DECEMBER 2021

# RACE TO ZERO

## How manufacturers are positioned for zero-emission commercial trucks and buses in Europe

Hussein Basma and Felipe Rodríguez


icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

## ACKNOWLEDGMENTS

The authors thank all reviewers of this report for their guidance and constructive comments, with special thanks to Pierre-Louis Ragon, Ben Sharpe, Claire Buysse, Shiyue Mao and Ray Minjares (International Council on Clean Transportation). Their reviews do not imply any endorsement of the content of this report.

Funding for this work was generously provided by European Climate Foundation.

International Council on Clean Transportation
1500 K Street NW, Suite 650
Washington, DC 20005

communications@theicct.org | www.theicct.org | @TheICCT

# TABLE OF CONTENTS

# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| HDV | Heavy-duty vehicles |
| ZE | Zero-emissions |
| OEM | Original equipment manufacturer |
| GVW | Gross vehicle weight |
| LFP | Lithium iron phosphate |
| NMC | Nickel manganese cobalt oxide |
| NCA | Nickel cobalt aluminum oxide |
| NaNiCl | Sodium nickel chloride |

# INTRODUCTION

Curbing $CO_2$ emissions from the transport sector is a key factor in achieving a global carbon-neutral economy by mid-century as accorded in the Paris Climate Agreement (UNFCCC, 2015). Although most of the progress made on zero-emission vehicle technologies in the past two decades has revolved around passenger cars, the electrification of trucks and buses is gaining momentum. This is mostly driven by ambitious regulations around the world mandating truck and bus manufacturers to reduce $CO_2$ emissions of their new vehicle fleet or setting clear sales requirements for zero-emission technologies. Key examples of such regulations are the European Union's $CO_2$ standards for heavy-duty vehicles, which currently mandate a 30% $CO_2$ reduction by 2030 (European Commission, 2018),[1] and California's Advanced Clean Truck regulations, which require that zero-emission trucks represent between 30% and 50% of new sales by 2030 (California Air Resources Board, 2020). Additionally, governments have begun to make long-term commitments for a 100% phase out of internal combustion engine medium- and heavy-duty trucks (Wappelhorst & Rodríguez, 2021).

This paper analyzes manufacturers' market readiness to develop and deploy zero-emission commercial trucks and buses to meet this upcoming target. The scope of the analysis is limited to EU 27 countries, the United Kingdom (UK), Switzerland, and Norway, collectively referred to as *Europe* in this report for simplicity. However, due to the global footprint of European truck and bus manufacturers, the findings have important implications for other regions. For this report, we analyzed the sales of new zero-emission heavy-duty vehicles (ZE-HDVs) over the past decade, using data from EV-Volumes.com[2] and IHS Markit Global S.à.r.l.[3] The report also summarizes recent announcements and commitments from manufacturers to decarbonize their new vehicle fleets. The first section contextualizes the analysis by providing a short overview of the global ZE-HDV market. Then, we present the specificities of the truck and bus market in Europe across the segments, followed by a detailed analysis of the European ZE-HDV market and technology development. The final section summarizes the main findings in this paper. The report's appendices include detailed information on the technical specifications of ZE-HDVs, model availability, and sales performance across different segments and manufacturers.

1 The European Union will review the $CO_2$ standards in 2022. The ambition of the 2030 target is expected to increase. Targets for 2035 and 2040 can also be set as part of the review process.

2 Data supplied by EV-Volumes.com. (Zero-emission commercial vehicle sales, 2021), http://www.ev-volumes.com.

3 Content supplied by IHS Markit Global S.à.r.l.; Copyright © IHS Markit Global S.à.r.l., 2021. All rights reserved.

# GLOBAL MARKET OF ZERO-EMISSION HEAVY-DUTY VEHICLES

The global sales of ZE-HDVs, that is battery-electric and fuel-cell electric HDV technologies, have been on the rise over the past years. China is by far the largest market with more than 99% of the cumulative global stock of ZE-HDV, as shown in Figure 1. Sales of ZE-HDVs reached a peak in 2016 at approximately 160,000 vehicles globally, after which sales declined, driven by tighter qualification requirement for ZE-HEV subsides adopted by China's central government to prevent fraud (Mao & Rodríguez, 2021). While more than 90% of the global ZE-HDV sales between 2010 and 2018 were buses, this trend is starting to change. Trucks represented more than 26% of the global new ZE-HDV registrations in 2020, increasing from 14% in 2019 and only 9% in 2018. In addition, more than 95% of the global ZE-HDV new registrations in 2020 are battery-electric, with fuel-cell electric technologies exhibiting a negligible market penetration.

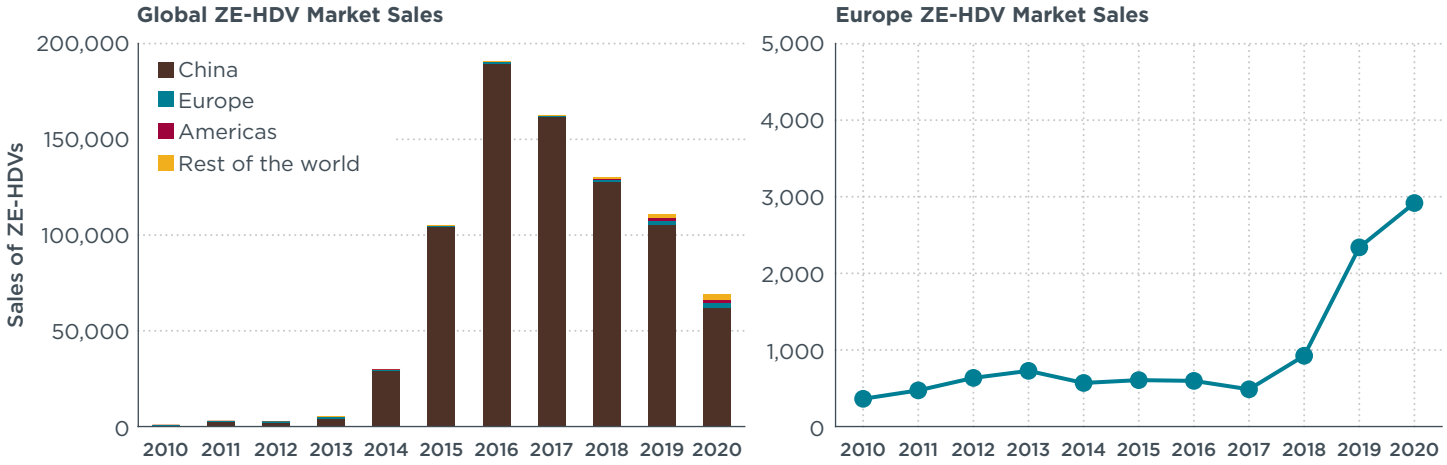


**Figure 1**. Global ZE-HDV sales (left) and Europe (EU 27, UK, Norway, and Switzerland) zero-emission HDV sales (right) between 2010 and 2020.

The right panel of Figure 1 shows the ZE-HDV sales in Europe between 2010 and 2020. In 2020, close to 3,000 ZE-HDVs were registered in Europe, representing a 40% increase relative to 2019. So far, Europe is the second largest market after China, outpacing the North American market (United States and Canada) in ZE-HDVs sales by over a factor of four. Despite this substantial increase, the ZE-HDV market in Europe is still nascent, representing just over 2% of the total sales of new trucks and buses in 2020. However, thanks to the existing and upcoming regulatory pull, truck and bus manufacturers are developing ambitious plans to invest in zero-emission commercial vehicles, signaling an accelerated market uptake in the coming years.

## CURRENT STATE OF THE TRUCK AND BUS MARKET IN EUROPE

The vast majority of new truck and bus registrations in Europe are conventional diesel vehicles, representing more than 98% of the sales between 2016 and 2018. The market share of alternative powertrains, that is, without a diesel engine, is shown in Figure 2. For most of the past decade, the market share of alternative powertrains remained at around 1.5%, mostly dominated by natural gas powertrains (Rodríguez et al., 2017). In recent years, however, the share of natural gas powertrains has seen a marked uptake, largely driven by the generous incentives provided by the German government (Mottschall et al., 2020). In 2020, 3% of the newly registered trucks and buses were natural gas powertrains. In the same year, electrified powertrains accounted for approximately 2.1% of the market, with battery-electric trucks and buses representing 1.1%, hybrid-electric vehicles 1%, and fuel-cell electric powertrains less than 0.01%.

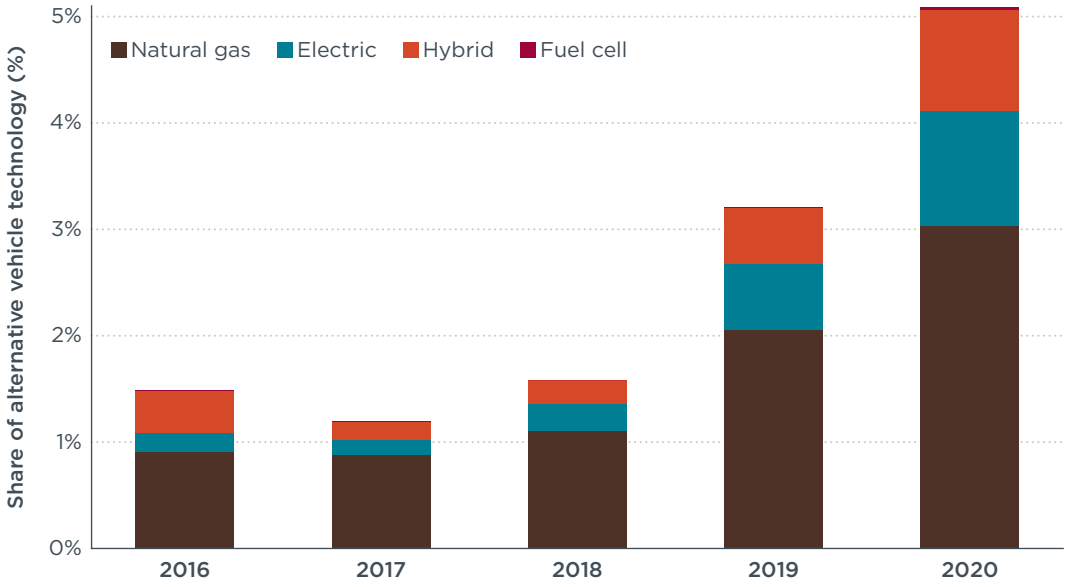


**Figure 2**. HDV new registrations market breakdown by alternative technology in Europe (EU 27, UK, Norway, and Switzerland) between 2016 and 2020.

