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Electrifying Freight: Battery-Powered Heavy Goods Vehicles

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Battery-powered and hydrogen fuel cell technologies are driving the energy transition in the UK's heavy goods vehicle market. By 2050, electric HGVs are expected to dominate road freight, with hydrogen playing niche roles in long-haul and heavy-duty segments. UK research in high-energy-density batteries, particularly solid-state and lithium-sulfur, will be crucial for global leadership in the electrification of freight.

Introduction

The HGV sector is a significant part of the UK's economy, supporting thousands of jobs and contributing substantially to the logistics industry. However, it is also a major source of emissions, accounting for 16% of carbon emissions in the transport sector and 6% of the UK's overall carbon emissions.[1] The sector's high energy demand and operational requirements make it challenging to decarbonise. Mileage by HGVs in the UK is projected to increase modestly from 16 billion miles in 2025 to 18 billion miles by 2060.[2]

The UK Government aims for net zero emissions in the HGV sector by 2050. The sale of new non-zero emission HGVs is being phased out by 2035 for vehicles under 26 tonnes and by 2040 for heavier ones. To support delivery of these commitments, options for the future regulatory framework governing CO_2 emissions from HGVs are being developed, including manufacturer-based CO_2 standards, zero-emission vehicle requirements and potential fleet adoption measures.[3] In parallel, the UK Government is making substantial investments in emerging technologies such as battery electric trucks and hydrogen fuel cells.[4]

Electrification through battery technology is expected to dominate the HGV sector from the mid-2030s. By 2050, battery electric vehicles are projected to make up nearly 90% of new sales of commercial vehicles (i.e., light goods vehicles, HGVs, buses, coaches and off-road vehicles).[5]

The UK Freight and HGV Industry

The road haulage sector plays a pivotal role in the UK economy, facilitating 89% of all freight movement, including 98% of food and agricultural products.[6] The sector supports 1.86 million jobs and contributed £16.9 billion to the UK's GDP in 2023.[7] With around 518,000 licensed HGVs[8] and approximately 270,000 drivers,[9] the efficiency of freight movements directly impacts the productivity and competitiveness of many key UK industries, underscoring its critical role in fostering economic activity across the country.

HGVs are primarily used for transporting goods, with their design influenced by the type, weight and volume of the cargo, as well as the distance travelled. HGVs are defined as

*Image: A Scania 40 R BEV 4x2 Highline, General cargo transport. Photo: Dan Boman, Scania

1 Department for Energy Security and Net Zero (February 2025). 2023 UK greenhouse gas emissions: final figures.
2 Department for Transport (December 2022). National Raid Projections.
3 Department for Transport (January 2026). Consultation on a New Heavy Goods Vehicle CO_2 Emissions Regulatory Framework for the UK.
4 UK Government (2021). UK confirms pledge for zero-emission HGVs by 2040.
5 DNV (2023). The Role of Hydrogen and Batteries in Delivering Net Zero in the UK by 2050.
6 Road Haulage Association (2024). Industry Facts and Statistics.
7 Department for Transport (July 2025). Overview of the road freight sector 2024.
8 Department for Transport (June 2025). Vehicle licensing statistics 2024.
9 NOMIS (September 2025). Annual Population Survey - Employment by occupation.

any commercial truck with a gross vehicle weight (GVW) exceeding 3.5 tonnes, while a light goods vehicle (LGV) refers to vehicles with a GVW of up to 3.5 tonnes. Examples of the various types of HGVs and their uses include:[10]

- Small rigid trucks: Used for urban and regional deliveries, handling lighter loads and shorter routes.
- Large rigid trucks: Designed for heavier loads, suitable for intercity and long-haul transportation (typically trips greater than around 200 miles).
- Articulated trucks: Ideal for long-distance freight, offering flexibility with detachable trailers for high-volume transport.

Rigid trucks range from 7.5 to 32 tonnes, while articulated trucks typically operate at a maximum weight of 44 tonnes.[11] For battery electric HGVs, battery weight counts against the GVW limit that reduces available payload relative to a diesel equivalent. While HGVs are generally weight-constrained, they can become volume-constrained when carrying less dense goods, such as parcels. In these cases, the capacity is limited more by space than weight, affecting the efficiency of transportation. This distinction is crucial in logistics, as it impacts how different types of cargo are managed and transported.

The UK's reliance on HGVs for freight transport to satisfy the diverse logistical demands of the economy, from local deliveries to long-haul routes, implies the need for advanced and adaptable vehicle technologies.

Transition to New Fuels and Technologies

The HGV industry is transitioning towards using new fuels and technologies, with battery electric HGVs, hydrogen fuel cell electric vehicles (FCEVs) and hydrogen-ICE (internal combustion engines) emerging as alternatives to traditional diesel engines. In Q2 2025, 0.9% of new HGVs registered in the UK were zero emission, rising to 9% for light goods vehicles.[12] The total value of the market opportunity, encompassing both HGVs and buses, is estimated to be £2.4 billion in 2035, with battery packs accounting for £790 million of the total driven by the adoption of solid-state and sodium-ion batteries.[13]

Diesel currently remains the dominant fuel in the UK, with 99% of the existing HGV fleet relying on diesel engines.[14] This extensive use is driven by the high mileage these vehicles cover, with the average HGV travelling around 100,000 miles per annum. Diesel engines offer excellent fuel efficiency and strong torque (which equates to pulling power), making them particularly suitable for heavy-duty applications. However, the industry is increasingly adopting alternatives to reduce emissions and pollution.[15]

Battery electric HGVs are emerging as the leading alternative to traditional diesel-powered HGVs, driven by advancements in battery technology for passenger vehicles. Battery electric HGVs benefit from higher efficiency and lower operational costs, making them particularly competitive in applications with predictable routes and frequent stops, such as urban deliveries. However, the current limitations in battery energy density and range, particularly under heavy loads, remain significant challenges, underscoring the need for robust recharging infrastructure at operator depots and en-route hubs to enable widespread adoption. Government programmes, such as the Zero-Emission HGV and Infrastructure Demonstrator[16] and the Depot Charging Scheme, are helping to address these challenges by supporting early uptake of battery electric and hydrogen HGVs alongside depot-based and public charging infrastructure.[17] Market uptake is also supported through capital grants (e.g., the plug-in truck grant[18]) and initiatives from devolved administrations.

