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RACE TO ZERO

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

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TABLE OF CONTENTS

Acronyms and abbreviations	ii
Introduction	1
Policy background	3
Overview of HD-NEV market in China	4
Key findings and discussion	11
Coaches and city buses.....	11
Straight trucks.....	11
Dump trucks.....	12
Utility vehicles	12
Tractor trucks.....	13
Summary of HD-NEV market readiness in China	14
Appendix 1. Truck manufacturers	15
Appendix 2. Utility vehicle manufacturers	20
Appendix 3. Bus manufacturers	25
Appendix 4. Tractor truck manufacturers	31
Appendix 5. Manufacturers with zero-emission models, and sales of buses, coaches, utility vehicles and trucks by 2019	34
Appendix 6. Manufacturers with zero-emission models and sales of dump trucks and tractor-trucks by 2019	35
References	36

ACRONYMS AND ABBREVIATIONS

HDV	heavy-duty vehicle
HD-NEV	heavy-duty new energy vehicle
ICE-HDV	internal combustion engine heavy-duty vehicle
BEV	battery electric vehicle
PHEV	plug-in hybrid vehicle
FCEV	fuel-cell electric vehicle
GVW	gross vehicle weight
GCW	gross combined weight
LD-NEV	light duty-new energy vehicle
MIIT	Ministry of Industry and Information Technology
MEE	Ministry of Ecology and Environment
CATARC	China Automatic Technology and Research Center Co., Ltd
SAE-China	Society of Automotive Engineering China
LFP	lithium ferrophosphate
NMC	nickel manganese cobalt oxide
LMO	lithium manganese oxide

INTRODUCTION

Sales of heavy-duty vehicles (HDV) in China have accelerated over the past two decades, nearly tripling between 2005 and 2020 from 1,787,000 units to more than 5,133,000 (CAAM, 2021) and creating the world’s largest HDV market. Most of those sales were centered in Beijing and in Guangdong Province. Provinces around the country’s perimeter, such as Heilongjiang and Xinjiang, also show relatively high registrations of HDVs compared to other inner regions (Delgado & Li, 2017).

HDVs generate about three-quarters of on-road NO_x emissions in China, and about half of particulate matter (PM) emissions (MEE, 2020), while representing only 7.8% of the vehicle stock (Xinhua News, 2018). This is one reason China is aggressively pursuing the deployment of zero-emission trucks and buses, mainly through subsidies and other incentives offered by the central and local governments. Most notably, China’s city buses are being replaced rapidly with zero-emission technologies; cities such as Shenzhen, Guangzhou, and Zhengzhou are close to completely electrifying their bus fleets (CCTV, 2019). As a result, the vast majority of the world’s zero-emission trucks and buses are now deployed in China. Over the past decade, China accounted for more than 95% of the global market for heavy duty new energy vehicles (HD-NEV) (Sharpe et al., 2020).

The Chinese HDV market is uniquely distributed across vehicle segments and manufacturers. Sales of conventional (internal combustion engine) HDVs are not dominated by long-haul tractor-trailers—as is the case in Europe—but by smaller straight trucks, as shown in Figure 1. However, the long-haul segment has seen the largest growth in recent years (Mao et al., 2021). With approximately 700 manufacturers, the Chinese HDV market is also much less consolidated than other major markets. In China, the aggregate market share of the top eight manufacturers is less than 70%, while in other major markets, such as the EU, Brazil, and India, the top eight or fewer manufacturers capture almost 100% of the market (Delgado & Li, 2017).

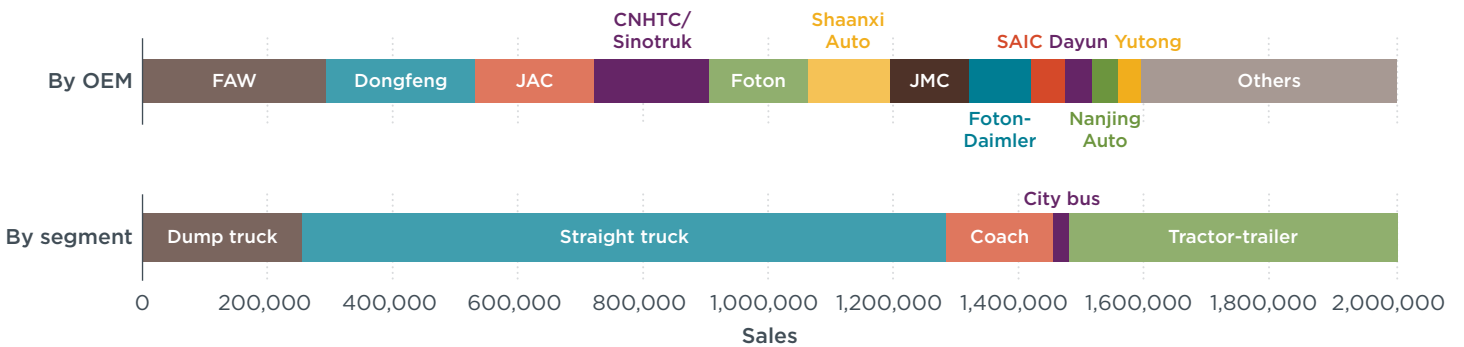


Figure 1. ICE-HDV sales by manufacturer (top) and by segment (bottom) in 2017

By contrast, the HD-NEV market, shown in Figure 2 for 2019, shows less fragmentation than the HDV market overall, in terms of both manufacturers and segments. While straight truck and tractor-trailer models dominated conventional HDV sales, city buses are the bulk of zero-emission models. HD-NEV manufacturers, as a group, also differ significantly from the set of ICE-HDV manufacturers. There were 964 original equipment manufacturers (OEMs) in the internal combustion engine heavy duty vehicle market; 207 of them were capable of offering HD-NEV models by 2019. The top five manufacturers of each market accounted for more than half of total sales. Foton is the only OEM listed in the top 5 in both conventional and HD-NEV markets in China, which may confirm Foton’s ambition to transition to electrification.

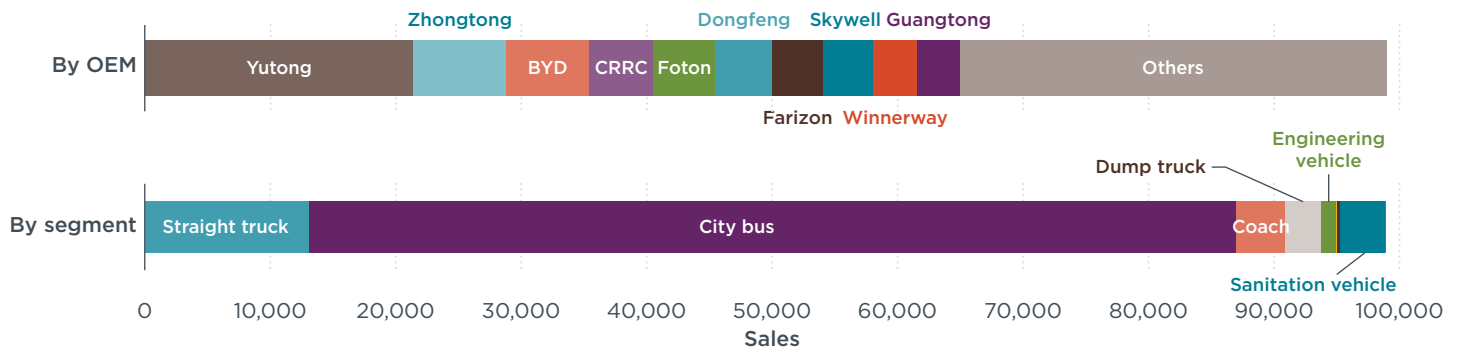


Figure 2. HD-NEV sales by OEM (top) and segment(bottom) in 2019

This paper identifies where Chinese manufacturers stand in the race to transition from ICE-HDVs to electric vehicle technologies. We summarize the current market for zero-emission trucks and buses and profile several manufacturers producing these vehicles across different truck and bus segments. By describing this market landscape, our goal is to highlight the challenges that future policies must address to accelerate this transition.

This study examines in detail new HD-NEVs¹ registered between 2017 and 2019. The analysis focuses on the most popular HDV segments in the Chinese market, including straight and box trucks, dump trucks, buses and coaches, utility vehicles,² and tractor trailers. The dataset for this study was provided by China Automatic Technology and Research Center Co., Ltd, also known as CATARC.

1 For the purpose of this study, HD-NEVs are defined as plug-in hybrid, battery electric, and fuel cell vehicles with gross vehicle weight over 3,500 kg, following China’s national standard on segmentation of vehicles GB/T 15089-2001.

2 According to Chinese national standard GB/T 17350-2009, the term *utility vehicle* refers to a set of functional vehicles such as engineering trucks, refrigerated trucks, and sanitation vehicles, among others. In general, the utility vehicle definition also includes dump trucks. For this report, however, dump trucks are presented separately. Utility vehicles in this report will therefore include any type of utility vehicles defined by the national standard other than dump trucks.

POLICY BACKGROUND

In the past decade, China has rapidly become the world's largest electric vehicle market, accounting for half of the world's electric vehicle sales and more than 90% of the stock of electric buses and trucks combined. This accelerated growth is the result of targeted policy efforts at the national and local level that have used concrete initiatives and tools such as pilot programs, incentives, vehicle regulations, and high-level strategies (ICCT & EV100, 2021).