Figure 3 shows the breakdown of new truck and bus registrations with a gross vehicle weight (GVW) above 3.5 tonnes for the year 2020 in Europe. All HDVs are classified under four main categories:

1. Light and medium trucks: Trucks with a 4×2 axle configuration and GVW below 16 tonnes. These vehicles represented close to 20% of the new HDV registrations in Europe in 2020.
2. Heavy trucks: Trucks with GVW above 16 tonnes including all 4x2, 6x4, 6x6, 8x2, 8x4, 8x6, and 8x8 axle configuration rigid and tractor trucks. These vehicles accounted for the majority of the HDV registrations in 2020 in Europe, at around 66%.
3. Buses and coaches: Standard, articulated, and double-decker buses of all lengths. Accounted for 12% of HDV registrations in Europe in 2020.
4. Other categories of HDV vehicles: Trucks for construction and off-road applications. Accounted for 3% of HDV registrations in Europe in 2020.

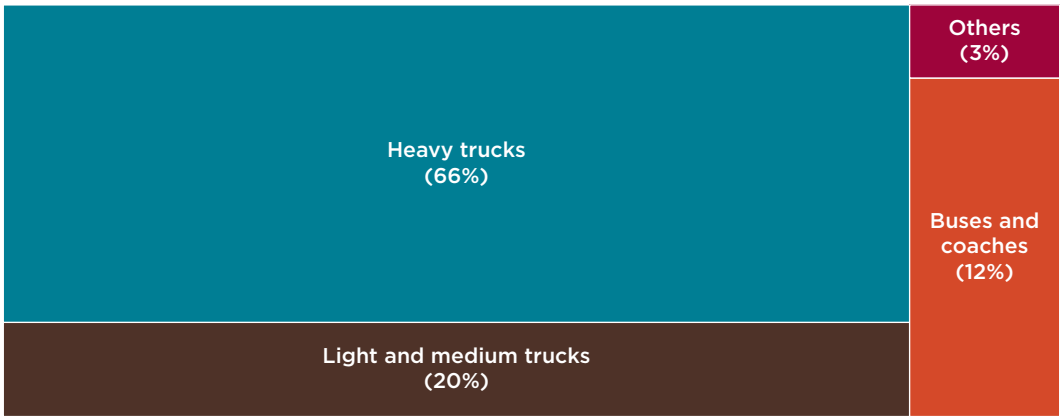


**Figure 3**. Breakdown of new truck and bus registrations in Europe (EU 27, UK, Norway, and Switzerland) by segment for the year 2020.

The truck and bus market in Europe is mainly dominated by a handful of manufacturers, as shown in Figure 4. Traton Group, which owns European brands Scania and MAN, and Daimler Trucks, which owns the brands Mercedes-Benz and Fuso in Europe, are each responsible for about a quarter of the new registrations in 2020. Volvo Group, which includes the brands Volvo Trucks and Renault Trucks, comes next with an 18% market share. Paccar, owner of DAF Trucks in Europe, and CNH Industrial, which owns IVECO, had each a market share of 9% and 12%, respectively, in 2020.

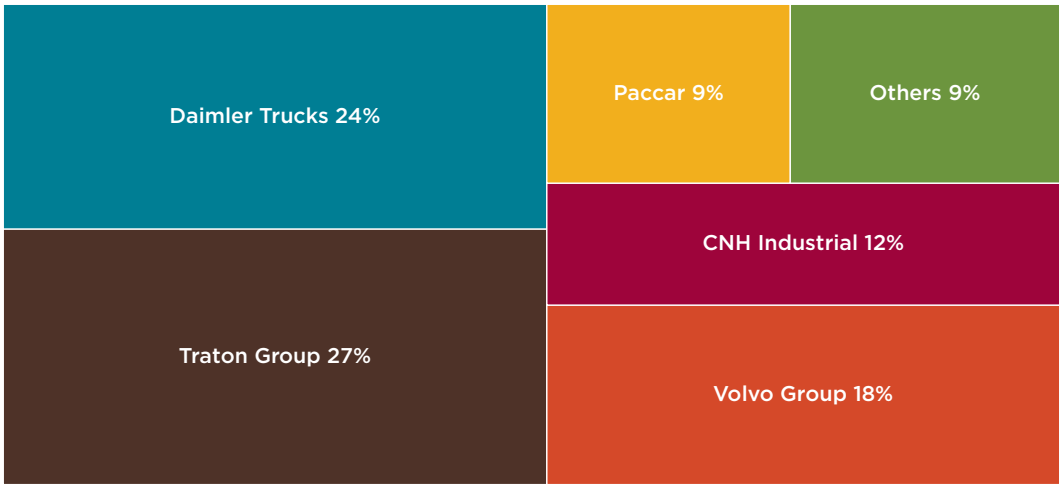


**Figure 4**. Breakdown of new truck and bus registrations in Europe (EU 27, UK, Norway, and Switzerland) by manufacturers for the year 2020.

The market share of each manufacturer in key heavy-duty vehicle segments is summarized in Figure 5. For the light and medium truck segments, Daimler Trucks is the dominant manufacturer with a 33% market share in 2020, with its products Mercedes-Benz Atego, Mercedes-Benz Sprinter, and Mitsubishi Fuso Canter dominating the market. CNH Industrial also has a high market presence with more than 20%, mainly through its truck models IVECO EuroCargo and the IVECO Daily van.  In this segment, Traton Group has a market share of 15%, while Volvo Group has a 9% market share.

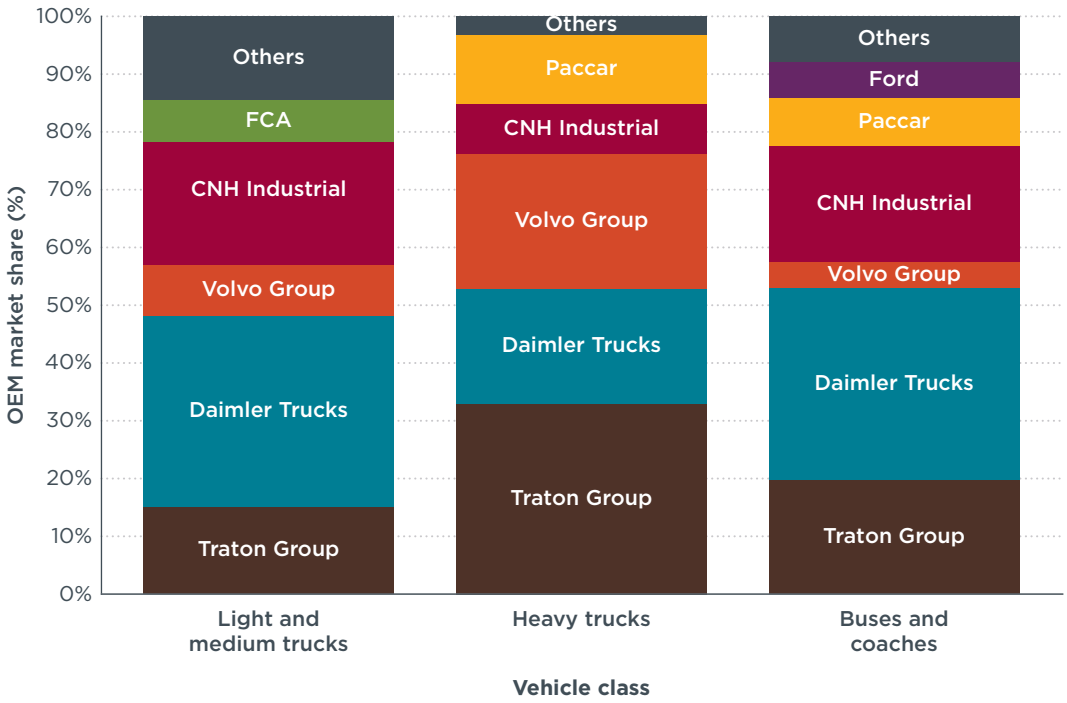


**Figure 5**. Market share by manufacturer in key vehicle segments in Europe (EU 27, UK, Norway, and Switzerland) for the year 2020

The market for heavy trucks is more consolidated, as this segment is largely dominated by tractor-trucks. Traton Group accounted for 33% of the new vehicles in this market in 2020, with its models MAN TGX and Scania R Series. Volvo Group's sales represented 23% of new trucks in this segment in the same year, followed by Daimler Trucks at 20%. Paccar recorded a 12% market share.

In the bus and coach segment, Daimler's market share is close to 33%, with high sales for the Citaro bus model. CNH Industrial follows with a 20% sales share, mainly through the IVECO Bus Crossway model. Traton Group's share is 19%, followed by Ford and Volvo with close to a 5% market share for each. Several other manufacturers, such as CAF Group, PSA Groupe, and VDL, combined have a market share close to 20%, highlighting how buses are a less consolidated segment compared to trucks.

This global overview of the European HDV market reveals how the same few manufacturers dominate across all HDV segments in Europe, but their respective market share varies from one segment to another.  Daimler and CNH Industrial are strongly present in the light and medium trucks, buses, and coaches' segments, while Traton Group and Volvo Group dominate the heavy trucks segment. Still, the heavy trucks segment is more consolidated, while buses involve higher shares of smaller manufacturer.

# ZERO-EMISSION HEAVY-DUTY MARKET IN EUROPE: GLOBAL OVERVIEW

ZE-HDV sales have been on the rise in Europe over the past five years, mainly driven by the deployment of battery-electric bus fleets across several European cities. Figure 6 presents the annual new ZE-HDV registrations in Europe from 2015 to 2020, segmented into three main categories discussed earlier: (1) buses and coaches, (2) light and medium trucks, and (3) heavy trucks. While ZE truck sales witnessed a significant increase over the past year, representing more than 40% of new ZE-HDV registrations in 2020, ZE buses represented more than 90% of the ZE-HDV sales between 2010 and 2015. In addition, more than 97% of ZE-HDV registrations in 2020 were battery-electric vehicles, with very limited presence of fuel-cell electric technologies.