As technology and infrastructure continue to develop, battery electric HGVs could account for around 20% of European

Table 1: Market opportunity for the HGV sector (including bus supply chains)

Component	Market value (£m)	Technology focus	Export potential
Battery packs	790	BEV & FCEV	High
Electric drive units	570	BEV & FCEV	Moderate
Fuel cell systems	880	FCEV	High
Hydrogen storage tanks	130	FCEV	Moderate
High-power converters	30	FCEV	Low
Total	**2,400**		

Source: Advanced Propulsion Centre (July 2024). UK HDV supply chain opportunities to 2035.

[10] Element Energy (2020). Costs, efficiencies and roll-out trajectories for zero emission HGVs, buses and coaches.
[11] ERM (2023). Why electrification of Great Britain's truck fleet can happen faster than many expect.
[12] Department for Transport (October 2025). Vehicle licensing statistics.
[13] Advanced Propulsion Centre (July 2024). UK HDV supply chain opportunities to 2035.
[14] SMMT (April 2024). The Road Ahead: Delivering a More Rapid Zero Emission HGV Transition.
[15] While recent regulations have significantly reduced nitrogen oxide emissions from diesel-powered HGVs, these emissions remain higher than those from petrol engines. Petrol engines are not typically used in HGVs because they do not provide the same fuel efficiency or power needed for hauling heavy freight.
[16] Innovate UK. Zero Emission HGV and Infrastructure Demonstrator (ZEHID) Programme.
[17] Department for Transport (January 2026). Consultation on a New Heavy Goods Vehicle CO_2 Emissions Regulatory Framework for the UK.
[18] OZEV (January 2026). Plug-in van and truck grant.

Battery-powered HGVs offer lower operational costs, improved energy efficiency and reduced noise pollution compared to traditional diesel-powered HGVs. Widespread adoption will depend on overcoming current challenges in energy density, range and weight, along with the development of an extensive recharging infrastructure that encompasses both depot-based charging and ultra-fast charging across the strategic road network.

road transport electricity demand by 2030 and capture the largest share of new sales from around 2035.[19] In the UK, energy demand from battery electric HGVs is projected to increase to around 18-35 TWh by 2050 across scenarios, while hydrogen demand for HGVs varies widely depending on the pathway.[20]

Hydrogen is another potential technology for HGVs due to its high gravimetric energy density, compared to both diesel and battery technologies, and is available in the form of hydrogen FCEVs or hydrogen-ICE. Hydrogen FCEVs generate electricity through a chemical reaction between hydrogen and oxygen, with the automotive industry prioritising polymer electrolyte membrane fuel cells due to their suitability for heavy-duty applications. Fast refuelling times also make this technology attractive compared to battery electric options. Hydrogen-ICE vehicles represent another approach to leveraging hydrogen as a fuel, operating similarly to traditional combustion engines but using hydrogen instead of diesel or petrol and producing small amounts of nitrogen oxides. Hydrogen-ICE vehicles are anticipated to take a much smaller share of the market than hydrogen FCEVs, potentially offering more of a transitional solution that capitalises on existing diesel-powered ICE technology.

The high gravimetric energy density of hydrogen compared to batteries could provide enough power for long-range trips without significantly reducing the maximum payload of the truck. Nevertheless, hydrogen-fuelled HGVs are not yet widely commercially available, with deployment currently limited to small numbers of vehicles operating in pilot fleets, constraining the ability to compare the power, range and payload capabilities of the two technologies at scale.

Despite this, several manufacturers have pursued the commercialisation of hydrogen-powered HGVs in recent years, signalling some industry interest. For example, the HGV manufacturer DAF, together with Toyota and Shell, are testing a hydrogen fuel cell powered HGV in the US, which has a similar power capability (i.e., the rate at which energy is delivered for acceleration or maintaining speeds) to the Scania battery-powered HGV capable of a 150-mile range. All fuel cell vehicles, including HGVs and passenger cars, will include a drive battery to provide transient power, allowing the fuel cell to operate at a continuous load. Scaling these vehicles beyond early deployments has proved difficult because hydrogen HGVs depend on the development of associated refuelling infrastructure and clear long-term regulatory frameworks to reduce investor uncertainty.

In response to these constraints, companies such as Hydrogen Vehicle Systems are developing **hydrogen-electric hybrid** HGVs. These hybrid solutions could potentially offer a balanced approach for long-haul routes, addressing the limitations of both standalone electric and hydrogen fuel cell technologies in terms of range and refuelling infrastructure.

Other low carbon fuels offer a transitional opportunity for reducing emissions within the existing diesel HGV fleet. They are unlikely to match the performance of future battery and hydrogen technologies but can leverage current infrastructure and technology. Low carbon fuels include:

- **Biofuels** such as biodiesel, bioethanol and biomethane are produced from sustainable feedstocks and can be integrated into existing fuel infrastructure, although they require modifications to engines and fuel systems to optimise performance and compatibility with higher blend ratios. These fuels can be blended at higher concentrations with conventional diesel, for example, biodiesel blends above 20%.[4] However, it is important to note that current biodiesel supplies in the UK, which amounted to around 1.5 billion litres in 2024, could only meet approximately one-third of the fuel needs of HGVs, underscoring the challenges in scaling biofuels to fully replace diesel.[21]
- **Synthetic fuels or e-fuels** are produced using a combination of hydrogen and carbon dioxide through chemical processes. These include fuels derived from bio-based components, as described above, or fuels produced through non-biological processes such as e-methanol. These fuels, however, are inherently low in efficiency and energy-intensive to produce. Efficiency is only expected to rise modestly from just 23% to 29% by 2050, making them far less efficient than direct electricity use.[21]
- **Natural gas** offers reduced air pollution, quieter operation and suitability for urban and night-time use. Natural gas can be utilised in vehicles as either compressed natural gas or liquefied natural gas, with each form requiring specialised storage and fuel systems designed to manage the specific properties and energy density of the gas.

An **electric road system** is another potential solution for the electrification of road freight, although it is still in the experimental stage. The technology uses catenary lines (i.e., a system of overhead wires), offering efficient energy use and the ability to integrate with existing infrastructure. However, it remains untested on a national scale and poses challenges such as high infrastructure costs and visual impact.

