Zero-Emission Commercial Vehicles
Accelerating the Transition

2025 Factbook for Investors

September 18, 2025

Smart Freight Centre

BloombergNEF

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About this report

Road freight remains central in supporting economic activity around the world, but the trajectory of the sector's carbon emissions currently does not align with climate targets set by governments globally.

This report documents the state of the zero-emission commercial vehicle market to help decision-makers navigate the nascent sector. It shows that despite economic and infrastructure challenges, the transition to cleaner road freight has started and is gathering pace. Market participants are actively addressing the risks related to the value of commercial vehicles and batteries throughout their lifetime, indicating that some of these hurdles are not as severe as originally expected.

The report was produced by BloombergNEF in partnership with Smart Freight Centre.

Smart Freight Centre

Smart Freight Centre (SFC) is a globally active non-profit organization for climate action in the freight sector. Our goal is to mobilize the global logistics ecosystem, in particular our members and partners, in tracking and reducing its greenhouse gas emissions. We accelerate the reduction of logistics emissions to achieve a zero-emission global logistics sector by 2050 or earlier, consistent with 1.5C pathways.

BloombergNEF

BloombergNEF (BNEF) is a strategic research provider covering global commodity markets and the disruptive technologies driving the transition to a low-carbon economy. Our expert coverage assesses pathways for the power, transport, industry, buildings and agriculture sectors to adapt to the energy transition. We help commodity trading, corporate strategy, finance and policy professionals navigate change and generate opportunities.

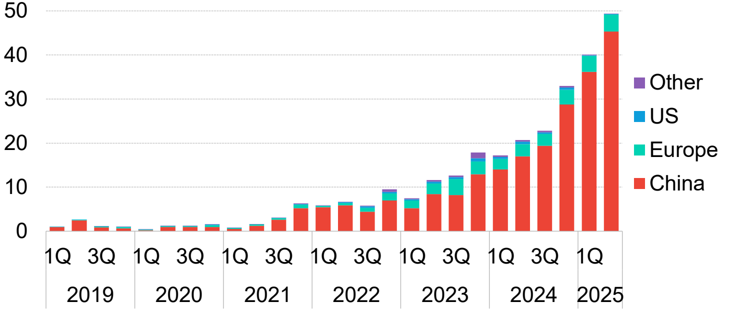
Introduction and key messages

The market for medium and heavy trucks with zero tailpipe emissions continues to grow quickly. Technology development, infrastructure expansion and policy actions mean electric trucks are already cost competitive in some countries and use cases. As the market expands, and manufacturers and operators gain more experience, some of the risks holding back wider adoption are increasingly being addressed.

- **Commercial vehicles** are set to become the largest contributor to road transport CO2 emissions. Without further action, the truck sector is far from a trajectory consistent with net-zero carbon emissions by 2050. Policy support for heavy vehicles and charging infrastructure in this segment is rising as a result, albeit unevenly across countries.
- **Zero-emission truck sales** approached 90,000 units globally in the first half of 2025, almost as many as in the whole of 2024. The global share of sales is on track to approach 4% in 2025. The Chinese market has widened its lead and accounts for more than 90% of global sales. The European market is growing strongly in more countries, while sales in the US have plummeted due to policy reversals.
- **Batteries** are the technology of choice for zero-emission trucks, capturing 97% of global sales. Trucks with swappable batteries continue to hold a sizeable share of the market in China, but this is declining as the market expands. The market for fuel cell trucks is concentrated in China and has steadily declined for the last year.

89,000	Electric trucks sold globally in 1H 2025, up 136% year-on-year
$4 billion	Government funding earmarked for truck chargers in Europe
0.6-1.2 million km	Range of battery warranties for recently-launched electric heavy-duty trucks

Global sales of zero emission trucks reach a record in 1H 2025



Source: BloombergNEF; see full list of sources in the Appendix. Note: Europe is the EU 27, the UK, Norway, Switzerland, Iceland and Liechtenstein. Includes medium- and heavy-duty trucks.

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Introduction and key messages

- **Prices** for truck batteries in China last year fell to $90 per kilowatt-hour. There were two main reasons: a focus on lithium iron phosphate (LFP) chemistry and significant overcapacity in the country. Truck battery prices outside of China were flat, due to muted demand growth.
- **Electric trucks** can be economically competitive today in locations with low electricity prices, high diesel prices, or, when trucks run at high utilization levels. As the economic case for electric trucks becomes clearer, controlling costs matters. With relatively high gaps between diesel and electricity prices – such as in China and some European countries – cost parity is closer than elsewhere. In the US, only the lowest electricity costs can make e-trucks as cheap as diesel trucks.
- **Large truck manufacturers** are far behind their zero-emission truck sales targets for 2030. In the face of policy uncertainties, some are re-adjusting their strategies, but in doing so, may miss opportunities. Still, several high profile bankruptcies of startup e-truck makers have had a limited impact on overall adoption.
- Most stakeholders currently assume very low **residual value** for the batteries in electric trucks. In practice, the battery can generate revenue as a stationary storage asset and have its materials recycled. A lack of detailed data on battery degradation and little experience with long-term use of electric trucks causes uncertainty on the value of these assets. Still, early data and anecdotal evidence indicate that such risks may not be as severe as originally thought.

Zero-emission commercial vehicle market

Different speeds in the transition to clean trucks

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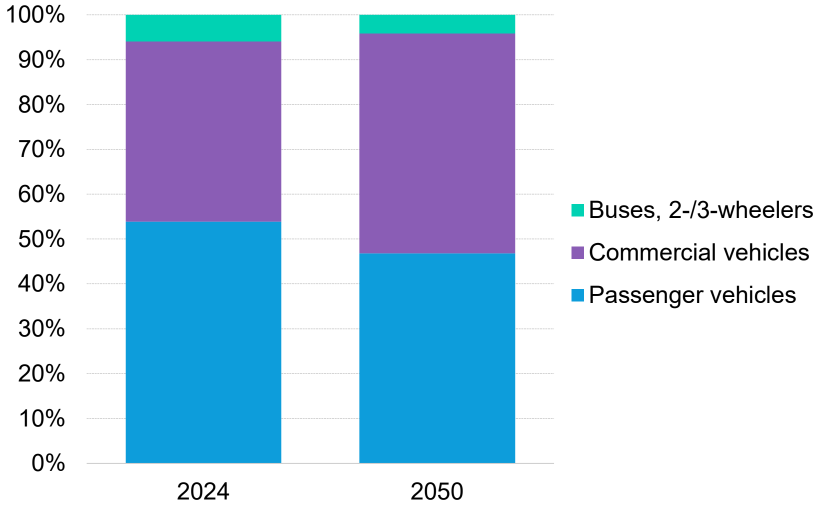
Zero-emission commercial vehicle market

Commercial vehicles are a growing share of road transport emissions

Distribution of CO2 emissions from road transport



Source: BloombergNEF's 2025 Electric Vehicle Outlook Economic Transition Scenario. Note: Includes emissions from fuel combustion and upstream emissions from electricity generation. 2050 scenario assumes no new policy intervention.

Global road transport emissions declined to 6.1 gigatons of CO2 (GtCO2) in 2024.

Most emissions come from the passenger car fleet, which stands at 1.3 billion vehicles. Electric vehicle sales continue to grow, even though regional variation in adoption rates persist. In 2024, about 17.6 million battery electric and plug-in hybrid cars were sold globally and accounted for almost 22% of new cars sales. The EV fleet exceeded 4% of cars on the road.

The commercial vehicle fleet today is close to 260 million vans and trucks, or about a fifth the size of passenger cars. Vans and trucks will account for the majority of global CO2 emissions before 2040.

The regional differences in adoption of zero-emission vans and trucks are more prominent than those of the passenger car sector. Adoption of such vehicles remains relatively low outside of a few countries and use cases, with a fleet of about 2.2 million electric vans and trucks.

By 2050, the commercial vehicle fleet will exceed 360 million vans, trucks and buses. While efficiency improvements and electrification can offset some of that growth, without further progress, such vehicles would emit almost 2GtCO2 – only 18% less than in 2024.

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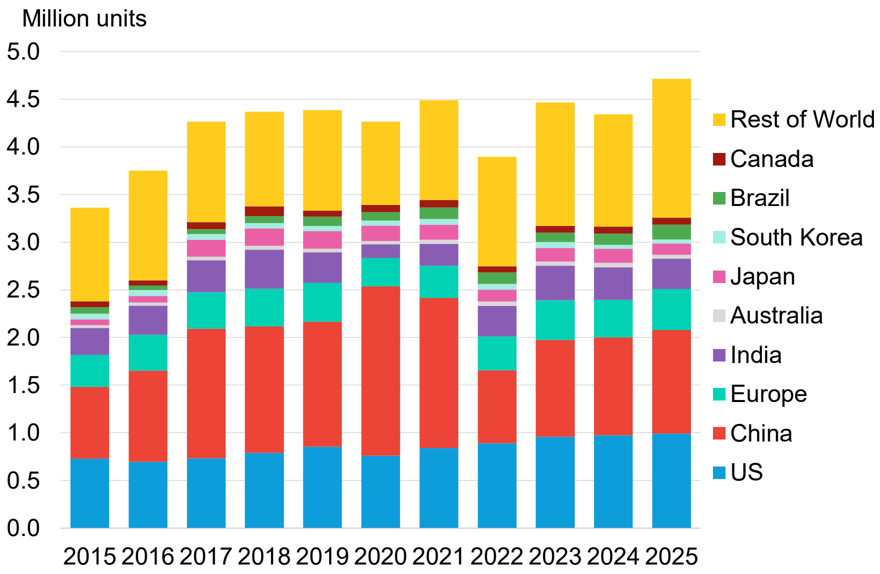
Global heavy commercial vehicle sales have remained stable for several years

Global sales of commercial vehicles by region



Source: BloombergNEF; see full list of sources in the Appendix. Note: Figures for 2025 are BNEF estimates. 'Europe' is the EU 27, the UK, Norway, Switzerland, Iceland and Liechtenstein.

Global medium- and heavy-duty truck sales were about 2.8% lower in 2024 at just under 4.4 million vehicles.

The Chinese market stabilised at about one million vehicles. Scrappage schemes and more efficient logistics continued to support fleet replacements and higher sales of more flexible tractors.

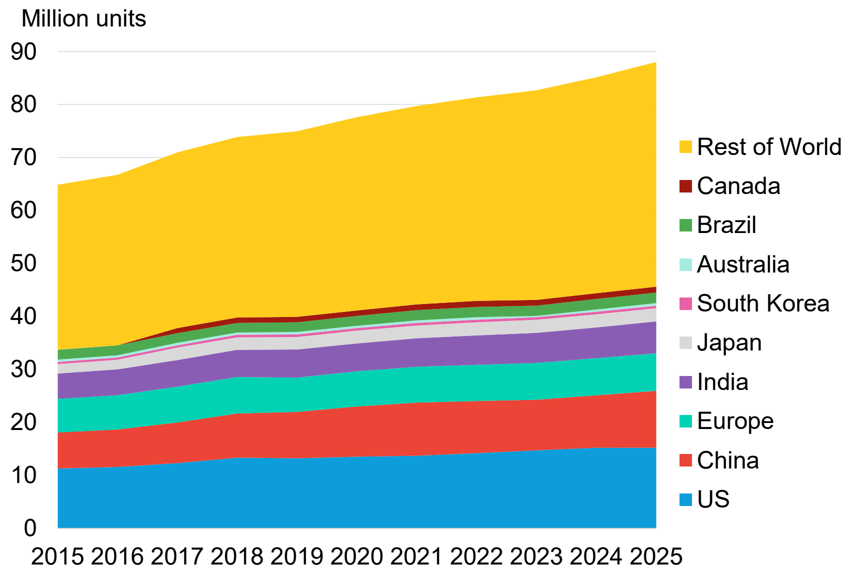
In the US, annual sales have been growing since 2020 with fleet purchases in anticipation of new emissions rules supporting recent sales. The US and Chinese markets combined account for about 45% of global sales, with Europe contributing another 9%. Sales in Europe were slightly above than the average of the last 10 years.

Most future sales growth will likely come from comparatively small markets in rapidly developing economies, such as India and Brazil. There, the truck market follows overall economic growth.

In this report, we account for medium- and heavy-duty commercial vehicles and exclude light-duty commercial vehicles, such as vans. The latter segment is about twice as large as that for all kinds of trucks combined. While vans and trucks share some similar technology options to reduce emissions, they also differ markedly in engineering, manufacturing, energy requirements and levels of customization.

The global commercial vehicle fleet continues to grow

Global fleet of commercial vehicles by region



Source: BloombergNEF; see full list of sources in the Appendix. Note: Figures for 2025 are BNEF estimates. 'Europe' is the EU 27, the UK, Norway, Switzerland, Iceland and Liechtenstein. Excludes light commercial vans.

More than 85 million medium- and heavy-duty trucks were on the road at the end of 2024 globally, growing in line with the global economy at about 3%.

About 40% of the global truck fleet runs on the roads of the US, China and Europe. The fleet of trucks in India is about the same as in Europe, despite large differences in economic output between them.

The global fleet size depends on the demand for goods movement, which fell by 2.8% in 2024. Long-term expectations of demand growth shift towards developing and emerging economies, where heavier trucks become more common as logistics infrastructure continues to improve.

Such growth patterns are affecting the adoption of cleaner propulsion technologies for commercial vehicles. In countries with more modest sales and fleet growth, such as the US and some European markets, new powertrains enter the mix by replacing existing vehicles.

In contrast, in many countries that are set to experience the strongest demand, especially for heavier vehicles, new trucks are also used to satisfy additional demand for goods movement and services.