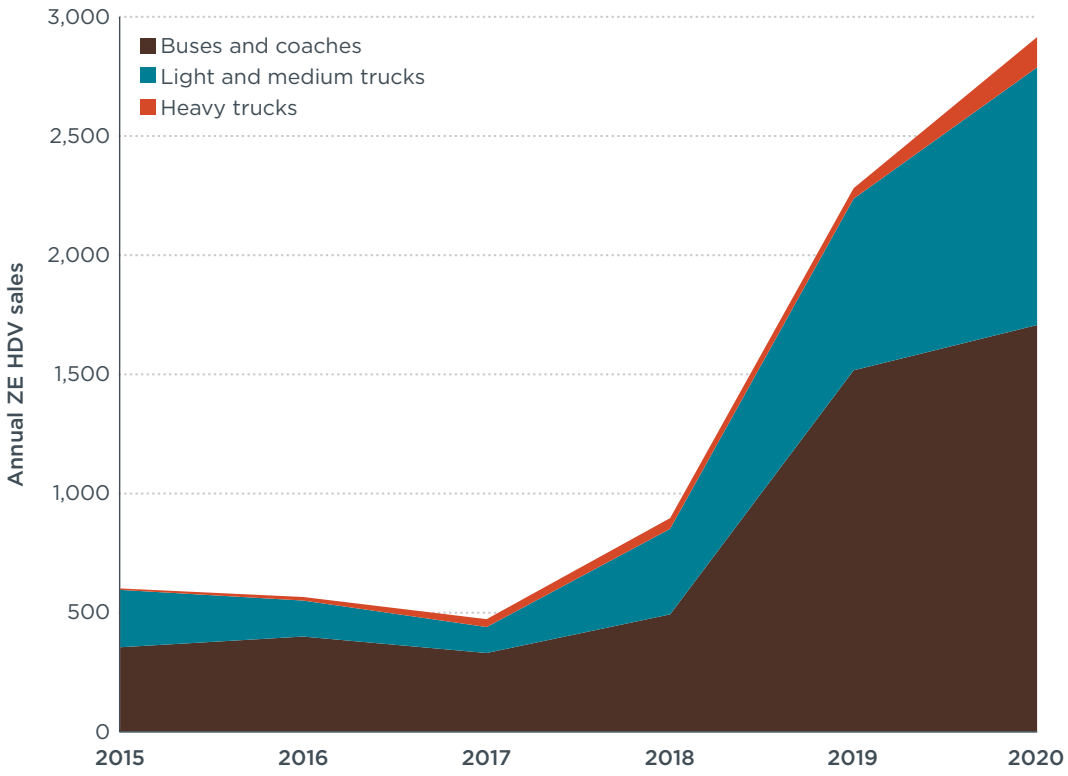


**Figure 6**. Annual ZE-HDV new registrations in Europe (EU 27, UK, Norway, and Switzerland)

Figure 7 and Figure 8 present the repartition of the cumulative sales of ZE buses and trucks across several European countries between 2016 and 2020. The Netherlands is home to 26% (~ 1,150 units) of the total ZE bus sales between 2016 and 2020 in Europe, followed by France with 17% (~ 750 units), Germany with 15% (~ 680 units), and Norway, the UK, and Sweden between 7% and 9 % each. The high share of ZE buses in these countries is mainly driven by regulations and mandates at the regional and municipal level in some major cities like London, Paris, and Amsterdam. The vast majority, 70% of the ZE bus sales between 2016 and 2020 in Europe, are battery-electric buses. As for ZE trucks in Europe, 65% (~ 1,800 units) of those trucks are in Germany, followed by France with 11% (~ 300 units), the UK with 8% (~ 200 units), and the Netherlands with 4% (~ 100 units).

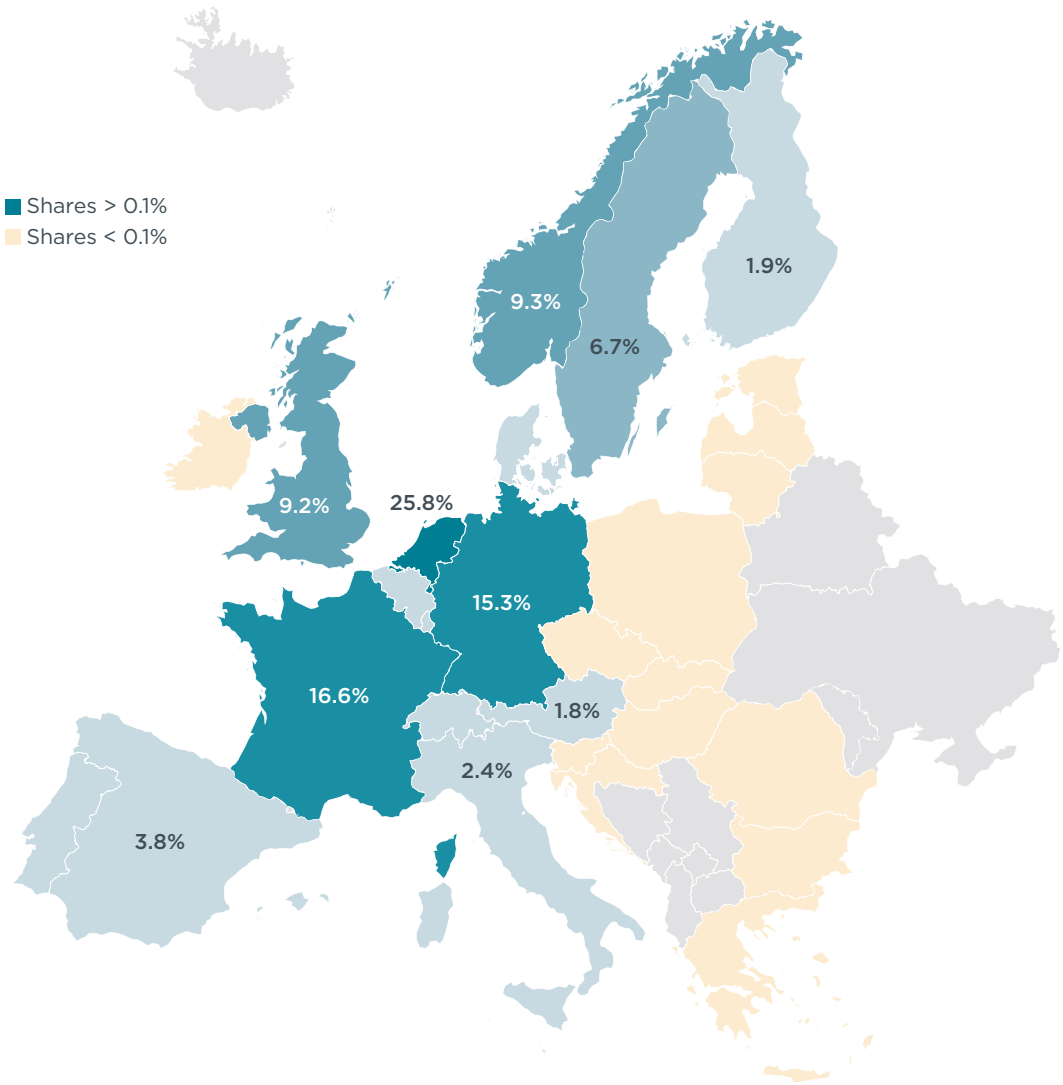


**Figure 7**. Sales distribution of zero-emission buses in Europe (EU 27, UK, Norway, and Switzerland) from 2016 to 2020.

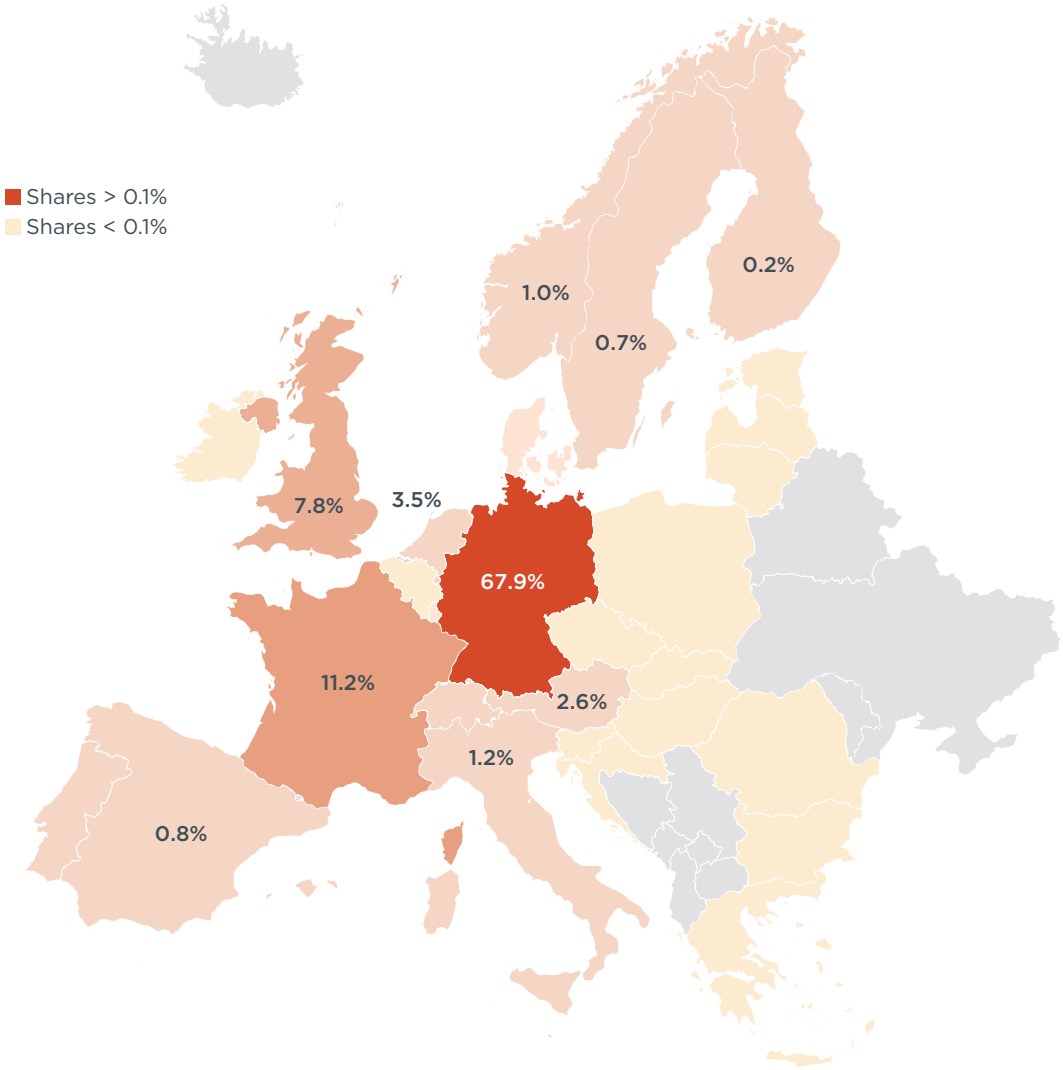


**Figure 8**. Sales distribution of zero-emission trucks in Europe (EU 27, UK, Norway, and Switzerland) from 2016 to 2020.

Unlike the diesel HDV market, the ZE-HDV market in Europe is more diverse, with almost 10 OEMs responsible for 75% of all the ZE-HDV registrations as shown in Figure 9. StreetScooter, owned by Deutsche Post DHL, had the highest market share by far in 2020 at around 24%, driven by the sales of its WORK XL big electric van. BYD's share of Europe's ZE-HDV registrations in 2020 was around 12.5%, thanks to its best-selling eBus K9 electric bus model. Volvo Group's market share in 2020 was close to 8%, while CAF group, with its Solaris buses, followed with 6%. Daimler's share was close to 5%, mostly driven by the deployment of the Mercedes-Benz eCitaro battery-electric city bus and the FUSO eCanter, while CNH, Yutong, and LDV follow with a 4%–5% market share each.

