Innovate UK

eFREIGHT 2030

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CATAPULT Energy Systems

The Road Ahead

National system impacts of HGV decarbonisation

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Contents

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1. Executive summary

Heavy Goods Vehicles (HGVs) play a critical role in the UK's economy but remain a major source of emissions. In 2023, HGVs were responsible for 16% of the UK's domestic transport greenhouse gas emissions[i], and 4.7% of emissions in the UK across all sectors[ii]. Therefore, decarbonising this sector is essential to achieving the UK's net zero targets.

Energy Systems Catapult is a partner in the eFREIGHT 2030 consortium, which sits within the Zero Emission HGV and Infrastructure Demonstrator (ZEHID) programme. eFREIGHT 2030, led by megawatt charging infrastructure developer Voltempo, brings together the charging sector, vehicle OEMs, HGV fleets and Energy Systems Catapult. The project aims to deliver eHGVs and charging infrastructure across the consortium's fleets and depots and explore, understand and build an evidence base to support the uptake of zero emissions HGVs beyond the ZEHID trials.

This report covers the Catapult's national whole systems modelling and analysis, investigating possible pathways for the UK HGV fleet composition, charging infrastructure, energy demand and emissions reductions. The insights from this report are intended to inform government, the energy sector, HGV fleets and charging infrastructure providers on the actions needed now to enable a commercially successful transition to zero-emission road freight.

The analysis draws on input from consortium workshops, which helped establish agreed assumptions about current market conditions and future trends. A range of scenarios were modelled to explore different possible futures and the impact of certain interventions. The scenarios explored in this report are summarised on the next page:

- **Core Scenario** – follows all main assumptions, including the sales bans of non-zero emission HGVs in 2035 and 2040 (based on weight).
- **Incentivised Transition Scenarios** – a group of scenarios based on different incentive packages, with an aim of reducing the cost to transition to electric HGVs (eHGVs).
- **Charging Scenarios** – a group of scenarios looking at different levels of shared access and managed charging.

There are currently around 487,000 HGVs in the UK, of which 99% use diesel as their primary fuel. This means a significant shift in the ways of working for the HGV sector is needed if it is to decarbonise. Figure 1 shows how the vehicle parc[1], average annual vehicle distance, and tailpipe emissions are broken down by different HGV types.

The following pages then provide a summary of the potential transition to 2050, alongside key findings and associated recommendations.

[1] Vehicle parc is the total number of vehicles in use at a given time, essentially the total vehicle population. A full list of definitions can be found in the appendices.

HGVs in 2023

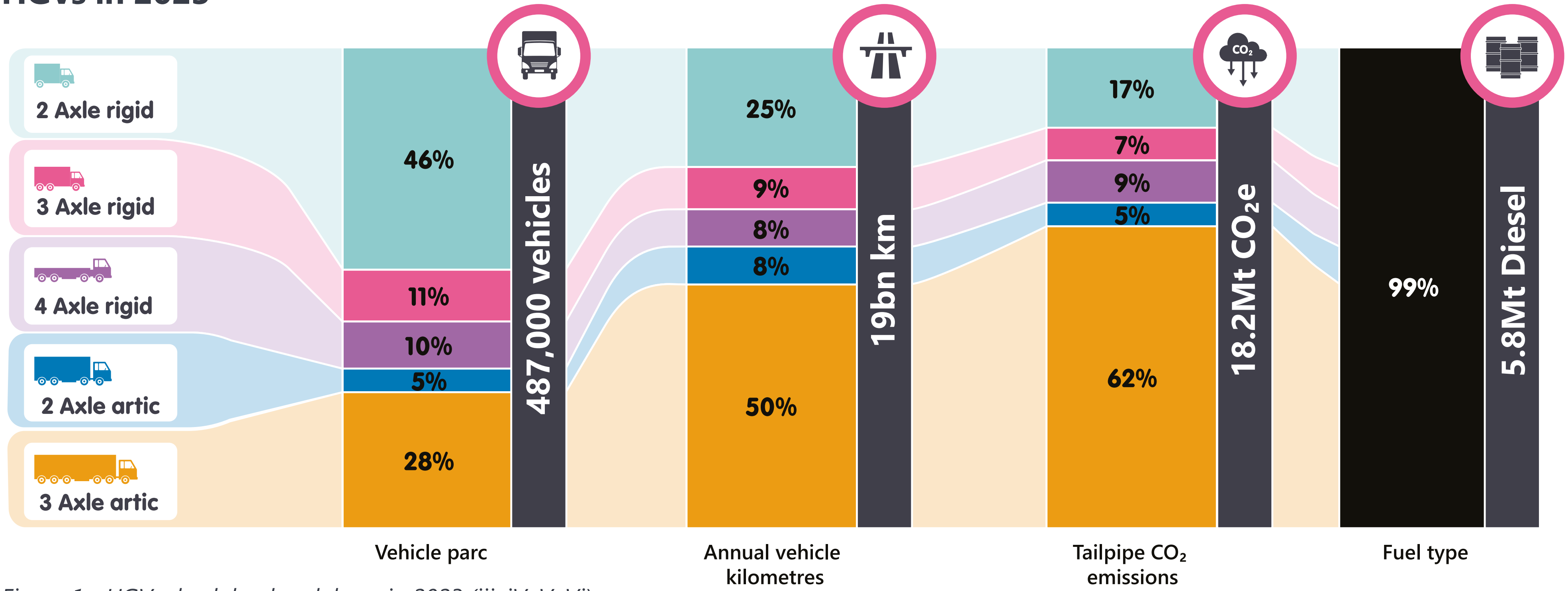


Figure 1 - HGV wheelplan breakdown in 2023 (iii, iV, V, Vi)

What could 2050 look like?

From the Core scenario

HGVs on the road

475,000 eHGVs
on the road

eHGVs make up 97% of the total fleet

100 H_2 HGVs
on the road

H_2 HGVs are 0.02% of the total fleet which is driven by a comparatively high Total Cost of Ownership (TCO)

12,000 ICE HGVs
on the road

Mostly smaller HGVs with long lifetimes but ~30% are still >40T

Charging outlets

425,000
charging outlets needed

Average install of 17,000 charging outlets a year

360,000
depot outlets installed

Public 2%
Shared Access 14%
Depot 84%

£22 Billion
on CAPEX

Estimated cost of Charging outlets only (not including installation, connection costs, or replacement at end of life)

Power demand

38 TWh
annual HGV electricity demand

Equivalent to about 12% of the total electricity used by the UK in 2023

11 GW
peak daily power demand

At around 17:30, without any managed charging

Shared Access 22%
Depot 78%

Demand split by location type
Depot 14:00-21:00
Shared Access 07:00 16:00

CO_2 emissions

21M tonnes of CO_2
saved annually vs 2025

This is a 98% reduction in annual modelled emissions compared with 2025

Exceeding the 7th Carbon Budget for HGV emissions by
13%

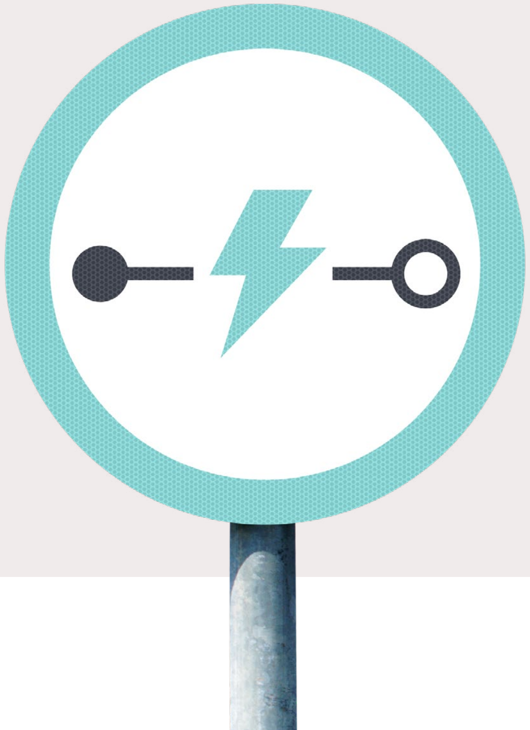
Between 2025-2050 other forms of transport may need to decarbonise quicker

515,000
tonnes CO_2 still being produced annually

Mostly from heavier HGVs

Key findings

Given our modelling assumptions **eHGVs are likely to dominate** as the zero-emission vehicle of choice across all HGV types, including long-haul journeys. In the short term Hydrotreated Vegetable Oil (HVO) could be widely adopted for long-haul HGVs. However, hydrogen HGVs could have a far higher TCO compared to eHGVs, limiting their uptake.