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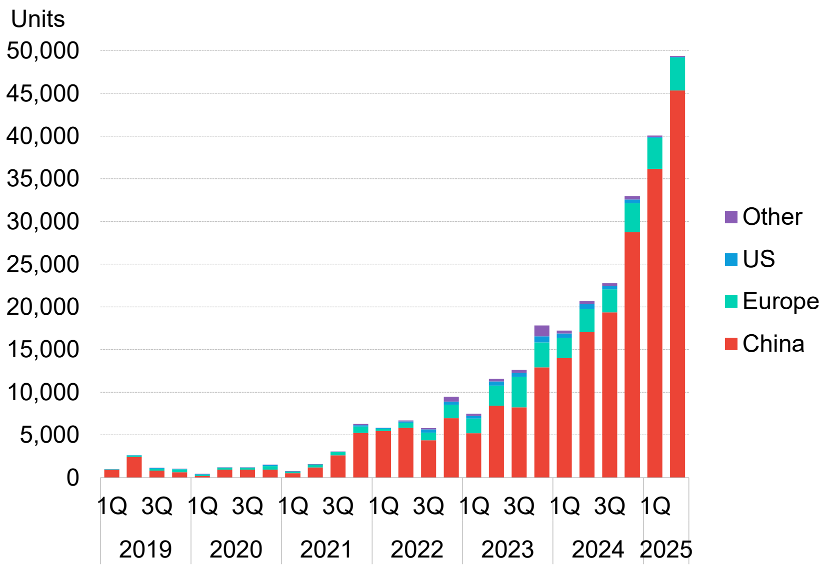
Clean truck uptake diverges with China leading and US falling further behind

Global sales of zero-emission medium- and heavy-duty trucks by region



Source: BloombergNEF; see full list of sources in the Appendix. Note: Europe is the EU 27, the UK, Norway, Switzerland, Iceland and Liechtenstein.

The global market for low- and zero-emission trucks has been steadily growing over the last three years. In 1H 2025 it was more than eight times larger than in the same period of 2022.

China is the largest market for battery and hydrogen trucks, accounting for more than nine out of 10 such vehicles sold globally in 1H 2025. The country's recent electric truck sales have been further boosted by scrappage subsidies since mid-2024. Domestic manufacturers including SANY, XCMG and others dominate the market with advanced products benefiting from the country's mature battery supply chain.

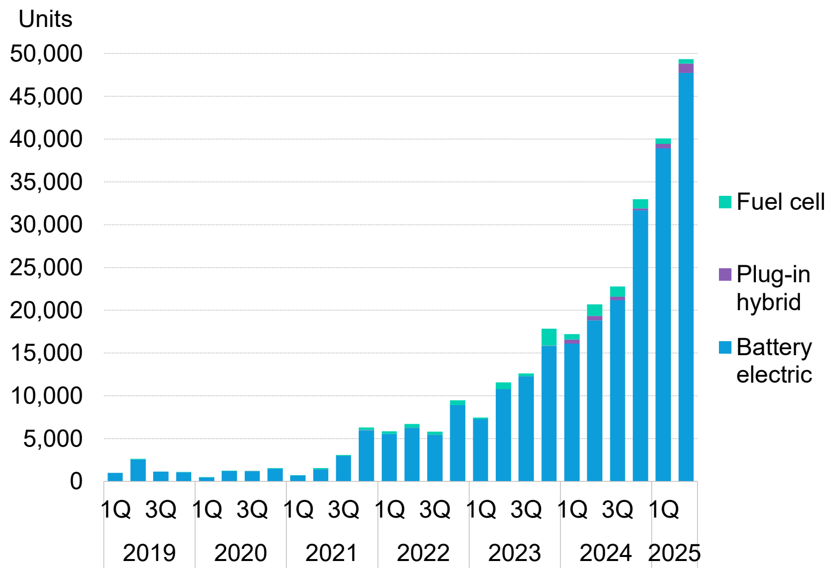
Sales in Europe continue to grow in 2025, as truckmakers phase in zero-emission models ahead of tightening emissions standards. Incumbent manufacturers like Volvo dominate the market in the region.

The US market for zero-emission trucks is slowing, with only 200 units sold in 1H 2025. The exit of startups like Nikola and the reversal of incentives by the Trump administration have contributed to the decline.

In other countries, electric trucks remain a niche market, with just a few dozen units sold in Japan, India, Canada and Australia. Chinese e-truck makers are already looking to global markets in Southeast Asia and Latin America to export their battery-powered trucks.

Batteries continue to dominate commercial EV sales as fuel cells retreat

Global sales of zero-emission medium- and heavy-duty trucks by fuel



Source: BloombergNEF; see full list of sources in the Appendix.

Fully electric vehicles (battery-electric vehicles, or BEVs) account for most clean truck sales globally. Mature battery supply chains and falling battery costs have made batteries the technology of choice for zero-emission trucks.

Batteries can easily meet the range requirements of urban routes, but long-haul trucking remains the next frontier. Over the past year, more Chinese battery makers have introduced new products for trucks, and fierce competition is driving improvements in battery energy density and vehicle range, although average e-truck range is still below 300 km.

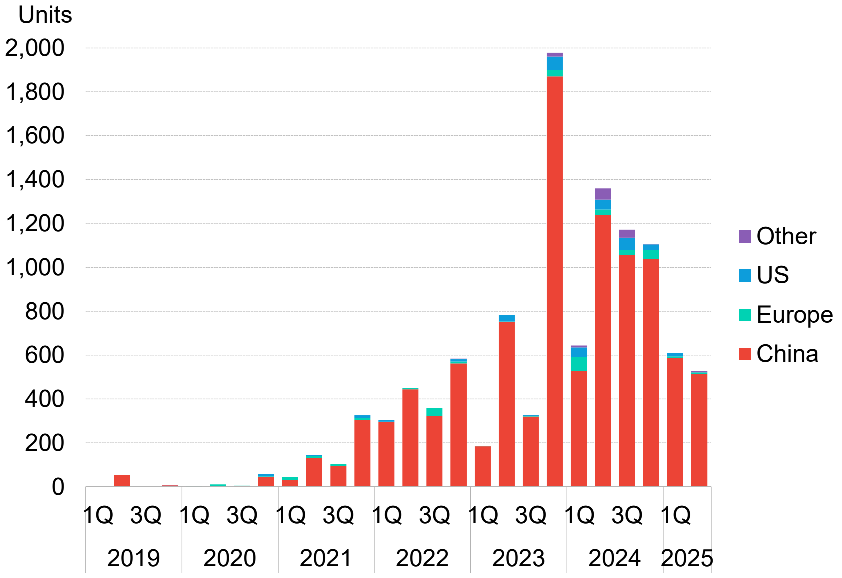
Plug-in hybrid truck sales are limited and only a small number of models are available. Still, PHEV sales exceeded fuel cell truck sales for the first time in the 2Q 2025, at over 1,000 units sold. This is largely driven by rising plug-in hybrid medium-duty truck sales in China.

In contrast, fuel cell truck sales in the first half of 2025 were only at around 1,000 units, half of the volumes sold in the same period last year. High vehicle and refueling costs remain barriers to adoption.

As battery technology becomes more advanced, BEVs with improved ranges are set to eat into the addressable market of fuel cell trucks, further diminishing the latter’s appeal.

Fuel-cell truck sales continue to slide

Global sales of fuel cell medium- and heavy-duty trucks



Source: BloombergNEF; see full list of sources in the Appendix. Europe is the EU 27, the UK, Norway, Switzerland, Iceland and Liechtenstein.

Global fuel cell truck sales plummeted in the first half of 2025. China made up most of the sales but the volumes are dropping as batteries are cheaper for road transport applications. While fuel cell trucks continue to enjoy perks like road toll exemptions in some parts of the country, these are unlikely to completely offset the high vehicle and refueling costs.

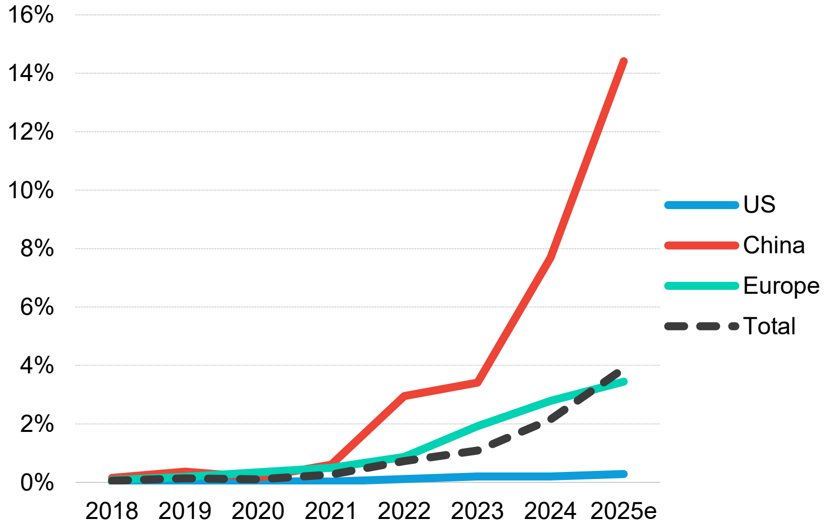
In North America and Europe, the collapse of fuel cell truck startups like Nikola and Hyzon has dampened the market. Legacy manufacturers are postponing fuel cell plans. For example, Daimler is delaying the commercial rollout of its liquid hydrogen truck from 2027 to the 2030s, due to the lack of refueling infrastructure and what it says are volatile overall market conditions.

While established truckmakers like Volvo and DAF are also trialing hydrogen combustion engine trucks, the technology is not commercially ready and faces similar refueling constraints as hydrogen fuel cell vehicles.

The prospects for hydrogen in road transport look dim. Cost for both the vehicles and fuel remain high, infrastructure is challenging, and government subsidies cannot last forever.

Adoption rates differ widely between countries, with China and the Nordics far ahead of the rest

Sales share of zero-emission medium- and heavy-duty trucks by region



Source: BloombergNEF; see full list of sources in the Appendix. Note: Adoption rate in 2025 is between January and June. Includes battery-electric, fuel-cell and plug-in hybrid medium- and heavy-duty trucks.

Electric trucks are approaching 4% of total sales globally in 2025, mostly on the back of rapid growth in China. Regional adoption patterns continue to differ widely.

Close to 80,000 e-trucks were sold in China in 1H 2025, already more than in all of 2024 and more than twice as many as in 2023. Continuous innovations in batteries and vehicles, as well as expanding charging infrastructure for trucks, have been supporting the market.

In Europe, a handful of countries are already at similar adoption rates as China. Still, overall volumes remain far lower, while battery supply chain challenges in the continent have kept some major manufacturers from expanding production.

In 1H 2025, zero-emission truck adoption in the US was about a 10th as high as in 2024, as a result of supply chain constraints, regulatory uncertainties and a lack of demand.

Outside of these markets, sales remain volatile and relatively low. Still, the e-truck market seems to be the entry point for Chinese manufacturers in several developing economies. Truckmakers from the country have been introducing various types of e-trucks as well as e-buses in several countries in Latin America, Southeast Asia and Africa.

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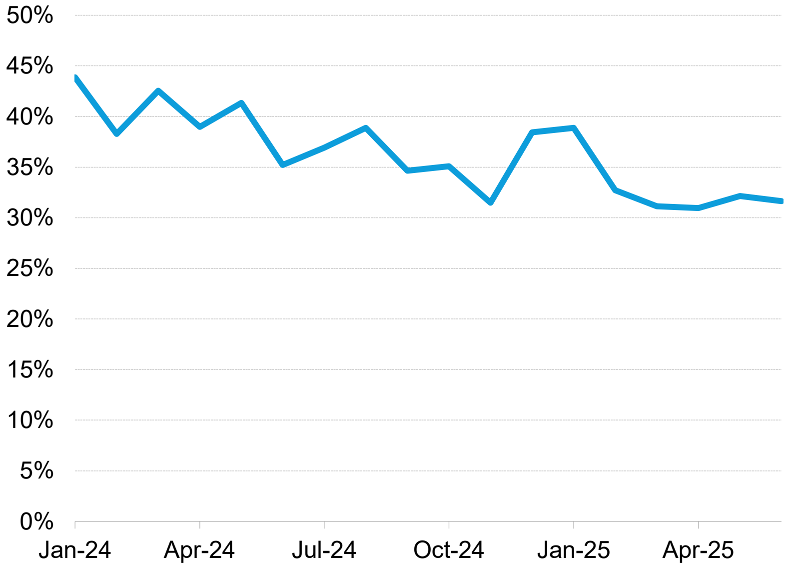
A pragmatic approach to zero-emission trucks has supported sales in China

Share of battery-swappable heavy-duty trucks within total battery electric truck sales in China



Source: BloombergNEF, cnworld.cn. Note: Not all trucks capable of battery swapping are using this capability and may be charging normally

Battery swapping continues to be part of China's electric truck growth story, even though its relative importance is declining. Truckmakers pursing battery swapping include CAMC, Foton, XCMG and others. The share of battery-swappable trucks in e-truck sales peaked in 2022 at almost 55%. Since then, such sales grew slower than the total market for battery trucks. It is a trend that has accelerated since 2024. In 1H 2025, about a third of battery trucks sold had swappable batteries.

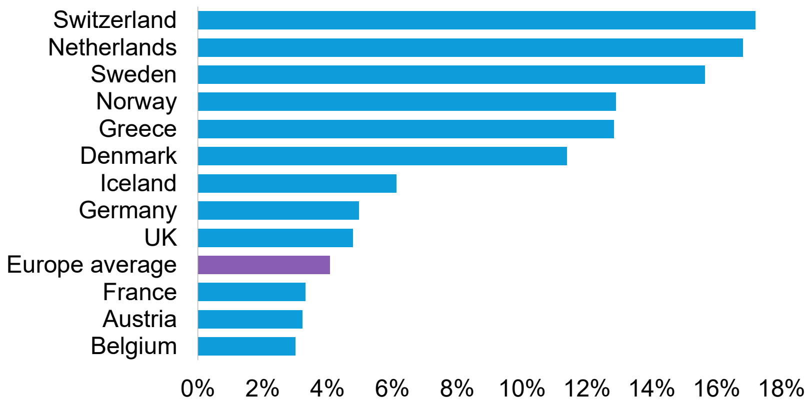
Still, absolute sales of these e-trucks continue to increase, as the market in 1H 2025 alone was more than twice as large as in 2023.

Battery swapping has several benefits for manufacturers and operators. Such e-trucks require smaller batteries, thereby reducing their upfront costs and helping smaller fleets adopt the technology. Battery swapping station developers and aggregators can provide rental services and take on residual value risk, while such battery banks can help stabilize the grid. Disadvantages include the high costs for the swap stations and the need for battery standardization across competing manufacturers.