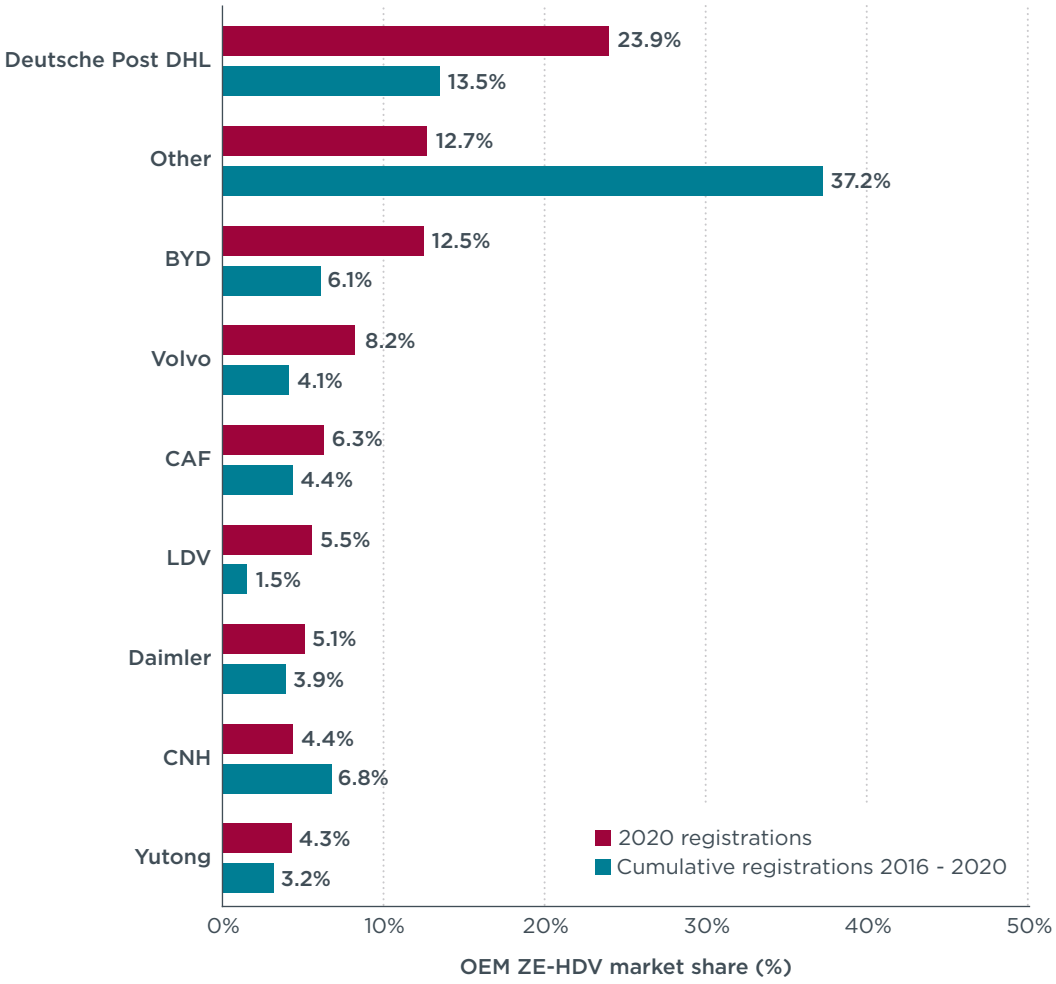


**Figure 9**. OEM market share of ZE-HDV aggregate sales between 2016 and 2020 and new registrations in 2020 in Europe (EU 27, UK, Norway, and Switzerland).

Battery-electric buses and trucks comprise most of the ZE-HDV market in Europe, and the design of their battery sizes is of upmost importance as it directly defines the vehicle driving range. Figure 10 shows the distribution of electric bus and truck battery size as a function of the gross vehicle weight. Electric bus battery size ranges from 60 kWh to 680 kWh depending on the bus application and available charging infrastructure. The standard 12m long buses with GVW around 20 tonnes, representing more than 50% of the total ZE bus sales between 2016 and 2020, are mainly equipped with 250 kWh–500 kWh batteries, providing a driving range between 90 km and 200 km based on the real-world energy consumption of these buses (Basma et al., 2020). Heavier buses, mainly 18m articulated buses with GVW around 30 tonnes, are also a favorable bus segment to be electrified, with reported battery sizes ranging between 200 kWh and 400 kWh. Their higher energy consumption forces operators to charge them at depots more frequently and at a higher power of 350 kW.

While the limited number of electric truck models and applications do not provide a conclusive technology overview, heavier trucks are being equipped with larger batteries to supply the truck additional energy needs, mainly driven by the currently available charging infrastructure that forces operators to charge at depots. For heavy trucks with GVW above 26 tonnes, battery sizes range from 250 kWh to 500 kWh. Lighter trucks in the range of 4 tonnes to 7 tonnes in GVW are mainly equipped with battery sizes in the range of 100 kWh. In addition to their weight, the mission profile of each truck highly impacts their required battery size and driving range (Basma et al., 2021).

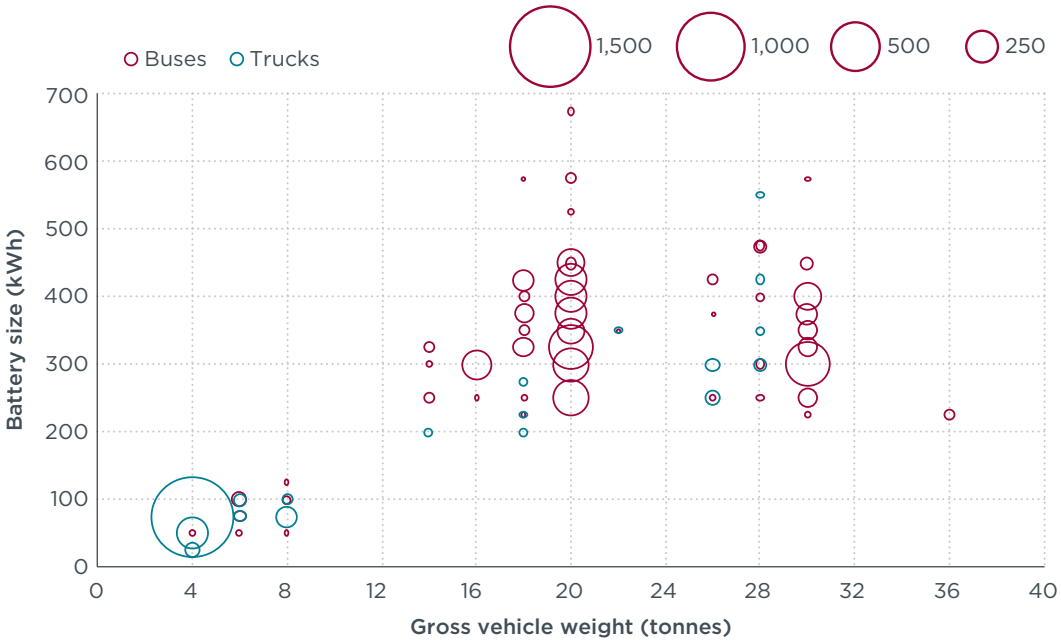


**Figure 10**. Distribution of electric buses and trucks battery as function of gross vehicle weight based on aggregate sales between 2016 and 2020 in Europe (EU 27, UK, Norway, and Switzerland) Resolution: 2 tonnes - 25 kWh.

# ZERO-EMISSION HEAVY-DUTY MARKET IN EUROPE: SEGMENT ANALYSIS

## BUSES AND COACHES

Buses have been early adopters of ZE-HDV technology, led primarily by battery-electric technology. This is mainly driven by regulations and mandates at the regional and municipal levels in several European countries such as the "100% 2025 Clean Bus Project" in metropolitan Paris (RATP Group, 2016), London's "Low Emissions Bus Zones" (London Assembly, 2015), the "Zero Emission Buses" project in Germany (NOW, 2019), the Netherlands' target of 100% ZE buses by 2025 (Ministerie van Infrastructuur en Waterstaat, 2016), the " Zero Emission Urban Bus System" initiative in the Europe (ZeEUS, 2014), and many other projects and initiatives. In addition, these segments are the easiest to decarbonize considering their pre-defined routes and schedules, which makes it more convenient to provide recharging or refueling stations at bus stops and depots.

The HDV bus market in Europe is mainly dominated by Daimler, CNH Industrial, and Traton Group, as these three OEMs were responsible for almost 70% of the 2020 new bus registrations in Europe. However, when it comes to the ZE-HDV bus market, BYD (21%), Volvo Group (12%) CAF (10%), Yutong (7%), VDL (7%), CNH Industrial (7%) and Daimler (6%) are the key players. It is worth mentioning the strong presence of non-European manufacturers in the ZE-HDV bus market, unlike the market for conventional buses.

BYD is a key player in the European ZE bus market, with more than 650 units are operating in Europe, mainly in the Netherlands (more than 300 units) and the United Kingdom (more than 100 units). The BYD Series K9 bus model is the most popular bus model, equipped with 324 kWh lithium iron phosphate (LFP) battery (BYD, 2021). In the second half of 2021, BYD is expected to deliver more than 440 units of the K9 Series to the United Kingdom, Finland, Italy, Norway, and Spain.

The Volvo electric bus model 7900 E (Volvo, 2021a) is being deployed in many European countries, with close to 250 units currently operating in Sweden, Norway, and the Netherlands. The 7900 E model is mainly equipped with a 400 kWh LFP battery and Volvo is currently preparing to deliver more than 120 units of this bus model to Sweden.

**Figure 11.** BYD k9 electric bus model

**Figure 12.** Volvo 7900 E electric bus model

Solaris Bus, part of CAF Group, is very active in Germany and Italy. The Urbino Electric model is their most common operating model equipped with a 240 kWh nickel manganese cobalt (NMC) battery. However, Solaris has revealed the NEW Urbino 15 LE Electric bus model, advertised as suitable for long-distance intra-city transport, will contain one of the largest batteries available in the European bus market, with capacity reaching 470 kWh (Solaris, 2020). Solaris is expected to deliver more units of its Urbino model, mainly to Poland, Italy, and Germany (87 units).