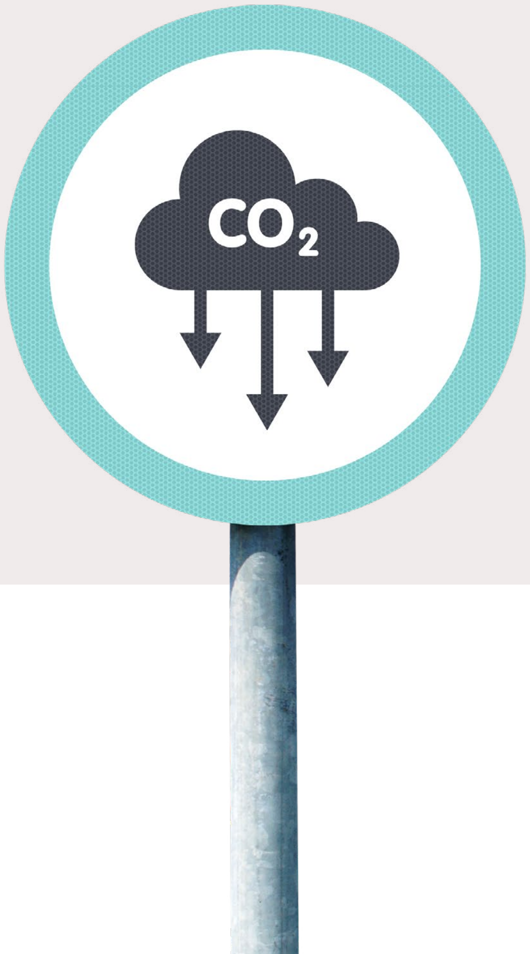


Long-haul 40t+ HGVs may require further incentives to encourage eHGV uptake, given these vehicles could lag behind other HGV types in reaching TCO parity with diesel. These long-haul 40t+ HGVs account for the **highest portion of emissions** out of all HGV types and reducing their emissions is likely to be critical to meet carbon budgets.

eHGV electricity demand in 2035 could exceed the current electricity demand in Wales (at 16TWh), and in 2045 it could exceed the current electricity demand in both Wales and Scotland (at 35TWh). **This is a significant amount of electricity to add to the electricity network**. This demand may coincide with the time of the UK wide electricity peak, meaning **managed charging could be required.**

To accommodate eHGV uptake, 70,000-90,000 dedicated eHGV charging outlets may need to be installed over the next five years, increasing to 200,000-230,000 by 2035. **This would require a swift charger rollout.**

Without further interventions, the **HGV market may not reach its carbon budget**, based on the HGV trajectory in the 7th Carbon Budget. However, **targeting incentives towards higher emitting HGVs may help** achieve the carbon budget.



A range of incentive packages were investigated, focussing on reducing the upfront cost of eHGVs. This has shown that targeting incentives at the heaviest HGVs could bring forward their uptake significantly. If carefully considered there could be mechanisms for this to be at no extra cost for the UK government compared to continuing the current plug-in grant. One option includes a carbon tax, which could be a government cost neutral way to incentivise eHGV uptake and could lead to a significant uptake of eHGVs. The downside of this is that it would add a cost burden to fleets, and likely disproportionately effect smaller operators, so detailed design would need to take these factors into consideration.

The split of depot vs shared access charging is still unknown but could have significant impacts on infrastructure and times of eHGV electricity demand. Even with around 25%-50% of eHGVs solely using shared access charging, some form of managed charging may still be needed at depots to avoid charging during peak times. V2X may also be able to help in the future with energy management.

Recommendations

The following recommendations are based on the key findings from the national HGV modelling, explored further within this report.

Fleet operators

Fleet operators should familiarise themselves with eHGV technology, the electricity market and charging market so they can make informed choices for their future operations, as eHGVs are likely to dominate zero emission HGVs.

Fleet operators should **understand the movement of their current fleet and determine how eHGVs could work within their operations.**

This will help them to understand:

- How hard-to-electrify journeys could be electrified? Hydrogen HGV options could add a significant additional cost to fleets.
- How many of their journeys could hit eHGV payload constraints? This could add extra costs to the fleet operator if extra eHGVs need to be purchased.
- How depot charging could be used to charge their eHGVs, how much shared access charging may be needed and what capacity may be available for V2X[2].

[2] Vehicle-to-Everything (V2X) is an overarching term for technology that allows energy to be transferred to and from an electric vehicle's battery. More details can be found in Section 5.3.

Fleet operators **committing to transition to eHGVs in large quantities may allow OEMs to secure supply of batteries at a lower cost.**

This could offer lower overall costs for fleet operators, and can be undertaken by individual fleets, or by fleets grouping together and using aggregated purchasing. Purchasing options are explored further in the eFREIGHT 2030 eHGV Purchasing Options and Considerations report.

Fleet operators should **investigate ways to reduce the cost of electricity for eHGVs, as energy costs are a significant part of the TCO.**

Electricity costs could account for around 20%-60% of an eHGV's TCO, depending on distance travelled and location of charging. While fleets have limited control over the cost of diesel, there are ways fleets could reduce their electricity costs. This could be through on-site generation, energy storage and managed charging for depot charging, or by negotiating competitive tariffs at shared access locations. Site based considerations, including co-location and behind-the-meter solutions, can be explored further in the Connecting HGVs and Electricity: Enabling systems and sites for eHGV charger integration report.

Fleet operators should **understand how flexible they can be with when and at what power they charge their eHGVs, while at base.**

This will help them to understand:

- If slower overnight charging could still allow all eHGVs to be fully charged for their departure time. This could reduce their addition to peak electricity demands on the network, likely reducing costs.
- If rapid overnight charging could fit within their operations. There may be high electricity demands throughout the day in the future and charging may need to shift overnight, especially in the winter.
- If they can benefit from charging at times of peak generation, especially in the summer. This may reduce electricity costs.

Fleet operators need to **understand what their uptake of eHGVs may be and the number of chargers they require over time**. They then need to **start engaging and sharing data with electricity network companies as soon as possible.**

This is because:

- Infrastructure can take time to install, and electricity network reinforcements need to be planned. Given many eHGVs may reach TCO parity with diesel in the next five years, the infrastructure will need to be in place to allow fleet operators to get the benefit of lower TCOs for eHGVs.
- Costs to install chargers and the network capacity available can vary significantly location by location. If depot charging installation costs are too high, fleets need to understand how shared access charging may impact their operations.
- There may be restrictions on when vehicles can charge in large quantities in their area, based on other local demands, both now and in the future.

Policy makers and regulators

The UK government should look at alternative incentive packages for zero emission HGVs, especially those targeted at long-haul HGVs, while considering wider energy network impacts of eHGV uptake.

The UK government should think about **targeting incentives towards long-haul 40t zero-emission vehicles**, as they may be the **furthest away from TCO parity** with diesel.

- Targeting incentives could mean reducing incentives to smaller HGVs and increasing incentives for HGVs struggling to decarbonise, ultimately balancing out at the same overall cost as continuing the current plug-in grant.
- By targeting the highest emitting HGVs, the HGV sector may be more likely to reduce emissions at a faster pace and reach carbon budgets.
- There may be wider impacts around the removal of incentives to smaller HGVs, which may affect overall zero emission HGV uptake. Changes to incentives should be considered carefully, in consultation with industry and taking into account wider implications. At the very least, the time and signalling of any removal of incentives would need to be carefully thought out.

The UK government should continue to **incentivise both upfront eHGV costs and charging infrastructure costs**.

The high charging infrastructure costs (including installation and connection to the network) may mean any TCO benefit of switching to an eHGV could be lost. This has already been recognised with the recent government funded Depot Charging Scheme. However, this funding has now closed and involved challenging timeframes for fleets to deliver on.

The UK government should **consider the impact of payload constraints on eHGV uptake**.

If fleet operators need to purchase a larger eHGV fleet compared to their diesel fleet this will add significant costs and likely delay the eHGV transition.

The UK government and Ofgem should recognise electricity network constraints may be a barrier to rapid eHGV uptake. This should be considered when choosing incentive packages and **support should be provided to network operators to enable rapid reinforcement**.

- Ofgem should provide help to network operators to ensure connecting to the electricity network does not become a barrier to eHGV uptake.
- When evaluating incentive packages, the UK government should consider the uptake of eHGVs in the short term to ensure there is not too much pressure put on the electricity network immediately.
- DfT, DESNZ and Ofgem should work together to ensure that policy for eHGVs and planning for the electricity network aligns. This is to promote policy interventions that fit within realistic network planning timeframes.

A **tax could be applied to carbon emitting ICE fuel** to discourage uptake, with the associated **revenue used to incentivise** eHGV uptake. This could be **cost neutral** to the government but would **put significant pressure on fleet operators**.

- This could significantly increase uptake of eHGVs without the need for additional government spending.
- However, the level of tax over time and distributional impacts would need considered carefully. Too high of a tax in the short term may disadvantage fleet operators who cannot switch to eHGVs due to electricity network constraints.
- Additionally, the tax could significantly impact the commercial viability of some fleets, especially considering the low profit margins of the sector.

The **UK Government should consider where innovation could be encouraged** to promote the uptake of eHGVs.

Areas for potential innovation include:

- How eHGVs can contribute to the flexibility of the electricity network.
- How managed charging could reduce pressure on the network and reduce costs for consumers.
- How electricity network operators can quickly connect chargers to the network.
- How charging infrastructure could be scaled up quickly to meet the future eHGV demand.

In the long term, the UK government may need to **consider scrappage schemes to reach net zero by 2050**.

Under almost all our scenarios there remains a small percentage of carbon emitting ICE vehicles on the road in 2050. Introducing a scrappage scheme may be necessary for the sector to reach carbon budgets.