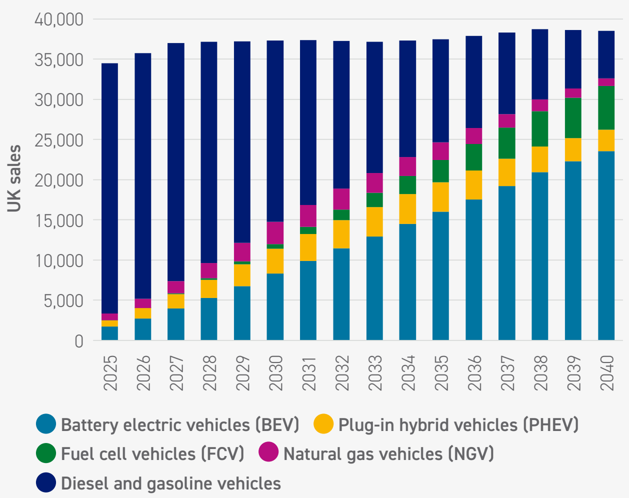
[19] IEA (2025). Global EV Outlook 2025.
[20] NESO (November 2025). Future Energy Scenarios: Pathways to Net Zero.
[21] Department for Transport (November 2025). Renewable transport fuel obligation 2024.

UK and Global Market Size

EV battery demand is set to rise in the 2030s with increasing use in larger vehicles such as buses and HGVs. The electrification of HGVs is advancing, but at a slower pace than that of passenger cars and LGVs.

Sales of zero- and low-emission HGVs in the UK are expected to increase from 7% in 2025 to 82% by 2040.[22] Although non-petrol/diesel technologies for HGVs will likely be more varied than for passenger cars and LCVs, the HGV market is still expected to be dominated by battery technology, similar to the passenger car market. In particular, battery electric vehicles (BEVs) are expected to account for 61% of total HGV sales (and 74% of zero- and low-emission HGVs) in 2040 while hydrogen FCEVs and plug-in hybrid EVs (PHEVs) are anticipated to capture 14% and 7% of the remaining total new HGV sales.[23] The dominance of BEVs relative to hydrogen FCEVs over the period to 2040 reflects lower total cost of ownership, higher energy efficiency and more mature charging infrastructure.

Figure 1: Projected UK sales of heavy-duty vehicles by electric, fuel cell and petrol/diesel vehicles



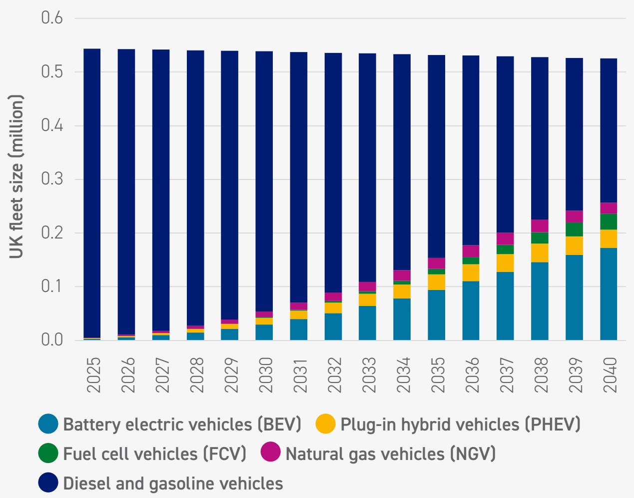
Sales of zero- and low-emission HGVs in the UK are expected to increase from 7% in 2025 to 82% by 2040.

Source: BNEF (2023). Long-Term Electric Vehicle Outlook 2023.

By 2030, the markets of North America, Europe and China are expected to produce around 600,000 battery electric HGVs per annum, with China leading at 340,000 units.[24] Most notably, China leads in medium- and heavy-duty zero emission vehicles (ZEV) sales, accounting for 80% of global sales, with significant growth in LGVs.[25] Major global truck manufacturers, including Daimler and Volvo, aim for ZEVs to represent 50%-60% of their European sales by 2030.[25] Within Europe, early adoption is most significant in Sweden and the Netherlands where battery electric HGVs accounted for around 6% of new sales in the first half of 2025.[26]

In terms of UK fleet size, the growth of the BEV, PHEV and FCEV fleet is gradual, achieving 45% of the total fleet by 2040. This compares favourably with other leading regions around the world, with China and Germany having up to half of their fleets as EVs and FCEVs while developing countries such as India are only expected to reach about 10%. Battery electric trucks outnumber hydrogen fuel cell trucks globally by a ratio of approximately 22 to 1.[25]

Figure 2: UK fleet size of heavy-duty vehicles by electric, fuel cell and petrol/diesel vehicles



Battery electric, plug-in hybrid vehicles and fuel cell electric vehicles will achieve 45% of the total UK fleet of heavy-duty vehicles by 2040.

Source: BNEF (2023). Long-Term Electric Vehicle Outlook 2023.

The pace of transition to new technologies will vary across vehicle types. For small rigid trucks, BEVs are expected to be the most widely used, particularly in urban and short-haul applications, because of their suitability for shorter routes and the anticipated expansion of depot-based charging infrastructure.

For long-distance and heavy-duty uses, battery electric HGVs could become viable alternatives by 2030, provided a robust charging infrastructure network is established. Large rigid trucks are likely to employ a mix of BEVs and hydrogen FCEVs. Improvements in battery technology and the expansion of public charging networks are expected to strongly favour BEVs, making them the dominant choice in this segment by 2040. FCEVs may find a niche in inter-city distribution where range requirements are more demanding, but their market share is expected to remain limited. For articulated trucks, the most challenging segment, FCEVs may play a more significant role due to their greater operational

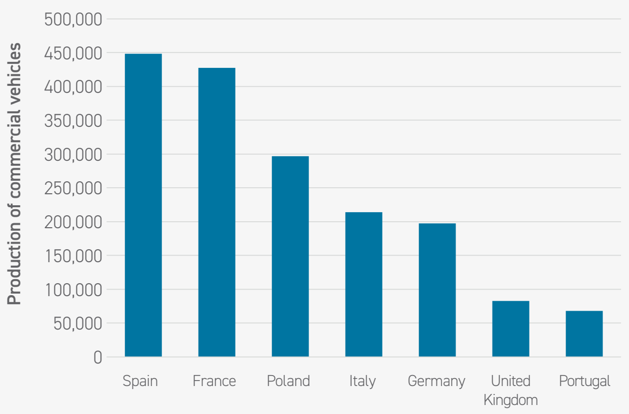
[22] BNEF (June 2023). Long-Term Electric Vehicle Outlook 2023 (under the economic transition scenario).
[23] BNEF (June 2023). Long-Term Electric Vehicle Outlook 2023.
[24] Strategy& (September 2024). Battery-electric trucks on the rise.
[25] BNEF (December 2023). Zero-Emission Vehicles Factbook.
[26] ICCT (September 2025). Market Spotlight Race to Zero.