Yutong is currently very active in France and Norway; close to 100 electric bus units of Yutong U-Series (U12) were ordered in Norway in 2020 and more than 150 units are operating in France since 2016. The U-12 electric bus is equipped with a 422 kWh LFP battery (Yutong, 2021), a significantly upgraded battery capacity in comparison to the standard buses equipped with 250 kWh batteries that have been operating in France since 2016. Yutong will be delivering more units of its U Series 12 to Denmark and to the United Kingdom.

VDL, the Netherlands-based bus manufacturer, has been very successful in deploying their electric bus Citea model (VDL, 2021), with close to 600 units operating in Europe as of 2020. The Citea electric bus model is offered as a 12 m city bus and an 18 m articulated bus. The former is usually equipped with a 288 kWh NMC battery, while the articulated bus model is equipped with a 525 kWh LFP battery. More units of the Citea model are expected to be delivered to Eindhoven in the Netherlands and to Finland.

Daimler's eCitaro bus model sold more than 200 units since 2019, making it the best-selling electric bus model, with most operating in Germany. The eCitaro bus model comes with 338 kWh or 441 kWh battery pack (Mercedes-Benz, 2021), enough to cover the entire daily bus energy needs on a single charge. In addition to the conventional NMC battery chemistry used by Daimler, the recent eCitaro bus model is offered using solid-state batteries, with a fleet of more than 37 such buses deployed in Hamburg in early June, 2021 (Randell, 2021, June 11). In 2021, Daimler is expected to deliver more than 200 units of the eCitaro, mainly in Germany (125 units) and in France (92 units).


**Figure 13.** Solaris Urbino electric bus model


**Figure 14.** Mercedes eCitaro electric bus model

Other OEMs are offering electric bus models, including CNH Industrial through its subsidiaries Iveco bus, Irizar, and Hueliez, but their market uptake is still inferior to the previously mentioned OEMs. Traton Group is offering the new MAN Lion's City E bus, equipped with a 480 kWh NMC battery for a 12 m standard bus, and a staggering 680 kWh NMC battery for its 18 m articulated bus (MAN Truck & Bus, 2021). The buses are currently under trial in Germany, and their driving range has been reported by MAN Truck and Bus to exceed 500 km.

As for fuel-cell electric buses, their market is still niche in Europe, but several OEMs are offering new models and some European cities have begun operating fleets of fuel-cell electric buses. Van Hool is the major key player in Europe, concentrated in the Netherlands and Germany where more than 30 hydrogen buses have been sold over the past two years. Its A330 model, based on a fuel cell stack supplied by Ballard (Van Hool, 2020), is based on a 350 bar hydrogen tank (Fuelcellbus.eu, 2015). Other OEMs are also offering fuel-cell electric buses, but with almost negligible market uptake up until December 2020, including CAF-Solaris, Daimler, and VDL.


**Figure 15.** Solaris Urbino 12 fuel cell bus model

The ZE-HDV bus market in Europe is gaining significant momentum over the past decade, driven by the Clean Vehicles Directive in Europe and the related minimum targets set for each member state, in addition to other regional and municipal mandates. Battery-electric buses are already roaming European streets in large numbers, with more models being announced by OEMs and more fleets being put in operation everyday across Europe. Fuel-cell electric technologies still lack model diversity, and very limited number of fleets are currently operating fuel cell buses in Europe. Although buses have been the focus of HDV electrification over the past years, some types of bus service such as regional buses and inter-city buses still lag behind other bus segments, mainly limited by the high daily driving ranges, imposing very large battery sizes. However, with OEMs offering a variety of models equipped with battery capacities of more than 600 kWh, such as the case of MAN Lion's E Bus, these bus segments could be on the verge of electrification over the next couple of years.

## HEAVY TRUCKS

The ZE market for heavy trucks is still niche, although several OEMs have put battery-electric trucks in operation, mainly truck in 4x2 axle configuration. Volvo is providing electric truck versions in the chassis FM, FMX and FH, with a variety of battery sizes ranging between 180 kWh –540 kWh (Volvo, 2021b), based on CATL LFP battery chemistry. Volkswagen's Traton is currently offering two models, MAN's eTGM truck equipped with a 180 kWh NMC battery (MAN Truck & Bus, 2020), and the Scania P-series full electric truck model with two options for battery capacities, 165 kWh and

300 kWh (Scania, 2020b). CNH is developing the IVECO-FPT-Nikola tractor truck with an expected battery capacity of 780 kWh and preliminary market launch date in 2023 (IVECO, 2020). Paccar will offer an electric truck model through DAF, its subsidiary in Europe, with an expected 282 kWh LFP battery pack and initial production date in 2021 (DAF, 2021d). Finally, Daimler's Mercedes-Benz just announced the launch of the eActros truck production, a truck equipped with 420 kWh battery (Daimler, 2021a).


**Figure 16.** MAN eTGM electric truck model

Rigid and tractor trucks with GVW above 16 tonnes, typically at 26 tonnes, and a 6×2 axle configuration represent more than 14% of the total European new HDV registrations in 2020, with Volkswagen, Daimler, CNH, Volvo, and Paccar almost dominating 100% of the market. Only a handful of ZE trucks in this weight range are currently operating in some European countries, with most of them still in the trial phase. Daimler's Mercedes-Benz Econic rigid truck, designed for urban use, will be put in production as of 2022 (Mercedes-Benz, 2020). While no information has been revealed regarding its battery capacity, the truck is expected to be used as a vocational truck around city centers, with an expected daily driving range reaching 100 km (Kane, 2020). Volvo's ZE trucks are also offered in the 6×2 axle configuration, but no orders have been put in place so far. Renault Trucks, part of Volvo Group, is offering the Renault Trucks D All Electric 6×2 rigid truck with a wide range of battery capacities between 200 kWh and 300 kWh (Renault Trucks, 2021a). DAF is also offering a 6×2 rigid truck, the DAF CF electric model, equipped with 350 kWh battery capacity and a GVW reaching 28 tonnes (DAF, 2021a).


**Figure 17.** DAF CF electric truck model


**Figure 18.** Renault Truck D all electric model

The Hyundai Xcient hydrogen fuel-cell electric truck has sold 46 units in Switzerland as of 2020. The truck is equipped with two 90 kW fuel-cell stacks and a hydrogen storage tank with a usable capacity of 31 kg, compressed at 350 bars. Hyundai announced that additional 1,600 Xcient truck units will be operated in Switzerland by 2025 (Hyundai, 2021). Another serious attempt to deploy a hydrogen fuel-cell electric truck is being made by Mercedes-Benz with its GenH2 truck model, which is based on the Actros chassis. The model is currently under trial, and series production is expected to start by 2027 (Daimler, 2021c). DAF's XF hydrogen truck, a 6x2 rigid truck still in its trial phase, is reported to be equipped with a 700-bars hydrogen storage tank (DAF, 2021c). Scania has already put in operation a hydrogen fuel-cell truck in Norway. The truck is equipped with a 350-bar hydrogen storage tank and 90 kW fuel cell stack (Scania, 2020a) and comes in a 6x2 axle configuration.

## LIGHT AND MEDIUM TRUCKS

Trucks with a 4×2 axle and a GVW of less than 16 tonnes accounted for 20 % of the total European new HDV registrations in 2020. Rigid trucks below 7.5 tonnes is by far the most important segment by volume as it represents more than 11% of the total HDV sales in Europe. Within this class, the StreetScooter Work XL 4-tonne is the most successful electric vehicle with its sales exceeding 250 units in 2020, mainly in Germany. The StreetScooter WORK XL is equipped with a 76 kWh battery (StreetScooter, 2020). StreetScooter, an RWTH Aachen university startup founded in 2010, was acquired by Deutsche Post DHL in 2014 to deliver electric vans to the German package delivery company. Despite deploying several hundreds of units of different variants of the StreetScooter electric vans, Deutsche Post DHL has been looking for buyers for its subsidiary StreetScooter over the past two years, with no official announcements yet on the company's long-term strategy in terms of model development, production, and deliveries.  Another model in this truck class is the Mercedes-Mitsubishi FUSO eCanter, which is equipped with an 83 kWh NMC battery and has than 80 units already operating in Germany (Mitsubishi, 2021). No hydrogen fuel-cell electric models have been announced so far by OEMs.


**Figure 19.** Deutsche Post DHL StreetScooter WORK XL electric truck model


**Figure 20.** Mitsubishi Fuso eCanter electric truck model

## OEMS ANNOUNCEMENTS AND COLLABORATIVE EFFORTS

OEMs are announcing several upcoming ZE-HDV models, especially for trucks, and many of them have planned series production for the next couple of years. With the increase in ZE-HDV models' availability, presumably driven by the EU's HDV $CO_2$ standards, several OEMs have announced targets regarding the market uptake of ZE-HDV for 2030 and beyond. Daimler has announced that potentially 60% of its new HDV registrations will be ZE by 2030, with a 100% target for ZE-HDV market uptake by 2039, becoming the first OEM to phase out internal combustion engines across all HDV segments (Daimler, 2021b). In addition, MAN trucks have announced targets for the market uptake of ZE-HDV by 2030, set as 40% of its new registrations in long-haul operation and 60% of its new registrations in regional delivery operation. MAN trucks will phase out combustion engines by 2040, striving for a 100% ZE-HDV market uptake (MAN, 2021).

Other OEMs have also announced ZE-HDV targets. Scania announced a 10% ZE-HDV market uptake by 2025, which will increase to 50% by 2030 (Scania, 2021b). Scania was also the only large truck manufacturer to endorse the Global Memorandum of Understanding (MOU) for Zero-Emission Medium- and Heavy-Duty Vehicles, aiming to achieve 100% market uptake of ZE-HDV by 2040 (Dutch Ministry for the Environment & CALSTART, 2021). Similarly, Volvo have announced a 7% target for its ZE-HDV market uptake by 2025, which will increase to 50% by 2030 (Volvo, 2021c).[4] Renault trucks has also set a 10% target for its ZE-HDV market uptake by 2025 (Renault Trucks, 2020). This will increase to only 35% by 2030, falling behind other major OEMs that have already announced targets between 50% and 60% (Renault Trucks, 2021b). Table 1 summarizes these announcements.

**Table 1.** Summary of manufacturers announcements regarding ZE-HDV market uptake targets

| Manufacturer | 2025 ZE-HDV announced market uptake targets | 2030 ZE-HDV announced market uptake targets | Announced 100% ZE-HDV market u ptake target |
|---|---|---|---|
| **Daimler** | Not announced | 60% | 2039 |
| **MAN** | Not announced | 40% – 60% | 2040 |
| **Scania** | 10% | 50% | 2040 |
| **Volvo** | 7% | 50% | Not announced |
| **Renault** | 10% | 35% | Not announced |

While most OEMs in Europe are still exploring several technology pathways through the deployment of several battery-electric and fuel cell-electric HDV models, Traton Group made its plans clear in this regard as it sees no future for fuel-cell HDVs in most applications, arguing that the battery-electric technology is the better alternative from a technical and economic perspective.