Pilot programs such as the landmark “Ten Cities, Thousand Vehicles” initiative, introduced in 2009, provided significant financial support for launching pilot projects in several cities for the rapid deployment of public fleets of electric vehicles, which were then gradually expanded to the private sector. Such pilot programs, in combination with central subsidies and incentives, helped to catalyze a mature electric vehicle market capable of sustaining more refined regulatory measures (He & Jin, 2021). After 2018, China began to shift from relying heavily on subsidies to providing a combination of incentives and sales quota regulations to ensure continued innovation, investment, and model availability in the Chinese automotive industry. As direct subsidies were reduced in early 2017, China introduced an innovative policy for light-duty (LD) vehicle deployment: NEV mandates (Cui, 2018).

The NEV mandate policy sets requirements for increased light-duty new energy vehicle (LD-NEV) production alongside existing fuel efficiency standards, with credit trading between the standards. China's first phase (2019–2020) of LD-NEV regulations increased the electric share of new passenger vehicle sales from 4.5% in 2018 to 6% in 2020 (Cui et al., 2020). The second phase is expected to increase the electric vehicle market share to 10%–12% of new sales, or greater, by 2023 (Lutsey et al., 2021).

The NEV mandate policy, requiring increased electric vehicle production and sales, has been the single most important driver of electric vehicle model availability and increased sales volume for light-duty vehicles. Now that the electric heavy-duty market is entering a phase of stable growth, thanks to the earlier pilot and subsidy programs, China is evaluating the introduction of a similar policy for trucks and buses (Caixin, 2021; China Energy News, 2019). The recently released *Energy-saving and New Energy Vehicle Technology Roadmap 2.0*, prepared by Society of Automotive Engineering (SAE) China, proposes targets regarding HD-NEV share of 12% by 2025, 17% by 2030, and 20% by 2035 (SAE-China, 2021).

In this regulatory context, this paper provides an overview of the HD-NEV market across different vehicle segments, and of the readiness of HDV manufacturers, quantified by model availability, to satisfy the increased demand that the heavy-duty NEV mandate regulation will bring about.

OVERVIEW OF HD-NEV MARKET IN CHINA

The Chinese HD-NEV market has grown swiftly in recent years, from ~2,000 units in 2010 to more than 130,000 units in 2016. However, the market has shrunk steadily since then, for several reasons. In 2016, China's central government sanctioned 5 HD-NEV manufacturers for fraud in their applications for subsidies (People.cn, 2016). In addition, subsidies to HD-NEV manufacturers have plummeted as the requirements to qualify for subsidies were tightened. This led to a marked reduction in sales of HD-NEVs after 2016 (Figure 3).

The sales downturn has not been felt equally across vehicle segments; zero-emission truck sales declined more markedly than sales of electric buses. Between 2017 and 2020, sales of zero-emission trucks fell by almost 90% (from 69,000 units to 6,700 units) while sales of zero-emission buses declined 23% (from 100,000 units to 78,000). (Figure 3). The market's stronger embrace of zero-emission buses compared to trucks can be attributed to incentives promoting zero-emission buses throughout China and to the easy availability of urban charging infrastructure in many Chinese cities. Because of this, China has become the world's leader in electric bus deployment. China's fleet of electric buses, at more than 400,000, accounts for 99% of the global total (Margolis, 2019).

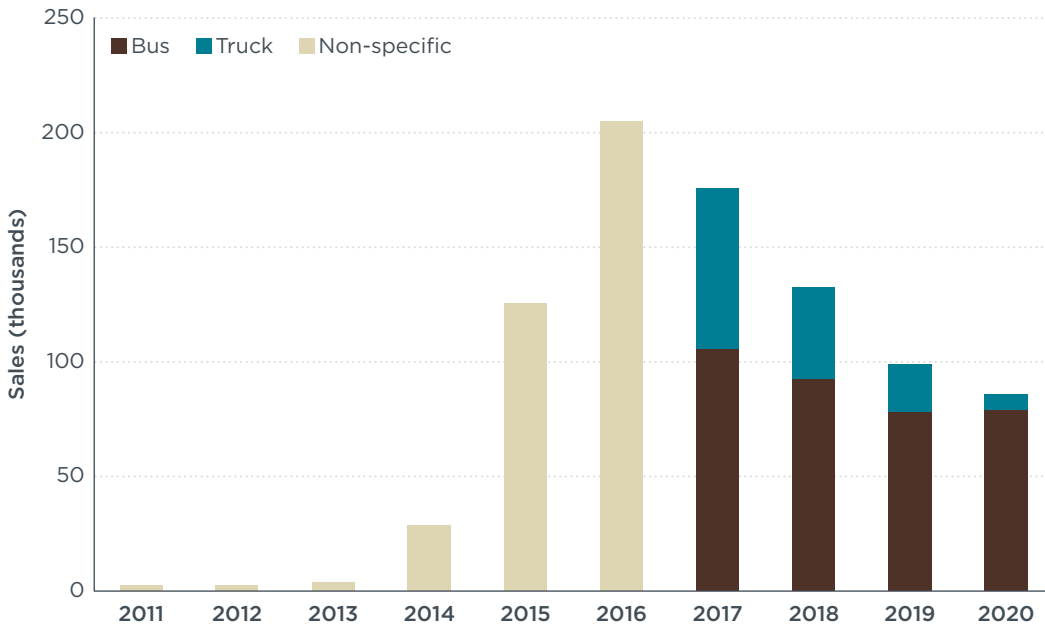


Figure 3. Total sales of HD-NEVs from 2011 to 2020 (IEA, 2021; Sharpe et al., 2020)

Figure 4 provides further insight into the structure of zero-emission truck segments over the 2017-2019 period. Zero-emission straight and box trucks accounted for more than 90% of total sales during this time. Dump trucks, a popular segment among all internal combustion engine (ICE)-powered trucks (see Figure 1), accounted for only 2.5% of zero-emission trucks during the period. Electric sanitation vehicles, however, surged in recent years due to local policies, and accounted for 3.9% of zero-emission trucks. Engineering vehicles, such as bulk transport, refrigerated vehicles, and tractor-trailers accounted for 1.7%, 1.3%, and 0.4% of the HD-NEV market, respectively.



Figure 4. Truck market segments as shares of the national truck market, 2017-2019

The HD-NEV market in China is less consolidated than the market for conventional HDVs. In 2019, the top 10 HD-NEV manufacturers accounted for 66% of the market, compared to ~75% for conventional manufacturers. Yutong Bus is the lead manufacturer, selling more than 10% of the total available models each year; trucks represent 29% of its HD-NEV sales and buses were to be the main products Yutong provided, accounting for about 30% of Yutong’s HD-NEV sales in 2019. Second-ranked Dongfeng Motor lost significant market share in 2019 as part of the overall contraction of the zero-emission truck market. In 2019, ZE trucks represented 81.93% of HD-NEV sales of Dongfeng Motor. Manufacturers such as Zhongtong, BYD, CRRC, and Guangtong maintained spots among the top 10 HD-NEV manufacturers in each year of the evaluation period. Skywell and Winnerway were listed as top 10 manufacturers in 2019 for the first time (Figure 5).