flexibility and range. However, as public charging networks expand, BEVs could gradually increase their share with hydrogen technology likely to be limited to long-haul routes where battery charging infrastructure is less developed.[10]

There is a higher potential for the early electrification of back-to-base (i.e., return trips to a central depot) HGV operations, with 65-75% of rigid HGVs and 30-35% of articulated vehicles capable of transitioning to battery HGVs ahead of the relevant 2035 and 2040 phase-out targets applicable to different HGV classes.[27]

In 2024, the UK manufactured 108,300 commercial vehicles, including LGVs, HGVs, buses and coaches. Of this total, around 15,300 are HGVs, with these primarily manufactured by Leyland DAF.[28] This level of manufacturing, which compares to UK registrations of 45,000 HGVs[29] positions the UK as a significant player in Europe, although much lower than the larger European producers such as Spain, France and Italy (Figure 3). The continued success and growth of the UK industry will depend on establishing HGV battery manufacturing in the UK. Proximity between vehicle and battery manufacturers delivers substantial benefits, including just-in-time production, enhanced supply chain resilience and the development of a knowledge ecosystem.[30]

Figure 3: Manufacture of commercial vehicles for selected European countries (annual average 2022-25)



The UK is a significant European manufacturer of HGVs, although production is much lower than, for example, Spain, France and Italy.

Source: International Organization of Motor Vehicle Manufacturers 2022-25 Production Statistics. Numerical data for figures.

HGVs and Battery Performance

Battery HGVs offer several advantages including high 'well-to-wheel' efficiencies, falling battery costs and reduced noise. However, meeting the demands of long range and high payloads will require ongoing improvements in battery energy density, total cost of ownership (TCO)[31] and infrastructure development.

Energy density

Recent advances in the energy density of lithium-ion batteries have significantly improved the range and operational viability of electric HGVs. Gradual improvements in active material energy density and manufacturing techniques have enabled mass-market battery chemistries such as LFP and NMC to gain significant market shares globally.[32] In addition, pack design improvements from the automotive sector, including larger format cells and innovative strategies such as cell-to-pack, have contributed to significant performance gains that will benefit electric HGVs.[33]

Electric HGVs have gained a foothold in the market with around 65% of medium-duty trucks and 49% of heavy-duty trucks now operating within distances supported by current battery technologies.[34] However, additional improvements in the energy density of batteries through the development of next-generation battery technology (see Box 1) could improve the business case for electric HGVs. Such advances will support heavier loads and long-haul operations by reducing pack sizes, as existing performance levels remain insufficient. However, these technologies will need to demonstrate higher energy densities and remain cost effective to ensure they do not negatively impact vehicle TCO.

While battery-electric options are emerging as the leading choice for HGVs, hydrogen fuel cells may retain a role in niche long-haul market segments where range requirements exceed projected battery performance. Hydrogen fuel cells could be suited to long-range trips due to the high energy density of hydrogen as a fuel. As well as higher density, HGVs will also require significantly greater energy capacity than passenger vehicles to support their substantial payloads, necessitating much larger battery pack capacities. The average length of haul for Great Britain-registered HGVs in 2023 was 106 km (66 miles) although HGVs typically undertake more than one trip in a day, resulting in daily distances above this figure.[35]

The advances in electric HGVs are illustrated in Figure 4. Early models and prototype products, introduced around the turn of the decade, had ranges up to 200 km and peak charging power of up to 200 kW. By 2023, electric HGVs suitable for everyday use became more common with greater range and peak charging power of nearly 400 kW. From 2024 onwards, long-haul electric HGVs have emerged, offering ranges of up to

[27] Transport & Environment (May 2023). HGVs on the road to net zero. How battery electric trucks can decarbonise GB road freight.
[28] International Organization of Motor Vehicle Manufacturers. Production Statistics (2024).
[29] SMMT (February 2025). Zero emission truck demand.
[30] The UK Gigafactory Commission: Britain's Battery Future (January 2026).
[31] The total cost of ownership includes all lifecycle vehicle costs such as purchase, depreciation and running costs (i.e., fuel, maintenance and insurance).
[32] Faraday Insight 18 (September 2023). Developments in Lithium-Ion Battery Cathodes.
[33] McKinsey - How batteries will drive the zero-emission truck transition (September 2024).
[34] Resources for the Future (May 2023). Medium- and Heavy-Duty Vehicle Electrification: Challenges, Policy Solutions and Open Research Questions.
[35] Department for Transport (July 2025). Domestic road freight statistics 2024.

Box 1: Battery innovations for the HGV market

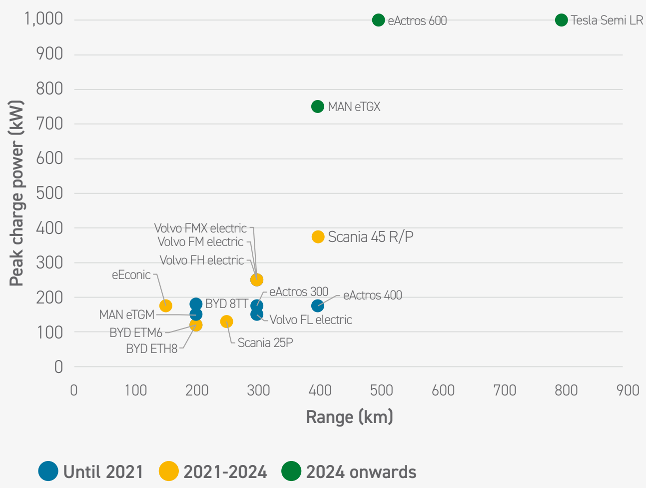
Battery HGVs are a viable alternative to diesel powered HGVs. However, they are limited by the battery energy density when it comes to long-haul movement of goods, as well as slower refuelling speeds compared to existing or hydrogen technologies. To address these constraints, new lithium-ion battery technologies such as solid-state batteries, silicon anodes and lithium-metal anodes are emerging as potential solutions. However, these innovations will need to demonstrate improved performance at acceptable costs to remain viable for electric HGV applications.