The European Automobile Manufacturers' Association (ACEA) announced in December 2020 that all new trucks sales will be fossil-free by 2040 (ACEA, 2020). Since the announcement targets fossil-free fuels, there is no commitment to phase-out combustion engines in this announcement.

The past year has also witnessed the establishment of a series of collaborative joint ventures between OEMs, OEMs and first tier suppliers, OEMs and energy suppliers, and OEMs and infrastructure developers. Most notably, Cellcentric, described as a Daimler truck and Volvo group company, is a 50:50 joint venture to develop and manufacture

4 Volvo internal presentation as reported by Transport & Environment (2021). *Easy Ride: why the EU truck $CO_2$ targets are unfit for the 2020s*

fuel cell systems (Cellcentric, 2021) as both OEMs aim for mass production of fuel cell units by 2025 ( Randall, 2021, April 29). Bosch will be supplying several key components for the fuel cell units development, such as the electric air compressor and other balance of plants (H2-View, 2021). In addition, Volvo Construction Equipment has announced the launch of a new test lab in Eskilstuna, Sweden, to test fuel cell solutions for HDVs and construction trucks (Volvo CE, 2021). Hyundai Motor Company and H2 Energy AG in Switzerland signed a joint venture contract (Hyundai-HM, 2019), called Hyundai Hydrogen Mobility, where Hyundai will be delivering close to 1,600 units of fuel cell electric trucks by 2025 in Switzerland. Regarding battery-electric trucks, Nikola Corporation and IVECO (part of CNH industrial) partnered to inaugurate a joint-venture manufacturing facility in Ulm, Germany, where the Nikola Tre electric truck model will be produced (Nikola, 2021).

Charging infrastructure for battery-electric trucks has been the core of several OEMs announcements in 2020–2021. Scania, MAN, Daimler, and Volvo Group have arranged a non-binding agreement that lays the foundation of a joint venture to deploy more than 1,700 charging points in Europe, investing more than 500 million euros (Scania, 2021a). Daimler has partnered with CATL, Shell, Engie, Siemens, and EVBox to accelerate the deployment of the Mercedes-Benz eActros long-haul truck in 2024. CATL will supply the battery technology for the eActros, with Siemens and EVBox supplying "smart infrastructure" solutions. In addition, Shell will set up a suitable infrastructure for hydrogen supply network for Daimler, mainly targeting liquid hydrogen supply for the GenH2 truck (Hampel, 2021). Finally, DAF trucks, subsidiary of Paccar, has revealed new charging solutions for its trucks, reaching 350 kW (DAF, 2021b).

Figure 21 provides a schematic of OEMs recent collaboration announcements and internal development plans.

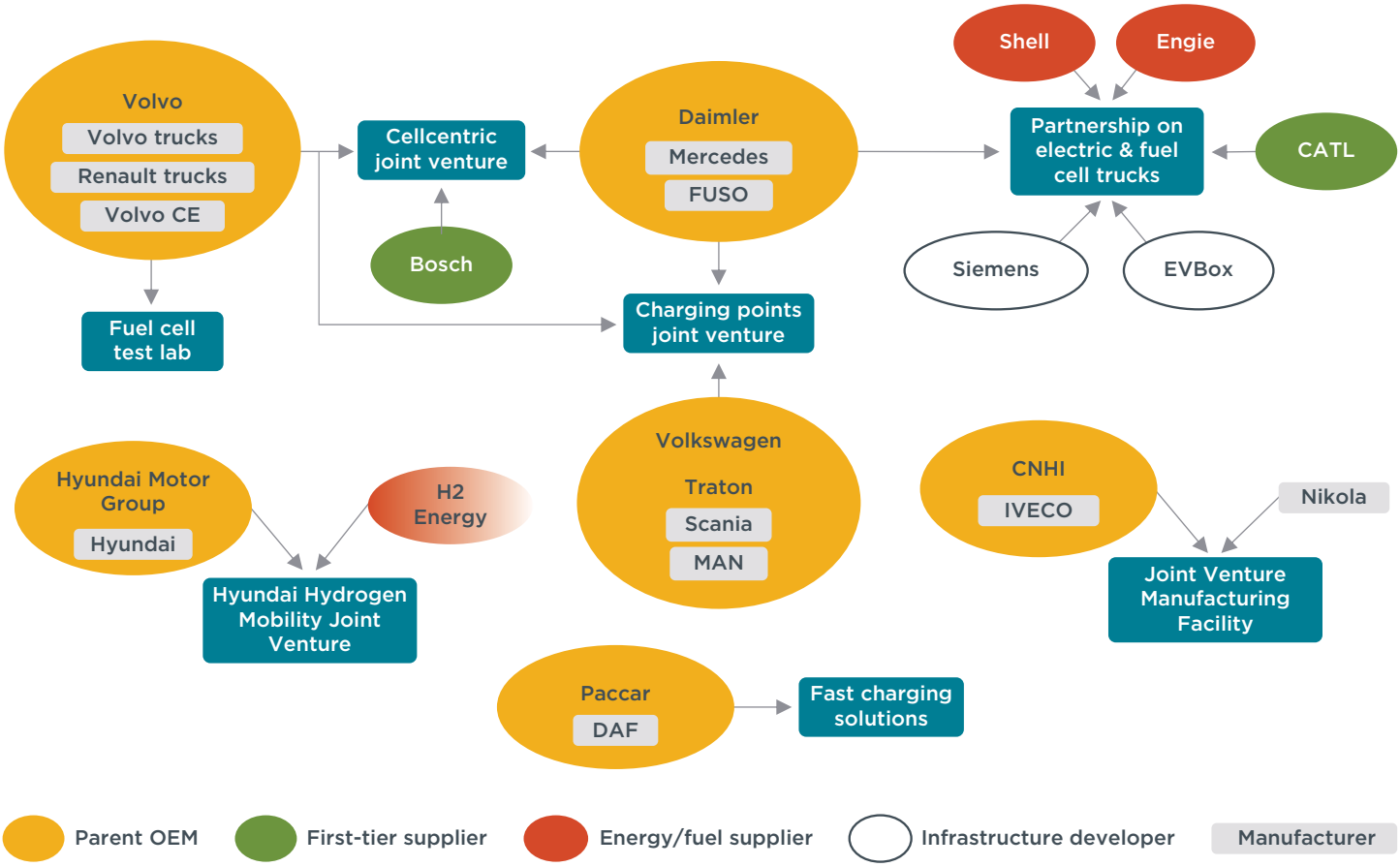


**Figure 21**. Schematic of collaborations and internal development plans of truck manufacturers with presence in Europe.

# SUMMARY ON THE MARKET READINESS OF ZE-HDVS IN EUROPE

This paper investigates the early market uptake of ZE-HDVs in Europe. Through analysis of the market and technological development, we arrive at the following main takeaways:

***The evolution of the early market for ZE-HDVs is promising***. In 2020, ZE-HDVs presented a mere 1% of new registrations in Europe, although this is double the 0.5% of registrations in 2019 and significantly above the 0.2% achieved in 2018. The vast majority of ZE-HDV new registrations, 95%, were battery-electric, with a very limited presence of fuel-cell electric technologies. Still, the European share in the global ZE-HDV market in 2020 was just short of 3%, substantially behind China but ahead of the North American market. The market uptake is expected to significantly increase over the next decade, driven by several OEMs announcements and EU-wide binding regulations regarding pollutants and $CO_2$ emissions of HDVs.

***The time of electric trucks has come***. Close to 90% of cumulative ZE-HDV sales between 2010 and 2020 were buses, as national and local initiatives across Europe have accelerated the electrifications of this HDV segment. Nonetheless, ZE truck sales are on the rise, making up 40% of total new ZE-HDV registrations in 2020, increasing from only 20% in 2017. Although countries such as Germany, France, and the Netherlands are hosting more than 75% of all the ZE trucks in Europe, other countries will likely grow their share as many new electric truck's deliveries are planned by the end of 2021.

***Room for many new players***. Unlike the conventional HDV market, the ZE-HDV market in Europe is comprised of a more diverse group of OEMs. In addition to the conventional key players like Daimler, Volvo, Paccar, and CNH, many new European and non-European entrants are recording a strong presence in this early market of ZE-HDVs, such as BYD, CAF, Yutong, VDL, and Van Hool.

***Alliances are pushing the technology development***. OEMs are teaming up to accelerate technology development and achieve series production as early as possible. New joint ventures have been formed, combining investment, expertise, and efforts in developing ZE-HDV technologies. In addition, OEMs are collaborating with first tier suppliers and infrastructure development entities to accelerate the deployment of ZE technologies, setting up the needed energy supply network and logistics.

***European manufacturers are divided on the technology pathway for long-haul trucks:*** Traton Group, the largest manufacturer of heavy trucks with its brands MAN and Scania, does not see a future for fuel cells and will be relying fully on battery electric solutions. Other manufacturers, such as Daimler Truck and Volvo Trucks with their joint venture, do see a role for hydrogen fuel cell trucks in long-haul operations.

***Batteries are leading over fuel cells***. More than 97% of ZE-HDV new registrations are battery-electric, with the fuel cell technology market still very nascent. Although this trend is mainly driven by buses, trucks are following with a majority of the ZE models offered being battery electric. Nonetheless, several OEMs have announced their plans to invest in hydrogen fuel cells by the middle of this decade.

***The future is zero-emission***. With the continuous increase in HDV model availability and diversity, steady improvement in battery and fuel cell technology, and the expected reduction in price of battery and fuel cell units, major OEMs have announced clear plans to phase out combustion engines from the HDV sector by 2040. In addition, most of the active OEMs in Europe have also announced short-term targets for their ZE-HDV market uptake by 2025 and 2030, with targets as ambitious as a 50% market uptake of ZE-HDV by 2030.

