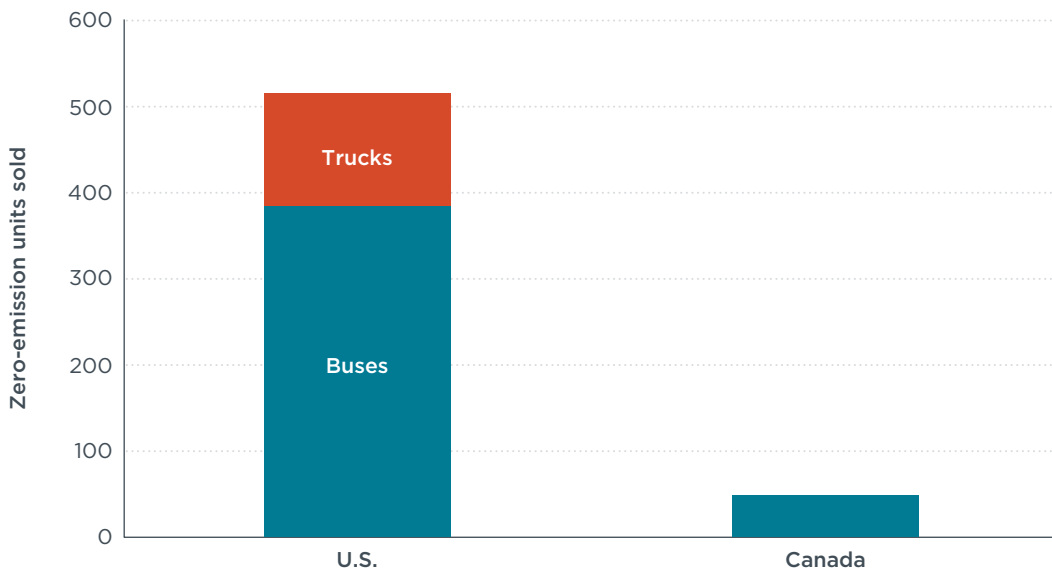


**Figure 4:** Fuel and technology market shares for heavy-duty trucks and buses in the United States and Canada in model year 2019. Market share data is based on IHS Markit TIPNet U.S. and Canada new registrations for model year 2019 trucks and buses through calendar year 2019.<sup>8</sup>

<sup>8</sup> Buses in the “BUS NON SCHOOL” category in the IHS Markit dataset are designated as transit or coach bus models based on information available from manufacturers’ websites.

## ZERO-EMISSION TRUCK AND BUS MARKET

Figure 5 shows the zero-emission truck and bus sales in the United States and Canada in 2019.<sup>9</sup> Altogether, there were about 440 zero-emission buses sold, and nearly 90% of these units were delivered in the United States, with the remaining 10% in Canada. Of these buses, roughly 430 of these are battery powered, with the remaining 10 being prototype hydrogen fuel cell buses currently being tested in pilot projects.



**Figure 5:** Zero-emission truck and bus sales in the United States and Canada in 2019.

Figure 6 shows the zero-emission bus and truck sales totals by manufacturer for companies with at least 10 models sold in 2019 in the United States and Canada. With roughly 200 buses sold in 2019, Proterra is the early zero-emission market leader, representing 35% of the total HDV market and over 45% of bus sales. BYD, New Flyer (NFI Group), and Daimler sold about 80 units each in 2019. With sales of over 50 battery-electric buses and almost 30 battery-electric trucks in 2019, BYD was the only manufacturer to have a significant standing in both the zero-emission bus and truck markets. Rounding out the top five in terms of total zero-emission HDV units sold was GreenPower, who sold about 70 battery-electric buses in 2019. Lion Electric, Paccar, and Blue Bird each sold 15 units or less in 2019.

<sup>9</sup> Data from EV-Volumes.com, On-road zero-emission commercial truck and bus sales in calendar year 2019, retrieved February 20, 2020, <http://www.ev-volumes.com>.

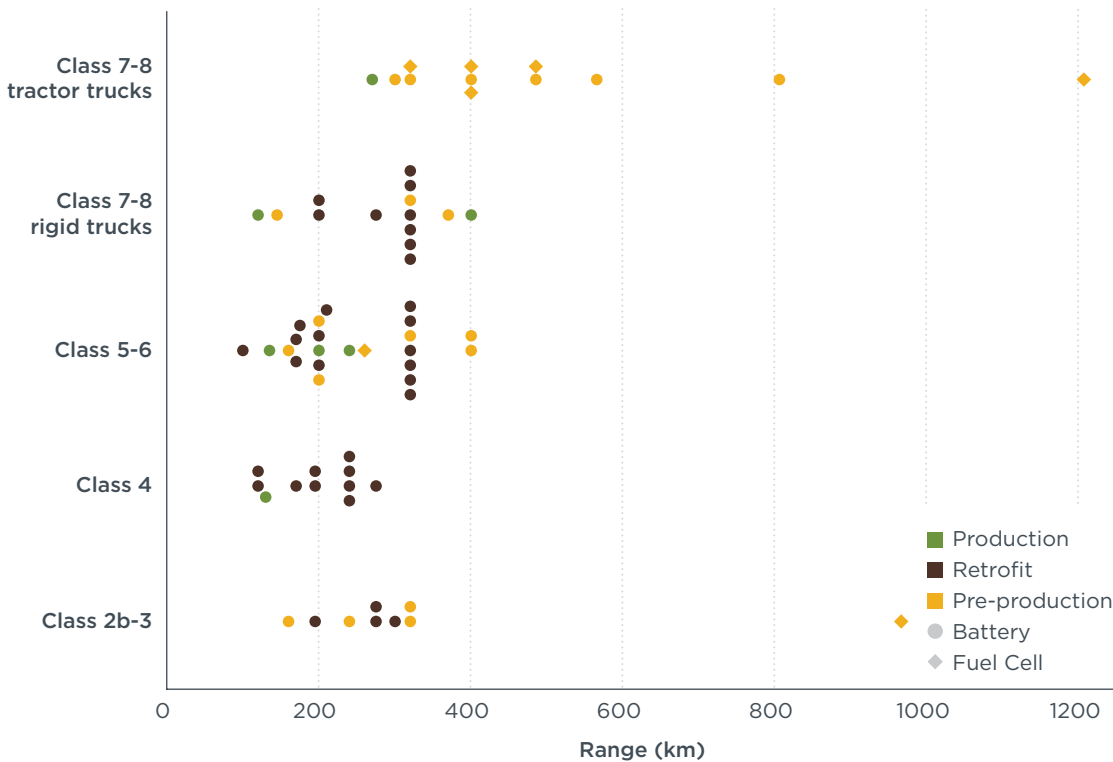


**Figure 6:** Zero-emission bus and truck sales in the United States and Canada for manufacturers with more than 10 units sold in 2019.

Figures 7 and 8 (and Tables E1 and E2 in Appendix E) summarize the zero-emission truck and bus models in the North American market. The figures show vehicle segments on the y-axis and manufacturer-stated maximum driving range on the x-axis. Each data point represents an individual zero-emission vehicle model. Green points are vehicle models currently offered by OEMs, while brown represents chassis models that can be upfitted with zero-emission powertrains. Yellow points represent vehicles which are not yet available for purchase and are either prototypes or are expected to be commercialized within the next one to two years. As a simplification, this group includes vehicle models that are in various stages of the pre-production phase—that is, before the model is available for customer purchase. This ranges from early prototypes to vehicle models that are currently under customer testing in real-world operations. For additional information about the vehicle models represented by each data point, see Appendices A through D. Battery-electric and hydrogen fuel cell vehicles are denoted with circles and diamonds, respectively.

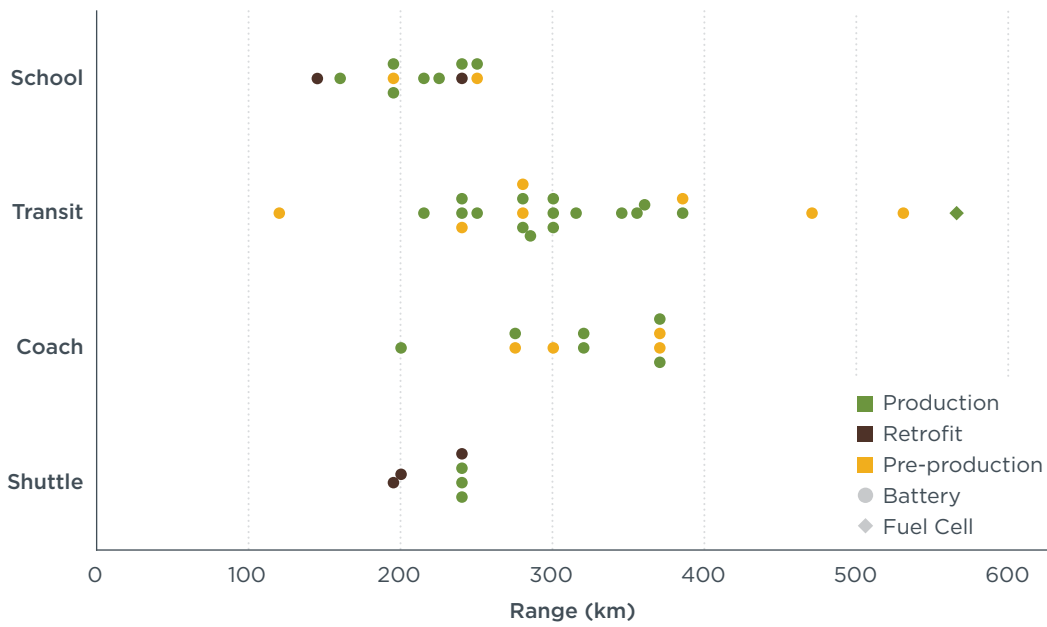
As shown in Figure 7, there is a large cluster of zero-emission models commercially available for Class 4 through 8 rigid trucks. Nearly all of these trucks are battery-powered, and maximum driving ranges are between 150 km and 400 km (roughly 90 to 250 miles). For Class 2B and 3 trucks, there are a few models with battery-electric powertrains that customers can currently order from startup companies that modify chassis from legacy OEMs to have electric components. However, zero-emission

products from OEMs are not yet available for purchase in the Class 2B and 3 segments. For Class 7 and 8 tractor trucks, there are only a limited number of battery-electric models for sale at present, but several other battery-electric and hydrogen fuel cell models with longer range capabilities are expected to reach the market over the next few years.



**Figure 7:** Available and announced zero-emission truck models in the United States and Canada.

The snapshot of available zero-emission bus models in Figure 8 shows that there are multiple models commercially available today across the various bus types. The transit segment has the most number of models, as well as the largest spread in terms of driving range—from about 100 km to over 500 km (roughly 60 to 310 miles).



**Figure 8:** Available and announced zero-emission bus models in the U.S. and Canada.

Table 2 summarizes zero-emission model availability by manufacturer and vehicle segment. The manufacturers are categorized into three groups: legacy OEMs, who represent the vast majority of the current HDV market; zero-emission vehicle manufacturers and start-ups that offer or plan to offer complete vehicles to end-users; and zero-emission powertrain suppliers, which are companies that integrate their energy storage and electric power systems into vehicle chassis platforms from legacy OEMs.