Electricity network operators

While currently the HGV sector is an almost insignificant customer of electricity networks it will not remain that way. Electricity network operators should understand when fleets may switch to eHGVs, when they may charge and at what power. This can allow for electricity network infrastructure to be planned in line with this eHGV uptake.

Electricity network operators should **engage with fleet operators**.

This is to understand:

- Their proposed eHGV uptake, so infrastructure can be in place when it is needed.
- The mix of depot vs shared charging, as this will influence the location and time of eHGV demand.
- How open fleet operators are to managed charging, flexible connections or V2X to help enable flexibility on the wider electricity network.

Electricity network operators should try to understand **how eHGV demand may fit with other growing electricity demands in the future to avoid high peak electricity demands**. Fleet operators should be engaged to ensure any solutions to avoid peak demands can work within their operations.

Electricity network operators should **start planning now** so infrastructure is in place when needed, as there could be a significant increase in eHGVs over the next five to ten years.

Electricity network operators should communicate the options for **quickly connecting high powered chargers** (for over 1MW connections), as eHGVs may need rapid charging, even overnight.

Chargepoint operators

Chargepoint operators should engage with fleets to understand what charging requirements they may have, both in terms of location and power ratings. They should also consider if V2X would be a worthwhile venture for eHGVs.

Chargepoint operators should **engage with fleet operators**.

This is to understand:

- The level of depot charging capacity available and what level of shared access charging there may need to be, as these locations will need different charging solutions.
- What charger power ratings fleets may need at their depot, so the right chargers are available for eHGVs.

Chargepoint operators should **understand how smart charging may develop in the future** to ensure the correct types of chargers are available that allow flexibility while ensuring eHGVs are fully charged.

Chargepoint operators should **understand the potential market for eHGV V2X**.

While eHGV V2X is still in trial phase, chargepoint operators should understand the appetite for V2X from fleet operators and determine what level of revenue may be possible.

- They should engage with energy suppliers, aggregators and DNOs to understand the practicalities of supplying electricity back to the grid and what costs may be associated with this.
- They should investigate solutions such as V2V to allow eHGVs to charge using other vehicles returning to base with remaining energy rather than charging during peak times.
- They should investigate how V2X chargers could be combined with on-site storage and generation to optimise sites.

2. Introduction

The UK government, in partnership with Innovate UK, is investing £200 million into the Zero Emission HGV and Infrastructure Demonstrator (ZEHID) programme, across four innovative projects. The programme aims to roll out up to 320 zero emission Heavy Goods Vehicles (HGVs) and deliver around 75 refuelling and electric charging sites, helping to provide the crucial infrastructure required for the haulage sector to decarbonise.

As a consortium partner, Energy Systems Catapult’s remit has been to ensure that the eFREIGHT 2030 trials can gather the evidence required to understand the challenges and opportunities of electric HGVs (eHGVs) in the real world. The Catapult has also been carrying out detailed analysis and insight to support a commercially successful and rapid decarbonisation of the freight sector.

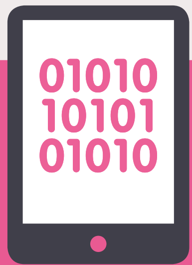
As part of this, the Catapult has completed its national whole systems modelling, investigating possible pathways for the UK HGV fleet, charging infrastructure requirements, energy demands and emission reductions. This report outlines the key findings from this modelling alongside recommendations for actions to take following this work.

Workshops were held with the eFREIGHT 2030 consortium to gather the best available data and to get a consensus on the most reasonable assumptions to make about the current HGV market and how that may change in the future. This has then been used in the Catapult's ESME Road Freight tool.

ESME Road Freight is a UK techno-economic model that uses detailed powertrain data and operating profiles to assess the role low and zero emission HGVs could play in the future vehicle parc. The model can be used to explore vehicle total cost of ownership (TCO), future fleet composition, energy demands and infrastructure requirements. By using cost and performance data, ESME Road Freight provides insights into cost-effective pathways to decarbonise UK road freight. The model does not represent fleets or energy demands geographically. It does however cover charging location types; depots and shared access[3].

Sessions were held with the eFREIGHT 2030 steering group to prioritise areas to investigate with the model. A range of scenarios were modelled to explore different possible futures and the impact of certain interventions. The scenarios are:

- **Core Scenario** – This follows all the main assumptions gathered in the workshops and includes a ban on the sale of non-zero emission HGVs in 2035 and 2040 (based on weight). It is assumed road freight demand remains the same out to 2050.
- **Incentivised Transition Scenarios** – These scenarios represent a range of cases based on different incentive packages, aimed at reducing the cost to transition to eHGVs. The three scenarios are:
  - Targeted Incentives
  - Supply Chain Incentives
  - Carbon Tax Incentives
- **Charging Scenarios** – These charging scenarios look at different levels of shared access charging, managed charging and the possibility of Vehicle-to-Everything.



The outputs from these scenarios can be seen and explored on our interactive online dashboard.

[3] A list of definitions and more detail on the charging locations can be found in the appendices.

3. A shift in gears: the transition to zero-emission HGVs

The scale of change

There are currently around 487,000 UK licensed HGVs on the road[v], travelling around 19 billion km per year[vi]. These HGVs emit around 18.2 million tonnes of CO_2e per year[vii] and consume around 5.58 million tonnes of diesel[viii]. There are many different types of HGV, from rigid vehicles with a gross vehicle weight (GVW) of 3.5 tonnes to articulated HGVs with a GVW of up to 44 tonnes. Figure 2 below shows how different body types of HGV make up the fleet, their average annual vehicle distance travelled and the carbon tailpipe emissions.

2-axle rigid vehicles make up around 45% of all HGVs in the UK. However, they only contribute around 25% of the total annual vehicle kilometres and an estimated 17% of emissions. Even though 3-axle articulated HGVs only make up 28% of the total fleet, they are responsible for around 50% of annual vehicle kilometres and an estimated 65% of tailpipe CO_2 emissions.

While 99% of HGVs currently use diesel as their primary fuel, this will need to change dramatically in the future as the fleet decarbonises. Our national modelling has looked at how the HGV fleet may change over time based on the cost of different types of vehicles. The Core Scenario follows the main assumptions agreed with the eFREIGHT 2030 consortium, as well as the government led non-zero-emission HGV sales bans and the current plug-in grant[ix].

Number of HGVs by Powertrain

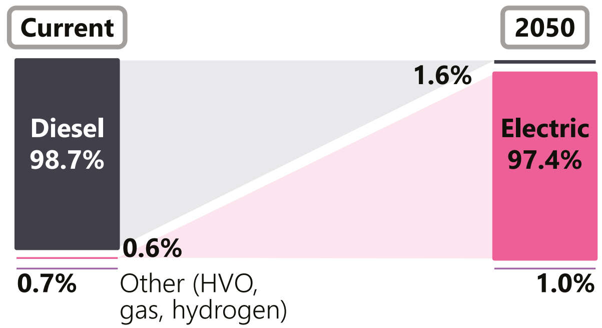


Figure 3 - Future Powertrains following the Core Scenario

HGVs in 2023

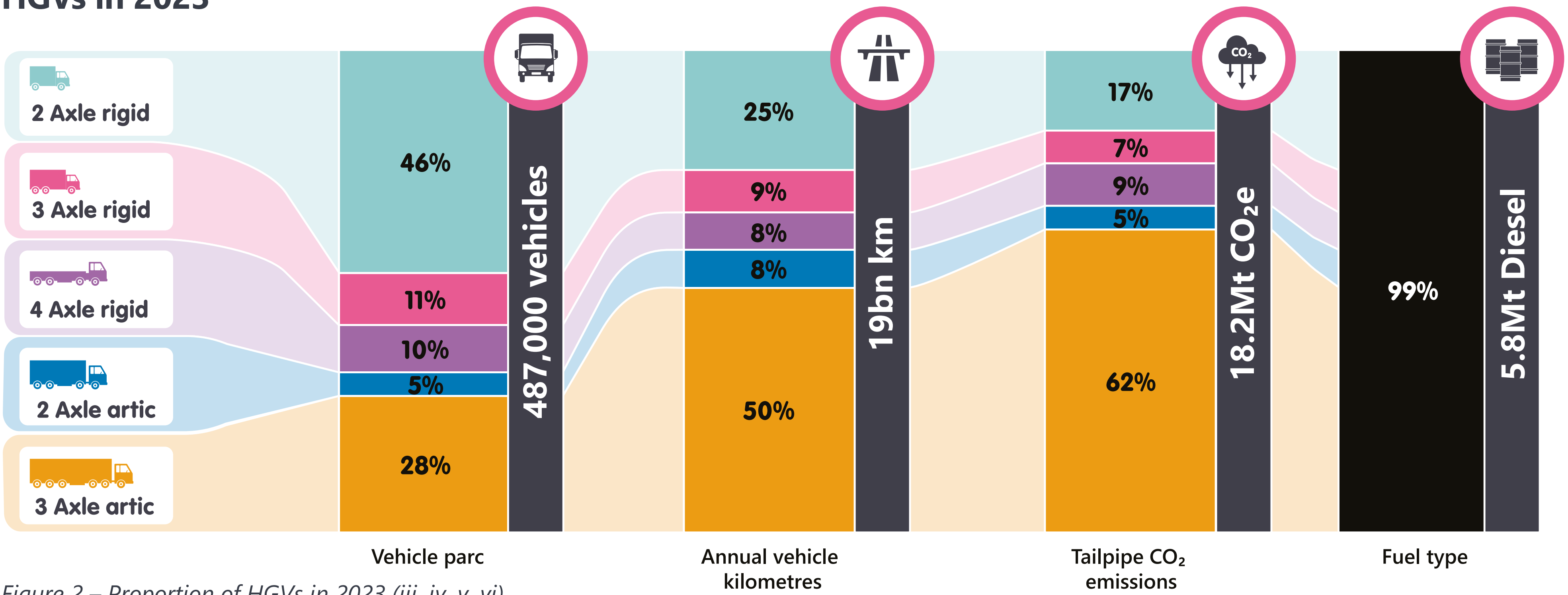


Figure 2 – Proportion of HGVs in 2023 (iii, iv, v, vi)