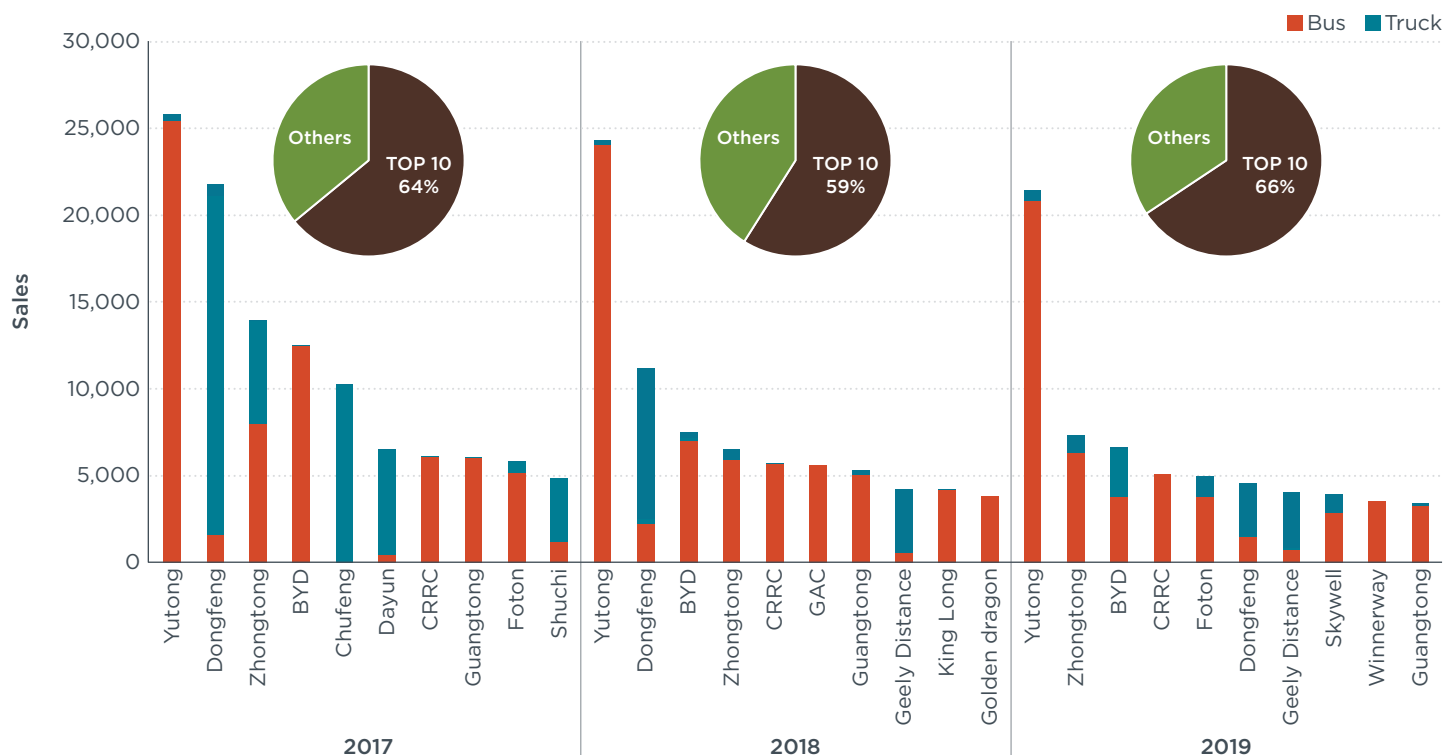


Figure 5. Top HD-NEV manufacturers by segment from 2017 to 2019

Heavy-duty vehicles have a variety of uses, each with different payload and range requirements. Figure 6 provides a detailed breakdown of the gross vehicle weight (GVW) and the zero-emission driving range of all HD-NEVs sold between 2017 and 2019.

The market for zero-emission buses comprises a large range of GVWs, from 4 to 28 tonnes, with ranges for electric buses that can exceed 800 km. Zero-emission buses with a GVW of 16 to 18 tonnes account for 52% of sales. The data discontinuity at 18 tonnes is a consequence of the number of axles used in urban buses and the limits on axle load set by Chinese national standards.³ In contrast to the weight and range variety of zero-emission buses, electric trucks mostly cluster in the 3.5–5 tonne GVW range, representing 91% of the sales. However, a small number of vehicles was commercialized in the heavier segments, with 2.2% being sold in GVWs of 16–32 tonnes.⁴ Some 66% of electric buses and 64% of electric trucks have ranges greater than 300 km.

³ GB 1589-2016: Limits of dimensions, axle load and masses for motor vehicles, trailers and combination vehicles.

⁴ The GVW only refers to the maximum weight of the cab, trailer, and payload; it does not capture the maximum weight carried by trailers. The term gross combined weight (GCW) is used to capture the complete maximum weight of a truck-trailer combination.

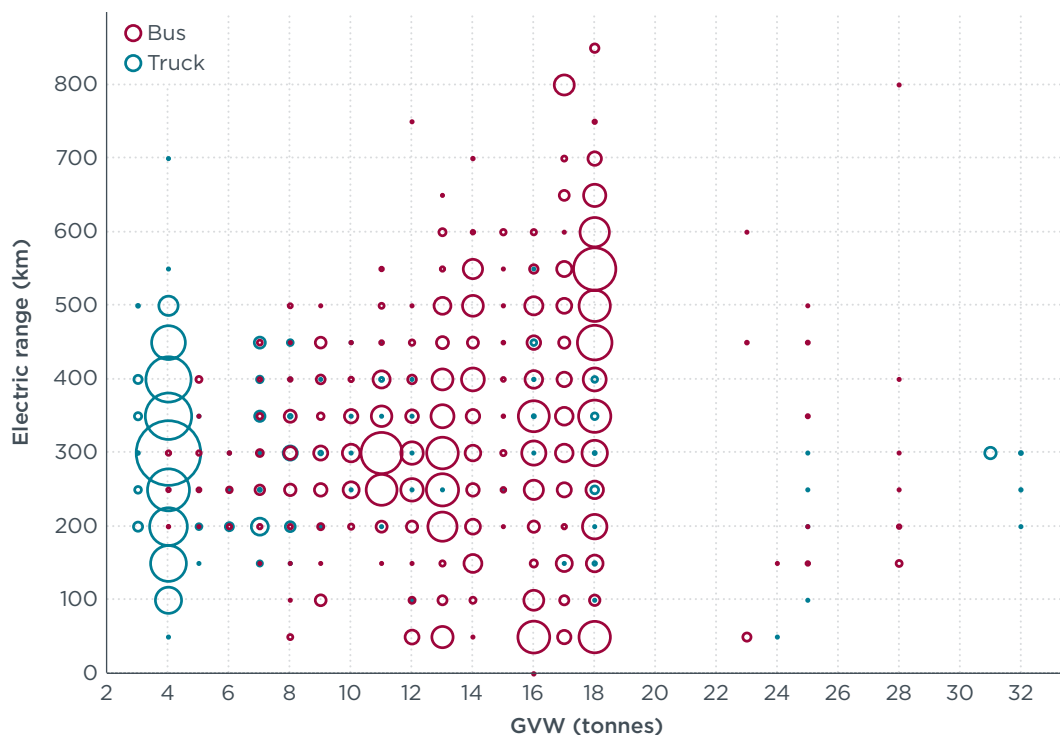


Figure 6. Electric range by GVW for each vehicle segment, 2017 to 2019

Figure 7 shows the market penetration of battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs) for buses and trucks in the evaluation period. BEV dominated the HD-NEV market for each vehicle segment throughout the period, accounting for 89% of zero-emission bus sales and 98% of zero-emission truck sales. Plug-in hybrid-electric technology was mostly used in buses, but the proportion of models with this technology declined from 9% to 4.5% by 2019, while fuel cell models saw rapid growth, from 1% to 3%. The Chinese government adjusted the financial incentive policies for manufacturers each year, which may have influenced sales. In 2017 and 2018, the Chinese government reduced subsidies on BEVs and PHEVs by 35% to 50% and increased technical requirements to qualify for subsidies. System energy density, electric range and E_{kg} ⁵ requirements were introduced, raising the threshold of eligibility for financial subsidies to BEVs. However, FCEVs became more competitive in 2019 as fuel cell technology continued to be encouraged by the government through tax waivers and financial subsidies totaling 400,000 CNY (Ministry of Finance, 2018; Ministry of Science and Technology, 2017).

⁵ E_{kg} measures the specific energy consumption relative to load capacity. $E_{kg} = E/M$, where E is energy consumption in Wh/km and M is the affiliated mass. M is assigned to be load capacity when load capacity \leq 180kg, 180kg when load capacity $>$ 180kg and $<$ 360kg, and $0.5 \cdot$ load capacity when load capacity \geq 360kg.

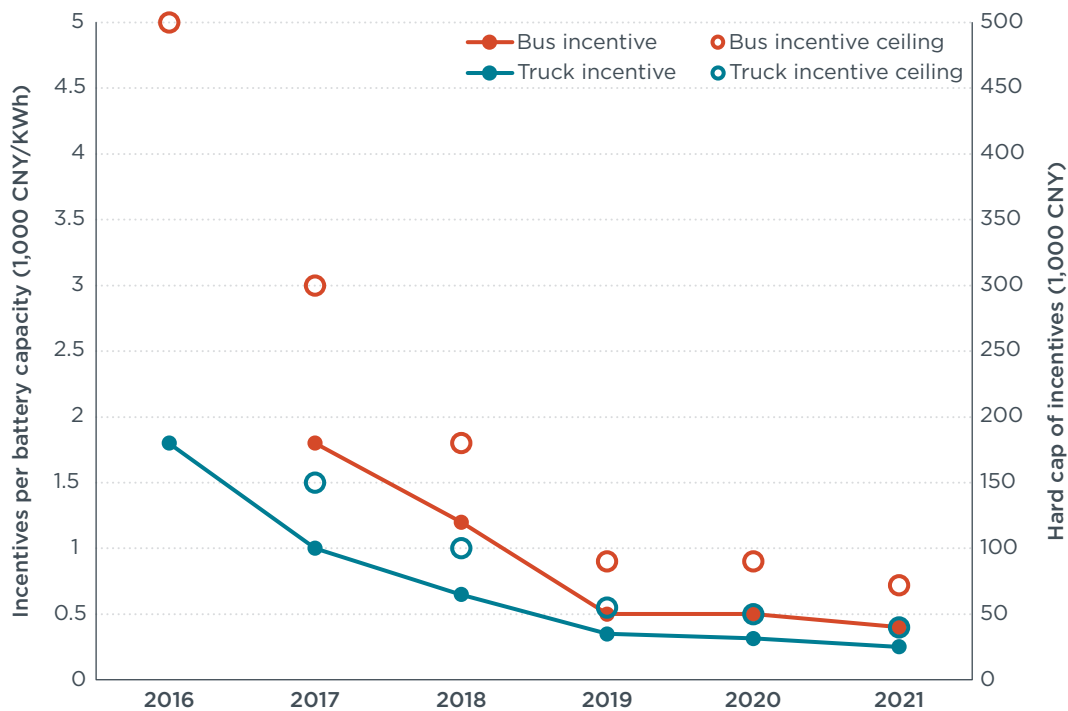


Figure 7. Incentives & incentive ceiling information for battery electric trucks and buses in China during 2016-2021. Only models with typical specifications (battery capacity > 50 KWh, non-fast charging trucks, and buses greater than 12m in length) are plotted in this diagram. No information is available for truck incentive ceiling and bus incentives per unit of battery capacity in 2016.