**Table 2:** Zero-emission model availability by manufacturer and heavy-duty vehicle segment.

	Corporate parent company	Class 7-8 tractor trucks	Class 6 - 8 refuse trucks	Class 4 - 6 trucks	Class 2B - 3 trucks & vans	Coach buses	School buses	Transit buses
Legacy OEMs	Daimler						Proterra	
	Ford			LightningElectric Motiv Phoenix Motors SEA Electric				
	Paccar	Meritor	Meritor Dana	Dana				
	Navistar			Volkswagen			Volkswagen	
	Volvo Group							BAE Systems; Dana TM4
	Isuzu			SEA Electric	SEA Electric			
	General Motors	x						
	Fiat Chrysler Automobiles							
	Toyota Group			SEA Electric				
	Hyundai							
	Autocar							
	Cummins (engines and powertrains)						x	x
	Blue Bird						Cummins	
	NFI Group						Siemens	Siemens Ballard
	Gillig							Cummins
	Van Hool						Proterra	
Zero-emission vehicle manufacturers	Proterra			x		x	x	
	BYD							
	GreenPower						Siemens	
	Lion Electric	Dana TM4	Dana TM4					
	Chanje							
	Xos							
	Tesla							
	Nikola							
Zero-emission powertrain suppliers	SEA Electric			x	x			
	Motiv			x				
	Dana / Nordresa			x				
	Lightning Systems			x	x			
	Phoenix Motors			x			x	
	Ballard (hydrogen fuel cell)	x						x

**Notes:**

**Green** - Manufacturer has at least one zero-emission model currently available for purchase

**Yellow** - Manufacturer has announced plans and timeframe for zero-emission product commercialization; prototypes or customer testing

**Red** - No zero-emission products have been announced to date

x - Company provides its zero-emission powertrain to another manufacturer for a vehicle model in that respective segment

## CLASS 7 AND 8 TRACTOR TRUCKS

Out of the four OEMs that account for virtually all tractor truck sales, Navistar is the only company that has not released a prototype zero-emission model or announced plans to bring a product to market. Freightliner (Daimler), Peterbilt (Paccar), and Volvo have already started putting their battery-electric tractor trucks into service for customer testing and pilot programs, and all three companies have announced plans to ramp up production and commercialization over the next year.

In addition to the four market-leading OEMs, several other legacy and zero-emission vehicle manufacturers have been active in developing prototypes and first-generation commercial products. Toyota and Kenworth (Paccar) are collaborating on the development and deployment of ten hydrogen fuel cell trucks in the Port of Los Angeles, a pilot project that began in the spring of 2019.<sup>10</sup> Hyundai is also working to commercialize hydrogen fuel cell technology for freight tractors, although the company has announced that it is targeting Europe for the initial launch of its XCIENT model.<sup>11</sup> Cummins released a battery-electric concept truck in 2017, although the company has not announced any plans to bring the truck to market.<sup>12</sup> In addition to its battery-electric powertrain offerings, Cummins has made significant investments in fuel cell technology and introduced a hydrogen-powered concept truck in October 2019.<sup>13</sup> Cummins acquired hydrogen fuel cell manufacturer Hydrogenics in June 2019 and has invested heavily in Loop Energy, a provider of fuel cell range extender for heavy-duty trucks.<sup>14</sup>

Two zero-emission vehicle manufacturers, BYD and Lion Electric, are currently offering battery-electric tractor trucks. BYD's 8TT model and Lion Electric's Lion8 are designed for regional haul and drayage applications and began real-world fleet operations in the past year.<sup>15</sup> Tesla, the leading manufacturer of all-electric passenger cars in North America, is working to bring its battery-electric Semi tractor to market by 2021.<sup>16</sup> In addition to Tesla, Nikola Motor Company is also bringing highly anticipated zero-emission products to market in 2021, though Nikola will be offering its trucks with the choice of a batteries or hydrogen as the primary energy source.<sup>17</sup> On September

10 "The Kenworth T680 with Integrated Toyota Hydrogen Fuel Cell Technology Stars at Port of Los Angeles," Paccar Inc., updated April 23, 2019, <https://kenworth.com/news-releases/2019/april/kenworth-toyota-pola/>.

11 "Hyundai Rolls Out Neptune Fuel-Cell Truck Concept," WardsAuto, updated November 1, 2019, <https://www.wardsauto.com/alternative-propulsion/hyundai-rolls-out-neptune-fuel-cell-truck-concept>.

12 "Cummins Unveils Next Generation of Energy-Diverse Products and Technology Solutions," Cummins Inc., updated August 29, 2017, <https://www.cummins.com/news/releases/2017/08/29/cummins-unveils-next-generation-energy-diverse-products-and-technology>.

13 Jack Roberts, "Cummins Showcases Hydrogen Fuel Cell Concept Truck," *Truckinginfo*, October 31, 2019, <https://www.truckinginfo.com/343699/cummins-showcases-hydrogen-fuel-cell-concept-truck>.

14 "Cummins To Acquire Hydrogenics," Cummins Inc., updated June 28, 2019, <https://www.cummins.com/news/releases/2019/06/28/cummins-acquire-hydrogenics>; Cummins Increases Investment in Loop Energy and Fuel Cells for Commercial Transport Applications," Cision Canada, updated March 24, 2020, <https://www.newswire.ca/news-releases/cummins-increases-investment-in-loop-energy-and-fuel-cells-for-commercial-transport-applications-883485953.html>.

15 "BYD Delivers 100th Battery-Electric Truck in the United States," BYD Motors Inc., updated January 8, 2020, <https://en.byd.com/news-posts/byd-delivers-100th-battery-electric-truck-in-the-united-states/>; Fred Lambert, "Lion unveils all-electric class 8 truck, will deliver emission-free booze," *Electrek*, March 12, 2019, <https://electrek.co/2019/03/12/lion-electric-class-8-truck/>.

16 "Tesla Delays Electric Class 8 Truck to 2021," *Truckinginfo*, updated April 30, 2020, <https://www.truckinginfo.com/357366/tesla-delays-electric-class-8-to-2021>.

17 Deborah Lockridge, "Nikola Going Public, Expects U.S. Electric Truck Production to Start Next Year," *Truckinginfo*, March 3, 2020, [https://www.truckinginfo.com/352314/nikola-going-public-expects-u-s-electric-truck-production-to-start-next-year?utm\\_source=website&utm\\_medium=contentoffers&utm\\_campaign=072120](https://www.truckinginfo.com/352314/nikola-going-public-expects-u-s-electric-truck-production-to-start-next-year?utm_source=website&utm_medium=contentoffers&utm_campaign=072120).

8, 2020, General Motors (GM) and Nikola announced a strategic partnership.<sup>18</sup> General Motor's \$2 billion USD investment gives them an 11% stake in Nikola. For Class 7 and 8 trucks, GM will be the exclusive global (outside of Europe) supplier of fuel cell systems. Their partnership also includes the design and production of zero-emission pickup trucks, as discussed in the Class 2B and 3 trucks section below.

## CLASS 6 THROUGH 8 REFUSE TRUCKS

Three OEMs—Mack (Volvo Group), Peterbilt (Paccar), and Autocar—are the sole legacy manufacturers of refuse trucks in the United States and Canada. Both Mack and Peterbilt introduced battery-electric models in early 2020, while Autocar has not yet announced plans to bring a zero-emission product to market.<sup>19</sup> Mack recently announced that customer orders for their battery-electric LR Electric refuse truck will begin in the fourth quarter of 2020, with deliveries starting in 2021.<sup>20</sup>

BYD and Lion Electric are the only zero-emission vehicle manufacturers that have brought refuse trucks to the market. However, Nikola will be entering refuse market in the coming years and recently announced a customer order for 2,500 battery-electric trucks and that delivery and testing will begin in 2022.<sup>21</sup>

## CLASS 4 THROUGH 6 TRUCKS

Across the heavy-duty truck market, the Class 4 through 6 segments have seen the most activity on zero-emission products in terms of the diversity of makes and models available. Virtually all the battery-electric trucks in these segments are designed to perform urban and regional delivery applications. By having predictable routes and vehicles that typically return to the same base every day, urban delivery is one of the segments that is most conducive for truck electrification. Moreover, trucks that operate in and around cities often have high visibility by the public, which is helpful for fleets and manufacturers looking to promote their commitment to environment sustainability. Of the legacy OEMs selling Class 4 through 6 trucks, GM and FCA are the only companies that have not formally announced plans to launch zero-emission products.

Zero-emission vehicle manufacturers BYD, Chanje, and Xos are offering battery-electric delivery trucks in this weight range. All of the zero-emission powertrain suppliers (SEA Electric, Motiv, Dana/Nordresa, Lightning Systems, and Phoenix Motors) are using custom chassis from legacy OEMs—Ford, Isuzu, and Hino (Toyota Group)—to offer battery-powered trucks and step vans.

## CLASS 2B AND 3 TRUCKS

Zero-emission product development from the dominant legacy OEMs in this segment (i.e., Ford, GM, and FCA) has been limited to date. While Ford and GM have announced

18 "Nikola And General Motors Form Strategic Partnership; Nikola Badger To Be Engineered And Manufactured By General Motors," General Motors, updated September 8, 2020, <https://investor.gm.com/news-releases/news-release-details/nikola-and-general-motors-form-strategic-partnership-nikola>.

19 John Hitch, "Mack's new electric truck to clear NYC trash without polluting air," *FleetOwner*, January 10, 2020, <https://www.fleetowner.com/equipment/article/21120199/macks-new-electric-truck-to-clear-nyc-trash-without-polluting-air>; "Pete shows off 3 electric trucks going into production in 2020", Bulk Transporter, updated October 30, 2019, <https://www.bulktransporter.com/equipment/trucks/article/21658299/pete-shows-off-3-electric-trucks-going-into-production-in-2020>.

20 "Mack LR Electric to Begin Production in 2021," Mack Trucks, updated September 16, 2020, <https://www.macktrucks.com/mack-news/2020/mack-lr-electric-to-begin-production-in-2021/>.

21 "Nikola Receives Landmark Order of 2,500 Battery-Electric Waste Trucks from Republic Services," Nikola Corporation, updated August 10, 2020, [https://nikolamotor.com/press\\_releases/nikola-receives-landmark-order-of-2500-battery-electric-waste-trucks-from-republic-services-91](https://nikolamotor.com/press_releases/nikola-receives-landmark-order-of-2500-battery-electric-waste-trucks-from-republic-services-91).



plans to bring all-electric pickup trucks to the market in the next two years, these will be light-duty models, and it is unclear whether the companies have plans to develop zero-emission products for the Class 2B and 3 segments. In the commercial van space, Ford is planning to offer a battery-electric variant of its Transit van in model year 2022.<sup>22</sup> Through a strategic partnership with Nikola Motors, GM is designing and manufacturing both the battery-electric and hydrogen fuel cell variants of the Nikola Badger pickup truck, which is expected to enter production by the end of 2022. At present, neither company has announced whether the Badger will be offered as a light- (8,500 lbs. GVWR or less) or heavy-duty (greater than 8,500 lbs. GVWR) model.