Our modelling indicates eHGVs are likely to dominate as the zero-emission HGV option of the future, based on the TCO. There were around 2,700 eHGVs on the road in 2023 , of which the majority were 2-axle rigid vehicles. The Core Scenario shows eHGVs could make up 97% of the total fleet in 2050, with around 470,000 eHGVs of all types on the road.

470,000
eHGVs in 2050.

Over 17,000 eHGVs added to the fleet every year on average between now and 2050.

38TWh
Annual Electricity Demand

Annual electricity demand from eHGVs in 2050.

eHGV electricity demand could exceed the current electricity demand in Wales and Scotland combined by 2045[ix].

Following the Core Scenario.

Given hydrogen HGVs could have a TCO potentially between 85% and 190% higher than eHGVs, hydrogen HGVs see a very small uptake in our modelling. **This means fleet operators should understand the movement of their current fleet and determine how eHGVs could work within their operations, as hydrogen HGVs could add significant cost to their operations.**

Almost 17,000 eHGV charging outlets needed per year between now and 2050

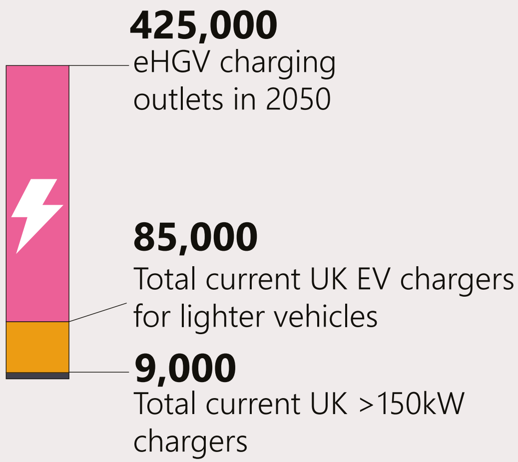


Figure 4 – Total charging outlets in 2050 in the Core Scenario vs current chargers (viii)

This eHGV uptake would mean a total overhaul of the current HGV fleet. In many cases this would mean a change to operations of HGVs to accommodate the eHGV alternative. It would also mean a significant number of charging outlets would be required to support these eHGVs.

Our modelling indicates there may need to be around 425,000 eHGV charging outlets in 2050 to accommodate the eHGV uptake seen in the Core Scenario. This is in addition to all the EV charging infrastructure required for light vehicles. Of these, 84% could be at depots, 14% at shared access locations and the remaining 2% at fully public sites. This means 360,000 outlets could need to be installed at depots over the next 25 years.

To install these chargers, network operators will need to be consulted. This is because the electricity demand from eHGVs could be very high, increasing pressure on the electricity network.

The annual eHGV electricity demand could be 38TWh in 2050 following the Core Scenario. The daily peak power demand could reach 11GW at around 17:30 without any managed charging. This would add challenges for the network. Reinforcement and solutions to balance future demands would need to be planned well in advance.[xi][xii]

The road to 2050

The scale of change in 2050 in the Core Scenario is significant, but what could the pathway be between now and 2050 look like? Our modelling provides an indication of when different types of eHGV may be purchased by fleets and the impact this could have on charging infrastructure and the wider electricity network. In our modelling, the uptake of zero-emission vehicles (ZEVs) is driven by the TCO, with the assumption fleets will be driven by cost when purchasing a new HGV.

Based on the data and assumptions gathered through engagement with the eFREIGHT 2030 consortium, rigid eHGVs could reach TCO parity with diesel by 2029. Articulated eHGVs traveling under 400km a day could reach TCO parity with diesel by 2030.

However, eHGVs travelling over 400km per day may lag behind other eHGVs for TCO parity, by around five years. It is assumed these long-haul 40t+ eHGVs[4] will require large batteries, which increases the upfront cost. They may also require more en-route charging, which could have a cost premium. This means the uptake of long-haul 40t+ eHGVs comes later than other eHGVs in our

eHGV TCO parity with diesel

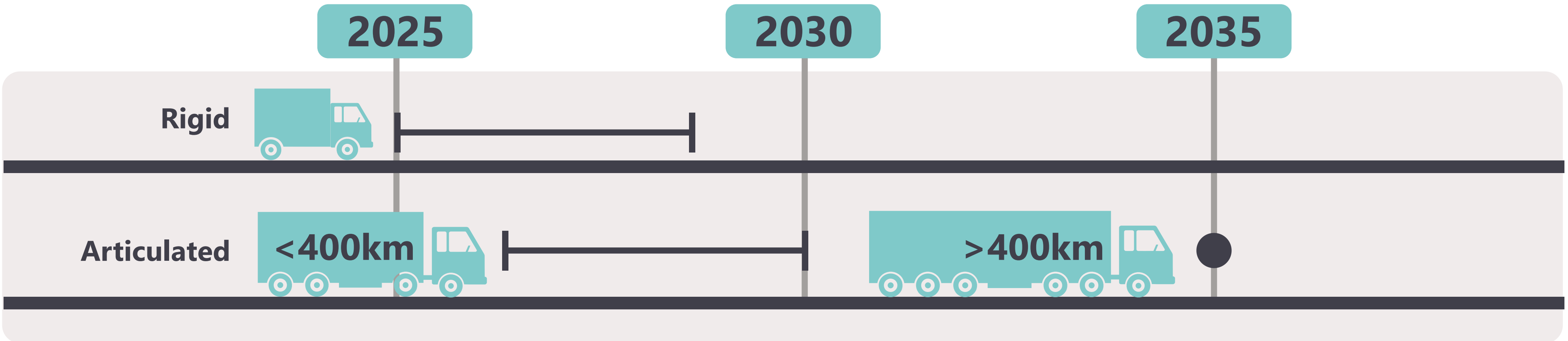


Figure 5 – TCO Parity between diesel and eHGV in the Core Scenario

[4] In this report long-haul HGVs are those travelling over 400km per day.

Core Scenario. This can be seen in Figure 6 below.

While long-haul 40t+ HGVs may only account for around 12% of UK HGVs on the road, they could account for around 45% of CO_2 tailpipe emissions. The emissions by HGV type can be seen in Figure 7 below, with a comparison to the 7th Carbon Budget[xiii].

Following 2035, as a result of the long-haul 40t+ eHGV TCO remaining high in our modelling, these HGVs may not transition to ZEV in a way that complies with the 7th Carbon Budget. Our modelling suggests this could result in an overshoot of around 13% by 2050. Therefore, long-haul 40t+ HGVs should be targeted to bring forward their decarbonisation. Mechanisms to encourage the earlier uptake of these vehicles, through a reduction in cost, is discussed further in the next section.

Even without encouraging the earlier uptake of long-haul 40t+ eHGVs, the infrastructure required for the eHGV rollout seen in Figure 6 could pose a significant challenge. The rollout of charging outlets and the annual electricity demand increases seen in the Core Scenario are shown below in Figure 8.