China's first-tier cities, namely Beijing, Shanghai, Guangzhou and Shenzhen, along with several large-sized cities in other regions (such as Chengdu of Sichuan province and Xi'an of Shaanxi province) have witnessed HD-NEV sales of more than 10,000 during the 2017-2019 period, which is shown in Figure 8. It is commonly acknowledged that zero-emission city buses will be deployed more easily than other electric vehicle segments, as China's public transportation system is mostly run by local state-owned companies, and Zero-Emission (ZE) city buses can be promoted via public funding and city campaigns. Tianjin, Zhengzhou, Chengdu, Xi'an, and Shenzhen, among others, are cities in which more ZE trucks than buses were sold during the period. This implies more acceptance and viability of HD-NEV in real-use cases.

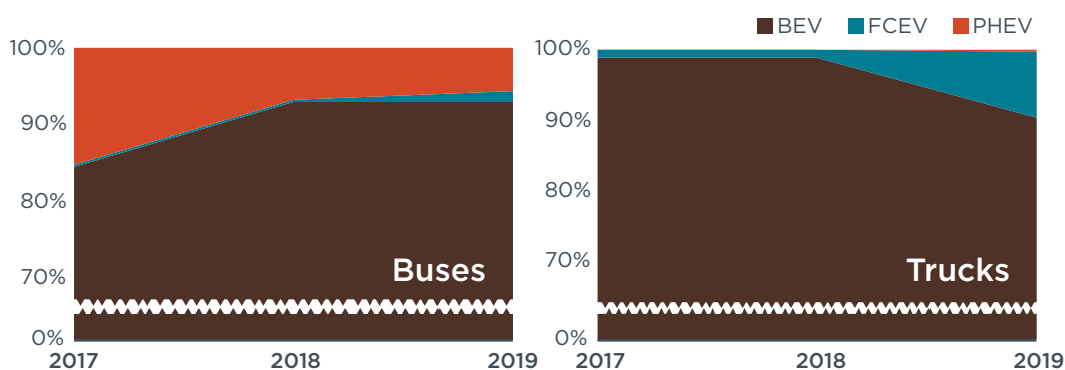


Figure 8. Fuel technology of buses and trucks from 2017 to 2019

Here is a summary of zero-emission activity highlights for several cities in China.

Beijing: Beijing deployed more than 9,500 ZE-buses, most of which were battery electric, as part of its program to deploy only ZE-buses by 2020 (Beijing Daily, 2018).

This target resulted in a higher priority being given to electric buses than to trucks and other ZE segments and led to greater sales of electric buses in Beijing over 3 years.

Shanghai: Shanghai set a goal of a 60% electric bus fleet in the urban area by 2020 (Xinhua News, 2016), which increased the demand for ZE-city buses between 2017 and 2019. The city surpassed the target, achieving a 67% penetration rate for ZE-city buses (11,919 units), according to an official source in early 2021 (Yicai, 2021).

Shenzhen: Shenzhen's commitment to electrify its road transportation system is highly ambitious. It is the first city in the world to feature a fully electric bus fleet, with ~16,000 electric buses. (WRI, 2018). Based on this success, and capitalizing on cheap electricity prices, Shenzhen's local government began to promote ZE trucks. (Shenzhen Development and Reform Commission, 2019). In addition to using purchase subsidies, tax waivers, and other policies commonly implemented in many cities, Shenzhen designed and implemented new incentives based on daily driving of ZE-trucks. Specifically, Shenzhen designed criteria for determining if vehicles qualify for the city's incentive program (Wang et al., 2020), including whether:

- » the model is listed in the Recommendation Catalog of New Energy Vehicle Models for Promotion and Adoption, released and updated by MIIT. A set of technical requirements must be met for a model to be included there.
- » the vehicle is connected to a supervision & monitoring platform administered by the Municipal Transportation Commission of Shenzhen.
- » the affiliated company of the vehicle owns at least 300 operating delivery vehicles, of which at least 100 delivery trucks or 50 refrigerated vehicles are battery electric.

Chengdu: Chengdu's local government has implemented comprehensive measures to improve local air quality in recent years. Chengdu promoted the exclusive use of zero-emission logistics vehicles within the urban area, as conventional trucks will be banned access to several areas during the day (EVHUI, 2019). Chengdu's strategy of favoring ZE trucks increased demand for them significantly during the evaluation period. It is also reported that Chengdu recorded the highest level of ZE truck sales in February 2021 (OFweek News, 2021).

Some cities with HD-NEV models are deployed beyond the geographic scope of **Figure 9**. For example, electric buses have been adopted in cities in northeast China, where several capital cities, such as Harbin (~4,400 vehicles), Changchun (~1,800 vehicles) and Shenyang (~1,800 vehicles), deployed electric buses during the period. Because electric trucks and buses struggle with range limitations in extremely cold weather (ViriCiti, 2020)—for example in northern regions such as Inner Mongolia and Xinjiang—it is a great challenge for local authorities to promote zero-emission models in these regions.

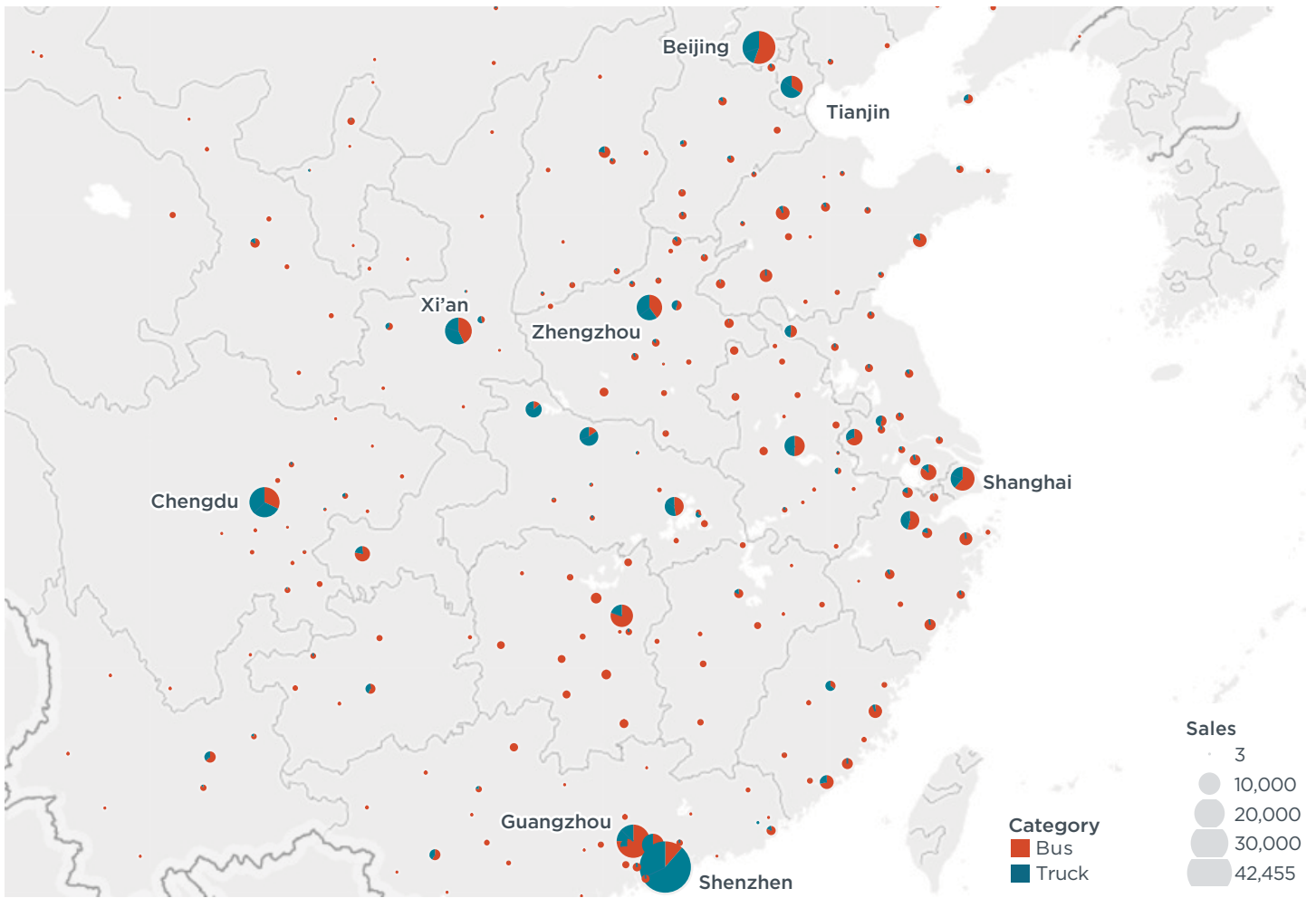


Figure 9. HD-NEV sales by city from 2017 to 2019 in China (part). The size of the pie charts indicates total sales.