Solid-state batteries, which replace the flammable liquid electrolyte in a lithium-ion battery with a lithium conducting ceramic, have the potential to reach higher energy densities compared to existing lithium-ion batteries. The gain in energy density comes from being able to use a lithium-metal anode, replacing graphite. This would allow HGVs to achieve longer ranges without adding excessive weight, a crucial factor in maintaining both performance and fuel efficiency. This technology has already been deployed in BEVs in China,[36] with many other companies racing to deploy this technology globally.[37]

Silicon anodes are promising alternatives to existing graphite-based anodes in lithium-ion batteries, offering significant improvements in energy density and power capability. Silicon can store much more lithium than graphite-based anodes, dramatically increasing the energy density of the battery. Silicon anodes can also support fast-charging batteries, with some silicon cells achieving a full charge in only 10 minutes.[38] Reducing charging speeds could open more routes for battery HGV applications, furthering the electrification of HGVs. However, silicon anodes expand and contract during the charge/discharge process, which degrades the material and impacts cycle life.

Lithium-metal anodes are theoretically the highest performing anode for lithium-ion batteries, offering a significant leap in energy density compared to graphite anodes. The primary challenge with lithium-metal anodes is the formation of dendrites, which can grow during charging and potentially short circuit the cell, causing safety issues. Research is underway to develop solid electrolytes or protective coatings that prevent dendrite growth, making lithium-metal anodes more stable and safer for commercial use. These advancements are bringing lithium-metal anodes closer to being viable for commercial applications, including electric HGVs.

Figure 4: Advances in electric-HGVs by peak charge power and range



Capabilities of battery electric HGVs have developed considerably since they were first introduced, with ranges up to 800 km now possible.

Source: Strategy& (September 2024). Battery-electric trucks on the rise.

800 km and peak charging power of up to 1,000 kW. For example, Scania's fully electric rigid and articulated option, with a 624 kWh battery and 410 kW power capability, provides a 350 km range for a 40-tonne load.[39] The Tesla Semi offers a 800 km range on a single charge, with 70% of its range rechargeable in 30 minutes using Tesla's Semi Chargers.[40] Some manufacturers suggest that battery electric HGVs could achieve ranges over 800 km in the near future.[41]

Efficiency and recharging

Battery electric HGVs are expected to be more efficient than hydrogen FCEVs, with BEVs having over twice the well-to-wheel efficiency of FCEVs. This higher efficiency makes BEVs a more cost-effective and energy-efficient option for many HGVs, particularly where range and payload requirements align with current battery technology. Conversely, hydrogen FCEVs, while offering advantages in range and refuelling times,[42] convert less than half of hydrogen's energy content into power, leading to lower overall efficiency and higher operational costs.

Such an efficiency gap challenges the broader adoption of FCEVs, especially in cost-sensitive markets. Recharging times for electric HGVs are much longer than diesel refuelling, which introduces a key operational constraint for freight businesses unless faster charging infrastructure is available.[34] In practice, electrified HGV fleets in Europe tend to be sized for the most demanding days of operation, meaning

[36] Electrive (November 2025). Nio drops 150 kWh battery with semi-solid electrolyte again.
[37] Volta Foundation (January 2026). Annual Battery Report 2025 (Solid State Section).
[38] EV Magazine - StoreDot & Polestar Unveil World's First 10-Minute EV Charge (May 2024).
[39] Scania. Battery Electric Truck.
[40] Tesla Semi. The Future of Trucking is Electric.
[41] ING (January 2026). Europe's e-truck market gains speed.
[42] APC (June 2025). The hydrogen landscape for automotive 2025.

that battery packs are often underutilised. The average depth of discharge from the trucks involved in the study was only 44%.[43]

The increased battery weight of heavy-duty electric vehicles typically reduces their payload capacity to 80% of that of diesel trucks.[34] It can also significantly reduce an HGV's range, with a 543 kg load leading to a loss in range of 15-20 km. This effect, while not unique to battery-powered vehicles, is more pronounced due to the longer recharging times compared to diesel. As technology improves, newer vehicles are addressing these range and recharging challenges. For example, 2024 models can drive 4.5 hours fully loaded and recharge with a 1 MW charger during a 45-minute break. Given that over 90% of Great Britain's articulated truck driver's shifts require less extensive driving than the range provided by this full charge, some 80% of trucks can obtain 70% of their energy from depot or slow overnight charging, reducing dependence on extensive motorway charging infrastructure.[11] A recent trial demonstrated an average energy efficiency of 1.08 km per kWh, resulting in a typical range of 270 km per full battery charge. Efficiency varied notably across driving conditions: 0.9 km/kWh in urban environments, yielding a range of 225 km and 1.2 km/kWh in rural areas, extending the range to 300 km.[44] Further advancements in pack design, such as the move from 400V to 800V pack architectures, could reduce the required charging time by up to 50%.[33]

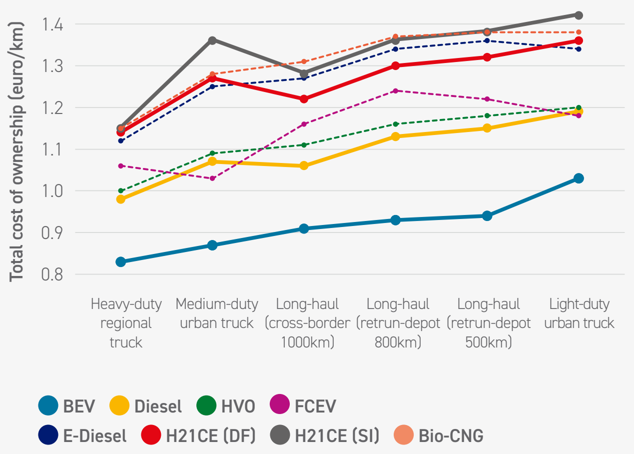
Hydrogen-ICEs present an alternative option, offering rapid refuelling and the reuse of existing technology, making them attractive during a transition period. However, their efficiency is lower than that of BEVs and FCEVs. Moreover, hydrogen combustion can still produce nitrogen oxides, though at levels significantly lower than those from conventional diesel engines.