eHGV uptake

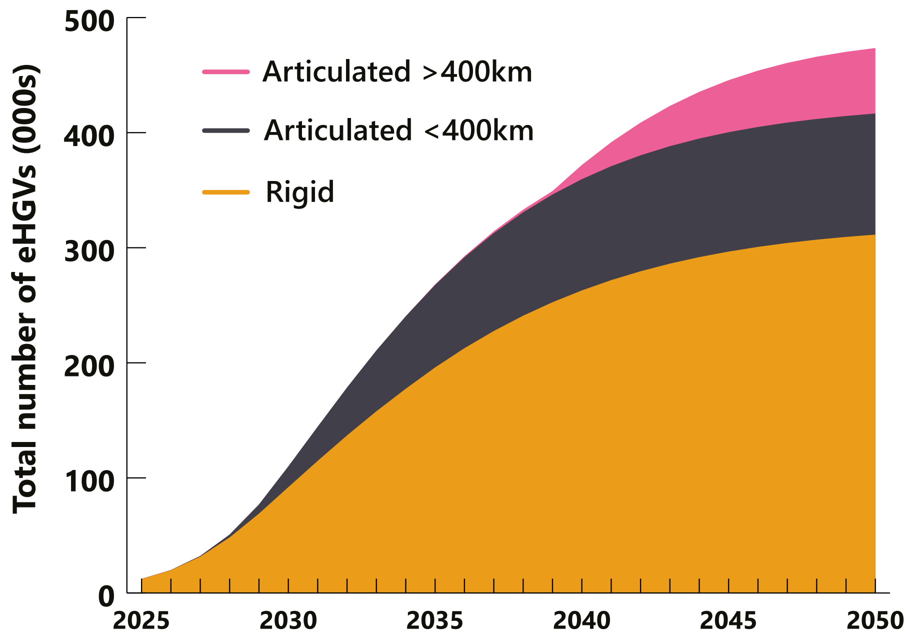


Figure 6 - eHGV uptake in the Core Scenario

HGV CO_2 emissions

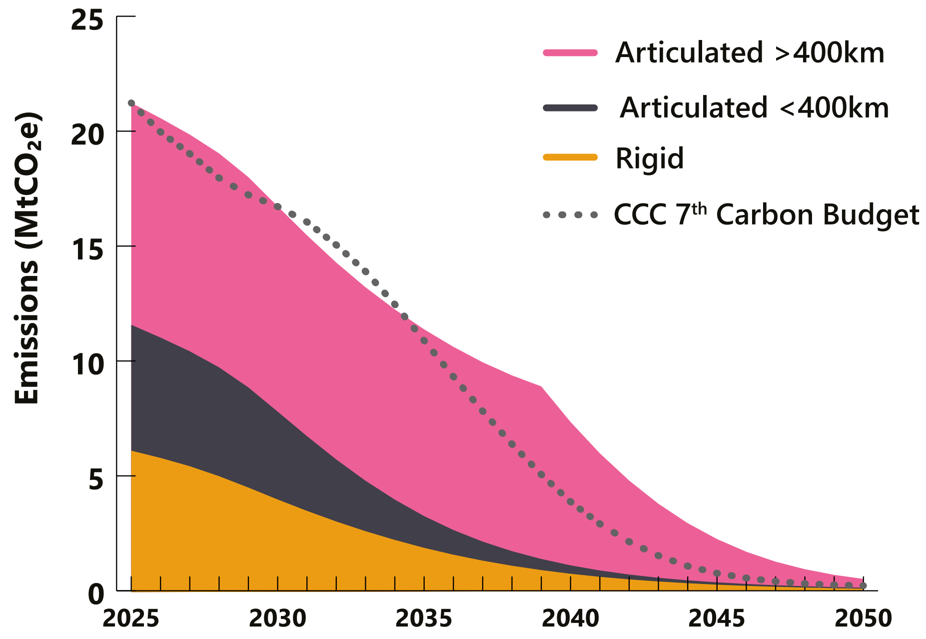


Figure 7 - CO_2 tailpipe emissions in the Core Scenario

There may need to be a rapid installation of chargers over the next five years, with an even faster installation rate following this. In the short term these chargers may be mostly for smaller eHGVs.

Following the uptake of the long-haul eHGVs, after the 2040 non-zero emission sales ban, there may be a significant increase in electricity demand given these vehicles are high consumers of energy. This would need to be planned to ensure the electricity network was ready for this increased demand. A route for this could be through existing planning processes, such as NESO's SSEP, CSNO and RESP[5] initiatives.

[5] Strategic Spatial Energy Plan (SSEP): A high-level, top-down zonal plan for Great Britain that maps out what types and capacities of electricity, and hydrogen, generation and storage are needed, where, and when.
Centralised Strategic Network Plan (CSNP): A national, long-term blueprint for transmission network infrastructure for GB.
Regional Energy Strategic Plan (RESP): Integrated, bottom-up regional multi-vector energy plans aligned with SSEP outputs but tailored to regional and local contexts.

Infrastructure rollout

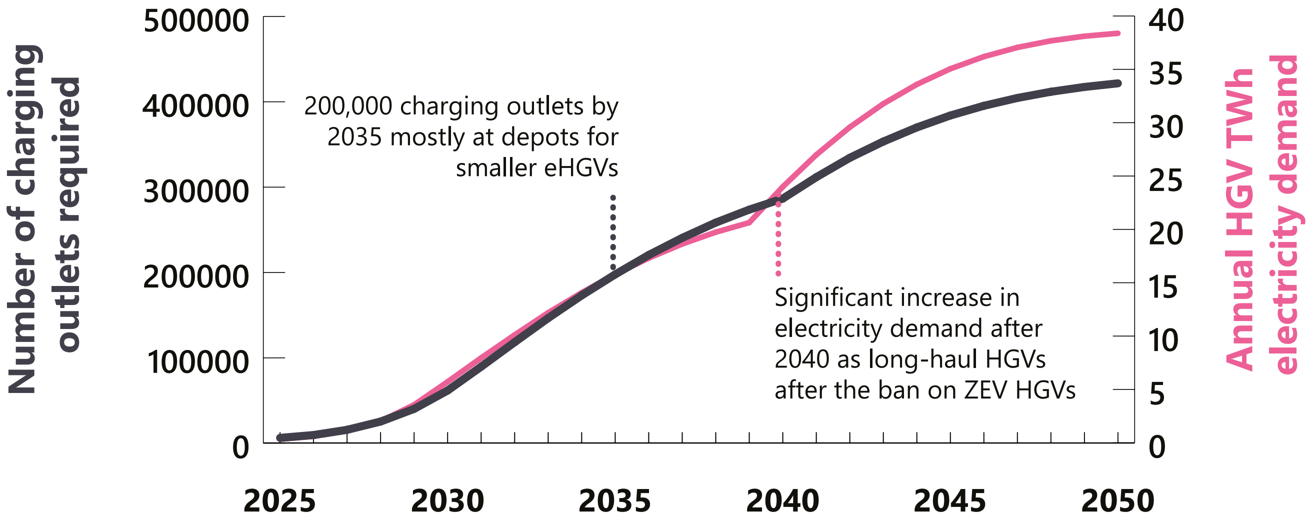


Figure 8 - Infrastructure rollout in the Core Scenario

4. The power of policy: driving eHGV adoption through incentives

As discussed in the previous section, long-haul 40t+ eHGVs may see a delayed uptake compared to other types of eHGV. Given these are the highest emitting type of HGV, enabling these to transition earlier to ZEVs is important to reach carbon targets. A range of incentive packages have been investigated, focussing on these long-haul 40t+ HGVs, with the findings summarised in this section.

The incentive scenarios are as follows:

Targeted Incentives

Instead of the current plug-in grant, in this scenario incentives are given to heavier HGVs that struggle to reach TCO parity between electric and diesel. There is an aim for the same total spend on incentives as the Core Scenario, but with more money spent on larger eHGVs instead of smaller eHGVs.

Supply Chain Incentives

In this scenario, a faster reduction in eHGV CAPEX has been assumed compared to the Core Scenario. It is assumed this would be driven by a commitment to switch to eHGVs from fleets, supported through government policy direction, allowing OEMs to plan and therefore reduce battery costs.

Carbon Tax Incentives

In this scenario, a carbon tax has been added to ICE fuels for HGVs (ramping up from 0% to 10% from 2030), with the associated revenue going towards incentives for eHGVs. Higher incentives go towards HGV segments generating higher tax (e.g. 3-axle articulated HGVs >40t). The current plug-in grant has been removed, with the only incentives coming from the tax revenue.

Total cost of ownership and eHGV uptake

The aim of the incentive packages is to reduce the upfront cost of eHGVs. This is because the upfront cost is a significant part of the TCO for eHGVs (currently between 45%-85% depending on HGV type, distance travelled and level of plug-in grant) and reducing this cost can make these vehicles more appealing to purchase compared with their diesel counterparts. It is assumed that once eHGVs reach TCO parity with diesel there will be a higher uptake.

While these incentive packages focus on the upfront cost of eHGVs, electricity costs and charging infrastructure costs are also significant factors in eHGVs uptake.

Electricity costs could account for around 20%-60% of an eHGV's TCO, depending on distance travelled and location of charging (between depot and shared access).

The Core Scenario shows that long-haul 40t+ eHGVs may reach TCO parity with diesel around 2035 (not accounting for the costs of installing charging infrastructure). Figure 9 shows how alternative incentive packages could change the year of TCO parity, potentially encouraging earlier uptake of long-haul 40t+ eHGVs. The TCO is dependent on many factors which can be investigated further in the eFREIGHT 2030 Financial Assessment Tool.

Fleet operators should investigate ways to reduce their electricity costs (such as on-site generation, storage and flexible charging) and the UK government should consider incentives for charging infrastructure as well as for the vehicles themselves.