KEY FINDINGS AND DISCUSSION

COACHES AND CITY BUSES

China has established itself as the world's most important market for zero-emission coaches and city buses. This is the result of policies enacted by China's central government and local authorities to promote aggressively the electrification of urban surface transit since 2009, when the first stage of the "Ten Cities, Thousand Vehicles" initiative was kicked-off (Xinhua News, 2009).

Coaches and city buses are the most popular segments of zero-emission heavy-duty vehicles in China. During the 2017-2019 period, several key manufacturers of zero-emission heavy-duty vehicles produced coaches and city buses on a massive scale—more than 10,000 vehicles. Legacy bus manufacturers such as Yutong, Zhongtong, BYD, CRRC, and King Long were key players in the market. China's coach and city bus market was dominated by LFP battery chemistry, which has lower energy density than NMC/NCA batteries but benefits from less expensive raw materials.

Geely Group became a relatively new player in the zero-emission coach and city bus market when Geely established a new subsidiary focusing on commercial vehicle production in 2016 (Geely commercial vehicle, 2020). Geely Commercial Vehicle's zero-emission line of buses includes battery electric and hydrogen fuel cell models.

With many cities worldwide promoting zero-emission buses, China's bus manufacturers are also exploring foreign markets, including in Europe, South Asia, and Latin America. BYD is one of the most successful Chinese bus manufacturers to promote electric buses in international markets. Reports indicate that BYD has deployed its models in London, Paris, and Bogotá, among others. (BYD, 2021; BYD Europe, 2020; Manthey, 2019)

STRAIGHT TRUCKS

From 2017 to 2019, Geely Group, Dongfeng Motor, SINOMACH and Dayun were the lead manufacturers of zero-emission straight trucks. Most of the world's legacy HDV manufacturers, except Foton-Daimler, offered zero-emission models by 2019 (see Appendix 5). Dongfeng Motor sold the most zero-emission straight trucks in the period with over 30,000 vehicles, followed by SINOMACH and Geely, each with more than 10,000 vehicles sold.

Because it is more affordable and safer, batteries based on lithium ferrophosphate (LFP) chemistry are becoming popular for battery electric straight trucks, and the share of batteries based on nickel manganese cobalt (NMC) chemistry declined in the 2017-2019 period. Several manufacturers such as Dongfeng Motor and SAIC-Maxus also produced trucks with lithium magnesium oxide (LMO) batteries. The market penetration of LMO in battery-electric trucks increased from 4% (2017) to 10% (2019). Because of concerns regarding safety issues at high temperatures, LMO has not become a mainstream solution for straight trucks.

As a leader in the straight truck market, Dongfeng Motor sold ~2,700 zero-emission trucks in 2019, accounting for about 21% of total available HD-NEV sales, but at levels considerably below previous years (down ~86% and ~67% from 2017 and 2018, respectively). This may be an indication of the challenges facing zero-emission straight trucks, or possibly the result of subsidy phase-outs. Dongfeng Motor produced zero-emission trucks with a maximum range of 380 km under a C-WTVC driving cycle, long enough for short-range delivery vehicles. Dongfeng Motor is ambitious in expanding its influence; it was part of a new joint venture in 2020, together with Chang'an Auto and FAW Group, to develop new NEV models and battery technologies (Monika, 2020). Also, Dongfeng Motor has collaborated with Toyota, FAW Group, and BAIC Motor to explore innovative fuel cell technologies for commercial vehicles (MarkLines, 2020).

SINOMACH, a state-owned corporation that produces heavy-duty machinery and trucks, is also one of the top zero-emission truck providers in China with ~14,900 vehicles available, accounting for 13.8% of total straight truck sales on the market in 2019. SINOMACH provided zero-emission truck models with a maximum range of 260 km and LFP and NMC battery chemistry.

Youngman Auto manufacturer sold 605 hydrogen fuel cell straight truck models during 2017-2019, being the most important player of hydrogen fuel cell technology in this segment.

DUMP TRUCKS

The zero-emission dump truck market is still in the incubation stage in terms of available models and sales, even though some HDV manufacturers, including BYD, Beijing Hualin, Geely-CAMC, Tri-ring, and Shaanxi Auto managed to offer a variety of zero-emission dump truck models during 2017-2019.

Manufacturers of zero-emission dump trucks are pursuing a fast-charging strategy in Shenzhen, China (BYD, 2018). There, zero-emission dump trucks are equipped with a battery capacity of 435 kWh and 280 km of maximum range. While a few other manufacturers—such as Dongfeng Motor, FAW, and Skywell-Golden dragon, among others—also offer zero-emission dump truck models, no sales were recorded during the analysis period.

LFP batteries are the mainstream choice for dump truck manufacturing because they are cheaper and safer than NMC batteries. As BYD is dominating electric dump truck production (with a 99% market share) in China, BYD's preference for LFP chemistry also shapes the game. BYD's T9ZT and T10ZT electric dump truck models have a maximum energy density of 131 Wh/kg, robust enough to support mining and port service.

Beijing Hualin Special Vehicle Co., Ltd., (often abbreviated Beijing Hualin) is a vehicle group whose focus is dump trucks, engineering vehicles, and sanitation vehicles. Beijing Hualin produced 4 models of zero-emission dump trucks, most of which were technically supported by BYD. Tri-ring and Shaanxi Auto also offered 1 and 8 models, respectively. Further details can be found in Appendix 6.

UTILITY VEHICLES

Beijing Hualin and Dongfeng Motor sold the most utility vehicles during the 2017-2019 period. Competition among manufacturers with available models is intense, as most of the key HDV manufacturers in China managed to produce electric and hydrogen fuel cell models, as summarized in Appendix 5. Yutong, Dongfeng Motor, BYD, Foton, Beijing Hualin, CNHTC/Sinotruk offered more than 50 models of zero-emission vehicles. Of particular note, Dongfeng Motor manufactured three fuel cell refrigerated truck models, Foton produced one fuel cell refrigerated truck model, and Beijing Hualin offered a sanitation vehicle model. Because utility vehicles are highly customized and specifically functional for different uses in daily operations, variants (which are recorded as models in the Appendix) are commonly offered to customers.

Zero-emission utility vehicles, especially those for public service such as sanitation vehicles, post vehicles, and express and logistics vehicles, are strongly encouraged and promoted by China's official authorities in recent announcements and publications (MOT, 2015; MOT et al., 2019). Officials are also considering advancing such a transition ahead of electrification of the entire fleet in China (Zhang, 2020). For this reason, it is expected that the market for zero-emission utility vehicles will be robust in the coming years.

In 2019, Skywell-Golden Dragon—abbreviated as Skywell—soared in zero-emission utility vehicle sales. Skywell accounted for 29% of sales of sanitation vehicles and 47% of

post vehicles among all manufacturers. The longest ranges of utility vehicles provided by Skywell are 243 km and 193 km for sanitation vehicles and post vehicles with max battery capacity as 387 kWh and 77 kWh, respectively. Beijing Hualin also produced 50 models of zero-emission sanitation vehicles with almost 20% of market share in 2019. The maximum range turned out to be 313 km with 348 kWh of battery capacity.

TRACTOR TRUCKS

Tractor trucks with zero-emission technologies, like dump trucks, are still at the incubation stage. There were few available models of tractor trucks by 2019. Most electric models were equipped with LFP batteries and have ranges of less than 200 km. Hence, current tractor truck models can be used for regional drayage but are still incapable of undertaking long-haul projects, such as the model produced by Geely-CAMC (360che.com, 2020).

Tri-ring Group and Dayun Auto produced the most zero-emission tractor trucks during 2017-2019 with 211 and 185 trucks, respectively. BYD produced the most available zero-emission models during 2017-2019, followed by Dongfeng Motor and Skywell-Golden Dragon.

In 2019, Hualing Xingma, also known as CAMC and a subsidiary entity under Geely Group, provided 49 zero-emission tractor trucks, accounting for 71% of total sales in that year. The maximum range of tractor trucks provided by CAMC was 127 km, which may support short range delivery only. Dayun Group and CNHTC/Sinotruk Group provided models with maximum ranges of 137 km and 67 km, respectively, in 2019.

To overcome limits on battery energy density and capacity, several manufacturers also provided hydrogen fuel cell models with a range over 400 km under C-WTVC driving cycles (MIIT, 2019). However, hydrogen-fueled tractor trucks have seen little market penetration to date.

SUMMARY OF HD-NEV MARKET READINESS IN CHINA

In this study, China's emerging HD-NEV market is being investigated from the perspective of both scale and strategy. Here are key takeaways from the analysis.

From follower to leader. China was long seen as a laggard in ICE-HDV industry, trailing the US, EU, and Japan. However, in the race to zero-emission trucks and buses, China has become a key player in the last decade and is now leading the manufacturing of both zero-emission trucks and buses across the globe. In particular, China dominates the global zero-emission bus market, most of which were battery electric, with more than 77,000 vehicles produced. It also sold more than 20,000 zero-emission trucks and utility vehicles in 2019.