Both SEA Electric and Lightning Systems are upfitting their electric powertrains onto the Ford Transit van chassis.<sup>23</sup> SEA Electric is also bringing Class 2B and 3 trucks to market through use of the Isuzu NLR, NNR, and NPR chassis.<sup>24</sup>

## COACH BUSES

Of the three OEM market leaders in the coach bus space, the Volvo Group (Volvo Bus, Prevost) is the sole company that has yet to bring a zero-emission product to market. Van Hool introduced its CX45E battery-electric coach in 2017, and Motor Coach Industries (NFI Group) launched two all-electric coach models—the D45 CRTE LE CHARGE and the J4500e CHARGE—over the past year.<sup>25</sup>

BYD is the only zero-emission vehicle manufacturer selling a coach bus, though Van Hool is using Proterra's electric powertrain in its CX45E model.<sup>26</sup>

## SCHOOL BUSES

In 2018, Blue Bird was the first legacy OEM to bring fully electric school buses to market.<sup>27</sup> The company's All American RE Electric and Vision Electric models use Cummins' electric powertrain system.<sup>28</sup> Thomas Built Buses (Daimler) and IC Bus (Navistar) both introduced battery-electric models within the past year.<sup>29</sup> The Thomas Built Bus C2 Jouley employs a Proterra electric powertrain, and Navistar leveraged its strategic alliance with Volkswagen for the powertrain development of the IC Bus chargeE.<sup>30</sup>

22 "2022 Ford All-Electric Transit," Ford Motor Co., accessed August 3, 2020, <https://www.ford.com/commercial-trucks/all-electric-transit/2022/>.

23 "SEA FORD TRANSIT EV," SEA Electric, accessed August 3, 2020, <https://www.sea-electric.com/products-old/transit-ev/>; "LightningElectric Ford Transit Passenger Van", Lightning Systems, accessed August 3, 2020, <https://lightningsystems.com/lightningelectric-ford-transit-shuttle/>.

24 "SEA ISUZU EVs," SEA Electric, accessed August 3, 2020, <https://www.sea-electric.com/sea-isuzu-evs/>.

25 "Van Hool builds first 100% electric coach for the American market," Van Hool NV, updated October 9, 2017, <https://www.vanhool.be/en/news/van-hool-builds-first-100-electric-coach-for-the-american-market>; "MCI to help operators empower zero emissions green goals with battery electric J4500e, installation of its first HVC charger in California," Motor Coach Industries, updated April 22, 2020, <https://www.mcicoach.com/media-center/2020-04-22-earth-day.htm>.

26 "The World's Largest Selection of Battery-Electric Buses", BYD Motors Inc., accessed August 3, 2020, <https://en.byd.com/bus/>; "The Proterra Powered CX45E Electric Motorcoach from Van Hool," Proterra, accessed August 3, 2020, <https://www.proterra.com/vehicles/proterra-powered-vehicles/coach-bus/>.

27 "Blue Bird Introduces All-New Electric School Bus Solutions," Blue Bird Corporation, accessed August 3, 2020, <https://blue-bird.com/about-us/press-releases/134-blue-bird-introduces-all-new-electric-school-bus-solutions>.

28 "Over 100 Blue Bird electric school buses plugging into districts," Cummins Inc., updated August 30, 2019, <https://www.cummins.com/news/releases/2019/08/30/over-100-blue-bird-electric-school-buses-plugging-districts>.

29 John Weaver, "Dominion chooses 50 electric Thomas Built Buses powered by Proterra," *PV Magazine*, December 17, 2019, <https://pv-magazine-usa.com/2019/12/17/dominion-chooses-50-electric-thomas-built-buses-powered-by-proterra/>; Ryan ZumMallen, "Navistar Brings an Electric School Bus to the Streets," *Trucks.com*, May 17, 2018, <https://www.trucks.com/2018/05/17/navistar-electric-school-bus-streets/>.

30 "Proterra and Thomas Built Buses Debut Electric School Bus," Proterra, updated October 30, 2018, <https://www.proterra.com/press-release/proterra-and-thomas-built-buses-debut-electric-school-bus/>; "IC Bus Takes chargeE On The Road," Navistar Inc., updated March 23, 2018, <https://news.navistar.com/2018-03-23-IC-Bus-Takes-chargeE-TM-On-The-Road>.

Zero-emission vehicle manufacturer GreenPower offers the Synapse 72 School Bus.<sup>31</sup> As is true for all of their bus models, GreenPower uses its own proprietary battery management system in combination with Siemens drive motors.<sup>32</sup> Lion Electric has three models (LionA, LionC, LionD) covering the various types of school buses.<sup>33</sup> Lion Electric designs and manufactures all of the components within its vehicles, including the battery packs and powertrains.<sup>34</sup>

## TRANSIT BUSES

Public transportation has long been a fertile proving ground for HDV zero-emission technology. While fuel cell buses were first introduced in North America in the early 2000s, costly fuel cell systems and a lack of hydrogen infrastructure has resulted in deployments being mostly limited to a few select markets, primarily in California.<sup>35</sup> Conversely, while battery-powered buses have emerged much more recently, rapidly decreasing battery costs and more accessible fuel (i.e., electricity) have resulted in battery-electric technology capturing the vast majority of the early zero-emission bus market. New Flyer (NFI Group) is the only bus OEM that offers a hydrogen fuel cell bus model for purchase in North America.<sup>36</sup>

Representing nearly half of all electric buses sold, Proterra holds a commanding lead in the early zero-emission bus market, but there are several well-positioned challengers, including GreenPower, New Flyer, and BYD. All of the leading legacy transit bus OEMs—New Flyer (NFI Group), Gillig, and Nova Bus (Volvo Group)—collaborated with zero-emission powertrain suppliers to develop their battery-electric models.

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31 “GreenPower Product Line,” GreenPower Motor Company Inc., accessed August 3, 2020, <https://www.greenpowerbus.com/product-line/#schoolbus>.

32 “GreenPower: About Us,” GreenPower Motor Company Inc., accessed August 3, 2020, <https://www.greenpowerbus.com/about-us/>.

33 “The Lion Electric Co. Products,” The Lion Electric Co., accessed August 3, 2020, <https://thelionelectric.com/en/products>.

34 “The Lion Electric Company,” The Lion Electric Co., accessed August 3, 2020, <https://thelionelectric.com/en/>.

35 “Fuel Cell Electric Bus History,” fuelcellbuses.eu, accessed August 3, 2020, <https://www.fuelcellbuses.eu/category/history>.

36 “New Flyer unveils Xcelsior CHARGE H2 bus becoming the first to offer two fuel cell-electric models eligible for federal funding,” New Flyer of America Inc., updated March 12, 2019, <https://www.newflyer.com/2019/03/new-flyer-unveils-xcelsior-charge-h2-bus-becoming-the-first-to-offer-two-fuel-cell-electric-models-eligible-for-federal-funding/>.

## SUMMARY

Several key takeaways can be deduced regarding the early market for zero-emission HDVs in the United States and Canada. In the race to bring zero-emission trucks and buses to market:

***We've just left the starting blocks.*** Zero-emission HDVs only account for a small fraction of a percent of the new HDV sales market. The roughly 570 units of zero-emission HDVs sold in the United States and Canada in 2019 represent less than 0.1% of the on-road commercial truck and bus market. Even in the transit bus segment, which has the largest penetration of zero-emission technology, fully electric vehicles made up a mere 3% of sales in 2019.

Over the next decade, we expect the transition to electric drive will continue to accelerate. By 2023, leading experts in the zero-emission HDV space expect the number of available models to double in the United States and Canada.<sup>37</sup> We expect that the combination of increased regulatory requirements from a growing set of national and sub-national governments, as well as steadily decreasing costs of zero-emissions vehicles and refueling infrastructure, will result in zero-emission HDVs overtaking diesel in the U.S. and Canadian market over the next two decades.

***Teams are emerging and changing rapidly.*** While there is certainly competition for early market share of zero-emission HDVs, there is a strong collaborative dynamic across the industry in zero-emission vehicle development and deployment. Recently, there has been a flurry of activity in the HDV industry in terms of new joint ventures, acquisitions, and major investments. To support the rapid development and commercialization of a growing diversity of zero-emission models, many formal and informal partnerships have emerged—even amongst direct competitors. Virtually all of the legacy OEMs have formed strategic relationships with or acquired smaller zero-emission suppliers to bolster their acumen in electric drive technology. And, several zero-emission manufacturers and powertrain companies have formed product development alliances with legacy OEMs and component suppliers.

***Rookies are pushing veterans to run faster.*** The surge of new entrants in the zero-emission HDV market include early market leaders such as Proterra, BYD, GreenPower, and Lion Electric. These and several other companies have entered the market over the past five years and are bringing a growing number of zero-emission models to commercial truck and bus customers. This influx of activity from start-ups is putting pressure on legacy OEMs to commercialize zero-emission technology and offer an increasing number of all-electric models across their product lines. Most legacy OEMs are making significant investments in electrification and developing their corporate strategies around a zero-emission future. Those companies that are falling behind in the race to bring zero-emission products to market are leveraging strategic partnerships with other better-positioned manufacturers and suppliers, as well as with zero-emission startups that are offering their powertrain solutions to OEMs.

***Electrons have a big early lead over protons.*** Battery-electric technology is dominating the early zero-emission HDV market, but several manufacturers are making significant investments and strategic partnerships to bolster their hydrogen fuel cell capabilities, particularly in the Class 7 and 8 tractor truck segment. The OEMs heavily investing in hydrogen fuel cell tractor trucks include Daimler, Paccar, Volvo, Toyota, Cummins, Hyundai, NFI Group, and Nikola.

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<sup>37</sup> Deborah Lockridge and John G. Smith, "Number of Zero-Emissions Commercial Vehicle Models Expected to Double by 2023," *Truckinginfo*, June 2, 2020, <https://www.truckinginfo.com/359610/number-of-zero-emissions-commercial-vehicles-models-expected-to-double-by-2023>.

## APPENDIX A: CLASS 4 THROUGH 8 TRUCK MANUFACTURERS

This appendix captures each of the OEMs with a combined U.S. and Canada market share of 3% or more across all fuel and technology types in the Class 4 – 8 truck segment. The market share data is based on IHS Markit TIPNet U.S. and Canada new registrations for model year 2019 trucks and buses through calendar year 2019.

### DAIMLER AG

<b>Subsidiary operating in North America</b>	Daimler Trucks North America
<b>Brands or companies in the on-road heavy-duty truck industry</b>	Alliance Truck Parts, Detroit Diesel Corporation (engines), Freightliner Custom Chassis Corporation, Freightliner Trucks (Class 5-8 trucks), SelecTrucks (used trucks redistribution network), Western Star Trucks (vocational and severe-duty segments), Mitsubishi Fuso Truck and Bus Corporation
<b>Class 4 – 8 truck market share in the United States and Canada</b>	29%
<b>Zero-emission technology offered in North America</b>	Battery-electric
<b>New business units, partnerships, and acquisitions</b>	<ul style="list-style-type: none"> <li>Daimler Truck AG and the Volvo Group have formed 50-50 joint venture on hydrogen fuel cell trucks<sup>a</sup></li> <li>Freightliner e-Mobility “ecosystem” launched in November 2019<sup>b</sup></li> </ul>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks			Freightliner eCascadia Initial deliveries: Aug. 2019 Production: 2022 <sup>c</sup>	400 km <sup>d</sup>
 Class 7-8 straight trucks			Freightliner MT50e Production: 2020 <sup>e</sup>	200 km
 Class 7-8 refuse trucks	-	-	-	-
 Class 4-6 straight trucks			eM2 Initial deliveries: Dec. 2018 Production: 2022 <sup>f</sup>	eM2: 370 km <sup>f</sup>
			eCanter: discontinued <sup>g</sup>	

<sup>a</sup> Stephane Babcock, “Daimler Truck, Volvo Group Form Fuel Cell Joint Venture,” Truckinginfo, April 21, 2020, <https://www.truckinginfo.com/356311/daimler-truck-ag-volvo-group-form-fuel-cell-joint-venture/>.