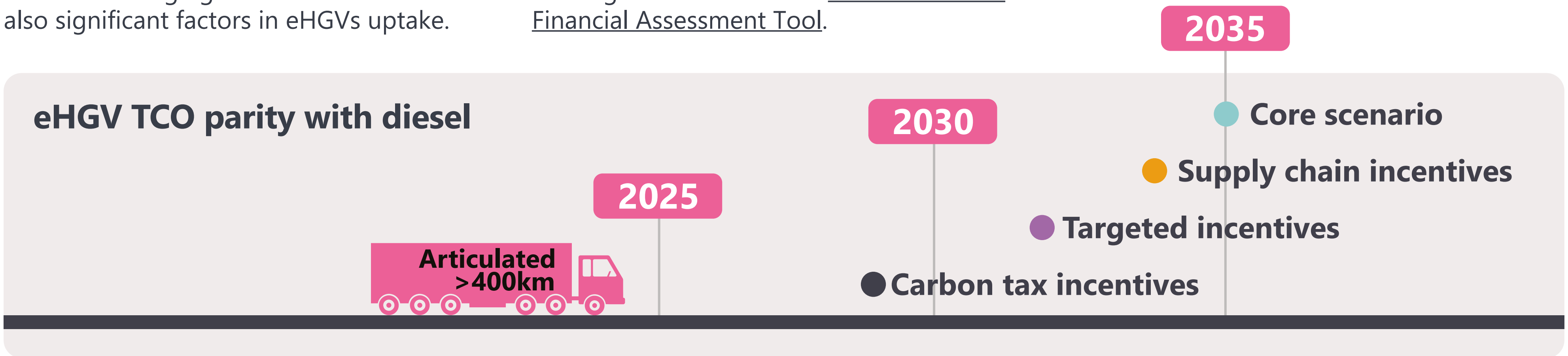


Figure 9 - Year of long-haul eHGV TCO partity by scenario

> Fleet operators committing to transition to eHGVs in large quantities may allow OEMs to secure supply of batteries and eHGVs at a lower cost.

As can be seen above, this would likely bring TCO parity between eHGVs and diesel forward. However, further incentives may still be needed to bring the TCO parity for long-haul 40t+ eHGVs in line with smaller vehicles.

These additional incentives do not necessarily need to cost the government extra money. The option of removing incentives for smaller HGVs, as they reach TCO parity with diesel, would allow larger incentives for heavier HGVs. This could mean the same total spend as continuing the current plug-in grant. As can be seen above, this has the potential to bring TCO parity forward for long-haul 40t+ eHGVs to around 2032. The years at which eHGVs may reach TCO parity, and therefore when incentives could be removed from those segments, are shown in Figure 5.

The Carbon Tax Incentives scenario shows the potential for a cost neutral way for the government to bring forward TCO parity between eHGVs and diesel for long-haul

Long-haul eHGV uptake

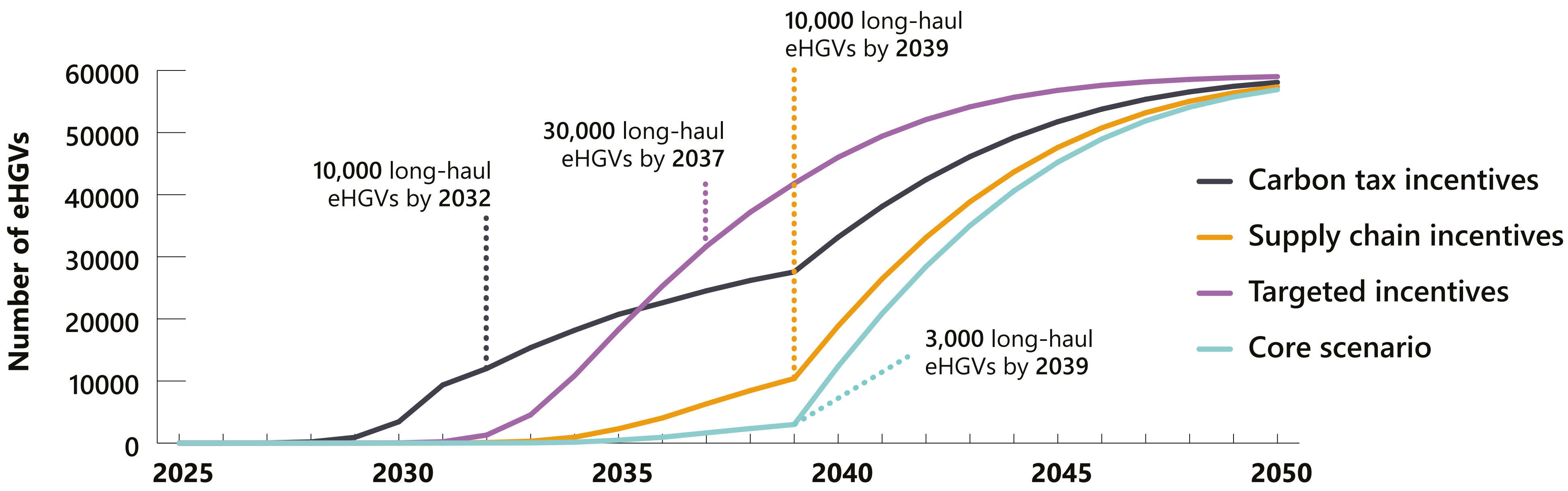


Figure 10 - Long-haul eHGV uptake by scenario

40t+ vehicles, to around 2029. However, this would increase costs for fleet operators due to increased fuel costs. This would likely disproportionately affect smaller fleet operators.

Figure 10 shows how the reduction in upfront cost for long-haul 40t+ eHGVs may encourage earlier uptake. By taxing Internal Combustion Engine (ICE) fuels and using the revenue to incentivise eHGV uptake, this would both disincentivise ICE HGVs and encourage eHGV uptake, meaning there could be a significant uptake by 2030. Alternatively, in the Targeted Incentives scenario, by focussing incentives at long-haul 40t+ zero emission HGVs instead of HGVs doing shorter journeys, there could be around 30,000 extra long-haul 40t+ eHGVs on the road by 2037 compared to the Core Scenario (which sees just 1,600 in that year).

This shows the significant impact incentive packages could have on long-haul eHGV uptake. The UK government should consider how it incentivises these vehicles specifically.

Tailpipe emissions

Given long-haul 40t+ HGVs are the highest emitting HGV type, having an earlier uptake of zero emission vehicles in this segment would likely mean a faster reduction in CO_2 tailpipe emissions. This is shown in Figure 11, where the Targeted Incentives scenario follows a trajectory that is closer to the carbon budget compared to the other scenarios.

Therefore, targeting incentives towards long-haul 40t+ HGVs could increase the likelihood of the UK meeting its carbon targets.

Annual tailpipe CO_2 emissions vs Carbon Budget 7

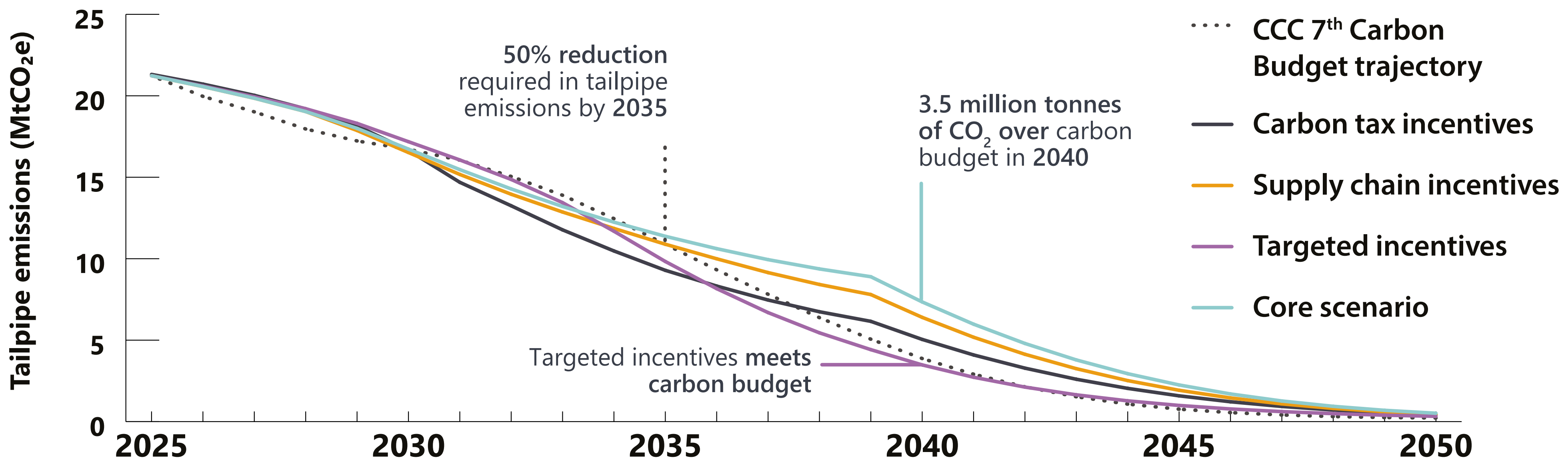


Figure 11 - Tailpipe emissions by scenario

Energy demands

This increase in uptake for long-haul 40t+ eHGVs would lead to higher electricity demands, especially given the high energy demand of these vehicles. However, depending on the incentives used, this may not impact the overall eHGV energy demand over the next five years, as shown by Figure 12.

In the Targeted Incentives scenario, removing incentives from smaller zero emission HGVs reduces uptake of those vehicles in the short term, reducing electricity demand. In the Core Scenario this persists up until 2032. However, there could be a significant increase of the heaviest long-haul eHGVs after this point, leading to dramatic increases in electricity demand up to 2040.