Cost

Battery electric HGVs are projected to achieve lower total cost of ownership (TCO) than diesel trucks across all use cases by the early 2030s, driven by fuel savings and operational efficiencies, even under conservative assumptions regarding battery technology and infrastructure costs. Cost considerations are particularly important in the UK haulage sector where operating margins are typically around 2%.[45] Zero-emission HGVs currently have higher upfront purchase costs than diesel equivalents. TCO parity is expected for small rigid battery electric HGVs in the mid-to-late 2020s and for the largest articulated HGVs in the first half of the 2030s.[46]

Battery electric HGVs have a TCO that is between 15% to 23% lower than diesel HGVs, depending on HGV class and operating range (Figure 5). Hydrogen fuel cell trucks also offer better TCO than diesel for medium- and light-duty urban trucks but remain 14% to 32% more expensive than battery-electric trucks reflecting higher vehicle purchase costs and the high cost of low-carbon hydrogen. Hydrogen combustion and bio-CNG powertrains have the highest TCO.

Figure 5: Total cost of ownership by truck classes and powertrain technologies by 2030



Battery electric HGVs have a total cost of ownership that is 15-23% lower than diesel HGVs.

Source: ICCT (November 2023). A total cost of ownership comparison of truck decarbonization pathways in Europe. Definitions of terms used in key.[47] Numerical data for figures.

Table 2: Total annualised cost of ownership for battery electric and diesel HGVs in 2030

Powertrain	Component	Cost
Diesel TCO	**Diesel TCO**	**£67,350**
EV differences	EV: Increased depreciation	+ £13,040
	EV: Infrastructure costs	+ £7,060
	EV: Increased financing costs	+ £4,820
	EV: Increased downtime costs	+ £530
	EV: Cost of payload loss	+ £2,630
	EV: Fuel cost savings	- £24,340
	EV: Maintenance cost savings	- £2,660
	EV: Vehicle excise duty exemption	- £850
BEV TCO	**BEV TCO**	**£67,580**

Source: Element Energy (April 2023) - Why Great Britain's long-distance heavy-duty HGVs can go battery electric.

[43] ICCT (2025). Real-world use cases for zero-emission trucks.
[44] BETT (January 2024). Battery Electric Truck Trial Final Report.
[45] Trans.info (December 2025). Fuel isn't the problem: What's really destroying UK haulage margins.
[46] Department for Transport (January 2026). Consultation on a New Heavy Goods Vehicle CO_2 Emissions Regulatory Framework for the UK.
[47] Definitions: HVO (hydrotreated vegetable oil); E-Diesel (synthetic diesel), FCEV (fuel cell electric vehicle); H2-ICE-DF (hydrogen ICE dual fuel); Bio-CNG (compressed natural gas from biomass); and H2-ICE-SI (hydrogen ICE spark ignition), which uses spark plugs to ignite hydrogen fuel for power generation.

While the above study shows battery electric HGVs have lower TCO than diesel across all major truck classes, the results are dependent on assumptions about costs, infrastructure and utilisation. For example, Table 2 illustrates that the TCO of diesel and battery-electric HGVs could be much closer in some long-distance use cases. Battery electric HGVs benefit from lower fuel and maintenance costs, but these are largely offset by higher costs for depreciation, infrastructure, financing, downtime and payload loss. The TCO comparison relates to operational scenarios for existing 44-tonne long-distance HGVs in 2030.

The upfront investment and fuel costs for battery electric HGVs are also expected to be lower than those for hydrogen fuel cell HGVs. Although the upfront costs for both technologies are currently higher than those of equivalent ICE vehicles, battery electric HGVs are projected to reach upfront cost parity for light and medium-duty trucks by 2030 and for heavy-duty trucks in the mid-2030s,[48] which is a few years after TCO parity is expected to be achieved. Falling battery prices have helped contribute to improved range and operational viability of electric HGVs. Between 2020 and 2024, battery pack sizes for heavy-duty trucks increased by around 70% for a less than 20% increase in cost per battery pack.[49] Battery costs are expected to continue to fall from around £150/kWh in 2025 to close to £50/kWh by 2050.[50]

BEVs have lower costs due to simpler propulsion systems and the economies of scale shared with the passenger vehicle market. In contrast, FCEVs are more expensive, driven by the complexity of their technology and reliance on costly materials such as platinum. In addition, hydrogen fuel cell drivetrains still require a battery to be installed to provide transient power, allowing the fuel cell to operate at a constant power output, increasing system complexity and cost. As the HGV market evolves, cost considerations will remain critical, with BEVs likely maintaining a competitive edge as battery costs decline, with second-life applications potentially providing additional support to residual values over time.

With the TCO of hydrogen vehicles already higher than their battery equivalents, further benefits of hydrogen vehicles, such as range and refuelling time, would need to be valued highly to make this the preferable business case. In several European markets, road charges that increase with distance travelled (termed mileage charging) and vehicle emissions further narrow the total cost gap between diesel and zero-emission HGVs.[38]

UK depot-based charging

Depot-based charging is likely to be the predominant strategy for battery HGVs, with 93% of chargers anticipated to be located at depots, 6% as public overnight chargers and 1% as public en-route chargers by 2030. Depot charging is particularly advantageous when vehicles return daily to a central depot, allowing for overnight charging or rapid charging during the day. In these cases, BEV adoption is not constrained by public charging infrastructure or fast charging costs but by the vehicle usage pattern.[27] While this offers the advantage of overnight charging, recharging times for heavy-duty EVs (up to nine hours depending on the power output from the charger) could affect operational schedules unless faster charging infrastructure is implemented. Most truck duty cycles support depot-based overnight charging, with light/medium and specialist urban trucks almost always returning to base and around 90% of regional trucks doing so. Long-haul operations are the main exception, with around 35% requiring access to public overnight charging.[51]

Depot-based business models are also well-suited to early electrification as they tend to focus on consistent and shorter routes. Battery electric rigid HGVs used for city, urban and regional deliveries, for example, are anticipated to achieve TCO parity as early as the mid-2020s due to smaller battery requirements and predictable daily mileage.[27]

The capital expenditure for hauliers to establish this depot infrastructure could be considerable but could be mitigated by the 60% lower operating costs of electricity compared to diesel.[52] For example, a typical depot may need to increase its electrical capacity by 300% to support a full fleet of electric HGVs, requiring significant investment in power supply upgrades and charging infrastructure.[53] As a result, many depots are likely to manage charging using smart scheduling and on-site battery storage to deliver high-power charging within existing grid constraints. At a system level, depot-based truck charging is expected to account for around half of total installed charging power required by 2030, indicating that local grid reinforcement will be a widespread requirement rather than a site-specific issue. Feasibility will, however, vary by operator, particularly for SMEs operating from leased or shared sites where grid capacity, space constraints or landlord permissions may limit installation of charging points.