<sup>b</sup> “Daimler Launches E-Mobility Ecosystem to Consult with Fleets on Going Electric,” Truckinginfo, updated November 12, 2019, <https://www.truckinginfo.com/344462/daimler-launches-e-mobility-ecosystem-to-consult-with-fleets-on-going-electric/>.

<sup>c</sup> “Freightliner Demo Fleet Logs 300,000 Miles Of Real-World Use,” InsideEVs, updated August 6, 2020, <https://insideevs.com/news/437432/freightliner-demo-fleet-300000-miles-use/>.

<sup>d</sup> “eCascadia: Leading the Charge in eMobility,” Daimler Trucks North America LLC, accessed August 3, 2020, [https://adsal.dtnaapps.com/AssetLibrary/4317-freightliner\\_ecascadia\\_sell\\_sh-2020-06-02.pdf](https://adsal.dtnaapps.com/AssetLibrary/4317-freightliner_ecascadia_sell_sh-2020-06-02.pdf).











<sup>e</sup> “FCCC Debuts Production MT50e All-Electric Chassis,” Daimler Trucks North America LLC, updated February 27, 2020, <https://daimler-trucksnorthamerica.com/PressDetail/fccc-debuts-production-mt50e-all-electric-chassis-2020-02-27>.

<sup>f</sup> “eM2: eMobility That Thinks Outside of the Box Truck,” Daimler Trucks North America LLC, accessed August 3, 2020, [https://adsal.dtnaapps.com/AssetLibrary/4318-freightliner\\_em2\\_sell\\_sheet-2020-06-02.pdf](https://adsal.dtnaapps.com/AssetLibrary/4318-freightliner_em2_sell_sheet-2020-06-02.pdf).

<sup>g</sup> “Mitsubishi Fuso Truck of America Discontinues New-Truck Sales,” Truckinginfo, updated May 27, 2020, <https://www.truckinginfo.com/359173/mitsubishi-fuso-truck-of-america-discontinues-new-truck-sales>.

## FORD MOTOR COMPANY







Subsidiary operating in North America	-
Brands or companies in the on-road heavy-duty truck industry	-
Class 4 - 8 truck market share in the United States and Canada	20%
Zero-emission technology offered in North America	Battery-electric
New business units, partnerships, and acquisitions	Ford has an alliance with Volkswagen AG for the development of commercial vehicles, including electric and autonomous technologies <sup>a</sup>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks	-	-	-	-
 Class 7-8 straight trucks			-	-
 Class 7-8 refuse trucks	-	-	-	-
 Class 4-6 straight trucks			-	-

<sup>a</sup> "Ford, VW Global Partnership Will Develop Commercial Vehicles," Truckinginfo, updated June 10, 2020, <https://www.truckinginfo.com/10118367/ford-vw-partner-to-develop-commercial-vehicles>.

## PACCAR

<b>Subsidiary operating in North America</b>	-
<b>Brands or companies in the on-road heavy-duty truck industry</b>	Kenworth, Paccar Leasing Company, Paccar Financial, Paccar Parts, Paccar Powertrain, Peterbilt
<b>Class 4 - 8 truck market share in United States and Canada</b>	19%
<b>Zero-emission technology offered in North America</b>	Battery-electric and hydrogen fuel cell
<b>New business units, partnerships, and acquisitions</b>	<ul style="list-style-type: none"> <li>Kenworth and Toyota are collaborating on fuel cell truck development</li> <li>Meritor is Peterbilt's primary supplier for battery electric powertrain systems<sup>a</sup></li> </ul>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks			Kenworth T680 fuel cell Pilot program; no production announced to date <sup>b</sup>	485 km <sup>b</sup>
			Peterbilt 579EV Initial deliveries: 2021 <sup>c</sup>	320 km <sup>c</sup>
			Peterbilt 220EV Initial deliveries: Aug. 2020 <sup>d</sup>	400 km <sup>d</sup>
 Class 7-8 straight trucks			-	-
 Class 7-8 refuse trucks			Peterbilt 520EV Initial deliveries: 2021 <sup>e</sup>	160 km <sup>e</sup>
 Class 4-6 straight trucks			Kenworth 270E / 370E	320 km <sup>f</sup>

<sup>a</sup> "Peterbilt Selects Meritor as Primary Supplier of Integrated Battery Electric Systems for Models 579EV AND 520EV," Paccar Inc., updated February 3, 2020, <https://www.peterbilt.com/about/news-events/news-releases/peterbilt-selects-meritor-primary-supplier-integrated-battery>.

<sup>b</sup> "The Kenworth T680 with Integrated Toyota Hydrogen Fuel Cell Technology Stars at Port of Los Angeles," Paccar Inc., updated April 23, 2019, <https://kenworth.com/news/news-releases/2019/april/kenworth-toyota-pola/>; Stephane Babcock, "Kenworth, Toyota Unveil Jointly Developed Hydrogen Fuel Cell Truck," Truckinginfo, updated April 22, 2019, <https://www.truckinginfo.com/330270/toyota-and-kenworth-unveil-jointly-developed-hydrogen-fuel-cell-truck>.

<sup>c</sup> John Fisher, "Paccar tests more zero-emission trucks ahead of 2021 production," *FleetOwner*, updated July 30, 2020, <https://www.fleetowner.com/running-green-article/21137951/paccar-tests-more-zeroemission-trucks-ahead-of-2021-production>.













<sup>d</sup> "Peterbilt Model 220EV Now Available for Customer Orders," Paccar Inc., updated August 19, 2020, <https://www.peterbilt.com/about/news-events/news-releases/peterbilt-model-220ev-now-available-customer-orders>

<sup>e</sup> "Peterbilt Touts Electric Truck Progress at CES," *Truckinginfo*, updated January 8, 2020, <https://www.truckinginfo.com/348202/peterbilt-displays-battery-electric-refuse-model-520ev-at-ces>.

<sup>f</sup> "Kenworth 270E / 370E specifications," Paccar Inc., accessed August 7, 2020, <https://www.kenworth.com/media/56821/k270e-4-page-02-24-2020-scroll.pdf>.

## NAVISTAR

<b>Subsidiary operating in North America</b>	-
<b>Brands or companies in the on-road heavy-duty truck industry</b>	International Truck (Class 4 – 8 trucks), Navistar Capital
<b>Class 4 – 8 truck market share in United States and Canada</b>	12%
<b>Zero-emission technology offered in North America</b>	Battery-electric
<b>New business units, partnerships, and acquisitions</b>	Navistar has a strategic alliance with Traton SE, a subsidiary of Volkswagen AG <sup>a</sup> NEXT eMobility Solutions launched in October 2019 as electric truck and bus business unit <sup>b</sup>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks			-	-
 Class 7-8 straight trucks			-	-
 Class 7-8 refuse trucks	-	-	-	-
 Class 4-6 straight trucks			eMV Initial deliveries: 2021 <sup>c</sup>	400 km <sup>c</sup>













<sup>a</sup> "Navistar Creates Electrification Business Unit, Unveils Battery-Electric Prototype," Navistar Inc., updated October 28, 2019, <https://news.navistar.com/2019-10-28-Navistar-Launches-New-Business-Unit-NEXT-eMobility-Solutions>.

<sup>b</sup> "Peterbilt Selects Meritor as Primary Supplier of Integrated Battery Electric Systems for Models 579EV AND 520EV," Paccar Inc., updated February 3, 2020, <https://www.peterbilt.com/about/news-events/news-releases/peterbilt-selects-meritor-primary-supplier-integrated-battery>.

<sup>c</sup> David Cullen, "Navistar Unwraps Electric Truck," *Truckinginfo*, October 28, 2019, <https://www.truckinginfo.com/343408/navistar-unwraps-electric-truck>.

## VOLVO GROUP

<b>Subsidiary operating in North America</b>	-
<b>Brands or companies in the on-road heavy-duty truck industry</b>	Mack Trucks (Class 6 – 8 trucks and refuse), Volvo (Class 7 – 8 trucks)
<b>Class 4 – 8 truck market share in United States and Canada</b>	9%
<b>Zero-emission technology offered in North America</b>	Battery-electric
<b>New business units, partnerships, and acquisitions</b>	Daimler Truck AG and the Volvo Group have formed 50-50 joint venture on hydrogen fuel cell trucks <sup>a</sup>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks			VNR Electric Semi Initial deliveries: late 2020 <sup>b</sup>	300 km
 Class 7-8 straight trucks			-	-
 Class 7-8 refuse trucks			LR Electric Initial deliveries: Q4 2020 <sup>c</sup>	Specifications <sup>d</sup>
 Class 4-6 straight trucks	-	-	-	-

<sup>a</sup> Stephane Babcock, "Daimler Truck, Volvo Group Form Fuel Cell Joint Venture," *Truckinginfo*, April 21, 2020, <https://www.truckinginfo.com/356311/daimler-truck-ag-volvo-group-form-fuel-cell-joint-venture>.

<sup>b</sup> John Fisher, "Volvo's first electric VNR ready for the road," *FleetOwner*, September 17, 2019, <https://www.fleetowner.com/running-green/blue-fleets/article/21704267/volvos-first-electric-vnr-ready-for-the-road>.









<sup>c</sup> "Mack LR Electric to Begin Production in 2021," Mack Trucks, updated September 16, 2020, <https://www.macktrucks.com/mack-news/2020/mack-lr-electric-to-begin-production-in-2021/>.

<sup>d</sup> "LR Electric," Mack Trucks, accessed August 7, 2020, <https://www.macktrucks.com/trucks/lr-series/lr-electric/>.



## ISUZU MOTORS

<b>Subsidiary operating in North America</b>	Isuzu Commercial Truck of America; Isuzu Commercial Truck of Canada; Isuzu Motors of America
<b>Brands or companies in the on-road heavy-duty truck industry</b>	-
<b>Class 4 - 8 truck market share in United States and Canada</b>	3%
<b>Zero-emission technology offered in North America</b>	Battery-electric
<b>New business units, partnerships, and acquisitions</b>	<ul style="list-style-type: none"> <li>Isuzu formed a strategic alliance with the Volvo Group to establish a global technology partnership<sup>a</sup></li> <li>Isuzu signed an agreement with Honda to undertake joint research on fuel cell powertrains for heavy-duty trucks<sup>b</sup></li> <li>Nordres developed the powertrain for the battery-electric N Series<sup>c</sup></li> </ul>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks	-	-	-	-
 Class 7-8 straight trucks	-	-	-	-
 Class 7-8 refuse trucks	-	-	-	-
 Class 4-6 straight trucks			Electric N Series	-









<sup>a</sup> "Volvo Group and Isuzu Motors intend to form strategic alliance," Isuzu Motors Limited, updated December 18, 2019, [https://www.isuzu.co.jp/world/press/2019/12\\_18.html](https://www.isuzu.co.jp/world/press/2019/12_18.html).