In the Carbon Tax Incentives scenario, the incentive given to a type of HGV is dependent on the amount of revenue generated from the fuel tax for that vehicle type. Given small HGVs travelling shorter distances use less fuel than long-haul HGVs, the level of incentive is also lower. This means a slower uptake of eHGVs for smaller vehicles in this scenario as well.

The levels of electricity demand and associated network reinforcement seen in Figure 12 could be challenging for network operators to accommodate in all scenarios.

Total eHGV electricity demand by scenario

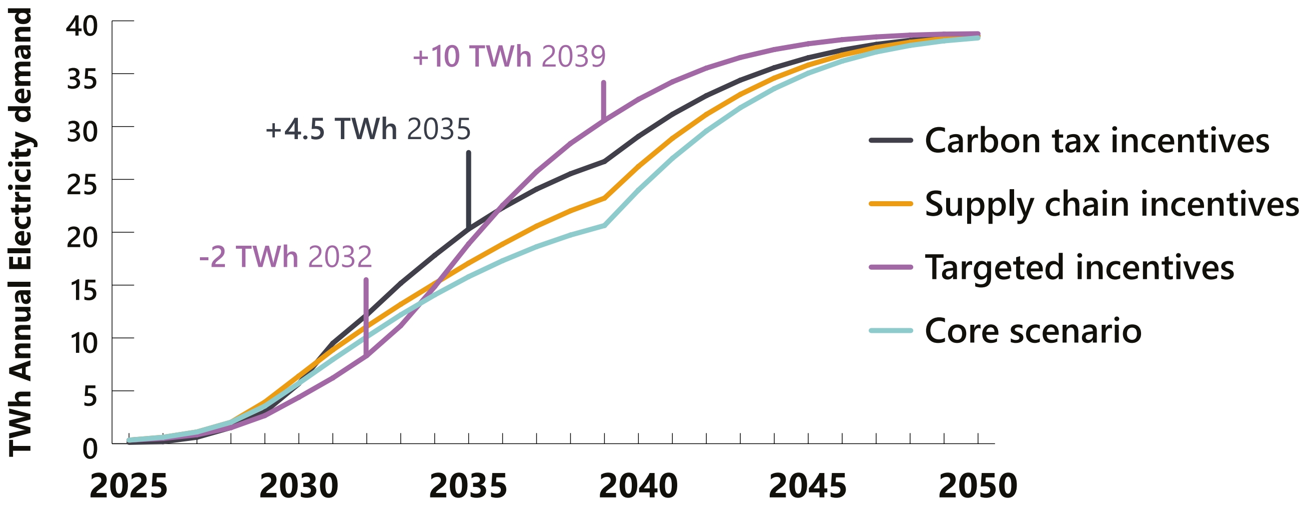


Figure 12 - Electricity demand by scenario

Therefore, the UK government and Ofgem should recognise the high volume of network reinforcement required may be a barrier to rapid growth in eHGV charger installations. This should be considered when choosing incentive packages and support should be provided to network operators to enable rapid reinforcement.

Charging infrastructure

Not only will the electricity network need to be reinforced rapidly, but charging infrastructure will also need to be installed quickly to accommodate eHGV uptake across all scenarios. There may need to be 90,000 new charging outlets by 2030 and a further220,000 by 2035 to accommodate the eHGV uptake seen in the Core Scenario, as shown in Figure 4 5.

While the Targeted Incentives and Carbon Tax Incentive scenarios show the possibility of a slower rate of charger installations over the next five years (due to a slower uptake of smaller eHGVs), the installation rate could still be challenging.

Installing a new network connection or upgrading an existing one for a charger installation can take time, and local network infrastructure may need upgrading to accommodate the additional demand. This has been demonstrated by the planning of the infrastructure for the eFREIGHT 2030 trial. In one case the timeframe provided by

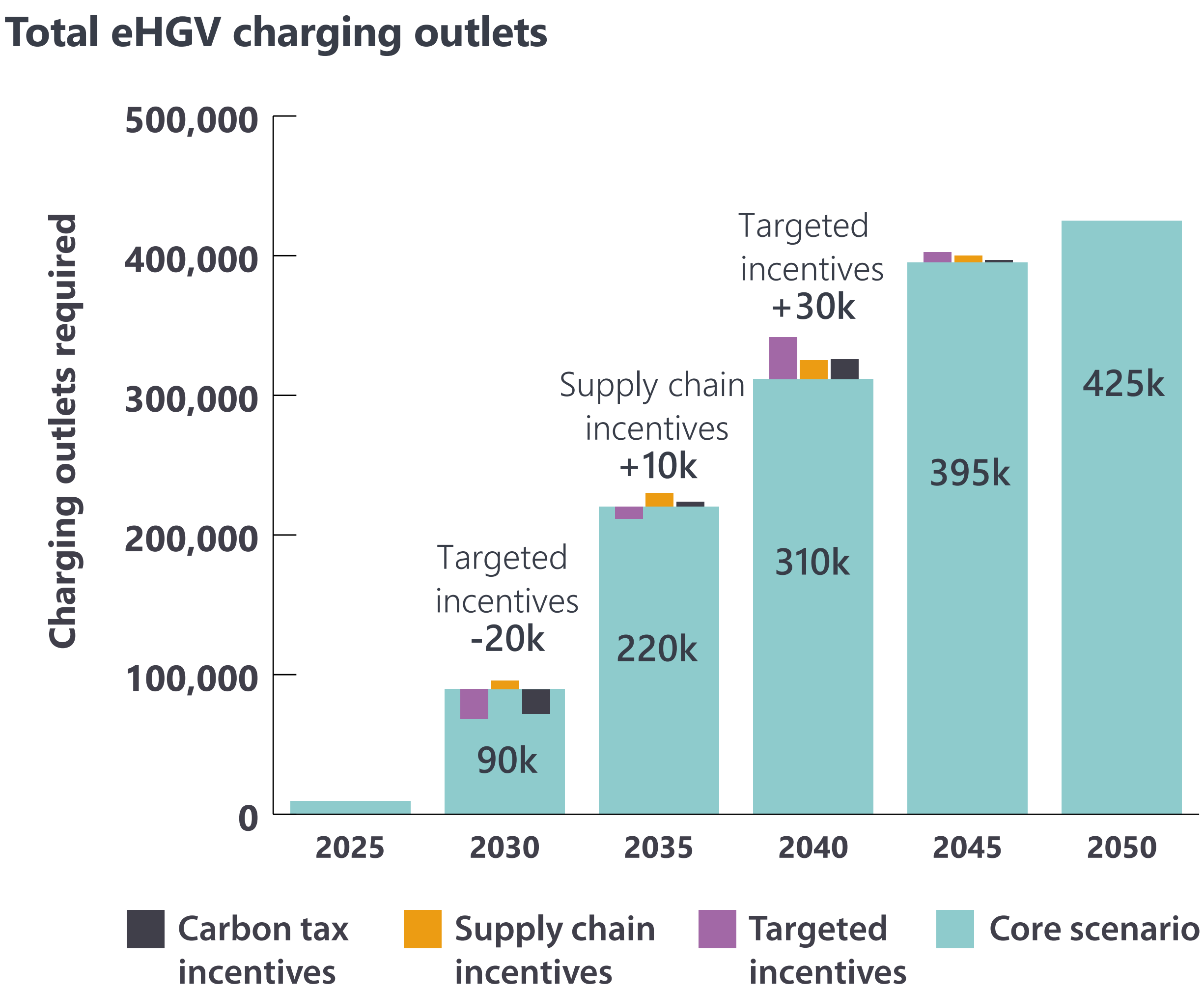


Figure 13 - Charging outlet installations vs Core Scenario

a DNO to connect to the network was over 5 years. This was for a single 1MW charger, but as the number and size of connections increase, so will the timeframes. More detail on connecting to the electricity network and innovative solutions for connecting quicker can be found in the Connecting HGVs and Electricity: Enabling systems and sites for eHGV charger integration report.

Therefore, fleet operators need to understand what their uptake of eHGVs may be, their locational energy demand and the number of chargers they require over time. They then need to start engaging and sharing data with DNOs as soon as possible.

Electricity network operators should also start planning now so infrastructure is in place when needed, as there could be a significant increase in eHGVs over the next five to ten years. NESO should include eHGVs within their strategic planning processes (such as the SSEP, RESP and CSNP).

5. Powering the fleet: the eHGV charging market and grid impact

Historic fleet telematics data of thousands of journeys from eFREIGHT 2030 consortium has been interrogated to analyse when and where eHGVs may stop during their journeys. This was used to derive average trip characteristics by HGV type over a typical working day, including distances travelled and dwell times at depots and potential shared access charging sites.

In the Core Scenario there is an assumption that eHGVs will charge at depots as much as possible, given this will likely be the location with the cheapest per kWh electricity cost[6]. It is also assumed that vehicles plug in and charge as soon as they arrive back at base, using a 150kW connection.

Following these assumptions, eHGV electricity demand could have a large peak at the same time as the current wider UK electricity system. This is shown in Figure 14, for eHGV electricity demand in 2030, 2040 and 2050 in the Core Scenario.