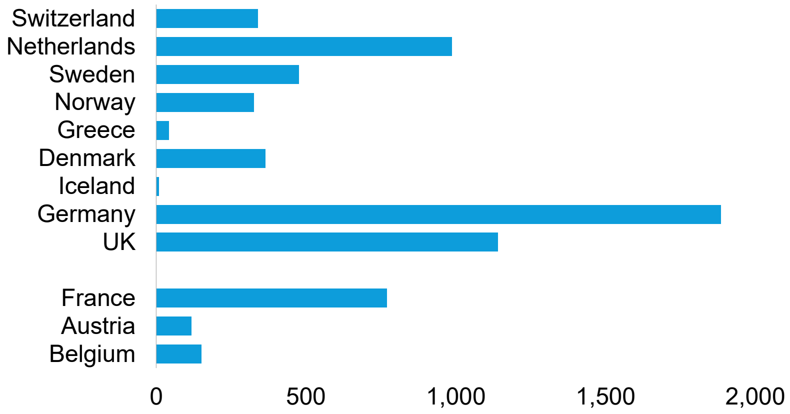
Outside of China, there are related activities in India. For example, SUN Mobility operates swap stations for different types of vehicles, including vans and trucks, and plans to expand in the country and abroad. In Japan, Mitsubishi Fuso and delivery company Yamato are trialing a version of the manufacturer's eCanter model with swappable batteries.

E-truck sales grow steadily in Europe, with a few markets jumping ahead

Zero-emission truck share of sales, 1H 2025



Zero-emission truck sales, 1H 2025



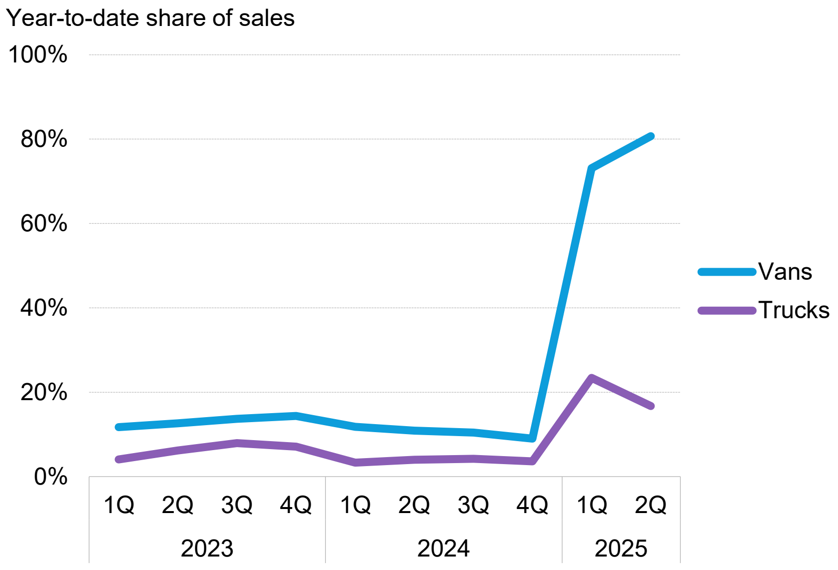
Source: BloombergNEF; see full list of sources in the Appendix. Note: Includes medium- and heavy-duty trucks. includes some plug-in hybrid vehicles.

European e-truck sales increased more than 50% year-on-year in 1H 2025, with growth accelerating in some large trucking markets such as the UK and France. In others, including Germany and Poland, sales were slightly lower than in 2024. Smaller markets, such as Belgium, Greece and Portugal, saw their e-truck markets grow rapidly, albeit from relatively low levels. Adoption rates of medium- and heavy-duty electric trucks exceeded 10% in 1H 2025 in six countries, compared to just one – Norway – in the same period in 2024. Still, e-truck sales remain less than 1% of the market in about a third of European countries.

Buyers are still mostly early adopters and companies with green obligations or those operating in countries with stricter policies than those at the EU-level alone. Duty cycles in urban distribution, municipal services and construction remain the main use cases for electric trucks.

Netherlands leads electric van uptake with policy support

Zero-emission registration share by segment in the Netherlands



Source: BloombergNEF, European Automobile Manufacturers Association.
Note: Includes some plug-in hybrid vehicles.

Electric van purchases skyrocketed in the Netherlands to reach more than 80% of total new registrations in the first half of 2025, the highest globally. By comparison, uptake of electric LCVs across Europe on average is only 10%.

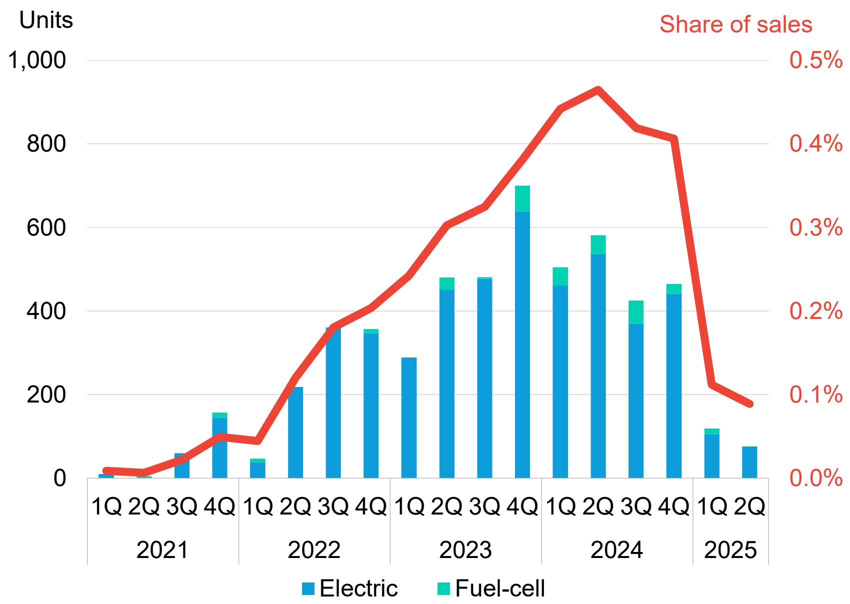
New zero-emission zones in Dutch cities are a big driver of electric commercial vehicle sales. Starting this year, municipalities were authorized to designate areas where no vans and trucks with tailpipe emissions are allowed. As of August 2025, 18 Dutch cities including Amsterdam, the Hague, and Eindhoven have already implemented zero-emission zones, with another 11 in planning.

While the government set a transitional period to exempt certain Euro 5 and 6 vehicles from zero-emission zone rules until 2030, the lifetime of new van and trucks will most likely exceed that timeframe, which incentivizes fleet owners to transition to EVs.

Netherlands also has the highest number of commercial vehicle chargers in Europe, at 177,040 public, semi-public, and private connectors as of mid-2025, according to Ecomovement. Companies such as Vattenfall, Equans and Allego lead in installed connectors, among more than 250 van and truck charge point operators, while public funding continues to flow to the sector.

The e-truck market in the US is in a state of limbo

Zero-emission truck sales and share of sales in the US



Source: BloombergNEF; see full list of sources in the Appendix. Note: Includes some plug-in hybrid vehicles.

Sales of electric trucks in the US plummeted in 1H 2025 amid policy changes. Fewer than 200 e-trucks were sold in 1H 2025, down by about 80% compared to the same period in 2024.

Some of the most consequential drivers of adoption are being threatened or eliminated. The federal CO2 emissions targets for medium- and heavy-duty trucks are effectively being relaxed following the Environmental Protection Agency's sweeping deregulatory activities. California lost its ability, awarded through an EPA-granted waiver, to set sales quotas. The state also halted the waiver application for a similar program directed to fleet purchases of such vehicles.

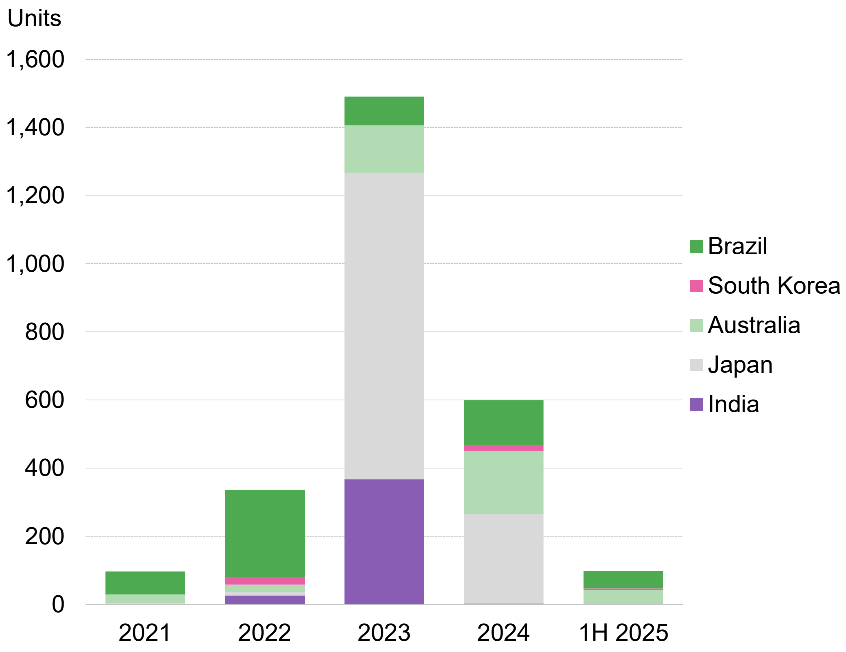
The domestic supply chain for truck batteries is in its infancy. Cell manufacturing plants are now being built and truckmakers currently import batteries from South Korea and elsewhere.

Despite the gloom, state-level programs and corporate activities point to latent demand for electric trucks. Purchase vouchers remain available in California, New York and other states. Programs to send demand signals and aggregate freight work with e-trucks are also established.

Also, truck charging stations continue to be built. Developers are raising funds and aim to establish large truck stops along busy freight corridors.

Electric truck sales are low in other countries, with pockets of high activity

Zero-emission truck sales in selected countries



Source: BloombergNEF; see full list of sources in the Appendix.

Zero-emission trucks have also been sold in Japan, India, Australia, Brazil and countries in Southeast Asia. The market remains small, even though manufacturers, fleets and charging providers are becoming more active in some countries.

In India, local manufacturers such as Tata Motors, Ashok Leyland and Eka Mobility have launched medium- and heavy-duty battery trucks recently, as the government aims to support the purchase of more than 5,500 such vehicles. Port operators and industrial companies have placed orders and had vehicles delivered in recent months.

Latin America has been the top export destination for Chinese electric and hybrid goods vehicles in 2024. Manufacturers JAC and Windrose have been making deliveries or announced orders in Mexico and Chile for light- and heavy-duty e-trucks, while Foton and Volvo will supply e-trucks to Maersk and Chilean cargo operator Sotraser.

In Brazil, companies such as JAC, BYD, XCMG, Mercedes-Benz and Volvo have delivered a few dozen battery trucks in 2025. Buyers include distribution and logistics companies, and municipalities. In the country, the main freight corridor connecting Sao Paulo and Rio de Janeiro is also gradually being electrified, with chargers installed, trials using e-trucks expanding and ambitious new programs developed.

Policies

More charging infrastructure, but policy uncertainty ahead

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Ambitious CO2 emissions targets for trucks are in place in major markets

CO2 emissions targets and zero-emission truck sales/fleet mandates

Country or Region and Period	Target by the end year of the period shown	Regulatory developments and outlook
EU, 2019-2035	65% lower tailpipe CO2	In place, but similar car, van targets were relaxed in 1Q 2025
• US, 2027-2032 • California, 2024-2035	• 15-53% lower tailpipe CO2 • 55-75% ZEV sales share for manufacturers • 100% ZEV purchase share for certain fleets	• EPA set to rewrite federal regulation • California shelved the fleet target and lost its waiver for the sales mandate
China, 2019-2025	11-18% lower fuel consumption	In place
Japan, 2015-2025	3-15% lower fuel consumption	In place

Source: BloombergNEF. Note: ranges refer to changes across commercial vehicle sub-segments; several of these targets extend beyond the years shown; California's Advanced Clean Fleets regulation hasn't yet received a waiver from the US Environmental Protection Agency and applies to certain fleets in the state.

Environmental regulations for trucks are some of the most effective policy tools to support the early stages of the zero-emission market. In some large truck markets, targets require average efficiency improvements from 0.3% to over 6% annually, and even as high as 14% for some vehicle types.

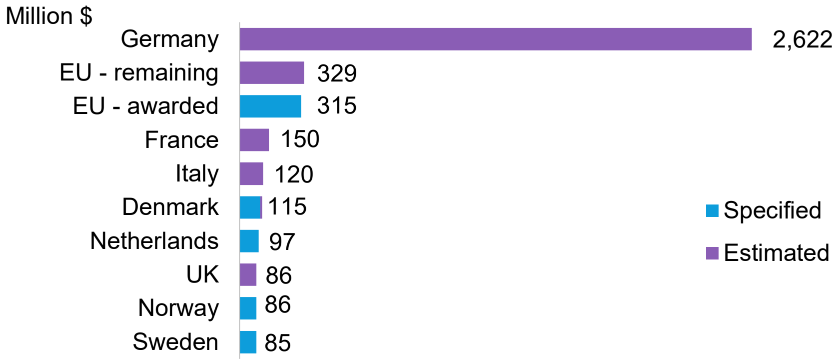
In Europe, CO2 emissions targets came into effect in 2025. While these standards remain in place, the European Commission buckled under pressure earlier this year and relaxed the compliance requirements of the targets for cars and vans. Any changes in the truck standards will negatively impact the industry's e-truck activities. In the US, expected regulatory changes are likely to water-down their efficacy.

In their current form, emissions targets in Europe and the US are set to lead to high levels of electrification, despite advancements in combustion engines, aerodynamics and materials.

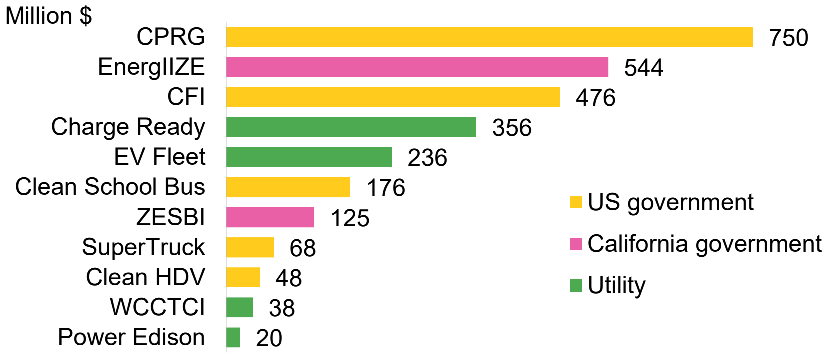
Outside of the California mandates, no major trucking market has sales or purchase quotas.