Incipient trucks and burgeoning buses. Compared to electric trucks, zero-emission buses and coaches dominated China's zero-emission market with a much broader coverage by gross vehicle weight (GVW). While zero-emission trucks were generally found in the 3,500-4,500kg weight class, zero-emission buses weigh up to 18,000 kg. The range of zero-emission trucks, around 300 km, is not adequate for many regional and long-haul uses.


A game with new players. HD-NEV is an emerging market with a window of opportunity for new entrants. Data on market share show that existing manufacturers in the conventional heavy-duty vehicle market did not capture the top position in HD-NEV sales. For example, FAW Group, JAC, CNHTC/Sinotruk, and Foton-Daimler lost their places among the top 10 manufacturers of HD-NEV market. On the other hand, some new players benefited from this change in market dynamics. BYD, CRRC, and Skywell, among others, made the most of their production of electric buses to secure top positions in the HD-NEV sales ranking among all manufacturers.

Electrons are trumping over protons. The HD-NEV market is dominated by battery electric models thanks to the development of battery technology brought by light duty vehicles. Only a few models are offered featuring hydrogen fuel cell technology. And some segments with heavy payload and extended range requirements struggle with the limited energy density of LFP batteries. Therefore, we expect to see new HD-NEV offerings with high energy density batteries and fuel cell powertrains in the near future.


In LFP we trust. The most popular battery chemistry for buses and trucks is LFP, i.e., lithium ferrophosphate. The proportion of LFP battery increased from 65% to 83% in terms of HDV gross sales during 2017-2019. LFP batteries are much more affordable and stable than NMC batteries, but they also suffer from lower energy density for daily use. The preference for LFP over NMC suggests that manufacturers still hold a conservative position on battery electric HDVs, because they prioritize the safety and reliability of LFPs over the superior long-distance performance of NMCs.

APPENDIX 1. TRUCK MANUFACTURERS

GEELY GROUP

Subsidiary entity for HD-NEVs	Geely Commercial Vehicle Co.
Business type	Private
Stock market listed	Yes
JV/partner manufacturers	--
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> • Geely partnered with CURO and POSCO to develop new business in South Korea in 2019. • Geely deployed a new model of TX4 into Southern Asia and partnered with Asia Cab in Nov. 2019.
Segment	 <p>Straight and box truck</p>
Market share	25%
GVW range (kg)	4,495
Sales in 2019	3,222
Available brand(s)	Farizon, Jialong
Available model(s)	E200, RE500, E200S, E5, E5L, E6
Max Range (Km)	297
Max battery capacity (kWh)	100
Zero-emission technology	Battery electric, hybrid plug-in
Battery chemistry	LFP, NMC
Max Energy density (Wh/kg)	137


DONGFENG MOTOR

Subsidiary entity for HD-NEVs	Dongfeng Auto Ltd.	
Business type	Joint venture by Nissan Motor and Dongfeng Motor	
Stock market listed	Yes	
JV/partner manufacturers	Nissan Motor	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Dongfeng launched a JV with Chang'an Auto and FAW Group in 2020 to develop new NEV models and battery business.⁶ Dongfeng partnered with Toyota, FAW Group, BAIC Motor and GAC Group to launch a new JV for fuel cell research on commercial vehicles in 2020.⁷ 	
Segment	 <p>Straight and box truck</p>	
GVW range (kg)	< 4,500	≥ 4,500
Market share	21%	
Sales in 2019	2,741	14
Available brand(s)	Chenglong, Huashen	
Available model(s)	EM10, EM21, EV300, EV350	
Max Range (Km)	380	233
Max battery capacity (kWh)	132	65
Zero-emission technology	Battery electric	
Battery chemistry	LMO, LFP, NMC	
Max Energy density (Wh/kg)	153	110

6 Tianyancha, "Company profile of China Automobile Innovation Corporation," <https://www.tianyancha.com/company/3441792116>, 2021.



7 Toyota, "Six Companies Establish R&D Joint Venture for Commercial Vehicle Fuel Cell Systems for the Creation of a Hydrogen-based Society in China," <https://global.toyota/en/newsroom/corporate/32732372.html>, 2020.

SINOMACH

Subsidiary entity for HD-NEVs	Hubei Xinchufeng Auto Co. CHTC Motor
Business type	State-owned
Stock market listed	No
JV/partner manufacturers	--
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> CHTC Motor acquired a Dutch heavy-duty manufacturer GINAF Truck in 2012 but sold by management buy-out in 2020.⁸
Segment	 <p>Straight and box truck</p>
Market share	13.3%
GVW range (kg)	4,495
Sales in 2019	1,708
Available brand(s)	CHTC, Xinchufeng
Available model(s)	Unnamed
Max Range (Km)	260
Max battery capacity (kWh)	97
Zero-emission technology	Battery electric
Battery chemistry	LFP, NMC
Max Energy density (Wh/kg)	131

⁸ "GINAF Trucks goes Dutch again after management buy-out," *Fleet Transport*, <https://fleet.ie/ginaf-trucks-goes-dutch-again-after-management-buy-out/>, 2020.


BYD

Subsidiary entity for HD-NEVs	BYD Auto Industry Co., Ltd.	
Business type	Private	
Stock market listed	Yes	
JV/partner manufacturers	Toyota, Hino Motor, Faurecia, Chang'an and Daimler	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> • BYD and Toyota launched a JV called BYD-Toyota EV Technology Co., Ltd. In Shenzhen, China in 2020.⁹ • BYD allied with Hino Motors to develop commercial BEV development in 2020.¹⁰ 	
Segment	 Straight and box truck	 Dump truck
Market share	0.1%	99%
GVW range (kg)	4,000 - 4,495	31,000
Sales in 2019	11	2,815
Available brand(s)	BYD	
Available model(s)	T3, T4, T5, T7, T10	T9ZT, T10ZT
Max Range (Km)	257	213
Max battery capacity (kWh)	84	435
Zero-emission technology	Battery electric	
Battery chemistry	NMC	LFP
Max Energy density (Wh/kg)	151.2	130.8

9 Toyota, "BYD, Toyota Launch BYD TOYOTA EV TECHNOLOGY Joint Venture to Conduct Battery Electric Vehicle R&D," <https://global.toyota/en/newsroom/corporate/32126024.html>, 2020.

10 BYD, "BYD and Hino sign a strategic business alliance agreement with a focus on Commercial Battery Electric Vehicles development," <https://www.byd.com/en/news/2020-04-23/BYD-and-Hino-sign-a-strategic-business-alliance-agreement-with-a-focus-on-Commercial-Battery-Electric-Vehicles-development>, 2020.




FEIDI MOTORS

Subsidiary entity for HD-NEVs	Feidi Auto Co.
Business type	Private
Stock market listed	No
JV/partner manufacturers	--
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Feidi Motors signed strategic agreement with ISUZU China Engine to develop new commercial vehicle models in Nov. 2020.¹¹
Segment	 Straight and box truck
Market share	1.9%
GVW range (kg)	3,510 – 4,495
Sales in 2019	244
Available brand(s)	Feidi
Available model(s)	Feidi W, Feidi Q, Ditu, Aochi
Max Range (Km)	165
Max battery capacity (kWh)	97
Zero-emission technology	Battery electric
Battery chemistry	LFP
Max Energy density (Wh/kg)	141

¹¹ Yang Zhang, "Feidi Motors and Isuzu (China) Engine Strategic Cooperation Signed." <https://www.163.com/dy/article/FRNJ66P70514R9L4.html>, 2020.

APPENDIX 2. UTILITY VEHICLE MANUFACTURERS


SKYWELL GROUP

Subsidiary entity for HD-NEVs	Skywell New Energy Automobile Co. Ltd and Shenzhen Skywell Automobile Co. Ltd.		
Business type	Private		
Stock market listed	Being listed soon		
JV/partner manufacturers	Xiamen King Long		
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Skywell is pursuing for IPO and being listed on Shanghai Exchange.¹² Skywell provided the first passenger vehicle model "Skywell ET5" in 2020.¹³ 		
Segment	 Post vehicle	 Engineering vehicle	 Sanitation vehicle
Market share	47%	1.8%	29%
GVW range (kg)	4,490	4,495 - 13,500	4,495 - 31,000
Sales in 2019	40	21	1,018
Available brand(s)	Skywell		
Available model(s)	Unnamed	Z04	Z04, Z06, Z10, Z18, Z25, Z31
Max Range (Km)	193	200	243
Max battery capacity (kWh)	77	161	387
Zero-emission technology	Electric battery		
Battery chemistry	NMC	LFP	LFP
Max Energy density (Wh/kg)	124	142	142

¹² Fan Wu, "Skywell Automobile intends to be listed on Shanghai Exchange, the newly brand 'Tianmei Automobile' to be released on market with bypass," <https://finance.sina.com.cn/stock/kechuangban/2020-11-17/doc-iiznctke1934414.shtml> (in Chinese), 2020.


¹³ Skywell official website, <http://www.skywellcorp.com/>.