<sup>b</sup> "Isuzu and Honda Sign an Agreement to Conduct Joint Research on Fuel Cell-powered Heavy-duty Trucks," Isuzu Motors Limited, updated January 15, 2020, [https://www.isuzu.co.jp/world/press/2020/1\\_15.html](https://www.isuzu.co.jp/world/press/2020/1_15.html).

<sup>c</sup> Aaron Marsh, "Isuzu testing out electric trucks," *FleetOwner*, May 9, 2018, <https://www.fleetowner.com/running-greer-ticle/21702107/isuzu-testing-out-electric-trucks>.

## TOYOTA GROUP

Subsidiary operating in North America	-
Brands or companies in the on-road heavy-duty truck industry	Hino Motors
Class 4 - 8 truck market share in United States and Canada	3%
Zero-emission technology offered in North America	Battery-electric
New business units, partnerships, and acquisitions	Toyota and Kenworth are collaborating on fuel cell truck development

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 7-8 tractor trucks	-	-	Kenworth T680 fuel cell Pilot program; no production announced to date <sup>a</sup>	485 kma
 Class 7-8 straight trucks	-	-	-	-
 Class 7-8 refuse trucks	-	-	-	-
 Class 4-6 straight trucks			SEA Hino 195 EV Initial orders: 2019 <sup>b</sup>	320 km <sup>c</sup>

<sup>a</sup> "The Kenworth T680 with Integrated Toyota Hydrogen Fuel Cell Technology Stars at Port of Los Angeles," Paccar Inc., updated April 23, 2019, <https://kenworth.com/news/news-releases/2019/april/kenworth-toyota-pola/>; Stephane Babcock, "Kenworth, Toyota Unveil Jointly Developed Hydrogen Fuel Cell Truck," *Truckinginfo*, updated April 22, 2019, <https://www.truckinginfo.com/330270/toyota-and-kenworth-unveil-jointly-developed-hydrogen-fuel-cell-truck>.

<sup>b</sup> Nigel Moffiet, "US provider orders 100 electric Hino 195s with SEA Electric," *transporttalk*, updated November 15, 2019, <https://transporttalk.co.nz/news/provider-orders-100-electric-hino-195s-sea-electric>.








<sup>c</sup> "SEA-Drive 120 specifications," SEA-Electric, accessed August 7, 2020, <https://www.sea-electric.com/wp-content/uploads/2020/05/SEA-Drive-120-USA-May20.pdf>.

## APPENDIX B: CLASS 2 AND 3 TRUCK MANUFACTURERS

This appendix captures each of the OEMs with a combined U.S. and Canada market share of 3% or more across all fuel and technology types in the Class 2 and 3 truck and van segment. The market share data is based on IHS Markit TIPNet U.S. and Canada new registrations for model year 2019 trucks and buses through calendar year 2019.

### FORD MOTOR COMPANY

<b>Subsidiary operating in North America</b>	-
<b>Brands or companies in the on-road heavy-duty truck industry</b>	-
<b>Class 2 - 3 truck market share in United States and Canada</b>	33%
<b>Zero-emission technology offered in North America</b>	Battery-electric
<b>New business units, partnerships, and acquisitions</b>	Ford has an alliance with Volkswagen AG for the development of commercial vehicles, including electric and autonomous technologies <sup>a</sup>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 <b>Class 2-3 trucks and vans</b>			All-electric Transit Production: 2022 <sup>b</sup>	-
			Ford has announced plans to produce a battery-electric F-150 starting in mid-2022 but has not announced plans to date for any electric pickup trucks or chassis in its heavy-duty product line <sup>c</sup>	-






<sup>a</sup> "Ford, VW Global Partnership Will Develop Commercial Vehicles," Truckinginfo, updated June 10, 2020, <https://www.truckinginfo.com/10118367/ford-vw-partner-to-develop-commercial-vehicles>.

<sup>b</sup> "2022 Ford All-Electric Transit Chassis Cab, Cutaway & Cargo Van," Ford Motor Company, accessed August 7, 2020, <https://www.ford.com/commercial-trucks/all-electric-transit/2022/>.

<sup>c</sup> "Ford Targets Mid-2022 for Electric F-150 and Transit Van," Truckinginfo, updated June 12, 2020, <https://www.truckinginfo.com/10118583/ford-targets-mid-2022-for-electric-f-150-and-transit-van>.






## FIAT CHRYSLER AUTOMOBILES

Subsidiary operating in North America	FCA US LLC
Brands or companies in the on-road heavy-duty truck industry	Ram
Class 2 – 3 truck market share in United States and Canada	30%
Zero-emission technology offered in North America	-
New business units, partnerships, and acquisitions	-

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 2-3 trucks and vans			-	-

## GENERAL MOTORS COMPANY

Subsidiary operating in North America	-
Brands or companies in the on-road heavy-duty truck industry	Chevrolet, GMC
Class 2 – 3 truck market share in United States and Canada	25%
Zero-emission technology offered in North America	Battery-electric and hydrogen fuel cell
New business units, partnerships, and acquisitions	G.M. formed a strategic partnership with Nikola Motors to engineer and manufacture the battery-electric and hydrogen fuel cell variants of the Nikola Badger pickup truck. <sup>a</sup>

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Class 2-3 trucks and vans			GM is bringing a battery-electric pickup truck to the market in late 2021 but has not announced plans to date for any electric pickup trucks or chassis in its heavy-duty product line <sup>b</sup>	-

<sup>a</sup> "Nikola And General Motors Form Strategic Partnership; Nikola Badger To Be Engineered And Manufactured By General Motors," General Motors, updated September 8, 2020, <https://investor.gm.com/news-releases/news-release-details/nikola-and-general-motors-form-strategic-partnership-nikola>.








<sup>b</sup> Nick Carey, "GM's electric pickup to hit dealer showrooms in fall 2021: CEO," *Reuters*, November 21, 2019, <https://www.reuters.com/article/us-gm-ceo-electric-pickup-idUSKBN1XV21X>.

## APPENDIX C: BUS MANUFACTURERS

This appendix captures each of the OEMs with a combined U.S. and Canada market share of 3% or more across all fuel and technology types in the coach, school, and transit bus segments. The market share data is based on IHS Markit TIPNet U.S. and Canada new registrations for model year 2019 trucks and buses through calendar year 2019.

### DAIMLER AG

<b>Subsidiary operating in North America</b>	Daimler Trucks North America		
<b>Brands or companies in the on-road heavy-duty bus industry</b>	Thomas Built Buses		
<b>Bus market share in United States and Canada</b>	Coach -	School 37%	Transit -
<b>Zero-emission technology offered in North America</b>	Battery-electric		
<b>New business units, partnerships, and acquisitions</b>	Thomas collaborated with Proterra (batteries and powertrain) on the development of the C2 Jouley electric school bus <sup>a</sup>		








Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses	-	-	-	-
 School buses			Saf-T-Liner C2 Jouley Initial deliveries : 2019 Production : 2020 <sup>a</sup>	215 km <sup>b</sup>
 Transit buses	-	-	-	-

<sup>a</sup> "Proterra and Thomas Built Buses Debut Electric School Bus," Proterra, updated July 26, 2019, <https://www.proterra.com/press-release/thomas-built-buses-electric-school-bus-powered-by-proterra-technology-receives-full-carb-and-hvip-certifications/>.

<sup>b</sup> "Saf-T-Liner C2 Jouley," Daimler Trucks North America, accessed August 7, 2020, <https://thomasbuiltbuses.com/school-buses/saf-t-liner-c2-jouley/>.

## NAVISTAR

<b>Subsidiary operating in North America</b>	-		
<b>Brands or companies in the on-road heavy-duty bus industry</b>	IC Bus		
<b>Bus market share in United States and Canada</b>	Coach -	School 33%	Transit -
<b>Zero-emission technology offered in North America</b>	Battery-electric		
<b>New business units, partnerships, and acquisitions</b>	IC Bus collaborated with Navistar's alliance partner, Volkswagen (batteries and powertrain) on the development of the chargeE electric school bus <sup>a</sup>		

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses	-	-	-	-
 School buses			chargeE Initial deliveries: 2018 Production: 2020 <sup>b</sup>	195 km <sup>c</sup>
 Transit buses	-	-	-	-








<sup>a</sup> "IC Bus Takes chargeE On The Road," Navistar Inc., updated March 23, 2018, <https://news.navistar.com/2018-03-23-IC-Bus-Takes-chargeE-TM-On-The-Road>.

<sup>b</sup> Susan Carpenter, "Can Electric School Buses Make the Grade?" *Trucks.com*, March 22, 2019, <https://www.trucks.com/2019/03/22/can-electric-school-buses-make-the-grade/>.

<sup>c</sup> "CE Series Electric," Navistar Inc., accessed August 7, 2020, <http://www.icbus.com/electric>.

## BLUE BIRD CORPORATION

Subsidiary operating in North America	-		
Brands or companies in the on-road heavy-duty bus industry	-		
Bus market share in United States and Canada	Coach -	School 30%	Transit -
Zero-emission technology offered in North America	Battery-electric		
New business units, partnerships, and acquisitions	Cummins produces the electric drivetrains that power Blue Bird's All American RE Electric and Vision Electric buses <sup>a</sup>		

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses	-	-	-	-
 School buses			All American RE Electric <sup>b</sup>	195 km <sup>b</sup>
			Vision Electric	195 km <sup>b</sup>
			Micro Bird G5 Electric	160 km <sup>c</sup>
 Transit buses	-	-	-	-










<sup>a</sup> "Over 100 Blue Bird electric school buses plugging into districts," Cummins Inc., updated August 30, 2019, <https://www.cummins.com/news/releases/2019/08/30/over-100-blue-bird-electric-school-buses-plugging-districts>.

<sup>b</sup> "Electric School Buses," Blue Bird Corporation, accessed August 7, 2020, <https://blue-bird.com/buses/electric-school-buses>.

<sup>c</sup> "Blue Bird Introduces All-New Electric School Bus Solutions," Blue Bird Corporation, accessed September 28, 2020, <https://blue-bird.com/about-us/press-releases/134-blue-bird-introduces-all-new-electric-school-bus-solutions>.

## NFI GROUP

<b>Subsidiary operating in North America</b>	-		
<b>Brands or companies in the on-road heavy-duty bus industry</b>	Alexander Dennis (transit buses and coaches), ARBOC Specialty Vehicles (transit buses and shuttles), Motor Coach Industries (coach buses), New Flyer (transit buses)		
<b>Bus market share in United States and Canada</b>	Coach 36%	School -	Transit 36%
<b>Zero-emission technology offered in North America</b>	Battery-electric; hydrogen fuel cell; trolley electric		
<b>New business units, partnerships, and acquisitions</b>	MCI and New Flyer's electric buses feature the Siemens electric drive system <sup>a</sup>		

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses			D45 CRTe LE CHARGE Initial deliveries: 2021 <sup>b</sup> J4500e CHARGE Initial deliveries: 2020 <sup>b</sup>	275 km <sup>c</sup> 370 km <sup>c</sup>
 School buses	-	-	-	-
 Transit buses			Xcelsior CHARGE Initial deliveries: 2017 <sup>d</sup>  Xcelsior CHARGE H2 Initial deliveries: 2019 <sup>f</sup>	215 to 360 km <sup>e</sup> 565 km <sup>g</sup>

<sup>a</sup> Richard Tackett, "MCI all-electric coaches Unveiled," *BusRide*, updated December 1, 2019, <https://busride.com/mci-all-electric-coaches-unveiled/>; "xcelsior Charge: Our zero-emission battery-electric bus", New Flyer of America Inc., accessed August 7, 2020, <https://www.newflyer.com/site-content/uploads/2019/06/Xcelsior-CHARGE.pdf>.