Government funding for truck charging is on the rise across the US and Europe

Estimated government funding for commercial vehicle charging programs in Europe, by market



Funding for charging infrastructure roll-out in the US from selected programs

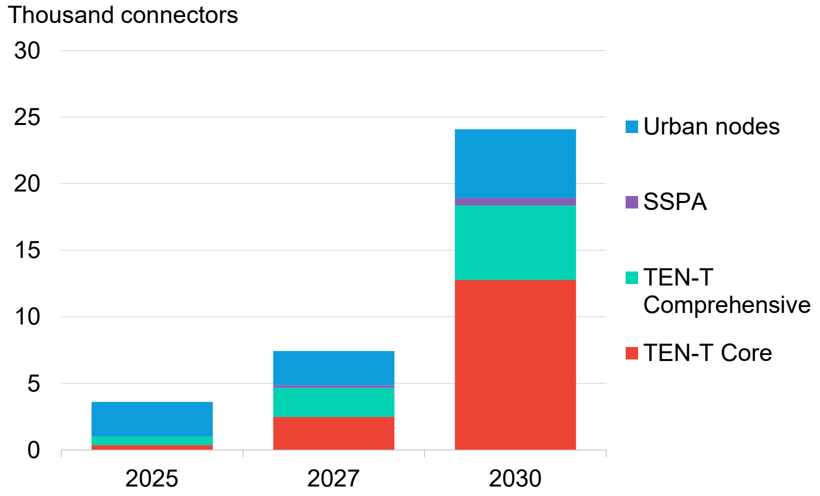


Source: BloombergNEF, Eco-Movement, US Environmental Protection Agency (EPA), California Clean Energy Commission (CEC), program websites, Federal Highway Administration, company press releases. Note: The data includes company targets, project announcements and grant funding awards. Some installations are estimated based on announced data. The list is not conclusive. Clean HDV is the Clean Heavy-Duty Vehicles Program, GGRF is the Greenhouse Gas Reduction Fund, ZESBI is the Zero-Emissions School Bus and Infrastructure Program, CPRG is the Climate Pollution Reduction Grant Program, CFI is the Charging and Fueling Infrastructure Discretionary Grant Program, WCCTCI is the West Coast Clean Transit Corridor Coalition Initiative.

In **Europe**, about $4 billion in government funding is set to go into commercial vehicle chargers. Key funding schemes are the Alternative Fuels Infrastructure Facility and a $2 billion program in Germany to install over 1,800 megawatt-scale chargers. It puts Germany as a global leader in the space. In **North America**, more than $3 billion in government and utility incentives for van and truck charger deployments are being set aside with the most funding focused in California.

EU shows the way with targets for infrastructure deployment

Estimate of public high-power chargers needed to meet the distance-based target for trucks along the EU TEN-T



Source: BloombergNEF, European Commission. Note: TEN-T network Core length: 49,700 km, Comprehensive: 87,000 km, Urban nodes: 431. SSPA stands for safe and secure parking areas. The BNEF charge point calculations assume 350 kW connectors along the TEN-T road network and 150kW connectors for urban nodes.

One of the European Commission's key policies is the Alternative Fuels Infrastructure Regulation(AFIR), which includes public charging deployment targets for heavy-duty vehicles. No other region has such a set of targets.

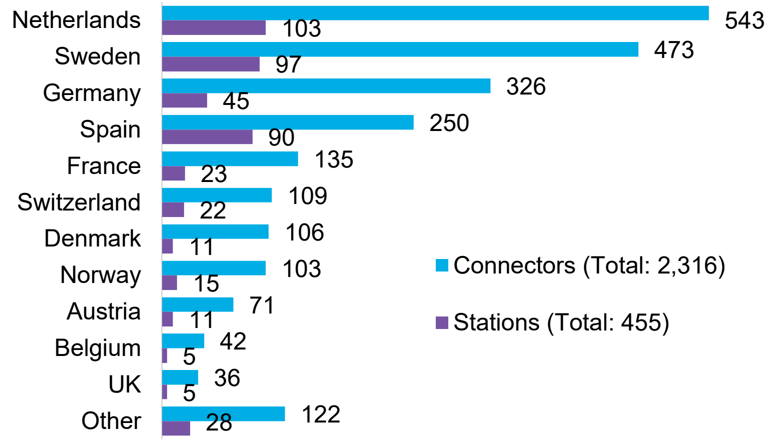
Those rules dictate the size of dedicated charging stations for commercial vehicles across key road networks and urban transport hubs. The targets start in 2025 and get progressively stricter with increased targets for the total power of stations and the individual chargers within them.

AFIR is a driving force for activity across Europe's member states and is supported by the Alternative Fuels Infrastructure Facility (AFIF), which is a multi-billion-euro funding program. The most recent awards have moved more heavily towards funding commercial vehicle charging as the passenger vehicle charging ecosystem is deemed to be largely up and running in Europe.

BloombergNEF calculated the number of commercial vehicle chargers required to fulfil the EU's mandates and found that the regulated number of chargers was slightly higher than BNEF's outlook, which includes 16,900 truck chargers in public and 149,900 in depots by the same date. This suggests the legislation will help to push more infrastructure into the ground to facilitate greater truck adoption.

More commercial vehicle chargers, backed by policy and business

Number of public commercial vehicle charger stations in Europe by country



Types of commercial vehicle charging companies by category

Truck makers	Real estate	Transportation and logistics	Fleet operators
DAIMLER TRUCK	PROLOGIS	DHL	amazon
VOLVO	CBRE	DB SCHENKER	PEPSI
Utilities	**Fuel retailers**	**Developers**	**Charge Point Operators**
Southern California EDISON, An EDISON INTERNATIONAL Company	Pilot. FLYING J	WattEV	EVgo
PG&E	CIRCLE K	Terawatt	electrify america

Source: BloombergNEF, Ecomovement, company websites. Note: Some stations serve both passenger and commercial vehicles.

The installation of charging infrastructure at depots and in public locations is a pre-requisite for adoption of electric trucks. At depots, fleet operators have more control to install their own infrastructure but public stations are needed for those without depots and who do long-haul travel.

Policy makers are supporting with subsidies and targets for infrastructure roll-out and businesses from a variety of sectors are beginning to be active in deploying chargers. For example, in Poland more than $550 million is available until 2029 for truck charging stations, while the Indian government plans to support the installation of 1,800 chargers for trucks and buses as part of the PM-E DRIVE scheme.

Manufacturers

Truckmakers slow down e-truck development in the face of challenges

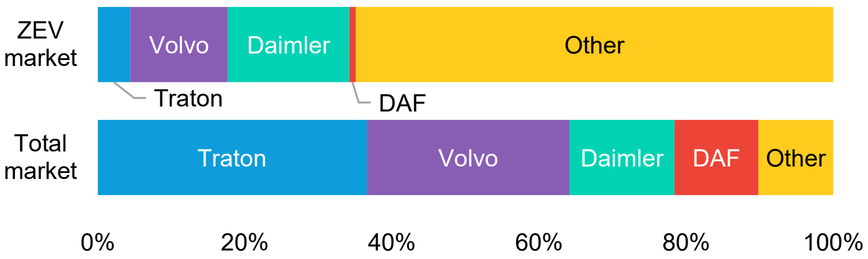
Smart Freight Centre

BloombergNEF

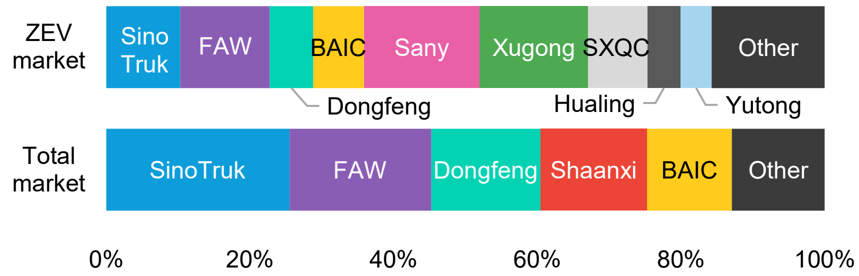
Manufacturers

The zero-emission truck market creates opportunities for new entrants

Manufacturer market shares in Europe



Manufacturer market shares in China



Source: BloombergNEF; see full list of sources in the Appendix. Note: Shows shares of medium- and heavy-duty trucks (defined in the Appendix) in 2H 2024-1H 2025. 'ZEV' is zero-emission vehicle and includes battery electrics and fuel cells.

The zero-emission truck market continues to attract new entrants. These include established truckmakers finding opportunities in new segments and newcomers from adjacent industries entering the commercial vehicle market.

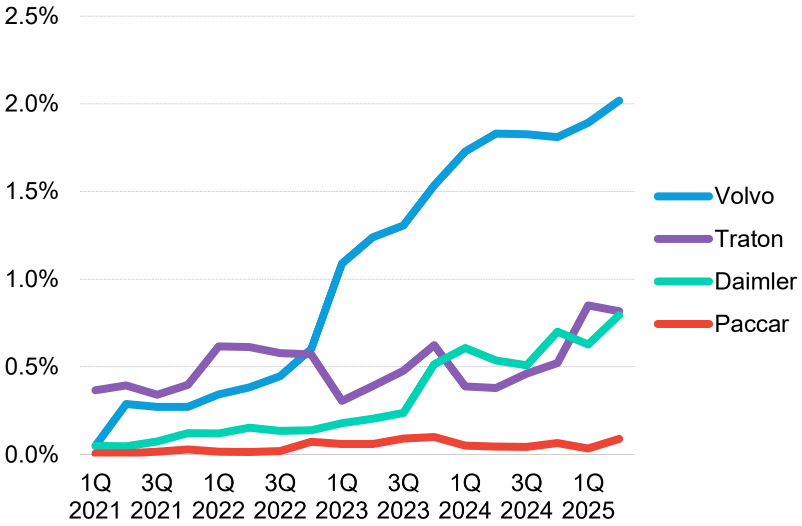
In Europe, manufacturers of large e-vans as well as a few retrofitters and some smaller companies account for a large part of the market.

In China, companies outside of traditional truckmaking continue to command high shares of the e-truck market. Incumbent truckmakers that account for almost 88% of the domestic market have captured just over a third of the market for electric trucks. Companies such as machinery manufacturers XCMG and Sany, and busmaker Yutong captured close to half the e-truck market in 1H 2025.

Startup manufacturers have stumbled, with some holdouts. Companies such as Nikola, Proterra, Arrival and Tevva went bankrupt in the last 18-24 months. Some of their assets, such as Proterra's and Nikola's were acquired by other truckmakers. At the same time, manufacturers including REE, Workhorse and Bollinger, have restructured through mergers, workforce reductions and other measures. XoS continues to deliver vehicles, while newcomer Harbinger has raised capital and announced orders for close to 5,000 vehicles.

ZEV sales remain low for many large truckmakers as they readjust plans

Zero-emission vehicle sales shares for Volvo, Daimler, Traton and Paccar



Source: Bloomberg Terminal, BloombergNEF, company reports. Note: Shows cumulative share of sales within a year. Includes medium- and heavy-duty trucks and buses.

Large truckmakers have set ambitious targets for zero-emission truck sales, but in the face of volatile adoption and immature supply chains outside of China, they are behind their anticipated sales levels.

Volvo sold roughly the same number of all-electric vehicles in 1H 2025 globally as in the same period in 2024. Daimler and Traton increased e-truck and e-bus sales but are still significantly behind Volvo.

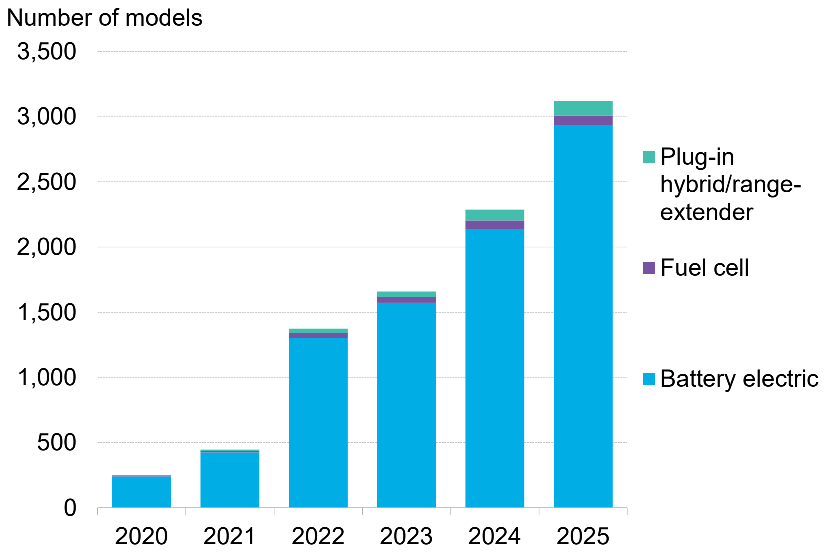
All three companies – which together account for around a quarter of global truck sales – have faced challenges in expanding e-truck sales. Traton's battery supplier, Northvolt, went bankrupt, which prompted the truckmaker to acquire some of the cell manufacturer's assets.

Volvo and Daimler have also adjusted the timing of their plans. Volvo pushed back the start of construction of its European cell manufacturing plant by up to two years, while Daimler re-calibrated its target for e-truck sales in Europe to 40% by 2030, from "up to 60%" previously.

Scaling up manufacturing capacity, especially in batteries and electric drivetrains, is a vital step as companies need to establish the supply chain necessary for higher sales in the years ahead. Such expansion of the technology portfolio requires high investment and remains challenging.

More than 3,000 commercial ZEV models are available in major markets

Zero-emission commercial vehicle models available



Source: BloombergNEF, company announcements, Calstart, 360che.com. Note: PHEV/REX are zero-emission vehicles for part of their operation, when relying on battery power alone. Includes light-, medium- and heavy-duty truck models.

Availability of zero-emission truck models is steadily increasing. More than 3,000 battery and fuel cell vans and trucks are now available from manufacturers in China, Europe and the US.