Around a dozen strategically located hydrogen refuelling stations could facilitate the early adoption of hydrogen FCEVs and support a significant proportion of UK freight movements.[54] Additionally, companies such as DAF, Toyota and Shell are trialling FCEV HGVs, which have demonstrated power capabilities comparable to existing diesel models and ranges suitable for long-haul applications.

Battery swapping at depots is emerging as a practical solution to enhance operational efficiency, reduce downtime and lower ownership costs of HGVs. Already widely used in micromobility markets,[55] it has become prominent in China, where nearly half of the 30,000 electric HGVs sold in 2023 were classified as battery-swappable models.[56] The technology enables rapid refuelling, optimised charging schedules and the separation of vehicle and battery

48 Energy Innovation (May 2025). The Emerging Cost Advantage of Battery Electric Heavy-Duty Trucks.
49 IEA (2025). Global EV Outlook 2025: Trends in heavy-duty trucks.
50 ERM (March 2024) ZEV HDV Update Trajectories for The Seventh Carbon Budget.
51 ICCT (October 2025). Charging infrastructure needs for battery electric trucks in the European Union by 2030.
52 National Infrastructure Commission (April 2019). Better Delivery: The Challenge for Freight.
53 BETT (July 2022). An Introduction to Deploying Battery Electric Trucks.
54 Hydrogen Energy Association (October 2025). Fuelling the future.
55 Faraday Insight 16 (February 2023). The Micromobility Revolution Gathers Momentum.
56 BNEF (September 2024). Zero-Emission Commercial Vehicles: The Time Is Now.

expenses, which reduces capital investment for smaller fleets by up to two-thirds.

UK public charging infrastructure

Although nearly all the 400,000 truck chargers needed by 2050 will primarily be depot-based, a public charging infrastructure network will still also be essential for the adoption of both BEVs and FCEVs. Increasing charger utilisation from 5% to 30% could reduce levelised infrastructure costs per kWh by around 80%, which could in turn reduce fuel costs per kilometre by around half.[19] Passenger BEVs have benefitted from the growing network of charging stations, which alleviates range anxiety and supports broader market penetration. Conversely, the currently underdeveloped state of hydrogen refuelling infrastructure and the low volume of domestic low carbon hydrogen production present a significant hurdle to the widespread adoption of hydrogen-powered HGVs.

In either case, battery electric and fuel-cell HGVs will require the buildout of new charging infrastructure for these vehicles. Hydrogen refuelling infrastructure is more expensive per charging point compared to electric chargers. However, a single refuelling station can serve a larger number of trucks per day and does not impact local electricity grid arrangements. In contrast, high-powered electric chargers are more cost-effective in terms of vehicle miles, can be built out modularly and are more easily scaled as the electrification of a truck fleet grows.

A combination of chargers will be needed for the public infrastructure network, with 350 kW chargers primarily positioned near warehouses to facilitate top-ups during loading, unloading and driver breaks, while 1 MW chargers will be located at motorway service areas and truck stops to cater for vehicles with high energy demands and limited downtime as vehicle charging capabilities increase. By 2050, a fully operational network would need around 2,000 x 350 kW chargers and 1,200 x 1 MW chargers to meet the demand from battery electric HGVs.[57] In practice, most HGV movements are concentrated along key UK freight corridors, with modelling indicating that up to 80% of public truck charging demand could be met by around 50 strategically located sites.[50]

Although the development of the HGV public charging infrastructure will initially be driven by the passenger car market, in places such as motorway service stations, where the transition is already well advanced, infrastructure requirements for zero-emission HGVs will be particularly influenced by:

- Established network routes typically followed by HGVs. This allows for the development of standardised refuelling infrastructure along these routes. The existing network can serve as a template for the new recharging and refuelling infrastructure needed for zero-carbon HGVs. The strategic road network (SRN) will remain the backbone of freight transport, with road haulage accounting for 79% of freight movement, two-thirds of which is concentrated on the SRN.[58]
- Legal requirements for rest periods. The availability of fast charging infrastructure during mandatory statutory rest breaks will be crucial (a standard 9-hour day allows for approximately 270 miles of travel at an assumed average speed of 60 mph). Such charging would significantly extend the operational range of BEVs without negatively impacting the business case, provided the charging network is robust and accessible.

Current charging technology could be adapted for HGVs if installed at strategic locations such as motorway service stations. However, the larger battery packs in HGVs may require longer charging times unless higher power cables are in place. For example, the Scania battery-powered HGV, which has a 375 kW charging capability, can be fully recharged in 90 minutes. However, substantial grid infrastructure investment will be necessary at service stations to ensure multiple HGVs can recharge efficiently and at the same time. At full adoption, peak power demand from electric HGV charging could exceed 10 GW by 2050, highlighting the need for coordinated grid planning.[59]

Other innovative technologies, such as contactless power transfer systems, which charge BEVs via electromagnetic induction without a physical connection, or pantographs connected to overhead wires, could address the range limitations of battery-powered HGVs. However, these technologies are costly to implement, require significant investment in new infrastructure and are not immediate solutions.