<sup>b</sup> "Earth Day 2020 marks an MCI milestone," Motor Coach Industries Inc., updated April 22, 2020, <http://www.mcicoach.com/media-center/2020-04-22-earth-day.htm>.

<sup>c</sup> "All-Electric MCI Models," Motor Coach Industries Inc., accessed August 7, 2020, [https://www.mcicoach.com/literatureAssets/D45\\_CRTe\\_LE/8/](https://www.mcicoach.com/literatureAssets/D45_CRTe_LE/8/).

<sup>d</sup> "Los Angeles orders 100 new all-electric buses, New Flyer unveils next-gen Xcelsior electric buses," New Flyer of America Inc., updated October 11, 2017, <http://www.mcicoach.com/media-center/2020-04-22-earth-day.htm>.

<sup>e</sup> Maximum range for various xcelsior variants. 35-ft.: 315 km; 40-ft.: 360 km; 60-ft. articulated: 215 km; "xcelsior Charge: Our zero-emission battery-electric bus," New Flyer of America Inc., accessed August 7, 2020, <https://www.newflyer.com/site-content/uploads/2019/06/Xcelsior-CHARGE.pdf>.








<sup>f</sup> "New Flyer unveils Xcelsior CHARGE H2 bus becoming the first to offer two fuel cell-electric models eligible for federal funding," New Flyer of America Inc., updated March 12, 2019, <https://www.newflyer.com/2019/03/new-flyer-unveils-xcelsior-charge-h2-bus-becoming-the-first-to-offer-two-fuel-cell-electric-models-eligible-for-federal-funding/>.

<sup>g</sup> "Xcelsior CHARGE H2," New Flyer of America Inc., accessed August 7, 2020, <https://www.newflyer.com/site-content/uploads/2019/03/Xcelsior-CHARGE-H2-web-1.pdf>.



## GILLIG CORPORATION

Subsidiary operating in North America	-		
Brands or companies in the on-road heavy-duty bus industry	-		
Bus market share in United States and Canada	Coach -	School -	Transit 32%
Zero-emission technology offered in North America	Battery-electric		
New business units, partnerships, and acquisitions	Cummins supplies the electric powertrain for Gillig's battery-electric transit bus <sup>a</sup>		

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses	-	-	-	-
 School buses	-	-	-	-
 Transit buses			Battery Electric Bus Production: 2019 <sup>b</sup>	240 km <sup>c</sup>










<sup>a</sup> "Zero-Emission Battery Electric Bus," Gillig LLC, accessed August 7, 2020, <https://www.gillig.com/battery-electric>.

<sup>b</sup> "Gillig battery-electric bus powered by Cummins now available," Gillig LLC, updated May 22, 2019, <https://www.greencarcongress.com/2019/05/20190522-gillig.html>.

<sup>c</sup> Alex Roman, "Gillig Unveils New 40-Foot Battery Electric Bus," *Gillig LLC*, updated May 27, 2019, <https://www.gillig.com/post/metro-gillig-electric-bus>.

## VOLVO GROUP

<b>Subsidiary operating in North America</b>	-		
<b>Brands or companies in the on-road heavy-duty bus industry</b>	Nova Buses (transit buses), Prevost (coach buses), Volvo (coach buses)		
<b>Bus market share in United States and Canada</b>	Coach 33%	School -	Transit 21%
<b>Zero-emission technology offered in North America</b>	Battery-electric		
<b>New business units, partnerships, and acquisitions</b>	Nova Bus' LFSe+ model is powered by BAE Systems electric drive system <sup>a</sup>		

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses			-	-
 School buses	-	-	-	-
 Transit buses			LFSe Initial deliveries: 2017 <sup>b</sup>	120 km <sup>c</sup>
			LFSe+ Production: 2019 <sup>d</sup>	470 km <sup>d</sup>

<sup>a</sup> "LFSe+: Powered by BAE Systems," Gillig LLC, accessed August 7, 2020, [http://novabus.com/wp-content/uploads/2019/10/LFSe-Brochures\\_Final\\_EN.pdf](http://novabus.com/wp-content/uploads/2019/10/LFSe-Brochures_Final_EN.pdf).










<sup>b</sup> "Nova Bus LFSe," Canadian Public Transit Discussion Board, updated July 29, 2019, [https://www.cptdb.ca/wiki/index.php/Nova\\_Bus\\_LFSe](https://www.cptdb.ca/wiki/index.php/Nova_Bus_LFSe).

<sup>c</sup> "Nova Bus LFSe," Nova Bus, accessed August 7, 2020, [http://novabus.com/wp-content/uploads/2017/09/2018\\_LFSE\\_EN\\_REV.pdf](http://novabus.com/wp-content/uploads/2017/09/2018_LFSE_EN_REV.pdf).

<sup>d</sup> "Nova Bus introduces the LFSe+, a new long-range electric bus with dual charging options," *TAAS Magazine*, updated October 15, 2019, [https://taas.news/article/109066/Nova\\_Bus\\_introduces\\_the\\_LFSe+\\_a\\_new\\_long-range\\_electric\\_bus\\_with\\_dual\\_charging\\_options](https://taas.news/article/109066/Nova_Bus_introduces_the_LFSe+_a_new_long-range_electric_bus_with_dual_charging_options).

## VAN HOOL

<b>Subsidiary operating in North America</b>	-		
<b>Brands or companies in the on-road heavy-duty bus industry</b>	ABC Companies (Van Hool's exclusive distributor in North America)		
<b>Bus market share in United States and Canada</b>	Coach 24%	School -	Transit 1%
<b>Zero-emission technology offered in North America</b>	Battery-electric		
<b>New business units, partnerships, and acquisitions</b>	Proterra provides the electric drive system for Van Hool's CX45E coach bus <sup>a</sup>		

Segment	Market share		Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
				
 Coach buses			CX45E Initial deliveries: 2019 <sup>a</sup>	300 km <sup>b</sup>
 School buses	-	-	-	-
 Transit buses			Van Hool sold fuel cell transit buses in the U.S. for several years, but the buses are now only offered in Europe <sup>c</sup>	-

<sup>a</sup> "Van Hool builds first 100% electric coach for the American market," Van Hool, updated October 9, 2017, <https://www.vanhool.be/en/news/van-hool-builds-first-100-electric-coach-for-the-american-market>.

<sup>b</sup> "Van Hool CX45E," Van Hool, accessed August 7, 2020, <https://www.abc-companies.com/van-hool-cx45e/>.









<sup>c</sup> "Hybrid Fuel Cell," Van Hool, accessed August 7, 2020, <https://www.vanhool.be/en/public-transport/agamma/hybrid-fuel-cell>.

## APPENDIX D: ZERO-EMISSION VEHICLE MANUFACTURERS

This appendix includes all of the zero-emission manufacturers that sold at least 10 units in 2019 per data from EV-Volumes.com.<sup>38</sup>

### PROTERRA

<b>Zero-emission truck market share</b>	-
<b>Zero-emission bus market share</b>	46%
<b>Zero-emission technology offered or being developed for North America</b>	Battery-electric
<b>New business units, partnerships, and acquisitions</b>	<ul style="list-style-type: none"> <li>• Daimler is an investor, and Proterra partnered with Freightliner Custom Chassis Corporation (Daimler) to develop the MT50e delivery truck chassis<sup>a</sup></li> <li>• Thomas Built Buses (school buses) and Van Hool (coach buses), and Optimal-EV (low-floor cutaway shuttle buses) utilize Proterra® batteries and/or electric drivetrains in their electric buses</li> <li>• Proterra announced its first international partnership with Australian bus manufacturer Bustech in August 2020</li> </ul>

Segment	Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
 Class 7-8 tractor trucks	-	-
 Class 7-8 straight trucks	-	-
 Class 7-8 refuse trucks	-	-
 Class 4-6 straight trucks	Freightliner Custom Chassis (Daimler) MT50e Production: 2020 <sup>b</sup>	200 km <sup>b</sup>
 Class 2-3 trucks and vans	-	-
 Coach buses	Van Hool CX45E Initial deliveries: 2019 <sup>c</sup>	300 km <sup>d</sup>
 School buses	Thomas Built Buses Saf-T-Liner C2 Jouley Initial deliveries : 2019 Production : 2020 <sup>e</sup>	215 km <sup>f</sup>
 Transit buses	Catalyst 35-ft.	385 km <sup>g</sup>
	Catalyst 40-ft.	530 km <sup>h</sup>

<sup>a</sup> "Proterra Closes \$155 Million Investment From Daimler, Tao Capital Partners, G2VP, and Others," Proterra, updated September 19, 2018, <https://www.proterra.com/press-release/proterra-closes-155-million-investment-from-daimler-tao-capital-partners-g2vp-and-others/>.  
<sup>b</sup> "FCCC Debuts Production MT50e All-Electric Chassis," Daimler Trucks North America LLC, updated February 27, 2020, <https://daimler-trucksnorthamerica.com/PressDetail/fccc-debuts-production-mt50e-all-electric-chassis-2020-02-27>.  
<sup>c</sup> "Van Hool builds first 100% electric coach for the American market," Van Hool, updated October 9, 2017, <https://www.vanhool.be/en/news/van-hool-builds-first-100-electric-coach-for-the-american-market>.  
<sup>d</sup> "Van Hool CX45E," Van Hool, accessed August 7, 2020, <https://www.abc-companies.com/van-hool-cx45e/>.  
<sup>e</sup> "Proterra and Thomas Built Buses Debut Electric School Bus," Proterra, updated July 26, 2019, <https://www.proterra.com/press-release/thomas-built-buses-electric-school-bus-powered-by-proterra-technology-receives-full-carb-and-hvip-certifications/>.  
<sup>f</sup> "Saf-T-Liner C2 Jouley," Daimler Trucks North America, accessed August 7, 2020, <https://thomasbuiltbuses.com/school-buses/saf-t-liner-c2-jouley/>.  
<sup>g</sup> "Catalyst 35 Foot Bus Performance Specifications," Proterra, accessed August 7, 2020, <https://www.proterra.com/wp-content/uploads/2020/06/Proterra-Catalyst-35-ft-Spec-Sheet-June-2020.pdf>.  
<sup>h</sup> "Catalyst 40 Foot Bus Performance Specifications," Proterra, accessed August 7, 2020, <https://www.proterra.com/wp-content/uploads/2020/06/Proterra-Catalyst-40-ft-Spec-Sheet-June-2020.pdf>.

<sup>38</sup> Data from EV-Volumes.com, On-road zero-emission commercial truck and bus sales in calendar year 2019, retrieved February 20, 2020, <http://www.ev-volumes.com>.