About two thirds of these models are light-duty commercial vehicles, such as delivery vans. More than 800 medium- and heavy-duty trucks are also available.

Batteries are the most common choice for such vehicles. The average zero-emission range of battery-electric models is 281 kilometers and has increased by about 8% since 2023. These trucks have the potential to take on regional and long-haul operations. Notably, the number of plug-in hybrid and range-extender models has quadrupled in the last couple of years, with most of these powertrains concentrated in the light-duty segment.

China has the highest selection of e-van and e-truck options, with almost 80% of globally available models offered in the country. European manufacturers are expanding product offerings to prepare for tightening CO2 rules, while the US market has stagnated as federal incentives and regulatory pressure drop.

Technology and economics

Better, cheaper batteries expand clean trucking opportunities

Smart Freight Centre   BloombergNEF

Battery trucks for heavy-duty, long-haul operations are already here

	Mercedes-Benz eActros 600	Volvo FH Aero Electric	Tesla Semi	MAN eTGX
GCW	44 metric tons	48 metric tons	37 metric tons	44 metric tons
Battery capacity	600 kWh	780 kWh	580* kWh	480 kWh
Range	500 km	600 km	480 km	500 km
Implied minimum fuel consumption	1.2 kWh/km	1.3 kWh/km	1.2 kWh/km	0.96 kWh/km
Series production	2024	2026	2025	2025
Availability	Europe	Europe	US	Europe

*Source: BloombergNEF, company press releases. Note: Range is “up to” and provided by the manufacturer; we have used the minimum specification for the range of vehicles on offer. Battery capacity refers to the highest available and to usable capacity when known, otherwise it is nominal. Availability refers to the regions in which the trucks are initially available for sale after launch. “GCW” refers to gross combination weight. *Calculated using reported range and efficiency.*

Battery electric trucks are now technically capable for operation in heavy-duty, long-haul duty cycles. While that was previously considered a restricted use case, manufacturers have already launched such vehicles. Buyers include logistics and consumer product companies, albeit at low volumes.

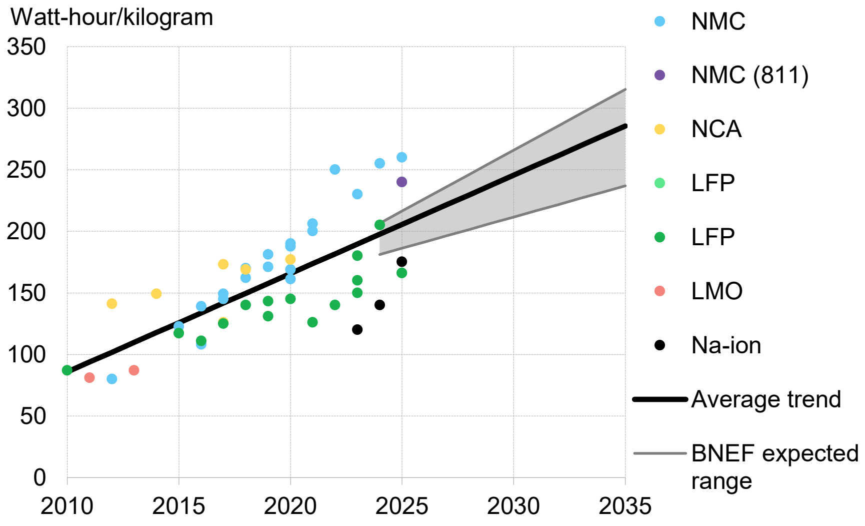
Those heavy-duty battery trucks employ a range of chemistries. Mercedes-Benz uses lithium-iron phosphate (LFP), MAN uses nickel manganese cobalt (NMC) and Volvo uses nickel cobalt aluminum (NCA) batteries. Tesla has not revealed the chemistry for the Semi, but the company produces both NMC and LFP variants.

The Mercedes-Benz, MAN and Volvo vehicles can also accept the megawatt charging standard (MCS), while Tesla has also developed a megawatt-level charging system.

The energy efficiency of these vehicles can be two to three times better than that of diesel equivalents, based on reported battery capacities.

Battery energy density improvements continue

Historical and estimated changes to battery-pack energy density



Source: BloombergNEF. Note: NMC = nickel manganese cobalt oxide; NMCA = nickel manganese cobalt aluminum oxide; NCA = nickel cobalt aluminum oxide; LFP = lithium iron phosphate; LMFP = lithium manganese iron phosphate; LMO = lithium manganese oxide; Na-ion = sodium ion.

The average battery pack energy density in battery-electric vehicles is set to exceed 200 watt-hours per kilogram in 2025, rising more than 4.5% compared to 2024.

Nickel manganese cobalt oxide (NMC) is the highest-performing battery chemistry group. Such batteries have energy densities exceeding 200 Wh/kg, with recent advancements accelerating the trend. For example, Svolt achieved 260Wh/kg in 2025, albeit targeting passenger car applications.

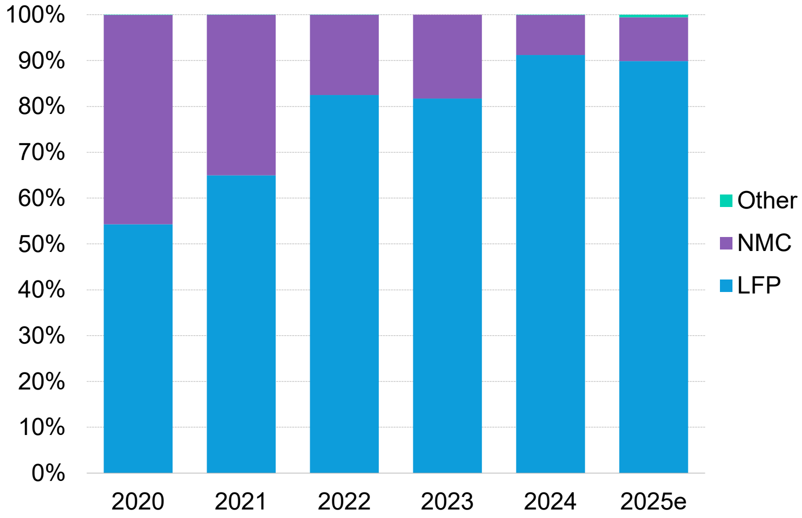
Lithium iron phosphate (LFP) technology, which is used in most e-trucks, also continues to progress. CATL has introduced a range of e-truck batteries with capacities between 600 and 1,000 kWh and expected efficiencies between 1.2-1.25 kWh per kilometer. These sit near the top range of reported values for heavy-duty battery trucks.

Batteries with higher energy density have lower material and manufacturing costs, are lower weight, and result in higher vehicle efficiency.

Smart Freight Centre BloombergNEF

LFP is the main choice for electric truck batteries

Battery chemistry of electric medium- and heavy-duty truck sales



Source: BloombergNEF, EV-Volumes. Note: 'LFP' is lithium iron phosphate; 'NMC' is nickel manganese cobalt oxide. Includes batteries used in vans, trucks and buses.

The lithium-ion batteries powering most commercial vehicles and buses use lithium iron phosphate (LFP) cathodes. Since 2022, LFP's share has grown rapidly, now accounting for almost 90% of capacity deployed in the sector globally.

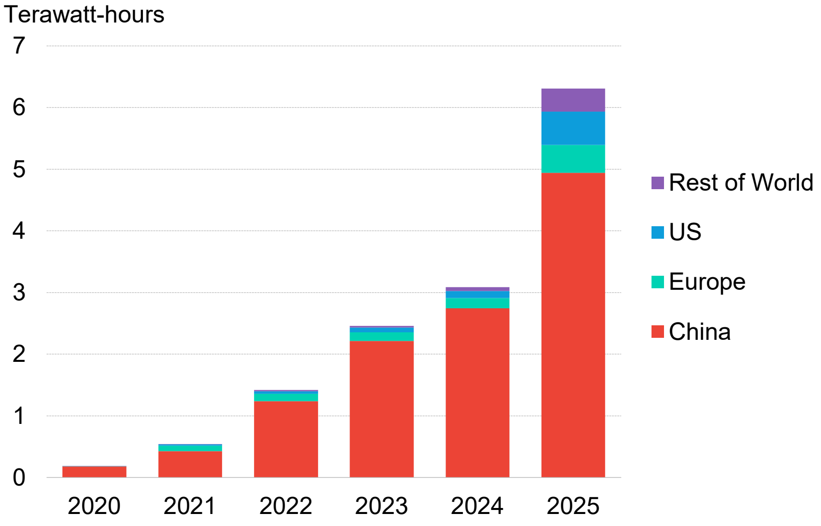
LFP's benefits include low cost, improved performance, good safety characteristics and high cycle life (meaning it can be charged and discharged more times). However, its energy density can be 30% lower than NMC.

Most e-trucks produced and sold in China use LFP batteries. Outside China, several truckmakers use a mix of chemistries, with LFP also gaining traction for their most recent vehicles.

- Paccar uses LFP in some of its latest models, and plans to produce such cells in the US in a joint venture with Cummins, Daimler and technology provider EVE Energy.
- Daimler is using LFP in its latest long-haul truck in Europe while it gets NMC cells from LG Chem and SK Group.
- Volvo is focusing on nickel cobalt aluminium oxide (NCA) cells supplied by Samsung SDI.
- Traton's brands Scania and MAN use NMC cells.

Battery manufacturing capacity keeps increasing globally

Commissioned and announced annual Li-ion battery cell manufacturing capacity



Source: BloombergNEF. Note: Shows as-reported capacity. Data up to 2024 includes fully commissioned capacity. Data for 2025 includes announced, under-construction and fully commissioned capacity, not de-risked. Data as of May 21, 2025.

Just over 3 terawatt-hours of annual lithium-ion battery manufacturing capacity is currently installed globally. By the end of 2025, manufacturers have announced plans to bring this up to more than 6 terawatt-hours of capacity, with most plants in China.

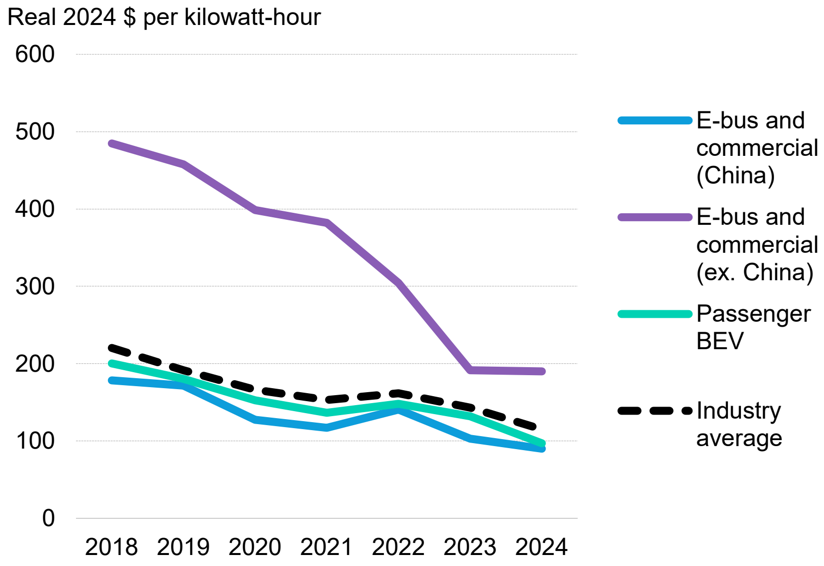
Battery manufacturers have often overestimated how quickly and how much of their planned battery cell manufacturing capacity will come online. Actual plants are often built smaller than originally announced, with long ramp-up times, varying by region and manufacturer experience. As a result, BNEF expects 3.8TWh of annual lithium-ion battery manufacturing capacity online globally by the end of 2025.

The volume of produced batteries can differ from commissioned nameplate capacity and will depend on plant utilization rates. These have been falling since 2022 and averaged 46% in China in 2024.

The upstream battery value chain, including components such as cathodes, anodes, separators and electrolytes, is also concentrated in China. Some 87% of the world's cathode processing capacity and 97% of anode capacity is in China. More companies like BASF, LG Chem, Umicore, Panasonic and Chinese firms like Gotion and Huayou Cobalt are making announcements for component plants in the US and Europe.

Battery prices continue to fall and are converging across sectors

Historical volume-weighted average lithium-ion battery pack prices by sector



Source: BloombergNEF. Note: Passenger battery-electric vehicle figures are a global average.

The volume-weighted industry-average battery pack price was $115 per kilowatt-hour in 2024, almost 20% less than the previous year. The drop is partly due to significant overcapacity, with battery manufacturers offering very low prices to maintain market share. Battery manufacturers have aggressively expanded production capacity in anticipation of surging demand, but EV sales have grown at a slower pace than some expected.

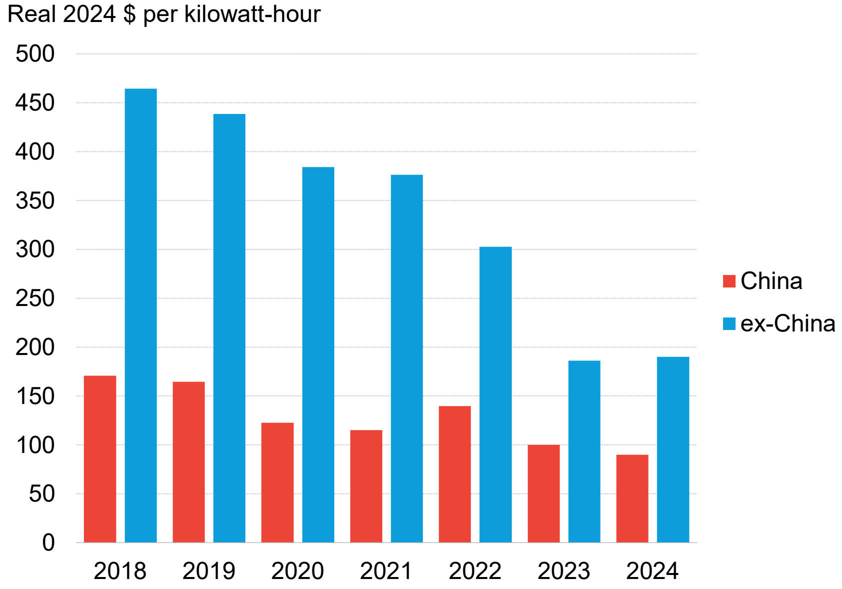
In addition to supply and demand dynamics, growing uptake of lower-cost lithium iron phosphate (LFP) batteries and their continued material cost decline pushed prices down.