# REFERENCES


ACEA – European Automobile Manufacturers' Association. (2020, December 15). All new trucks sold must be fossil free by 2040, agree truck makers and climate researchers. https://www.acea.auto/press-release/all-new-trucks-sold-must-be-fossil-free-by-2040-agree-truck-makers-and-climate-researchers/

Basma, H., Beys, Y., & Rodríguez, F. (2021). *Battery electric tractor-trailers in the European Union: A vehicle technology analysis*. Retrieved from the International Council on Clean Transportation. https://theicct.org/publications/eu-tractor-trailers-analysis-aug21

Basma, H., Mansour, C., Haddad, M., Nemer, M., & Stabat, P. (2020). Comprehensive energy modeling methodology for battery electric buses. *Energy*, *207*, 118241. https://doi.org/10.1016/j.energy.2020.118241

BYD. (2021). *The BYD K9 Battery Electric Bus*. https://en.byd.com/wp-content/uploads/2019/07/4504-byd-transit-cut-sheets_k9-40_lr.pdf

California Air Resources Board. (2020). *Advance Clean Trucks Regulation Final Regulation Order*. https://ww3.arb.ca.gov/regact/2019/act2019/fro2.pdf

Cellcentric. (2021). *cellcentric—A Daimler Truck & Volvo Group Company*. Cellcentric. https://www.cellcentric.net/en/

DAF. (2021a). *DAF introduces CF Electric with Extended Range*. https://www.daf.com/en/news-and-media/news-articles/global/2020/q3/daf-introduces-cf-electric-with-extended-range

DAF. (2021b). *DAF introduces charging stations for electric vehicles*. https://www.daf.com/en/news-and-media/news-articles/global/2021/q2/29-04-2021-daf-introduces-charging-stations-for-electric-vehicles

DAF. (2021c). *Hydrogen: An option in the long term for powering trucks*. https://www.daf.com/en/about-daf/sustainability/alternative-fuels-and-drivelines/hydrogen

DAF. (2021d, January). *DAF LF Electric for 'zero emission' urban distribution*. https://www.daf.com:443/News and Media/News Articles/Global/2021/Q1/27 01 2021 DAF LF Electric for zero emission urban distribution

Daimler. (2021a). *A new truck for a new era: Mercedes-Benz eActros celebrates its world premiere*. https://media.daimler.com/marsMediaSite/en/instance/ko/A-new-truck-for-a-new-era-Mercedes-Benz-eActros-celebrates-its-world-premiere.xhtml?oid=50352780

Daimler. (2021b). *Daimler Strategy Day*. https://www.daimler.com/dokumente/investoren/praesentationen/daimler-ir-presentation-daimler-truck-strategy-day-may-2021.pdf

Daimler. (2021c, May 19). *Mercedes-Benz fuel-cell truck prototype*. https://www.daimler.com/innovation/drive-systems/hydrogen/start-of-testing-genh2-truck-prototype.html

Dutch Ministry for the Environment & CALSTART. (2021). *Global Memorandum of Understanding (MOU) for Zero-Emission Medium- and Heavy-Duty Vehicles*. https://globaldrivetozero.org/MOU/

European Commission. (2018). *Proposal for a Regulation of the European Parliament and of the Council setting CO2 emission performance standards for new heavy duty vehicles part1/2*. Hart Publishing. https://doi.org/10.5040/9781782258674

Fuelcellbus.eu. (2015, December 1). *12/13 meter Fuel Cell Electric Buses*. Fuel Cell Electric Buses. https://www.fuelcellbuses.eu/wiki/concept-fuel-cell-buses/1213-meter-buses-fuel-cell-buses

H2-View. (2021, June 18). *Bosch to supply fuel cell components to cellcentric*. Hydrogen View. https://www.h2-view.com/story/bosch-to-supply-fuel-cell-components-to-cellcentric/

Hampel, C. (2021, May 20). Daimler Trucks partners with CATL, Shell, Siemens, Engie & EVBox. *Electrive.Com*. https://www.electrive.com/2021/05/20/daimler-trucks-partners-with-catl-shell-siemens-engie-evbox/

Hyundai. (2021). *XCIENT Fuel Cell | HYUNDAI Truck & Bus*. https://trucknbus.hyundai.com/global/en/products/truck/xcient-fuel-cell

Hyundai-HM. (2019, August 26). Hyundai and H2 Energy sign Joint Venture Contract. *Hyundai Hydrogen Mobility*. https://hyundai-hm.com/en/2019/08/26/hyundai-and-h2-energy-sign-joint-venture-contract/

IVECO. (2020). *CNH Industrial brands IVECO and FPT*. https://www.iveco.com/en-us/press-room/release/Pages/CNH-Industrial-brands-IVECO-and-FPT-together-with-Nikola-Motor-Company.aspx

Kane, M. (2020). All-Electric Mercedes-Benz eEconic Is Coming. *InsideEVs*. https://insideevs.com/news/393591/electric-mercedes-benz-eeconic/

London Assembly. (2015, March 17). *London Low Emissions Bus Zones*. London City Hall. https://www.london.gov.uk//what-we-do/environment/pollution-and-air-quality/cleaner-buses

MAN. (2021). *Executive Board and General Works Council agree on Key Issues Paper to realign the Company*. Executive Board and General Works Council Agree on Key Issues Paper to Realign the Company. https://press.mantruckandbus.com/corporate/executive-board-and-general-works-council-agree-on-key-issues-paper-to-realign-the-company/

MAN Truck & Bus. (2020). *MAN eTGM | MAN DE*. https://www.man.eu/de/en/truck/all-models/the-man-etgm/etgm.html

MAN Truck & Bus. (2021). *MAN Lion's City E Bus*. https://www.man.eu/de/en/bus/the-man-lion_s-city/electric-drive/man-lion_s-city-e.html

Mao, S., & Rodríguez, F. (2021). *Race to zero: How manufacturers are positioned for zero-emission commercial trucks and buses in China*. Retrieved from the International Council on Clean Transportation. https://theicct.org/publications/china-race-to-zero-aug2021

Mercedes-Benz. (2020). *The fully electric Mercedes-Benz eEconic is coming.* Mercedes Benz Special Trucks World. https://mbs.mercedes-benz.com/en/econic/clean-power-on-the-finishing-straight.html

Mercedes-Benz. (2021). *Mercedes-Benz Buses: Technical brochures*. https://www.mercedes-benz-bus.com/en_DE/buy/services-online/download-technical-brochures.html

Ministerie van Infrastructuur en Waterstaat. (2016, April 15). *Dutch public transport switches to 100 percent emissions-free buses*. https://www.government.nl/latest/news/2016/04/15/dutch-public-transport-switches-to-100-percent-emissions-free-buses

Mitsubishi. (2021). *FUSO eCanter*. https://www.mitfuso.com/en-us/models/ecanter#overview

Mottschall, M., Kasten, P., & Rodríguez, F. (2020). *Decarbonization of on-road freight transport and the role of LNG from a German perspective*. Retrieved from the Institute for Applied Ecology (Öko-Institut e.V.). https://theicct.org/publications/on-road-freight-lgn-germany

Nikola. (2021). *IVECO and Nikola inaugurate joint-venture manufacturing facility for electric heavy-duty trucks in Ulm, Germany*. Nikola Motor Company. https://nikolamotor.com/press_releases/iveco-and-nikola-inaugurate-joint-venture-manufacturing-facility-for-electric-heavy-duty-trucks-in-ulm-germany-131

NOW. (2019). *Project Overview: Zero Emission Buses in Germany*. https://www.now-gmbh.de/en/news/pressreleases/project-overview-zero-emission-buses-in-germany/

RATP Group. (2016). *A 100% environmentally friendly bus fleet thanks to the Bus2025 plan*. https://www.ratp.fr/en/groupe-ratp/join-us/a-100-environmentally-friendly-bus-fleet-thanks-bus2025-plan

Randall, C. (2021, April 29). Cellcentric aims to mass produce fuel cells by 2025. *Electrive.Com*. https://www.electrive.com/2021/04/29/fc-joint-venture-cellcentric-aims-for-mass-production-by-2025/

Randell, C. (2021, June 11). Mercedes delivers first eCitaro G with solid state batteries. *Electrive.Com*. https://www.electrive.com/2021/06/11/mercedes-delivers-first-ecitaro-g-with-solid-state-batteries/

Renault Trucks. (2020). *Renault trucks starts serial production of its electric trucks*. http://www.renault-trucks.com/en/newsroom/press-releases/renault-trucks-starts-serial-production-its-electric-trucks

Renault Trucks. (2021a). *Renault trucks d all-electric* https://www.renault-trucks.co.uk/product/renault-trucks-d-all-electric

Renault Trucks. (2021b). *Renault trucks to offer an electric range for each market segment from 2023*. http://www.renault-trucks.com/en/newsroom/press-releases/renault-trucks-offer-electric-range-each-market-segment-2023

Rodríguez, F., Muncrief, R., Delgado, O., & Baldino, C. (2017). *Market penetration of fuel efficiency technologies for heavy-duty vehicles in the European Union, the United States, and China*. Retrieved from the International Council on Clean Transportation. https://theicct.org/publications/market-penetration-fuel-efficiency-technologies-heavy-duty-vehicles-european-union

Scania. (2020a). *Norwegian wholesaler ASKO puts hydrogen powered fuel cell electric Scania trucks on the road*. https://www.scania.com/group/en/home/newsroom/news/2020/norwegian-wholesaler-asko-puts-hydrogen-powered-fuel-cell-electric-scania-trucks-on-the-road.html

Scania. (2020b). *Scania launches fully electric truck with 250 km range*. https://www.scania.com/content/scanianoe/group/en/home/newsroom/press-releases/press-release-detail-page.html/3768729-scania-launches-fully-electric-truck-with-250-km-range

Scania. (2021a). *Commercial vehicle giants invest in European charging network for electric trucks*. https://www.scania.com/group/en/home/newsroom/news/2021/Commercial-vehicle-giants-invest-in-European-charging-network-for-electric-trucks.html

Scania. (2021b). *Scania's commitment to battery electric vehicles*. https://www.scania.com/group/en/home/newsroom/news/2021/Scanias-commitment-to-battery-electric-vehicles.html

Solaris. (2020). *Solaris Urbino 15 LE electric—Product catalogue 2020/2021*.