## BUILD YOUR DREAMS (BYD)

Zero-emission truck market share	13%
Zero-emission bus market share	21%
Zero-emission technology offered or being developed for North America	Battery-electric
New business units, partnerships, and acquisitions	-

Segment	Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
 Class 7-8 tractor trucks	8TT Initial deliveries: 2018 <sup>a</sup>	270 km <sup>b</sup>
 Class 7-8 straight trucks	-	-
 Class 7-8 refuse trucks	8R Initial deliveries: 2018 <sup>c</sup>	120 km <sup>d</sup>
	6R Initial deliveries: 2019 <sup>e</sup>	135 km <sup>f</sup>
 Class 4-6 straight trucks	5F	200 km <sup>g</sup>
	6F	200 km <sup>h</sup>
 Class 2-3 trucks and vans	-	-
 Coach buses	23-ft. Motor Coach (C6M)	200 km <sup>i</sup>
	35-ft. Motor Coach (C8M)	320 km <sup>i</sup>
	40-ft. Motor Coach (C9M)	320 km <sup>k</sup>
	45-ft. Motor Coach (C10M)	370 km <sup>l</sup>
 School buses	-	-
 Transit buses	30-ft. Transit Initial deliveries: 2018 <sup>m</sup>	240 km <sup>n</sup>
	35-ft. Transit Initial deliveries: 2017 <sup>o</sup>	345 km <sup>p</sup>
	40-ft. Transit Initial deliveries: 2014 <sup>q</sup>	285 km <sup>r</sup>
	60-ft. Transit	355 km <sup>s</sup>

<sup>a</sup> "BYD Delivers First Battery-Electric Truck to the Port of Oakland," BYD Motors Inc., updated May 22, 2018, <https://en.byd.com/news-posts/press-release-byd-delivers-first-battery-electric-truck-to-the-port-of-oakland/>.

<sup>b</sup> "Electric Tough: Long-Range 100% Battery Electric Class 8 - 105,000 lbs GCWR," BYD Motors Inc., accessed August 9, 2020, <https://www.californiahvip.org/wp-content/uploads/2019/07/2019-BYD-8T1-Cut-Sheet-190306.pdf>.

<sup>c</sup> "Seattle's First Electric Refuse Trucks to be Delivered by BYD," BYD Motors Inc., updated July 17, 2018, <https://en.byd.com/news-posts/press-release-seattles-first-electric-refuse-trucks-to-be-delivered-by-byd/>.

<sup>d</sup> "Electric Tough: Long-Range 100% Battery Electric Class 8 Refuse Truck - Up to 66,000 lbs GCWR," BYD Motors Inc., accessed August 9, 2020, <https://www.californiahvip.org/wp-content/uploads/2019/07/2019-BYD-8R-Cut-Sheet-180801.pdf>.

<sup>e</sup> "BYD, WRT, and AMREP Jointly Launch Electric Refuse Truck to Serve Carson, CA," BYD Motors Inc., updated April 15, 2019, <https://en.byd.com/news-posts/press-release-byd-wrt-and-amrep-jointly-launch-electric-refuse-truck-to-serve-carson-ca/>.

<sup>f</sup> "Electric Tough: Long-Range 100% Battery Electric Class 6 - Cab Chassis - 26,000 lbs GVWR," BYD Motors Inc., accessed August 9, 2020, <https://www.californiahvip.org/wp-content/uploads/2019/07/2019-BYD-6R-Cut-Sheet-180801.pdf>.

<sup>g</sup> "Electric Tough: Long-Range 100% Battery Electric Class 5 Cab Chassis," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2018/07/5f\\_redesign6-23-18.pdf](https://en.byd.com/wp-content/uploads/2018/07/5f_redesign6-23-18.pdf).

<sup>h</sup> "BYD 6F Cab-Forward Truck," BYD Motors Inc., accessed August 9, 2020, <https://www.californiahvip.org/vehicles/byd-6f-17-class-6-cab-forward-truck/>.

<sup>i</sup> "The BYD C6M Battery Electric Zero Emissions 23' Coach," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2019/07/c6m-cut-sheet\\_final\\_digital.pdf](https://en.byd.com/wp-content/uploads/2019/07/c6m-cut-sheet_final_digital.pdf).

<sup>j</sup> "The BYD C8M Battery Electric Zero Emissions 35' Coach," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2019/07/c8m-cut-sheet\\_final\\_digital.pdf](https://en.byd.com/wp-content/uploads/2019/07/c8m-cut-sheet_final_digital.pdf).

<sup>k</sup> "The BYD C9M Battery Electric Zero Emissions 40' Coach," BYD Motors Inc., accessed August 9, 2020, <https://en.byd.com/wp-content/uploads/2019/01/byd-c9m-zero-emission-battery-electric-bus-specs-1-1.pdf>.

<sup>l</sup> "The BYD C10M Battery Electric Zero Emissions 40' Coach," BYD Motors Inc., accessed August 9, 2020, <https://en.byd.com/wp-content/uploads/2019/01/byd-c10m-2019-spec-sheet-1.pdf>.

<sup>m</sup> "BYD Announces New Electric Bus Deliveries To Santa Barbara, UC San Francisco," BYD Motors Inc., updated February 1, 2018, <https://en.byd.com/news-posts/press-release-byd-announces-new-electric-bus-deliveries-to-santa-barbara-uc-san-francisco/>.

<sup>n</sup> "The BYD K7 Battery Electric Zero Emissions 30' Transit," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets\\_k7-30-1r.pdf](https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets_k7-30-1r.pdf).

<sup>o</sup> "First Zero Emission Battery-Electric Transit Buses Coming To State Of Maryland," BYD Motors Inc., updated April 19, 2017, <https://en.byd.com/news-posts/press-release-first-zero-emission-battery-electric-transit-buses-coming-to-state-of-maryland/>.

<sup>p</sup> "The BYD K9S Battery Electric Zero Emissions 35' Transit," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets\\_k9s-35\\_1r.pdf](https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets_k9s-35_1r.pdf).









<sup>q</sup> "BYD Unveils World's Largest Battery Electric Vehicle," BYD Motors Inc., updated October 14, 2014, <https://en.byd.com/news-posts/byd-unveils-worlds-largest-battery-electric-vehicle/>.

<sup>r</sup> "The BYD K9 Battery Electric Zero Emissions 40' Transit," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets\\_k9-40\\_1r.pdf](https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets_k9-40_1r.pdf).

<sup>s</sup> "The BYD K11 Battery Electric Zero Emissions 60' Transit," BYD Motors Inc., accessed August 9, 2020, [https://en.byd.com/wp-content/uploads/2019/07/k11-cut-sheet\\_final\\_digital.pdf](https://en.byd.com/wp-content/uploads/2019/07/k11-cut-sheet_final_digital.pdf).

## GREENPOWER MOTOR COMPANY INC.

Zero-emission truck market share	-
Zero-emission bus market share	17%
Zero-emission technology offered or being developed for North America	Battery-electric
New business units, partnerships, and acquisitions	

Segment	Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
 Class 7-8 tractor trucks	-	-
 Class 7-8 straight trucks	-	-
 Class 7-8 refuse trucks	-	-
 Class 4-6 straight trucks	EV Star CarGo+ Initial deliveries anticipated Aug. 2020 <sup>a</sup>  EV Star CC	240 km <sup>b</sup>
 Class 2-3 trucks and vans	-	-
 Coach buses	-	-
 School buses	Synapse 72 School Bus Initial deliveries: 2017 <sup>c</sup>	225 km <sup>d</sup>
 Transit buses	30-ft. Transit (EV250) Initial deliveries: 2016 <sup>e</sup>	300 km <sup>f</sup>
	40-ft. Transit (EV350) Initial deliveries: 2018 <sup>g</sup>	
	45-ft. Transit double-decker (EV550) Initial deliveries: 2016 <sup>h</sup>	

<sup>a</sup> "GreenPower Completes First EV Star CarGo+ Serving the Cargo and Delivery Market," GreenPower Motor Company Inc., updated August 10, 2020, <https://www.greenpowerbus.com/first-ev-star-cargo-serving-cargo-delivery-market/>.

<sup>b</sup> "The EV Star," GreenPower Motor Company Inc., accessed September 18, 2020, <https://www.greenpowerbus.com/product-line/ev-star-product-line/>.

<sup>c</sup> "GreenPower Receives \$1.1 Million Order for Three Synapse 72 All-Electric School Buses," GreenPower Motor Company Inc., updated October 19, 2017, <https://www.greenpowerbus.com/greenpower-receives-1-1-million-order-three-synapse-72-electric-school-buses/>.

<sup>d</sup> "Synapse 72 School Bus and Synapse Shuttle Bus Specifications," GreenPower Motor Company Inc., accessed August 9, 2020, <http://www.greenpowerbus.com/wp-content/uploads/2015/12/Synapse72-Synapse-Shuttle-Bus-Specification-FEB20-2018-908x1024.jpg>.

<sup>e</sup> "GreenPower Announces Sale of an EV250 Thirty Foot Transit Bus to Twin Transit Agency in the State of Washington," GreenPower Motor Company Inc., updated February 25, 2016, <https://www.greenpowerbus.com/greenpower-announces-sale-of-an-ev250-thirty-foot-transit-bus-to-twin-transit-agency-in-the-state-of-washington/>.









<sup>f</sup> "Product Line: Transit Buses," GreenPower Motor Company Inc., accessed August 9, 2020, <https://www.greenpowerbus.com/product-line/>.

<sup>g</sup> "GreenPower Delivers and Receives Payment for 2 EV350 All-Electric Transit Buses to the City of Porterville, CA," GreenPower Motor Company Inc., updated March 15, 2018, <https://www.greenpowerbus.com/greenpower-delivers-receives-payment-2-ev350-electric-transit-buses-city-porterville-ca/>.

<sup>h</sup> "GreenPower Announces Letter of Intent to Lease its EVC550 All-Electric Double Decker with the Greater Victoria Harbour Authority and CVS Tours," GreenPower Motor Company Inc., updated December 1, 2015, <https://www.greenpowerbus.com/greenpower-announces-letter-of-intent-to-lease-its-evc550-all-electric-double-decker-with-the-greater-victoria-harbour-authority-and-cvs-tours/>.

## LION ELECTRIC

Zero-emission truck market share	-
Zero-emission bus market share	3%
Zero-emission technology offered or being developed for North America	Battery-electric
New business units, partnerships, and acquisitions	Lion Electric collaborated with Boivin Electric on the development of the Lion8 refuse truck <sup>a</sup>

Segment	Zero-emission models	Manufacturer-stated maximum range (km) and other vehicle specifications (if available)
 Class 7-8 tractor trucks	Lion8 Urban Truck initial deliveries: 2020 Lion7 initial deliveries: 2021	400 km <sup>b</sup>
 Class 7-8 straight trucks	-	-
 Class 7-8 refuse trucks	Lion8 Refuse Truck initial deliveries: 2020	400 km <sup>b</sup>
 Class 4-6 straight trucks	Lion6 Urban Truck initial deliveries: 2020 Lion5 initial deliveries: 2021	-
 Class 2-3 trucks and vans	-	-
 Coach buses	-	-
 School buses Initial deliveries: 2017 <sup>c</sup>	LionA Mini School Bus	Specifications <sup>d</sup>
	LionC Electric School Bus	Specifications <sup>e</sup>
	LionD Electric School Bus	Specifications <sup>f</sup>
 Transit buses	LionM Multiuse Midi/minibus	Specifications <sup>g</sup>

<sup>a</sup> "Lion Electric and Boivin Evolution Announce Initial Sales of Lion8 Zero Emission Refuse Trucks to Waste Connections," The Lion Electric Co., updated July 6, 2020, [https://thelionelectric.com/img/medias/Press\\_Release\\_Waste\\_Connections\\_Final.pdf](https://thelionelectric.com/img/medias/Press_Release_Waste_Connections_Final.pdf).