SUNLONG BUS

Subsidiary entity for HD-NEVs	Jiangsu Sunlong Automobile Ltd and Sichuan Sunlong Automobile Ltd.
Business type	Private
Stock market listed	No
JV/partner manufacturers	--
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Sunlong Bus was acquired by Dongxu Optoelectronic Technology Co Ltd with 3 billion CNY in 2017¹⁴
Segment	 Engineering vehicle
GVW range (kg)	7,990 - 8,990
Market share	65.50%
Sales in 2019	767
Available brand(s)	Sunlong
Available model(s)	Unnamed
Max Range (Km)	320
Max battery capacity (kWh)	88
Zero-emission technology	Fuel cell
Battery chemistry	LFP, LMO
Max Energy density (Wh/kg)	129

¹⁴ Dongxu Optoelectronic Technology (000413.SZ), "Acquisition Plan," <https://q.stock.sohu.com/newpdf/201726111140.pdf>, 2017.



BEIJING HUALIN SPECIAL VEHICLE CO., LTD.

Subsidiary entity for HD-NEVs	--
Business type	State-owned
Stock market listed	No
JV/partner manufacturers	BYD
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> • Beijing Hualin Special Vehicle Co., Ltd. become a JV by Beijing Sanitation Engineering Group Sanitation Equipment Co., Ltd and BYD since 2015.¹⁵ • Beijing Hualin Special Vehicle Co., Ltd. is technically supported by BYD for zero-emission trucks and utility vehicles since 2015.¹⁶
Segment	 Sanitation vehicle
Market share	20.1%
GVW range (kg)	4,000 - 32,000
Sales in 2019	707
Available brand(s)	Hualin
Available model(s)	Unnamed
Max Range (Km)	313
Max battery capacity (kWh)	348
Zero-emission technology	Battery electric
Battery chemistry	LFP, LMO
Max Energy density (Wh/kg)	141

¹⁵ Beijing Hualin Auto official website, "Introduction," <http://www.bjhltzc.cn/about.asp?id=34>, 2021.




¹⁶ Ibid

GEELY GROUP

Subsidiary entity for HD-NEVs	Geely Commercial Vehicle Co.	
Business type	Private	
Stock market listed	Yes	
JV/partner manufacturers	--	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Geely delivered E6 box trucks to China Post in Nov. 2020.¹⁷ 	
Segment	 Engineering vehicle	 Refrigerated truck
Market share	6.7%	8%
GVW range (kg)	4,495	3,650 - 4,495
Sales in 2019	78	23
Available brand(s)	Farizon Auto	
Available model(s)	Unnamed	E200, E200S, E6
Max Range (Km)	267	173
Max battery capacity (kWh)	88	50
Zero-emission technology	Battery electric, plug-in hybrid	Battery electric, plug-in hybrid
Battery chemistry	LFP, NMC	NMC
Max Energy density (Wh/kg)	131	146

¹⁷ Geely Commercial Vehicles, "Farizon E6 delivered to China Post, which helps build a national green logistics system," <https://www.geelycv.com/news/info/100.html>, 2020.

DONGFENG MOTOR



Subsidiary entity for HD-NEVs	Dongfeng Auto Ltd.		
Business type	Joint venture by Nissan Motor and Dongfeng Motor		
Stock market listed	Yes		
JV/partner manufacturers	Nissan Motor		
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Dongfeng launched a JV with Changan Auto and FAW Group in 2020 to develop new NEV models and battery business.¹⁸ Dongfeng partnered with Toyota, FAW Group, BAIC Motor and GAC Group to launch a new JV for development of fuel cell on commercial vehicles in 2020.¹⁹ 		
Segment	 Refrigerated truck	 Engineering vehicle	 Sanitation vehicle
Market share	9%	1%	6.9%
GVW range (kg)	4,495 - 7,600	4,300 - 7,320	4,200 - 8,270
Sales in 2019	26	11	243
Available brand(s)	Chenglong, Huashen		
Available model(s)	Unnamed		
Max Range (Km)	307	380	240
Max battery capacity (kWh)	103	132	314
Zero-emission technology	Battery electric		
Battery chemistry	LFP, NMC	LFP, NMC	NMC
Max Energy density (Wh/kg)	140	149	164

¹⁸ Tianyancha, "Company profile of China Automobile Innovation Corporation," <https://www.tianyancha.com/company/3441792116>, 2021.

¹⁹ Toyota, "Six Companies Establish R&D Joint Venture for Commercial Vehicle Fuel Cell Systems for the Creation of a Hydrogen-based Society in China," <https://global.toyota/en/newsroom/corporate/32732372.html>, 2020.



APPENDIX 3. BUS MANUFACTURERS

YUTONG GROUP

Subsidiary entity for HD-NEVs	Yutong Bus Co., Ltd.	
Business type	Private	
Stock market listed	Yes	
JV/partner manufacturers	--	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Yutong partnered with StarPower Semiconductor to develop new motor control system in 2020.²⁰ 	
Segment	 City bus	 Coach
Market share	26.4%	33.3%
Sales in 2019	19,522	1,305
Available brand(s)	Yutong	
Available model(s)	- Battery electric: U10, U12, E6, E6PLUS, E8i, E8PLUS, E10, E8, E10i, E12DD - Hybrid: H8, H12	ZK6820BEV, ZK6117BEV, ZK6827BEV, ZK6907BEV
Max Range (Km)	467	437
Max battery capacity (kWh)	351	334
Zero-emission technology	Battery electric, fuel cell, plug-in hybrid	Battery electric, fuel cell
Battery chemistry	LFP, LMO	LFP
Max Energy density (Wh/kg)	161	142



²⁰ Yutong Bus, "Yutong Bus and StarPower Semiconductor jointly develop commercial vehicle motor control system solutions based on SiC technology," <http://www.yutong.com/news/yutongnews/06/2020FELFn6zWrV.shtml>, 2020.

KING LONG

Subsidiary entity for HD-NEVs	King Long United Automotive Industry Co. Ltd.	
Business type	State-owned	
Stock market listed	Yes	
JV/partner manufacturers	Grammer AG, Shaanxi Auto	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> King Long and Grammer AG launched a JV for seat supplies in 2018.²¹ 	
Segment	 City bus	 Coach
Market share	12.4%	12.9%
Sales in 2019	9,143	504
Available brand(s)	King Long, Golden dragon, Higer	
Available model(s)	City light series, Smart city light series, Xiaoyao, Longyue	Longwei II series, XMQ6125 series, Jieguan 3 series, Jieguan 3T series, Haorui
Max Range (Km)	536	440
Max battery capacity (kWh)	543	327
Zero-emission technology	Battery electric	Battery electric
Battery chemistry	LFP, LMO	LFP
Max Energy density (Wh/kg)	161	161



²¹ Yue Tu, "King Long Motors signed a contract with Grammer AG to jointly build high-profile bus seats," https://m.chinabuses.com/news/7/article_85498.html, 2018.

ZHONGTONG BUS

Subsidiary entity for HD-NEVs	Zhongtong Bus Holding Co., Ltd.	
Business type	State-owned	
Stock market listed	Yes	
JV/partner manufacturers	-	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Zhongtong launched a JV with Broad-Ocean Motor to develop new fuel cell system in 2017.²² 	
Segment	 City bus	 Coach
Market share	8.4%	3.2%
Sales in 2019	6,198	124
Available brand(s)	Zhongtong	
Available model(s)	Ruitong V60, N10, N12, LCK6108EVG series, LCK6809EVG series	Shiteng series, E-07, LCK6117EV series
Max Range (Km)	473	267
Max battery capacity (kWh)	351	219
Zero-emission technology	Battery electric, fuel cell, plug-in hybrid	Battery electric
Battery chemistry	LFP, LMO	LFP
Max Energy density (Wh/kg)	161	161

²² Xianhe Chang, "Broad-Ocean Motor plans to invest 440 million US dollars to establish a joint venture with Zhongtong Bus," <http://finance.sina.com.cn/stock/s/2017-07-29/doc-ifyinwmp0626022.shtml>, 2017.



BAIC GROUP

Subsidiary entity for HD-NEVs	Beiqi Foton Motor Co., Ltd. Beijing Foton Daimler Automotive Co., Ltd.	
Business type	State-owned	
Stock market listed	Yes	
JV/partner manufacturers	Daimler	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Foton will launched a new JV with Daimler AG to produce Mercedes-Benz Trucks with model Actros.^{23,24} 	
Segment	 City bus	 Coach
Market share	5%	1.7%
Sales in 2019	3,687	66
Available brand(s)	Foton	
Available model(s)	BJ6851, BJ6105, BJ6805, BJ6180, BJ6123, BJ6140	HC8, HC9, BJ6113, BJ6122, HC11, HC12, BJ6120, BJ6122, BJ6956, BJ6132
Max Range (Km)	437	332
Max battery capacity (kWh)	304	255
Zero-emission technology	Battery electric, fuel cell, plug-in hybrid	Battery electric
Battery chemistry	LFP, LMO, LTO	LFP, LMO
Max Energy density (Wh/kg)	161	160

23 Daimler AG, "Daimler Truck AG and Foton start joint production of Mercedes-Benz Trucks in China for China," <https://media.daimler.com/marsMediaSite/en/instance/ko/Daimler-Truck-AG-and-Foton-start-joint-production-of-Mercedes-Benz-Trucks-in-China-for-China.xhtml?oid=48325926>, 2020.