StreetScooter. (2020). *StreetScooter WORK XL*. https://www.streetscooter.com/wp-content/uploads/2018/09/sco12308_flyer_iaa_work_xl_rz_web.pdf

United Nations Framework Convention on Climate Change (UNFCCC). (2015). *The Paris Agreement | UNFCCC*. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement

Van Hool. (2020). *Hybrid Fuel Cell—A-gamma—Public transport*. Van Hool. https://www.vanhool.be/en/public-transport/agamma/hybrid-fuel-cell

VDL. (2021). *VDL Citea Electric Bus*. https://www.vdlbuscoach.com/en/products/citea/citea-electric

Volvo. (2021a). *Specifications Volvo 7900 Electric*. https://www.volvobuses.com/en/city-and-intercity/buses/volvo-7900-electric/specifications.html

Volvo. (2021b). *Volvo FM Electric*. https://www.volvotrucks.com/en-en/trucks/trucks/volvo-fm/volvo-fm-electric.html

Volvo. (2021c). *Volvo Trucks ready to electrify a large part of goods transports*. https://www.volvotrucks.com/en-en/news-stories/press-releases/2021/apr/volvo-trucks-now-ready-to-electrify.html

Volvo CE. (2021). *Volvo CE takes big step towards a carbon neutral future with hydrogen Fuel Cell Test Lab*. http://www.volvoce.com/global/en/news-and-events/press-releases/2021/volvo-ce-takes-big-step-towards-a-carbon-neutral-future-with-hydrogen-fuel-cell-test-lab/

Wappelhorst, S., & Rodríguez, F. (2021, August 26). Global overview of government targets for phasing out internal combustion engine medium and heavy trucks. *ICCT Staff Blog*. https://theicct.org/blog/staff/global-targets-ice-hdvs-aug21

Yutong. (2021). *U12 E-vehicles Yutong*. https://en.yutong.com/products/U12-europe.shtml

ZeEUS. (2014). *Zero Emission Urban Bus System*. https://zeeus.eu/

# APPENDIX A: ZE BUS MODELS – BATTERY ELECTRIC

| Mercedes Buses | |
|---|---|
| **Parent manufacturer** | Daimler |
| **Segment** |  City bus |
| **Model** | e-Citaro |
| **ZE technology** | Battery-electric |
| **Length** | 12 m |
| **Battery capacity** | 338 kWh / 441 kWh |
| **Battery chemistry** | NMC / Solid state |
| **Cumulative sales (2016–2020)** | 200 units |
| **New registrations in 2020** | 91 units |
| **Upcoming deliveries** | 200 units |

| BYD | |
|---|---|
| **Parent manufacturer** | BYD |
| **Segment** |  City bus |
| **Model** | K9 Series |
| **ZE technology** | Battery-electric |
| **Length** | 12 m |
| **Battery capacity** | 324 kWh |
| **Battery chemistry** | LFP |
| **Cumulative sales (2016–2020)** | 650 units |
| **New registrations in 2020** | 363 units |
| **Upcoming deliveries** | 441 units |

| Yutong | |
|---|---|
| **Parent manufacturer** | Yutong |
| **Segment** |  City bus |
| **Model** | U Series 12 |
| **ZE technology** | Battery-electric |
| **Length** | 12 m |
| **Battery capacity** | 422 kWh |
| **Battery chemistry** | LFP |
| **Cumulative sales (2016–2020)** | 292 units |
| **New registrations in 2020** | 125 units |
| **Upcoming deliveries** | - |

| Solaris | |
|---|---|
| **Parent manufacturer** | CAF |
| **Segment** |  City bus |
| **Model** | Urbino |
| **ZE technology** | Battery-electric |
| **Length** | 12 m–18 m |
| **Battery capacity** | 240 kWh / 470 kWh |
| **Battery chemistry** | NMC |
| **Cumulative sales (2016–2020)** | 392 units |
| **New registrations in 2020** | 184 units |
| **Upcoming deliveries** | ~ 100 units |

| Volvo | |
|---|---|
| **Parent manufacturer** | Volvo |
| **Segment** |  City bus |
| **Model** | 7900 E |
| **ZE technology** | Battery-electric |
| **Length** | 12 m |
| **Battery capacity** | 400 kWh |
| **Battery chemistry** | LFP |
| **Cumulative sales (2016–2020)** | 251 units |
| **New registrations in 2020** | 169 units |
| **Upcoming deliveries** | 120 units |

| VDL | |
|---|---|
| **Parent manufacturer** | VDL |
| **Segment** |  City bus / Articulated bus |
| **Model** | Citea |
| **ZE technology** | Battery-electric |
| **Length** | 12 - 18 m |
| **Battery capacity** | 288 kWh / 525 kWh |
| **Battery chemistry** | NMC / LFP |
| **Cumulative sales (2016–2020)** | 634 units |
| **New registrations in 2020** | 61 units |
| **Upcoming deliveries** | - |

| Irizar | |
|---|---|
| Parent manufacturer | CNH |
| **Segment** |  City bus |
| **Model** | ie |
| **ZE technology** | Battery-electric |
| **Length** | 12 m |
| **Battery capacity** | 376 kWh |
| **Battery chemistry** | NaNiCl |
| **Cumulative sales (2016–2020)** | ~ 100 units |
| **New registrations in 2020** | ~ 10 units |
| **Upcoming deliveries** | - |

| Hueliez | |
|---|---|
| **Parent manufacturer** | CNH |
| **Segment** |  City bus |
| **Model** | GC/X Series |
| **ZE technology** | Battery-electric |
| **Length** | 12 m |
| **Battery capacity** | 350 kWh |
| **Battery chemistry** | NMC |
| **Cumulative sales (2016–2020)** | ~ 200 units |
| **New registrations in 2020** | 110 units |
| **Upcoming deliveries** | - |

| Man Bus | |
|---|---|
| **Parent manufacturer** | Volkswagen |
| **Segment** |  City bus / Articulated bus |
| **Model** | Lion's City E |
| **ZE technology** | Battery-electric |
| **Length** | 12 m–18 m |
| **Battery capacity** | 480 kWh / 680 kWh |
| **Battery chemistry** | NMC |
| **Cumulative sales (2016–2020)** | 30 units |
| **New registrations in 2020** | 22 units |
| **Upcoming deliveries** | - |

# APPENDIX B: ZE BUS MODELS – FUEL CELL ELECTRIC

| Solaris | |
|---|---|
| **Parent manufacturer** | CAF |
| **Segment** |  City bus |
| **Model** | Urbino H2 |
| **ZE technology** | Fuel cell electric |
| **Length** | 12 m |
| **Battery capacity** | 120 kWh |
| **Fuel cell unit supplier** | Bombardier |
| **Cumulative sales (2016–2020)** | - |
| **New registrations in 2020** | - |
| **Upcoming deliveries** | - |

| Van Hool | |
|---|---|
| **Parent manufacturer** | Van Hool |
| **Segment** |  City bus / Articulated bus |
| **Model** | A Series 330 |
| **ZE technology** | Fuel cell electric |
| **Length** | 12 m–18 m |
| **Battery capacity** | 100 kWh / 200 kWh |
| **Fuel cell unit supplier** | Emrol |
| **Cumulative sales (2016–2020)** | 40 units |
| **New registrations in 2020** | 28 units |
| **Upcoming deliveries** | - |

| Wrightbus | |
|---|---|
| **Parent manufacturer** | Wrightbus |
| **Segment** |  Double decker |
| **Model** | StreetDeck Hydroliner |
| **ZE technology** | Fuel cell electric |
| **Length** | Not known |
| **Battery capacity** | 80 kWh |
| **Fuel cell unit supplier** | Valence / Ballard |
| **Cumulative sales (2016–2020)** | - |
| **New registrations in 2020** | - |
| **Upcoming deliveries** | - |

# APPENDIX C: ZE TRUCK MODELS – BATTERY ELECTRIC

| Volvo Trucks | |
|---|---|
| **Parent manufacturer** | Volvo |
| **Segment** |  Rigid /tractor tucks Truck class 4 / class 5 |
| **Model** | FM/FMX/FH |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 16 tonnes–26 tonnes |
| **Battery capacity** | 180 kWh–540 kWh |
| **Battery chemistry** | LFP |

| Renault Trucks | |
|---|---|
| **Parent manufacturer** | Volvo |
| **Segment** |  Rigid tucks Truck class 9 |
| **Model** | D Series |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 16 tonnes–26 tonnes |
| **Battery capacity** | 200 kWh–300 kWh |
| **Battery chemistry** | Not Known |

| Man Trucks | |
|---|---|
| **Parent manufacturer** | Volkswagen |
| **Segment** |  Rigid /tractor tucks Truck class 4 / class 5 |
| **Model** | e-TGM |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 16 tonnes–28 tonnes |
| **Battery capacity** | 180 kWh |
| **Battery chemistry** | NMC |

| Scania | |
|---|---|
| **Parent manufacturer** | Volkswagen |
| **Segment** |  Rigid /tractor tucks<br>Truck class 4 / class 5 |
| **Model** | P Series |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | Not Known |
| **Battery capacity** | 165 kWh–300 kWh |
| **Battery chemistry** | Not Known |

| Mercedes Trucks | |
|---|---|
| **Parent manufacturer** | Daimler |
| **Segment** |  Tractor tucks<br>Truck class 5 |
| **Model** | e-Actros |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 25 tonnes |
| **Battery capacity** | 420 kWh |
| **Battery chemistry** | Not Known |

| Futuricum | |
|---|---|
| **Parent manufacturer** | Designwreck |
| **Segment** |  Rigid /tractor tucks<br>Truck class 4 / class 5 / class 9 / class 10 |
| **Model** | FM Logistics / FH Semi / FH Logistics |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 16 tonnes–42 tonnes |
| **Battery capacity** | 170 kWh–340 kWh |
| **Battery chemistry** | NMC |

| FUSO | |
|---|---|
| **Parent manufacturer** | Daimler |
| **Segment** |  Rigid tucks Truck class 0 |
| **Model** | e-Canter |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 7.49 tonnes |
| **Battery capacity** | 83 kWh–116 kWh |
| **Battery chemistry** | NMC |

| Streetscooter | |
|---|---|
| **Parent manufacturer** | Deutsche Post DHL |
| **Segment** |  Rigid tucks Truck class 0 |
| **Model** | WORK XL |
| **ZE technology** | Battery-electric |
| **Gross vehicle weight** | 4.2 tonnes |
| **Battery capacity** | 76 kWh |
| **Battery chemistry** | - |

# APPENDIX D: ZE TRUCK MODELS – FUEL CELL ELECTRIC

| Hyundai | |
|---|---|
| Parent manufacturer | Hyundai Motor |
| **Segment** |  Rigid tucks Truck class 4 |
| **Model** | Xcient |
| **ZE technology** | Fuel cell electric |
| **Gross vehicle weight** | 26 tonnes |
| **Battery capacity** | 72 kWh |
| **Fuel cell unit supplier** | Hyundai |
| **Hydrogen tank size** | 31 kg (usable) |

| Mercedes Trucks | |
|---|---|
| **Parent manufacturer** | Daimler |
| **Segment** |  Rigid tucks Truck class 4 / class 9 |
| **Model** | Actros Gen H2 |
| **ZE technology** | Fuel cell electric |
| **Gross vehicle weight** | 18 tonnes–26 tonnes |
| **Battery capacity** | 70 kWh |
| **Fuel cell unit supplier** | Not Known |
| **Hydrogen tank size** | Not Known |

| Paccar | |
|---|---|
| **Parent manufacturer** | DAF |
| **Segment** |  Rigid tucks Truck class 9 |
| **Model** | DAF XF |
| **ZE technology** | Fuel cell electric |
| **Gross vehicle weight** | 6 tonnes–16 tonnes |
| **Battery capacity** | Not Known |
| **Fuel cell unit supplier** | Toyota |
| **Hydrogen tank size** | Not Known |

www.theicct.org

communications@theicct.org

twitter @theicct

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

BEIJING | BERLIN | SAN FRANCISCO | SÃO PAULO | WASHINGTON