<sup>b</sup> "Lion8 Zero-Emission Class 8 Urban Truck," The Lion Electric Co., accessed August 9, 2020, [https://thelionelectric.com/documents/en/Lion8\\_all\\_applications.pdf](https://thelionelectric.com/documents/en/Lion8_all_applications.pdf).

<sup>c</sup> According to EV-Volumes.com data, The Lion Electric Co. began delivering buses in the U.S. in 2017. However, the data set does not have information about the individual bus models.

<sup>d</sup> "LionA All-Electric Type A School Bus," The Lion Electric Co., accessed August 9, 2020, [https://thelionelectric.com/documents/en/onepager\\_LionA\\_EN.pdf](https://thelionelectric.com/documents/en/onepager_LionA_EN.pdf).

<sup>e</sup> "LionC All-Electric Type C School Bus," The Lion Electric Co., accessed August 9, 2020, <https://thelionelectric.com/documents/en/BrochureLionCang.pdf>.

<sup>f</sup> "LionD All-Electric Type D School Bus," The Lion Electric Co., accessed August 9, 2020, [https://thelionelectric.com/documents/en/liond\\_specs\\_en.pdf](https://thelionelectric.com/documents/en/liond_specs_en.pdf).

<sup>g</sup> "LionM Technical Specifications," The Lion Electric Co., accessed August 9, 2020, <https://thelionelectric.com/documents/en/BrochureANGLionM.pdf>.

## APPENDIX E: AVAILABLE AND ANNOUNCED HEAVY-DUTY ZERO-EMISSION TRUCK AND BUS MODELS

This appendix lists the zero-emission truck (Table E1) and bus (Table E2) models that are currently available or have been announced by manufacturers as coming to market in the next 1 to 2 years.

**Table E1:** Zero-emission truck models (corresponds to the data points in Figure 7)

Category	Model name	Manufacturer-stated maximum range (km)	Technology	Commercialization status
Class 2b-3	Workhorse Trucks C1000	160	Battery	Pre-production
Class 2b-3	LightningElectric LEV120	195	Battery	Retrofit
Class 2b-3	Workhorse Trucks C650	240	Battery	Pre-production
Class 2b-3	SEA Electric Isuzu NLR EV	275	Battery	Retrofit
Class 2b-3	SEA Electric Isuzu NNR EV	275	Battery	Retrofit
Class 2b-3	SEA Electric Ford Transit EV	300	Battery	Retrofit
Class 2b-3	Bollinger B1	320	Battery	Pre-production
Class 2b-3	Bollinger B2	320	Battery	Pre-production
Class 2b-3	Nikola Badger	965	Fuel cell	Pre-production
Class 4	Dana Nordresa W4	120	Battery	Retrofit
Class 4	Dana Nordresa T4	120	Battery	Retrofit
Class 4	Mitsubishi FUSO eCanter	130	Battery	Production
Class 4	Motiv EPIC E-450 Box Truck	170	Battery	Retrofit
Class 4	LightningElectric E-450 Cutaway	195	Battery	Retrofit
Class 4	Motiv EPIC E-450	195	Battery	Retrofit
Class 4	Dana Nordresa W4+	240	Battery	Retrofit
Class 4	Dana Nordresa T4+	240	Battery	Retrofit
Class 4	Motiv E-450 Work Truck	240	Battery	Retrofit
Class 4	Phoenix Motorcars ZEUS 500	240	Battery	Retrofit
Class 4	SEA Electric Isuzu NPR EV	275	Battery	Retrofit
Class 5-6	Dana Nordresa T5	100	Battery	Retrofit
Class 5-6	BYD 6R	135	Battery	Production
Class 5-6	Xos MDV	160	Battery	Pre-production
Class 5-6	Motiv EPIC F-53	170	Battery	Retrofit
Class 5-6	Motiv EPIC F-59	170	Battery	Retrofit
Class 5-6	LightningElectric F-59	175	Battery	Retrofit
Class 5-6	Freightliner MT50e	200	Battery	Pre-production
Class 5-6	Mercedes-Benz eActros	200	Battery	Pre-production
Class 5-6	BYD 6F	200	Battery	Production
Class 5-6	Dana Nordresa T5+	200	Battery	Retrofit
Class 5-6	Dana Nordresa T6	200	Battery	Retrofit
Class 5-6	LightningElectric Low Cab	210	Battery	Retrofit
Class 5-6	Chanje V8100	240	Battery	Production
Class 5-6	Workhorse Trucks / Plug Power EGEN	260	Fuel cell	Pre-production
Class 5-6	Lion Electric Lion6	290	Battery	Production
Class 5-6	Kenworth K270E	320	Battery	Pre-production
Class 5-6	SEA Electric Hino 195 EV	320	Battery	Retrofit
Class 5-6	SEA Electric Hino 917 EV	320	Battery	Retrofit
Class 5-6	SEA Electric Isuzu NQR EV	320	Battery	Retrofit
Class 5-6	SEA Electric Isuzu NRR EV	320	Battery	Retrofit
Class 5-6	SEA Electric F-59 EV	320	Battery	Retrofit
Class 5-6	SEA Electric F-650 EV	320	Battery	Retrofit
Class 5-6	Navistar eMV	400	Battery	Pre-production
Class 5-6	Peterbilt 220EV	400	Battery	Pre-production
Class 7-8 rigid trucks	BYD 8R	120	Battery	Production
Class 7-8 rigid trucks	Peterbilt 520EV	145	Battery	Pre-production
Class 7-8 rigid trucks	SEA Electric Hino FM EV	200	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric Hino GH EV	200	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric F-750 EV	275	Battery	Retrofit
Class 7-8 rigid trucks	Kenworth K370E	320	Battery	Pre-production
Class 7-8 rigid trucks	SEA Electric Hino FG EV	320	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric Hino FE EV	320	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric Isuzu FRR EV	320	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric Isuzu FTR EV	320	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric Isuzu FSD EV	320	Battery	Retrofit
Class 7-8 rigid trucks	SEA Electric Isuzu FSR EV	320	Battery	Retrofit
Class 7-8 rigid trucks	Freightliner eM2 106	370	Battery	Pre-production
Class 7-8 rigid trucks	Lion Electric Lion8	400	Battery	Production
Class 7-8 tractor trucks	BYD 8TT	270	Battery	Production
Class 7-8 tractor trucks	Volvo (Volvo Group) VNR	300	Battery	Pre-production
Class 7-8 tractor trucks	Peterbilt 579EV	320	Battery	Pre-production
Class 7-8 tractor trucks	Toyota Beta	320	Fuel cell	Pre-production
Class 7-8 tractor trucks	Freightliner eCascadia	400	Battery	Pre-production
Class 7-8 tractor trucks	Hyundai Neptune	400	Fuel cell	Pre-production
Class 7-8 tractor trucks	Hyundai XCIENT	400	Fuel cell	Pre-production
Class 7-8 tractor trucks	Xos ET-One	485	Battery	Pre-production
Class 7-8 tractor trucks	Kenworth T680	485	Fuel cell	Pre-production
Class 7-8 tractor trucks	Nikola Two	565	Battery	Pre-production
Class 7-8 tractor trucks	Tesla Semi	805	Battery	Pre-production
Class 7-8 tractor trucks	Nikola One / Two	1205	Fuel cell	Pre-production



**Table E2:** Zero-emission bus models (corresponds to the data points in Figure 8)

Category	Model name	Manufacturer-stated maximum range (km)	Technology	Commercialization status
Coach	BYD C6M	200	Battery	Production
Coach	MCI D45 CRTe LE CHARGE	275	Battery	Pre-production
Coach	BYD C8MS	275	Battery	Production
Coach	Van Hool CX45E	300	Battery	Pre-production
Coach	BYD C8M	320	Battery	Production
Coach	BYD C9M	320	Battery	Production
Coach	MCI J4500e CHARGE	370	Battery	Pre-production
Coach	MCI D45 CRTe CHARGE	370	Battery	Pre-production
Coach	BYD C10M	370	Battery	Production
Coach	BYD C10MS	370	Battery	Production
School	Starcraft eQuest XL	145	Battery	Retrofit
School	Blue Bird Micro Bird GS Electric	160	Battery	Production
School	Navistar chargE	195	Battery	Pre-production
School	Blue Bird All American RE Electric	195	Battery	Production
School	Blue Bird Vision Electric	195	Battery	Production
School	Thomas C2 Jouley	215	Battery	Production
School	Greenpower Synapse 72	225	Battery	Production
School	Lion Electric LionA	240	Battery	Production
School	Phoenix Motorcars ZEUS 600	240	Battery	Retrofit
School	Lion Electric LionD	250	Battery	Pre-production
School	Lion Electric LionC	250	Battery	Production
Shuttle	LightningElectric E-450	195	Battery	Retrofit
Shuttle	Optimal EV SILF	200	Battery	Retrofit
Shuttle	Greenpower EV STAR	240	Battery	Production
Shuttle	Greenpower EV STAR+	240	Battery	Production
Shuttle	Greenpower EV STAR ADA	240	Battery	Production
Shuttle	Phoenix Motorcars ZEUS 400	240	Battery	Retrofit
Transit	Nova Bus (Volvo Group) LFSe	120	Battery	Pre-production
Transit	New Flyer Xcelsior CHARGE 60'	215	Battery	Production
Transit	GILLIG 40' Transit	240	Battery	Pre-production
Transit	BYD 30' Transit	240	Battery	Production
Transit	Lion Electric LionM	240	Battery	Production
Transit	Lion Electric LionC	250	Battery	Production
Transit	Letenda Electrip	250	Battery	Pre-production
Transit	Mercedes-Benz eCitaro	280	Battery	Pre-production
Transit	Mercedes-Benz eCitaro G	280	Battery	Pre-production
Transit	Greenpower EV250	280	Battery	Production
Transit	Greenpower EV300	280	Battery	Production
Transit	BYD 40' Transit	285	Battery	Production
Transit	Greenpower EV350	300	Battery	Production
Transit	Greenpower EV400	300	Battery	Production
Transit	SEA Electric E4B	300	Battery	Production
Transit	New Flyer Xcelsior CHARGE 35'	315	Battery	Production
Transit	BYD 35' Transit	345	Battery	Production
Transit	BYD 60' Transit	355	Battery	Production
Transit	New Flyer Xcelsior CHARGE 40'	360	Battery	Production
Transit	Proterra Catalyst 35'	385	Battery	Pre-production
Transit	Greenpower EV550	385	Battery	Production
Transit	Nova Bus (Volvo Group) LFSe+	470	Battery	Pre-production
Transit	Proterra Catalyst 40'	530	Battery	Pre-production
Transit	New Flyer Xcelsior CHARGE H2	565	Fuel cell	Production



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