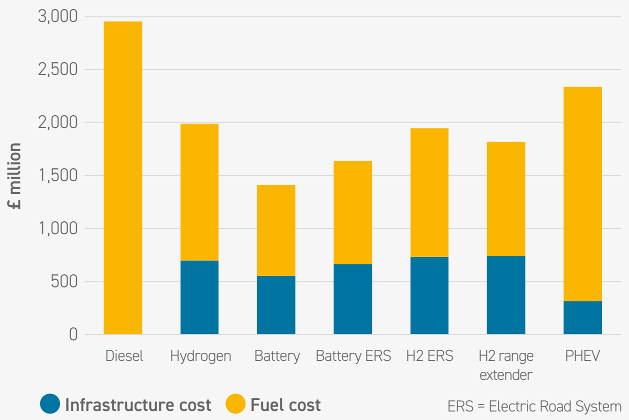
Battery electric HGVs will require a significant investment in charging infrastructure, estimated to cost a cumulative £11.4 billion compared to £7.7 billion cumulative required for hydrogen refuelling stations. However, when considering total operating and infrastructure costs, battery electric HGVs are more cost-effective due to significantly lower fuel costs (Figure 6).

Barriers to infrastructure deployment for battery HGVs - such as grid connection challenges, planning permissions and the complexities of securing landlord consent - highlight the need for a streamlined and consistent national framework to accelerate progress.[60] The SMMT has recommended increasing government investment and strategic planning to overcome these obstacles. Key proposals include expanding Project Rapid to develop dedicated HGV charging infrastructure along major road networks, accelerating the creation of a comprehensive national strategy for charging and hydrogen refuelling infrastructure, as well as implementing a regulatory framework that provides certainty to manufacturers and operators regarding fleet decarbonisation.[14]

Hydrogen FCEVs will require widespread hydrogen refuelling infrastructure to enable successful uptake. While some users may install dedicated hydrogen recharging infrastructure

[57] Element Energy (April 2023). Why Great Britain's long-distance heavy-duty HGVs can go battery electric.
[58] National Highways (2023). Connecting the Country. Our long-term strategic plan to 2050.
[59] Energy Systems Catapult (January 2026). Charging ahead for eHGVs.
[60] SMMT (April 2024). Position Paper. The Road Ahead: Delivering a More Rapid Zero-Emission HGV Transition.

Figure 6: Annualised fuel and infrastructure costs for zero-emission HGV technologies over the 2020 to 2060 period



When considering total operating and infrastructure costs, battery electric HGVs are the most cost-effective due to significantly lower fuel costs.

Source: Ricardo Energy & Environment (January 2020). Zero Emission HGV Infrastructure Requirements. Report for Committee on Climate Change. Numerical data for figures.

at depots, a network of refuelling stations along key freight routes will be necessary at a minimum. Existing hydrogen refuelling infrastructure is significantly underdeveloped, with many existing public stations being shut down due to a lack of demand from hydrogen-based passenger and HGV vehicles. This presents a 'chicken and egg' dilemma: demand for hydrogen vehicles is limited by insufficient refuelling stations, while infrastructure investment is stalled by low vehicle uptake.

Conclusion

The transition to low- or zero-carbon HGVs is advancing rapidly, albeit from a low current uptake, with battery electric and hydrogen fuel cell drivetrains emerging as the most viable options for mass market adoption. HGVs will be subject to a UK government mandate to phase out the sale of petrol and diesel HGVs by 2040, with different timelines by vehicle class. Along with the requirements imposed by regulations, consumers and freight operators will also influence the choice of technologies.

The adoption of BEVs is driven by cost reductions and efficiency improvements. The sharp decline in battery costs has already positioned BEVs as the most cost-effective alternative option to diesel in many applications when considering the total cost of ownership, particularly in urban and short-haul duty cycles. By 2040, BEVs are expected to comprise 45% of the UK commercial vehicle stock, increasing to 80% of the stock by 2050. Hydrogen FCEVs, however, are likely to remain a niche solution, particularly suited to high-payload and long-range applications.

To support the transition to battery electric HGVs and address the operational demands of the freight industry, the following strategic actions are recommended:

- Invest in next-generation technologies, such as solid-state batteries and silicon anodes, to accelerate advancements in battery energy density and reduce ultra-fast charging times, supporting long-haul applications and heavy payloads.
- Promote the UK production of HGV-specific battery systems, particularly high-capacity packs for long-haul vehicles and advancements in thermal management, cycle life and weight optimisation.
- Upgrade and expand the HGV-specific UK charging infrastructure, particularly strategically located public ultra-fast charging points on the SRN as well as depot-based solutions.
- Invest in grid capacity upgrades and power supply resilience to ensure the charging network meets the energy demands of an increased electric HGV fleet, with investment focused on high-demand freight corridors and urban logistical hubs.
- Integrate renewable energy sources, such as solar and wind, into charging infrastructure to reduce reliance on conventional power grids, and lower energy costs.
- Strengthen collaboration among energy providers, policymakers and industry stakeholders (Road Haulage Association, Logistics UK etc.) to address technical and logistical challenges, particularly in coordinating depot and public charging networks.

Despite the growing presence of BEVs, challenges remain in the commercial segment, especially in scenarios that require long ranges and heavy payloads. In these cases, hydrogen fuel cell vehicles present a potential alternative, offering quick refuelling times and higher energy density. However, the high costs associated with hydrogen fuel cell technology and the limited development of refuelling infrastructure continue to constrain their adoption. Consequently, while hydrogen FCEVs may secure some market share in specific heavy-duty applications, BEVs are expected to remain the more practical and widely adopted choice across most commercial vehicle categories. New battery technologies such as solid-state batteries, silicon anodes and lithium-metal anodes are under development, which could help further increase the projected market share of battery HGVs by providing higher energy density and faster charging cells.

Achieving a zero-emission heavy-duty vehicle fleet by 2050 is feasible but will necessitate extensive planning, coordination and investment in infrastructure, alongside robust government policy support. With targeted efforts across industry and government, the transition to zero-emission HGVs has the potential to reduce dependency on imported fuels, create new jobs and position the UK as a leader in the electrification of freight.

About the Faraday Institution and Faraday Insights

The Faraday Institution is the UK's independent institute for electrochemical energy storage research, skills development, market analysis, and early-stage commercialisation. We bring together academics and industry partners in a way that is fundamentally changing how basic research is carried out at scale to address industry-defined goals.

Our 'Faraday Insights' provide an evidence-based assessment of the market, economics, technology and capabilities for energy storage technologies and the transition to a fully electric UK. The insights are concise briefings that aim to help bridge knowledge gaps across industry, academia and government. If you would like to discuss any issues raised by this Faraday Insight or suggest a subject for a future Insight, please contact Stephen Gifford. Sign up today to be added to the distribution list for future Faraday Insights.

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