The requirements for pack and cell design, and power output, vary by sector, which in turn affects pricing. In China, electric buses and commercial EVs had the lowest volume-weighted average pack price in 2024 at $90/kWh. They were followed by passenger battery-electric vehicles at $97/kWh, falling below the $100/kWh mark for the first time.

Prices have been converging across sectors as the industry grows, even though price declines for truck packs outside China stalled in 2024. Differences depend on maturity of the technology and order volumes, but also varied cell and pack design and manufacturing requirements across applications.

Truckmakers still pay more for their batteries outside China

Average lithium-ion battery pack prices for commercial vehicles and buses



Source: BloombergNEF 2024 battery price survey

Chinese companies have slashed the cost of truck and bus batteries far quicker than Western ones.

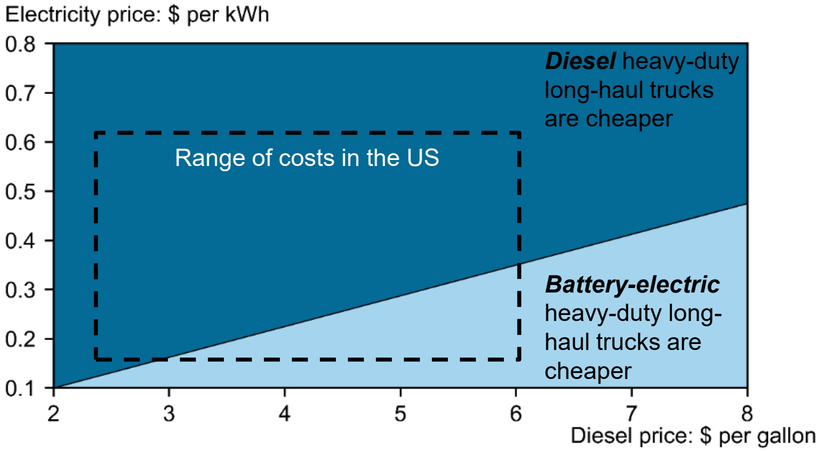
With China's domestic passenger EV market starting to saturate in some segments, the nation's manufacturers have turned to commercial EVs to absorb some of the excess production. That shift has raised the quality and quantity of batteries in that segment and delivered lower prices. The volume-weighted average bus and truck battery pack price fell 13% to $90/kWh in China in 2024. Prices from Western manufacturers held steady.

By contrast, Europe and the US have much less developed supply chains for electric trucks. Prices for e-truck batteries are more than twice as high as in China, at $190/kWh with challenges in scaling up. Supply chain constraints in Europe, and subsequent slowing growth, could partly explain the stagnant prices.

The US market for e-trucks is smaller than in Europe, and tiny compared to China's. One of the major projects for truck batteries in the country, the JV between Paccar, Daimler, Cummins and EVE, expects only to start producing cells later this decade.

Battery trucks can be competitive in long-haul operations, but controlling costs matters

Total cost of ownership ratio of battery electric to diesel heavy-duty long-haul trucks



Source: BloombergNEF. Note: Colors using the ratio of the total cost of ownership of battery electric over diesel heavy-duty trucks. A long-haul diesel truck costs $180,000 and a BEV with 500-mile (800-kilometer) range costs $250,000, assuming BNEF's 2030 estimated battery price of $80 per kWh. A diesel truck drives eight miles per gallon and a BEV drives 0.5 miles per kWh.

Long-haul operations account for about half of energy demand in trucking, with suitable zero-emission trucks already on offer. Two main contributors to the total cost of ownership (TCO) are vehicle and fuel costs, which vary widely across manufacturers and regions.

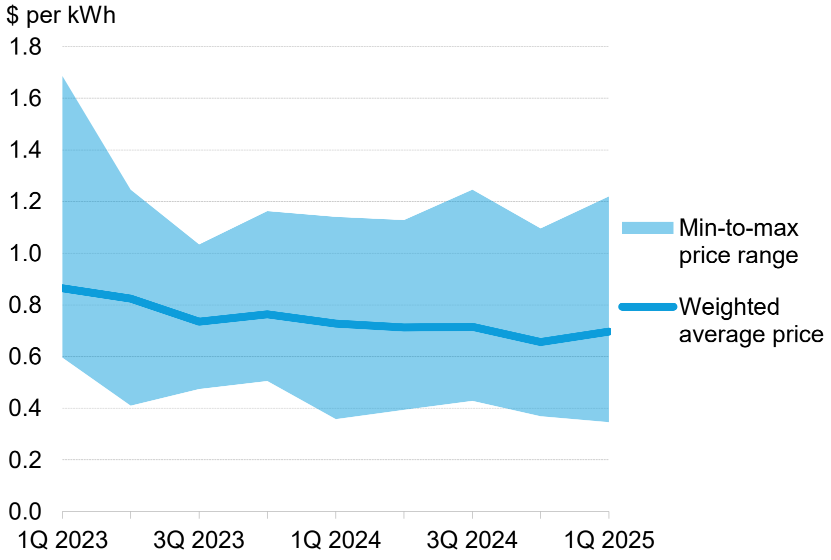
Reducing the capital costs for electric trucking is critical to make the technology competitive. Once these approach and drop below $300,000 for a 500-mile (800-kilometer) battery truck the economic benefits of e-trucks rise quickly.

With diesel fuel costs within their historical variation range in the US and Europe, long-haul e-trucks can be competitive at high annual utilization and at the higher end of diesel costs. Diesel prices have varied from $2.50 to $6 per gallon in the US from 2010 to 2025. In Europe, the range was roughly $5 to $10 per gallon.

When heavy-duty, long-haul e-truck prices fall toward $250,000, which we expect around 2030, electricity and diesel fuel costs begin to matter more. For high utilization, electricity prices should be around $0.2 per kilowatt-hour or less in the US, and lower than $0.35/kWh in Europe. These prices are within the range of electricity rates for industrial or commercial consumers, even though charging station operators have not always been able to realize them.

High public charging costs can make truck economics less attractive

Fast public charging costs for battery electric commercial vehicles in Europe



Source: BloombergNEF, EcoMovement. Note: Shows the average ad-hoc charging cost weighted by network size at 50 kW+ chargers that accept trucks heavier than 12 metric tons gross vehicle weight across 17 European countries.

The average cost to charge a battery electric truck at a fast public charger in Europe was $0.70 per kWh, as of 1Q 2025. This reflects the ad-hoc prices on offer, and significantly cheaper rates are available through subscriptions and fuel cards. Larger demand signals from the freight industry can also support the signing of power purchase agreements to secure more favorable prices.

Still, such rates are about three times higher than industrial and commercial tariffs. These averaged between $0.23 and $0.27 per kWh across EU countries, depending on the level of consumption.

Charging prices vary between markets. Rates in France and Sweden were $0.57 per kWh and $0.60 per kWh, respectively, likely driven by lower wholesale electricity costs. The gap to industrial rates can still be large. Such consumers in Sweden can pay as low as $0.11 per kWh.

The Netherlands was the most expensive public fast charging market assessed out of 17 European countries. Public charging prices averaged $0.81 per kWh, which is prohibitively high for regular use.

Outside of depot charging, public slow charging can provide a cheaper alternative, with prices averaging $0.51 per kWh across 10 European markets for which data was available.

Smart Freight Centre BloombergNEF

Risks throughout the electric truck and battery lifecycle

A spotlight on key operational uncertainties that hinder adoption, and emerging data to mitigate them

Electric truck and battery lifecycle

The large-scale adoption of electric trucks will rely on economics that undercut those of equivalent diesel vehicles. While the total cost of ownership of battery-powered commercial vehicles is declining, manufacturers, fleet owners and fuel providers face uncertainties in determining the precise TCO in various duty cycles.

This section presents the phases of the lifecycle of an electric truck and its battery, and identifies key operational uncertainties that hinder investment. It also presents emerging data, and points out data gaps, on parts of that lifecycle to help market participants start addressing such risks.

For several parts of the value chain, experience in the market around costs and performance is limited. Still, anecdotal information from fleet operators, financiers and service providers indicates that most of these risks are gradually being addressed. Some early data also reveal that some of these risks may not be as severe as originally thought by market participants.

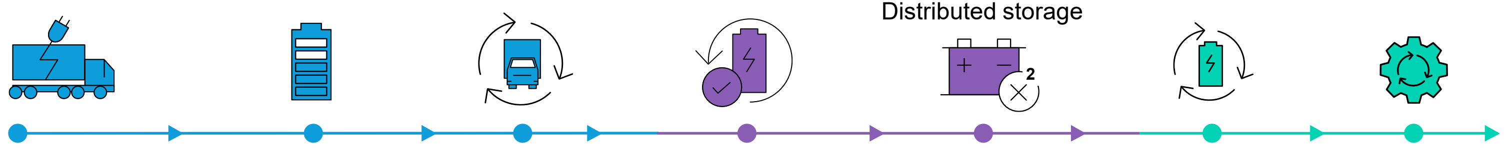
Activities such as demand aggregation are also on the rise and can help mitigate some risks. For example, programs in the US, India and Mexico plan to group buyers for electric trucks and associated transport work to increase scale and spread risks.

In addition, coordination across the value chain is an important lever to help reduce risks. For example, fleet owners and energy storage developers are largely unfamiliar with each other's operations and economics. Financial institutions that serve both industries or specialized companies can bridge that knowledge gap and capture some of the benefits of integrating all parts of the value chain.

Other aspects of the electric trucking ecosystem exist that are not readily captured by this value chain or a TCO calculation. The buildout of electric truck manufacturing capacity, the deployment of suitable charging infrastructure, the expansion of truck-specific battery cell manufacturing capacity, grid upgrades and other factors will also determine the viability of electric trucks in different regions and use cases.

Electric truck and battery lifecycle

Phases	Vehicle use			Repurposing		Recycling	
	Truck usage and charging	Battery degradation	Additional truck owners	Battery repackaging	Second life use Grid storage / Distributed storage	Cell recycling	Material reuse



Stakeholders

Vehicle use		Repurposing		Recycling
Charging station operator	Fleet and charging operator	Fleet and charging operator	Storage service provider	Storage service provider
Fleet operator	Truck and battery manufacturer	Truck and battery manufacturer	Charging station operator	Charging station operator

Key risks and uncertainties

Vehicle use: **Operational** and **asset-level** risks.

Lack of **real-world e-truck usage and charging data** prevent optimized vehicle deployment and **unknown battery degradation** creates uncertainties in depreciation rates and results in higher financing rates.

Repurposing: **Warranty and financing** risks, as well as **asset liabilities** for second-life battery users.

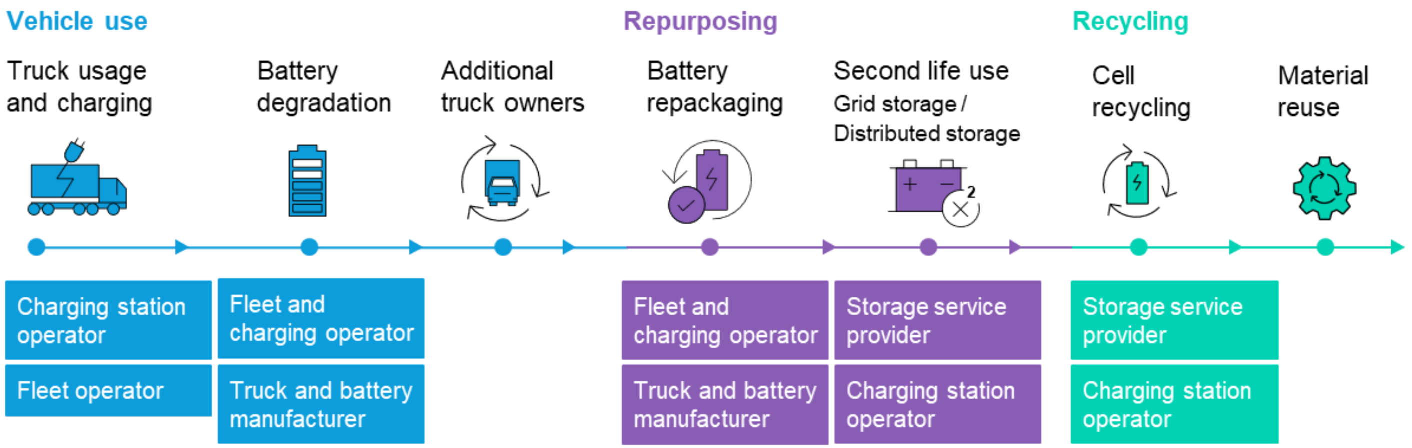
A variety of **safety regulations**, requirements to **store and transport** large volumes, and technology and engineering complications of used electric truck batteries.

Recycling: **Investment, financing** and **operational** risks.

Volatile material prices and **competition with second-life** applications, as well as diverse battery designs may result in high initial and operational costs.

Source: BloombergNEF

Electric truck and battery lifecycle



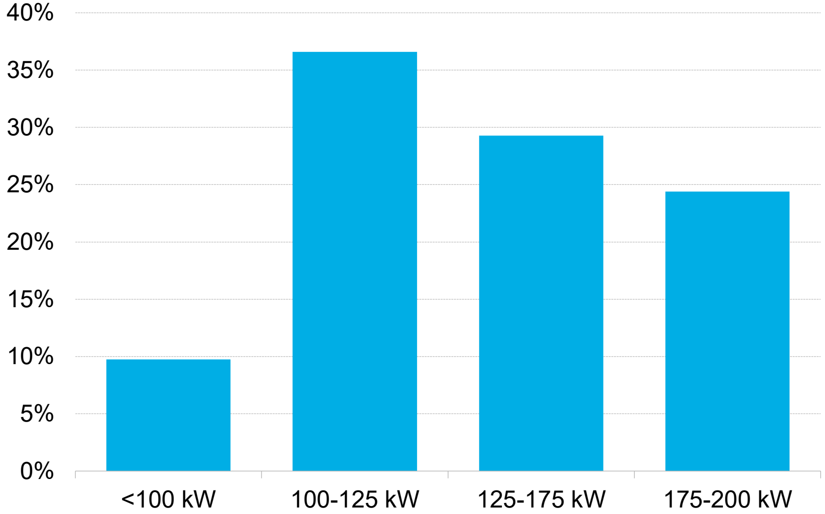
The value of trucks available in the market is well defined. Fleet owners and operators perform detailed calculations of revenue potential at every point throughout a vehicle's lifetime and compare that with the truck's total cost of ownership for its remaining life. Operational uncertainties remain, such as future fuel costs and demand for trucking services. These affect the risk of acquiring and owning the vehicle, and result in fluctuations in the resale value of used trucks.