24 Yilei Sun and Brenda Goh, "Daimler to revamp China plant to make Actros trucks as sales surge," <https://www.reuters.com/article/daimler-china/daimler-to-revamp-china-plant-to-make-actros-trucks-as-sales-surge-idUSL4N2HZ0NU>, 2020.

BYD

Subsidiary entity for HD-NEVs	BYD Auto Industry Co., Ltd.	
Business type	Private	
Stock market listed	Yes	
JV/partner manufacturers	GAC Group, ADL	
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> • BYD jointed with ADL to provide electric bus models in UK.²⁵ 	
Segment	 City bus	 Coach
Market share	4.9%	1.6%
Sales in 2019	3,645	63
Available brand(s)	BYD	
Available model(s)	K6, K7, K8, K8S, K9	
Max Range (Km)	417	383
Max battery capacity (kWh)	331	253
Zero-emission technology	Battery electric	Battery electric
Battery chemistry	LFP	LFP
Max Energy density (Wh/kg)	142	142


²⁵ BYD and ADL, News page of the official website, <https://www.evbus.co.uk/news/>, 2020.

WINNERWAY MOTORS

Subsidiary entity for HD-NEVs	Winnerway Motor, Ltd.	
Business type	Private	
Stock market listed	No	
JV/partner manufacturers	--	
Recent business partnership, acquisition and development	--	
Segment	 City bus	 Coach
Market share	4.7%	0.4%
Sales in 2019	3,501	15
Available brand(s)	Winnerway	
Available model(s)	KMT6601GBEV, KMT6600GBEV, KMT6106GBEV series, KMT6119HBEV, KMT6802GBEV series	KMT6602HBEV
Max Range (Km)	373	170
Max battery capacity (kWh)	304	62
Zero-emission technology	Battery electric	
Battery chemistry	LFP, LMO	LFP
Max Energy density (Wh/kg)	161	145


APPENDIX 4. TRACTOR TRUCK MANUFACTURERS

GEELY GROUP

Subsidiary entity for HD-NEVs	Hanma Technology Group Co., Ltd. Anhui Hualing Xingma Automobile (Group) Co., Ltd. (CAMC)
Business type	Private
Stock market listed	Yes
JV/partner manufacturers	--
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Hanma Technology was acquired by Geely Commercial Vehicle Group in 2020.²⁶ Hualing Xingma launched a JV with Hebei Province Construction & Investment Group and Longgang Investment Company to develop new HDV chassis and utility vehicles.
Segment	 Tractor truck
Market share	71%
GVW range (kg)	25,000
Sales in 2019	49
Available brand(s)	Hualing Junma
Available model(s)	Unnamed
Max Range (Km)	127
Max battery capacity (kWh)	323
Zero-emission technology	Battery electric
Battery chemistry	LFP
Max Energy density (Wh/kg)	158

²⁶ Monika, "Geely's CV arm to buy 15.24% stake in Anhui-based CV manufacturer Hualing Xingma," http://autonews.gasgoo.com/china_news/70017368.html, 2020.


DAYUN GROUP

Subsidiary entity for HD-NEVs	Yuncheng Dayun Auto Co., Ltd. (HDV and NEV) Chengdu Dayun Auto Co., Ltd. (Light trucks) Shiyan Dayun Auto Co., Ltd. (Medium-sized trucks)
Business type	Private
Stock market listed	No
JV/partner manufacturers	Daimler AG
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> Dayun once was reported to launch a new JV with Daimler AG in 2016²⁷ to equip engines from Daimler AG.
Segment	 Tractor truck
Market share	13%
GVW range (kg)	18,000 – 25,000
Sales in 2019	9
Available brand(s)	Dayun
Available model(s)	N8H, E8 ²⁸
Max Range (Km)	137
Max battery capacity (kWh)	375
Zero-emission technology	Battery electric
Battery chemistry	LFP
Max Energy density (Wh/kg)	135

²⁷ Dayun Group official website, “Dayun heavy truck equipped with Mercedes Benz ‘heart’ Rising with new power,” <http://www.dayunauto.com/news-newsdetail-61-1682>, 2017.

²⁸ These models have not been available since 2020.

NHTC/SINOTRUK GROUP

Subsidiary entity for HD-NEVs	Sinotruk Group Chengdu Wangpai Commercial Vehicle Ltd.
Business type	State-owned
Stock market listed	Yes
JV/partner manufacturers	TRATON Group
Recent business partnership, acquisition and development	<ul style="list-style-type: none"> • CNHTC/Sinotruk jointly established a new JV with TRATON Group, a subsidiary of Volkswagen Group, to introduce MAN into Chinese market in 2018.²⁹
Segment	 <p>Tractor truck</p>
Market share	8.7%
GVW range (kg)	18,000
Sales in 2019	6
Available brand(s)	HOWO
Available model(s)	T5G
Max Range (Km)	67
Max battery capacity (kWh)	194
Zero-emission technology	Battery electric
Battery chemistry	LFP
Max Energy density (Wh/kg)	142

²⁹ Volkswagen group official website, "TRATON and Chinese Sinotruk significantly expand strategic partnership," https://www.volkswagenag.com/en/news/2018/09/TRATON_Sinotruk.html#, 2018.

APPENDIX 5. MANUFACTURERS WITH ZERO-EMISSION MODELS, AND SALES OF BUSES, COACHES, UTILITY VEHICLES AND TRUCKS BY 2019³⁰

	Manufacturers	Coach		City bus		Straight truck		Utility vehicle	
		Models	Sales	Models	Sales	Models	Sales	Models	Sales
With ZE models only	Geely	3 ³¹	- ³²	40	-	41	11,006	4	179
	Winnerway	9	15	59	4,074	2	-	3	-
With both ICE and ZE models	Yutong	102	5,519	302	64,818	4	-	65	-
	Zhongtong	47	872	273	19,381	28	7,529	2	50
	Dongfeng Motor	75	48	126	4,815	200	30,705	69	1,452
	King Long	139	1,689	378	28,220	6	-	10	-
	Skywell-Golden dragon	188	3,853	296	7,556	57	784	45	1,095
	Nanjing Auto	13	-	-	-	76	3,462	32	29
	CRRC	30	1,102	270	14,851	7	22	7	-
	BYD	22	1,110	150	22,077	26	313	51	98
	Foton	48	1,034	149	10,165	41	2,795	69	53
	Sunlong	45	3,646	347	4,763	9	70	5	772
	Guangtong	62	2,024	178	9,904	13	409	12	-
	Geely-CAMC	2	-	3	-	14	3	15	-
	Ankai	32	159	140	7,035	1	-	-	-
	Beijing Hualin	-	-	-	-	4	44	50	1,478
	Shuchi	16	909	23	755	11	4,313	-	-
	Asiastar	44	638	156	4,526	2	-	-	-
	Dayun	17	-	30	-	100	8,787	11	47
	CNHTC/Sinotruk	6	610	22	3,694	3	-	64	-
	Chery	3	46	40	1,052	57	133	15	649
	SAIC-MAXUS	11	542	5	-	51	5,549	16	407
	Youngman	13	1	63	739	4	605	-	-
	Feidi	-	-	-	-	176	269	1	18
	Shaanxi	1	-	28	-	46	2,598	31	476
SINOMACH	5	-	7	-	47	14,914	16	13	
Sunwin	5	90	48	1,949	-	-	-	-	
Joylong	19	107	15	1,448	4	3,321	2	1	
FAW	2	-	33	-	67	3,874	24	52	
JMC	17	-	41	826	21	3,581	13	51	
JAC	5	-	-	-	37	2,830	20	1	
ISUZU	-	-	-	-	2	-	-	-	

³⁰ Information for Appendix 5 and 6 is retrieved from an online type-approval model database at <http://www.chinacar.com.cn/search.html>.

³¹ Models are summarized across their entire history for each manufacturer variants with distinct MIIT type approval code are also included. Only zero-emission models are presented in this table, including both battery electric and hydrogen fuel cell models.

³² Hyphens (-) indicate no available sales data during 2017-2019 period.

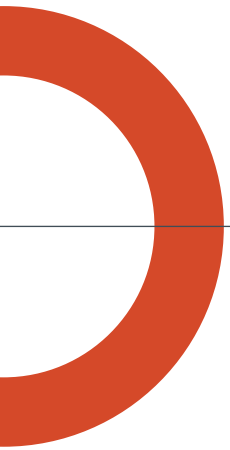
APPENDIX 6. MANUFACTURERS WITH ZERO-EMISSION MODELS AND SALES OF DUMP TRUCKS AND TRACTOR-TRUCKS BY 2019

Manufacturers	Dump truck		Tractor truck	
	Models	Sales	Models	Sales
Zhongtong	2	-	-	-
Dongfeng Motor	3	-	5	1
Skywell-Golden dragon	18	-	5	-
BYD	8	3,015	7	24
Foton	-	-	3	-
Geely-CAMC	9	17	1	54
Beijing Hualin	4	161	-	-
Dayun	-	-	3	185
Chery	2	-	-	-
SAIC-MAXUS	-	-	2	-
Tri-ring	1	11	1	211
Shaanxi	8	11	-	-
FAW	10	-	2	-
JMC	-	-	1	-

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