Determining the resale value of electric trucks includes additional complications for fleet owners and financiers. For example, vehicle manufacturers do not provide warranties that extend beyond the vehicle use phase and limited, non-standard data make assessment of the battery's state of health challenging.

As the assets – the vehicle and its battery – move between owners and across use cases, uncertainties in the next phase of the value chain can result in higher cost of capital with companies reluctant to assume further liabilities.

Charging patterns show potential to limit operating risks and costs – 1/2

Charging speed per truck charging session



Source: BloombergNEF, Ampcontrol. Note: Charging speed was calculated by dividing energy consumption by session duration.

**The real-world data were provided by Ampcontrol and show usage of medium- and heavy-duty electric trucks at six commercial vehicle charging stations in Southern California, collected between May and November 2024.*

Fleet owners face **operational risks** in using electric trucks, and clearer, more extensive data on charging patterns can help them optimize truck deployment in routes with promising economics. Station operators can also better estimate site utilization, a critical parameter affecting their economics.

A dataset* of charging behavior of electric trucks with battery capacities between 400 kilowatt-hours to about 650 kWh showed that:

- Trucks refueled for a few hours at moderate speeds of 100-200 kW.
- Trucks charged at several sites instead of one.

The characteristics of many applications, including urban deliveries, drayage and municipal services, fit within those operating parameters. Such trucks have the time to charge over several hours, limiting some operating and cost concerns. While differences in actual routes exist, fleet owners can get more comfortable deploying e-trucks in such duty cycles.

At the same time, fleets would require an extensive refueling network to match their routes. That includes locations around industrial and distribution facilities, but also along major highways.

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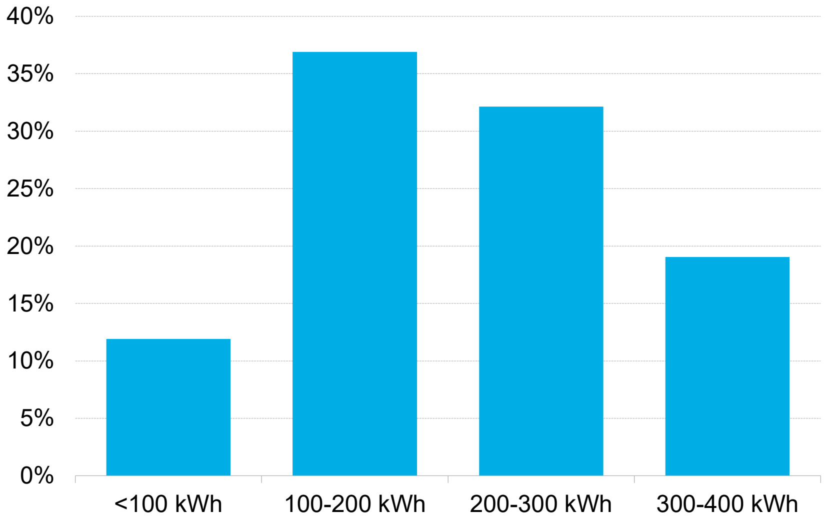
Charging patterns show potential to limit operating risks and costs – 2/2

Electricity consumed per truck charging session



Source: BloombergNEF, Ampcontrol. Note: The real-world data were provided by Ampcontrol and show usage at six electric commercial vehicle charging stations in Southern California, collected between May and November 2024.

Truck charging station developers and operators face **operating and project risks** in building such sites**.** Electricity needs will be significant, and charging behavior patterns can help them size the power available at each location while maximizing utilization.

Additional observations from the Sothern California dataset show that:

- Six charging stations consumed 3.4 gigawatt-hours in six months, while the biggest site averaged 9 megawatt-hours on its peak day.
- The share of a truck's battery charged at each session varied widely.
- Site utilization peaked during the week and was low on weekends, while demand also varied throughout the day between sites.

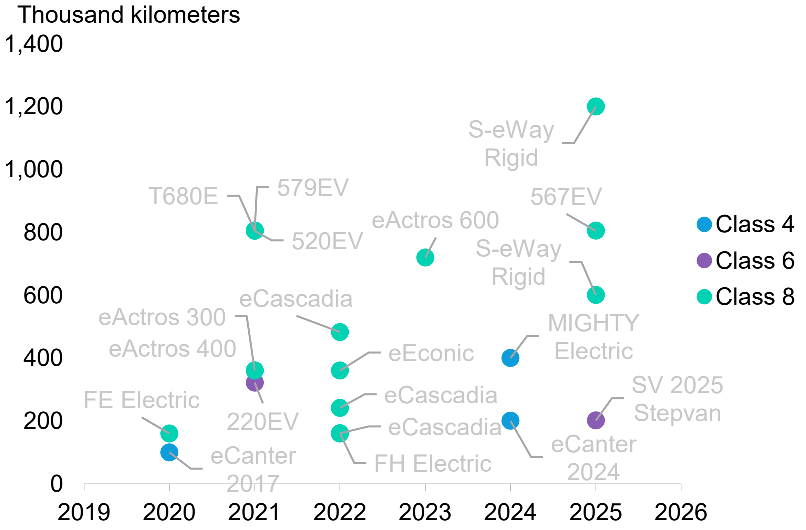
While charging patterns may be hard to predict, there is also potential to shift charging to low-demand hours via battery storage or time-of-use rates. The low usage on some days and sites is also an opportunities to charge at lower costs or to open facilities for other vehicles and drivers.

Truck charging operators will become big electricity consumers and can lower electricity costs with power purchase agreements and onsite generation. In addition, flexible electric truck charging could also support the integration of renewable energy sources.

Smart Freight Centre BloombergNEF

Electric truck warranties imply long battery lifetime, but it’s still early days

Battery-electric medium- and heavy-duty truck driving distance under battery warranty



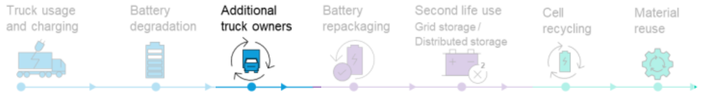
Source: BloombergNEF, companies. Note: Warranty conditions vary and typically cover a battery State of Health down to 70-80%, which may be defined differently across manufacturers. The vehicle list is non-exhaustive. Reflects the year of introduction of various vehicles.

Electric truck owners face **asset-level and operational risks** caused by uncertainties in the longevity of batteries. Manufacturer warranties for these batteries are indications of lifetime performance. They can provide confidence in long-term use and can serve as estimates for potential further applications.

Early data show that truckmakers expect batteries to last between 200,000 and more than 500,000 kilometers, depending on vehicle type. At that time, batteries have reached their useful life in the truck but still maintain 70-80% of their initial capacity.

Warranty lengths also increase with vehicle size. Heavier trucks – which are driven for hundreds of thousand of kilometers over their lifetime – have warranties for longer distances. Some recent models with driving ranges exceeding 400 kilometers such as the Mercedes-Benz eActros 600 and Peterbilt 567 EV, offer warranties for more than 700,000 kilometers. Iveco offers a battery warranty for as much as 1.2 million kilometres.

Warranties may also increase with more experience and newer battery technology. The latest iteration of the eCanter has a warranty of 200,000 kilometers, twice as much lifetime distance as its predecessor, as battery capacity, driving range and efficiency have also improved.

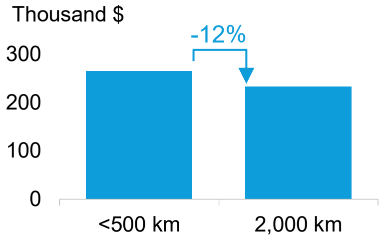


Risks throughout the electric truck and battery life cycle

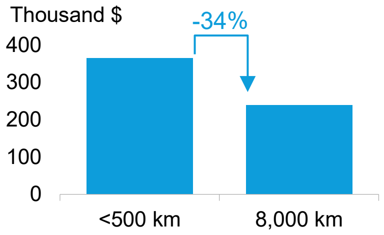
Electric truck depreciation seems high, but the data is sparse

Battery truck list prices for select models

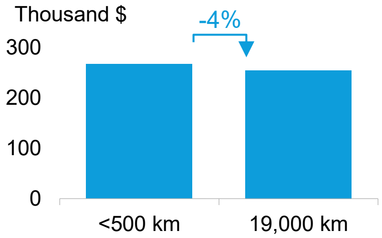
Freightliner EM2



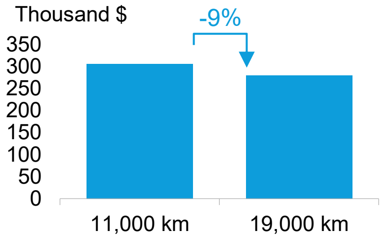
Kenworth T680E



Mercedes-Benz eActros 300



Mercedes-Benz eActros 600



Source: BloombergNEF, truck sales websites, full list in the Appendix. Note: The T680E was introduced in 2021, the EM2 and eActros 300 in 2022 and the eActros 600 in 2023. "New" refers to trucks driven less than 500 km. Shows listed, rather than transacted, prices.

Many smaller fleets buy used, rather than new, trucks. These owners face **financing constraints** and, with e-trucks, **additional operating risks** due to uncertainties in the technical capabilities of used batteries.

Fewer than 30,000 electric trucks are on the road in Europe and the US, most recently deployed, and the used-vehicle market remains thin.

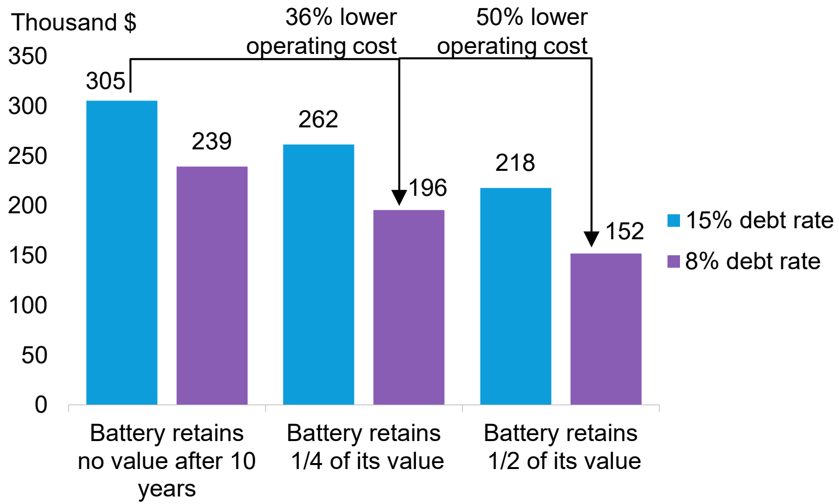
Early data indicate a relatively high hit on prices after the initial purchase in the US. Losses range between 10% and over a third of the original value after a few thousand miles of use. Diesel equivalents may loose around 25% of their value at the start of a year, when driven up to 80,000 miles, even though such rates fluctuate with market conditions.

In Europe, the decline in the truck value looks somehow smaller for the latest generation trucks.

Government subsidies can also impact the apparent depreciation using data from listings sites. For example, resale values will be based on the post-subsidy cost of the truck, while the listing of a new vehicle may show the pre-subsidy price. Beyond the vehicle itself, other factors also affect depreciation of battery trucks, such as the extent of the charging network in the region it is sold, the broader market for trucking services, as well as electricity and diesel prices.

Technology and market uncertainty have a large impact on economics

Battery cost of a heavy-duty electric truck under different residual value and financing conditions



Source: BloombergNEF. Note: Assumes a battery worth $175,000, which would be enough for a 500-mile driving range in a heavy-duty, long-haul truck in 2025; financing is split in 25% equity and 75% debt with 10-year loan duration; the truck drives 50,000 miles annually and is used for 10 years; the discount rate is zero.

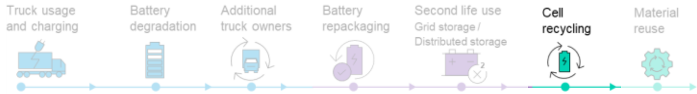
Uncertainties along the lifecycle of the electric truck can show up on **reduced value** assigned to the battery and on **high financing rates**.

A battery typically reaches the end of its useful life in a truck when it drops to about 70-80% state of health (SoH)*. While its capacity may have reduced at that point, the battery still holds value. Among other applications, it can be used in the same or similar vehicles in less demanding duty cycles, or as part of a stationary energy storage system.

The impact of improperly estimating the value of the battery is large and can quickly swing the economics of electric trucks into and out of competitiveness versus diesel equivalents. In addition, low battery residual values also imply risk and can lead to higher financing rates.

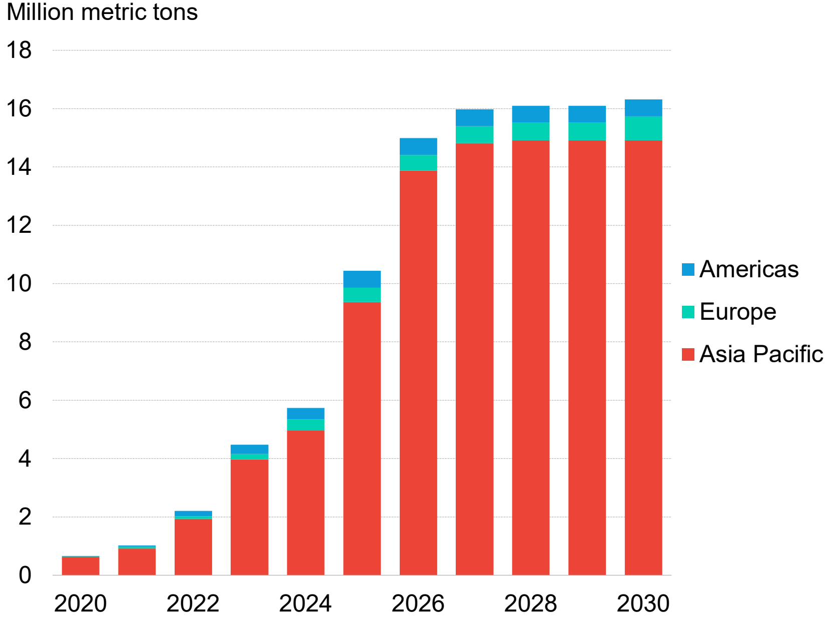
The battery of a heavy-duty electric truck capable of 500 miles driving range is an asset that, when manufactured, may cost $150,000-200,000 by 2030. Its lifetime cost to a truck owner may range from a high of just over $300,000 to more than a third lower, at less than $200,000 using lower financing rates and assigning a residual value to the battery.

**State of Health (SoH) measures battery performance over time. There is no universal definition on the metric used to calculate SoH and manufacturers may use different methodologies.*



End-of-life batteries can supply a sizeable share of key battery metals

Global announced nameplate battery recycling capacity



Source: BloombergNEF. Note: Data as of February 2024.

Recycled batteries can help offset raw material costs, relieve resource constraints and reduce a vehicle's carbon footprint. **Volatile material market prices**, **high investments** and **engineering differences** between batteries are some of the challenges for market participants.

The recycling industry's growth drivers include regulatory mandates, economic incentives to recover valuable metals, the rising volume of end-of-life batteries, as well as the emergence of new business models, such as vertically-integrated repurposing and recycling facilities.

Governments, particularly in China and Europe, are implementing policies that mandate material recovery rates, establish collection networks, and require lifetime battery traceability to facilitate the market's expansion.

Recycling capacity is set to increase rapidly, particularly in China. By 2030, announced recycling plants will be able to process more than 2.5 times as much material as in 2024. However, that may far exceed material available to recycle across all parts of the recycling process.

While the industry is facing challenges at its early stages, it is also maturing. By the time today's truck batteries reach their end of life, this could be a viable market.

Appendix

Description of the electric truck battery lifecycle – *vehicle use phase*

Truck usage and charging

Description

Truck utilization patterns vary widely between segments and use cases, as routes adapt to trade and traffic patterns, as well as customer needs.

For electric trucks, matching driving range with the availability of charging infrastructure and the cost of electricity, poses an additional complication.

Key barriers and challenges

While fleet operators have experience with route planning and refueling, they **lack data on electric truck usage and charging patterns.** That can prevent optimizing truck deployment in use cases with favorable TCO.

Such uncertainty can create **operational risks** for fleet owners and charging station developers, for which utilization is a critical parameter influencing their profitability.

Battery degradation

Description

Truck batteries lose part of their capacity with use, affecting their capability to perform useful transport work.

Degradation depends on battery technology and engineering, duty cycle and environmental conditions, as well as charging patterns throughout the electric truck's lifetime.

To date, few battery trucks have been driven to the end of their lifetime, outside of China.

Key barriers and challenges

The **scarcity of real-world degradation data** can hide actual performance of electric truck batteries and create **uncertainties in depreciation rates**. That may create **asset-level risks** for owners and manufacturers.

In the absence of experience, truckmakers may be conservative in setting warranty limits. Still, some advertise batteries that can last for more than 1 million kilometers and as long as 1.6 million kilometers (1 million miles), even though battery warranties typically cover a shorter overall driving distance.

Description of the electric truck battery lifecycle – *vehicle use phase*

Additional truck owners

Description

A new truck will remain with the first owner for a few years, depending on the segment and duty cycle. For example, fleets may keep new heavy-duty trucks in long-haul operations for about five years.

Owners of second-hand vehicles can deploy them in completely different applications than the original buyer, as some costs, such as for maintenance and fuel, increase with the truck's age.

Owners of second-hand electric trucks need to match the reduced battery capabilities with the requirements of new use cases.

Key barriers and challenges

Smaller fleets and even individual owners are the more likely buyers of second-hand electric trucks. These operators typically have **reduced access to equity capital** and have **higher financing costs**.

They face similar **operational risks** as first owners, but with additional uncertainties related to the technical capabilities of e-trucks with degraded batteries.

Description of the electric truck battery lifecycle – *repurposing*

	Description	Key barriers and challenges
Battery repackaging	End-of-life batteries need to be collected, transported, tested, sorted, disassembled and stored before being re-used or sent for recycling. Depending on the volume of the batteries and the duration of storage, such activity can result in high costs.	Stakeholders need to account for various storage and transport **safety regulations**, especially when crossing state and national policy borders, limit **transport distances**, and minimize the time- and energy-intensive **testing and sorting** processes. Intermediary companies may be holding **large asset liabilities** during that time. Manufacturer warranties are likely not valid once the battery is removed from the vehicle, while they have not yet been assembled in revenue-generating products.
Grid storage **Behind-the-meter storage**	Second-life batteries are best suited for applications with low power demand, low power-to-energy ratios, short cycle life requirements, and less frequent charging and discharging cycles, often in small and medium-scale systems.	Original battery manufacturers may avoid associating themselves with second-life systems due to concerns about safety incidents and potential brand damage from degraded performance. This transfers the responsibility for providing warranties to the second-life battery producers, who may assume **warranty and liability risks.**

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Description of the electric truck battery lifecycle – *recycling*

Cell recycling

Description

Cell recycling typically involves crushing end-of-life batteries and then separating their components, such as cathode material, anode material, electrolytes, and electrodes, for material recovery.

Two main methods are used: pyrometallurgical and hydrometallurgical processes.

Material reuse

The most critical and valuable metals recovered from recycling are cobalt, nickel, and lithium. Copper, manganese, and graphite can also be recovered. The recovery rates can range from 25% to 96% of the materials in a lithium-ion battery cell.

Key barriers and challenges

Recovered materials can be used in manufacturing new batteries and can also contribute to supply chain resilience.

The conditions favoring cell recycling and material reuse relate to the condition of the battery, such as its State of Health and its chemistry, as well as the market prices for the various metals recovered. **Stakeholders face uncertainty and potential volatility** for raw material prices.

Other challenges include **high initial costs**, **diverse battery designs**, and **competition with second-life battery applications**.

Companies employing integrated repurposing and recycling business models can efficiently direct batteries that fail second-life qualification directly into the recycling stream at the same facility, optimizing logistics and costs.

Defining commercial vehicles

	Vehicle segment	Typical use cases
Main focus of the report	Heavy-duty commercial vehicle (HCV)	Refuse, drayage, construction, freight
Main focus of the report	Medium-duty commercial vehicle (HCV)	Distribution, utility and municipal services, freight
	Light-duty commercial vehicle (HCV)	Last-mile delivery, distribution
	Municipal buses and coaches	Urban and inter-city people transport

Source: BloombergNEF. Note: Segmentation is for the purpose of clarifying content in this report. For gross vehicle weight rating thresholds in different countries, see Slide 53.

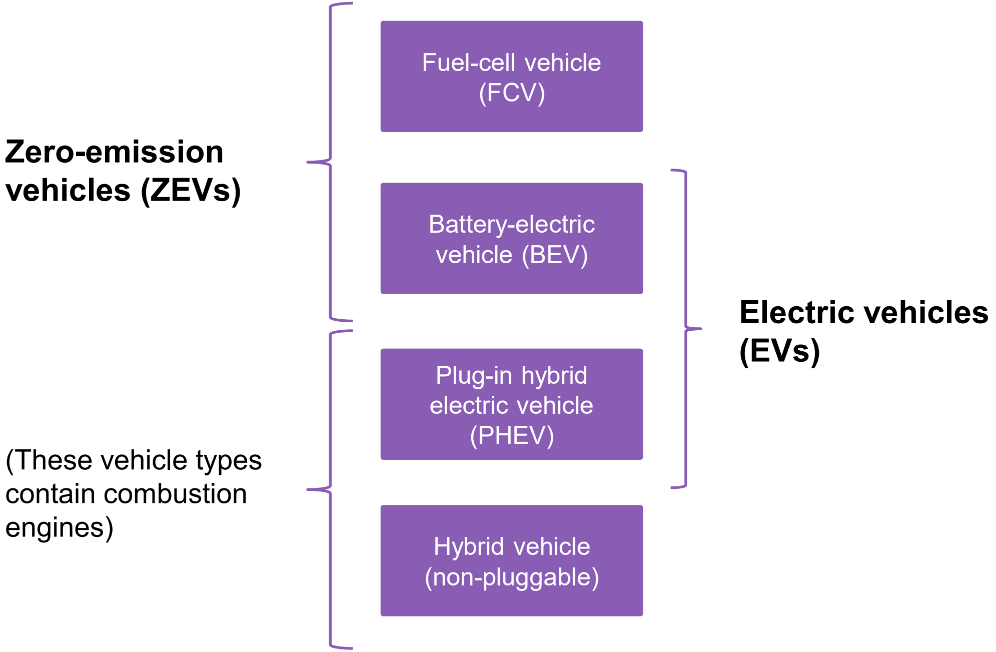
Commercial vehicles come in many types and perform several functions. Their operations vary widely, even for similar vehicles in the same weight segment.

Light-duty commercial vehicles are typically vans or small trucks that operate within and around cities. They are the largest segment in terms of fleet and sales within the sector. Zero-emission models mostly consist of battery-electric vehicles, and adoption has been growing globally, albeit at different speeds across countries.

Medium- and heavy-duty trucks are used in several, disparate duty cycles. These include infrastructure maintenance, municipal services, urban distribution, and short- and long-haul goods movement, among others.

While these vehicles' sales and fleet are considerably lower than for light-duty commercial vehicles, they consume relatively more energy.

Defining electric vehicles (EVs) and zero-emission vehicles (ZEVs)



Source: BloombergNEF. Note: Categorizations are only for the purpose of clarifying content in this report.

For the purposes of this report, we define zero-emission vehicles (ZEVs) as those vehicles that never emit carbon dioxide from their tailpipes.

This means that in our categorization, ZEVs only include pure battery-electric vehicles (BEVs) and fuel-cell vehicles (FCVs), neither of which have internal combustion engines.

It is understood that these vehicles should be fueled from clean electricity or hydrogen if they are to be truly zero-emission in operation.

Electric vehicles (EVs) as a category are commonly understood to include plug-in hybrids (PHEVs).

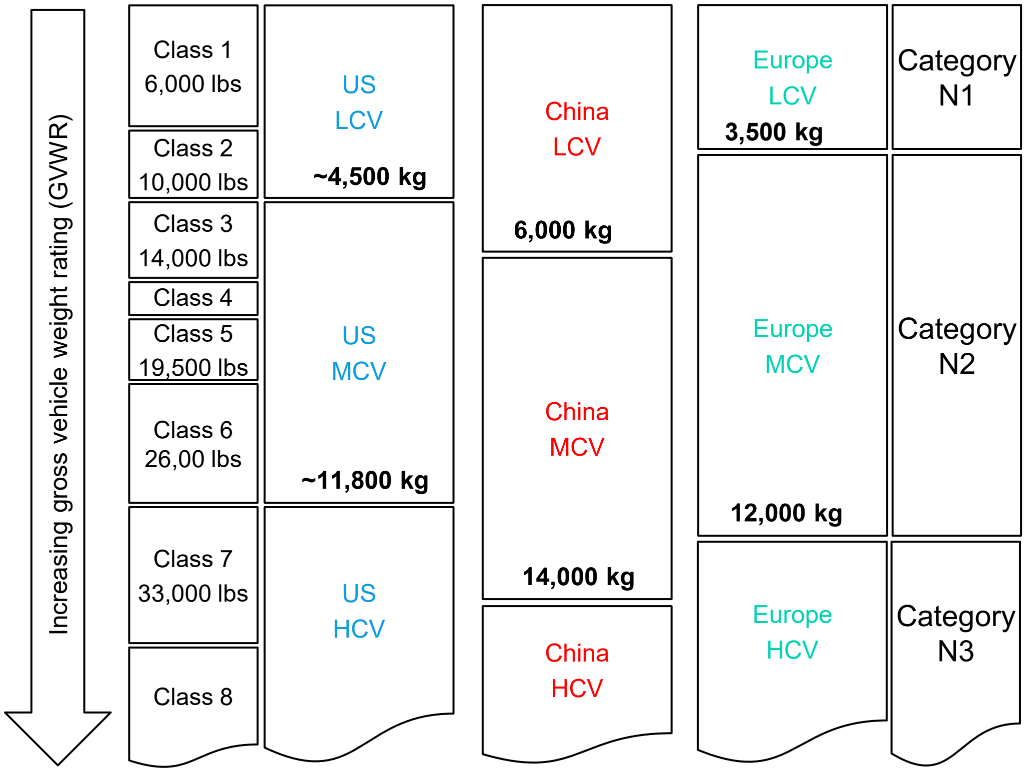
In this report, as in all other BNEF publications, we include PHEVs in our definition of EVs, alongside pure BEVs.

However, PHEVs are excluded in some portions of this report that focus on ZEVs, as defined above.

Pages that focus on the broader category ‘EVs and FCVs’ encompass all of the above.

Hybrid vehicles that cannot be charged from an external power source are not included in our definitions of ZEV or EV.

Commercial vehicle classification



- The weight thresholds between segments follow the classification of registered commercial vehicles as used in different countries.
- In the US, we chose Class 2 vehicles as the threshold for light-duty commercial vehicles (LCV) to be as close as possible to both the European and Chinese limits.

Note: 'LCV', 'MCV', and 'HCV' refer to low-, medium-, and heavy-duty commercial vehicles.

Data sources for sales and fleet

- BloombergNEF
- Bloomberg Terminal
- China Automotive Technology and Research Center
- FTR Associates
- Wards Automotive
- European Automobile Manufacturers' Association (ACEA)
- European Alternative Fuels Observatory
- South Korean Ministry of Trade, Industry and Energy (MOTIE)
- EV-Volumes
- Japan Automobile Dealers Association (JADA)
- Ministry of Road Transport and Highways of India
- Australia Bureau of Infrastructure and Transport Research Economics (BITRE)
- Ministry of Transport (Brazil)
- Brazilian Association of Automotive Vehicle Manufacturers (ANFAVEA)
- Various other national registration agencies
- autoline.info
- truck1.eu
- planet-trucks.com
- truck-mobiles.de
- trucklocator.co.uk
- truckpaper.com
- truckscout24.com
- trucksnl.com

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