If this were the case, this could add significant costs to fleets as electricity prices could be increased at the time of high eHGV demand. This would also mean extra cost for electricity infrastructure if eHGVs added to peak demands, both in terms of balancing demand and supply and building network capacity.

There are several mechanisms that could reduce this peak or move it away from the wider UK peak. This could be through managed charging, more shared access charging or through Vehicle-to-Everything. These are discussed in the following sections.

[6] It is assumed that depots will have the cheapest per kWh electricity cost as a markup will likely be applied at public charging locations.

Daily electricity demand in the Core scenario

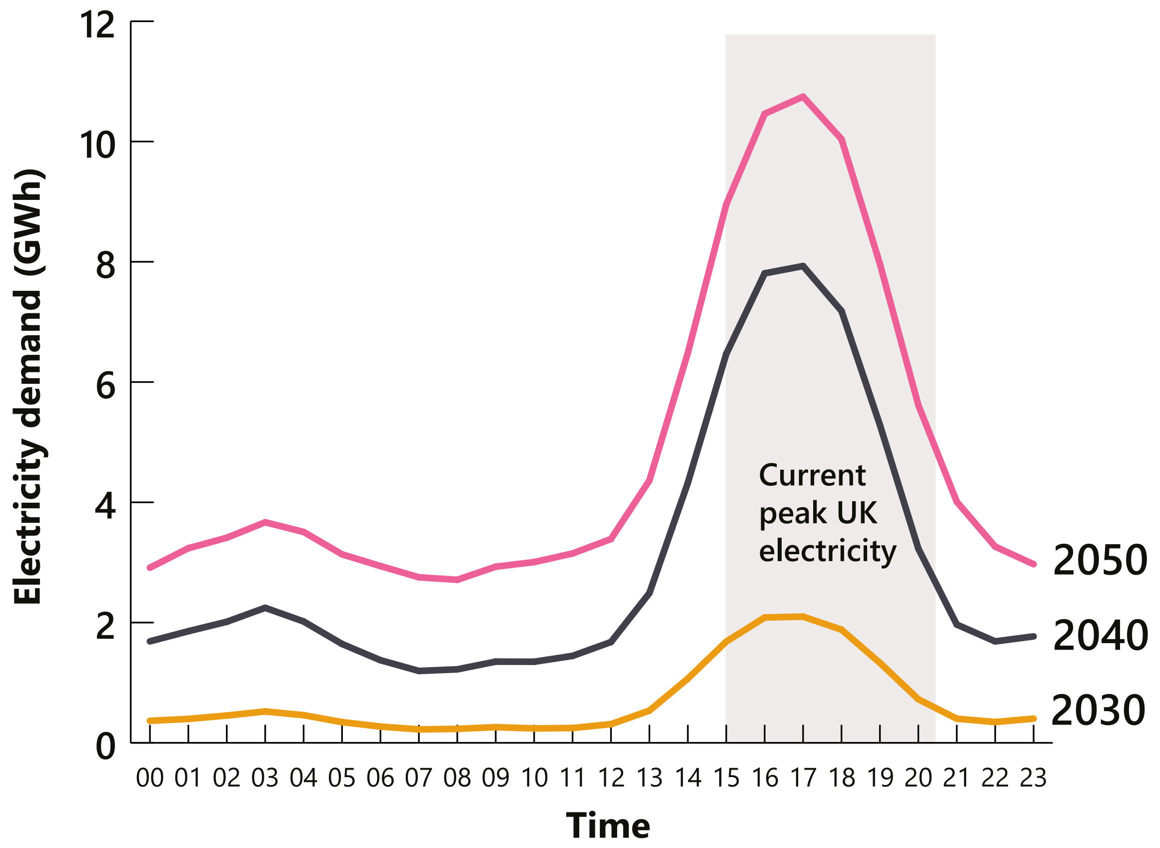


Figure 14 - 2050 Core Scenario daily electricity demand profile

Managed charging

To reduce the eHGV demand during peak times, there could be a range of solutions. One simple solution is to use lower powered chargers (or high-powered charger at a lower charging rate) where possible. In cases where eHGVs are plugged in all night, lower powered chargers could help reduce the peak.

This is dependent on eHGV operations, as some eHGVs may still require high powered chargers. However, even a mix of low- and high-powered chargers could reduce the peak demand significantly, as shown by Figure 15.

Whilst this may be a simple short-term solution, as the demands on the electricity network change over time, more eHGV demand may need to be shifted overnight. This may be even more critical in the winter where the electrification of heat and industry may lead to high electricity demands during the daytime, meaning eHGV demand may need to be delayed to overnight. This would require chargers that can deliver more energy in a shorter charging window.

Daily demand with managed charging (2050)

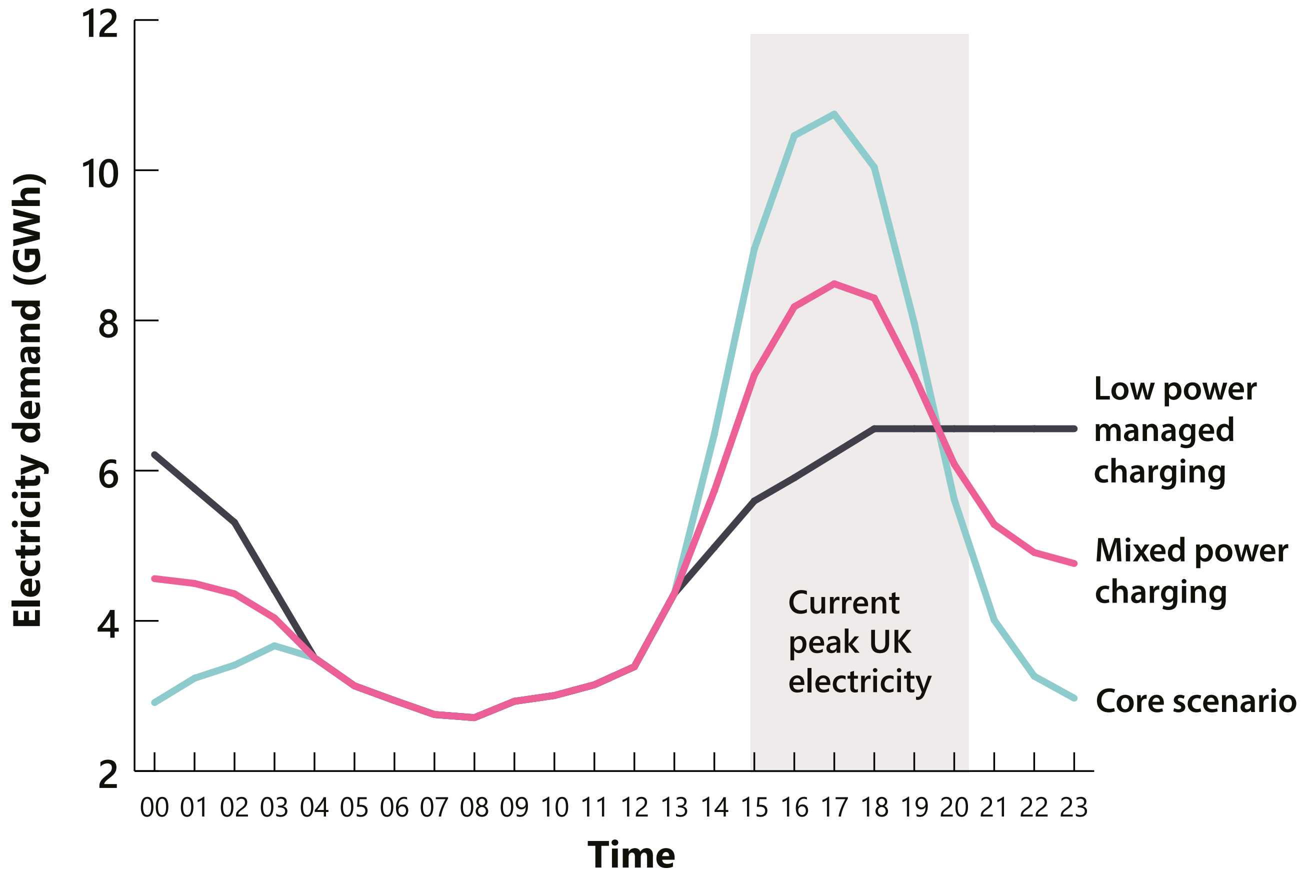


Figure 15 - 2050 demand profile with lower powered charger

Potential future dynamic overnight charging profiles across the summer and winter are shown in Figure 16.

Given there could be a range of managed charging options, **fleet operators should understand how flexible they can be with what power and when they can charge their eHGVs while at base, while still being able to meet their operational requirements.**

If all of road transport (including cars and vans) charged overnight this would likely create a new peak demand overnight, potentially at the time of the lowest electricity generation.

Therefore, electricity network operators should try to understand how eHGV demand may fit with other electricity demands in the future to avoid high peak electricity demands. Fleet operators should be engaged to ensure any solutions to avoid peak demands can work within their operations.

Managed charging profiles based on wider network (2050)

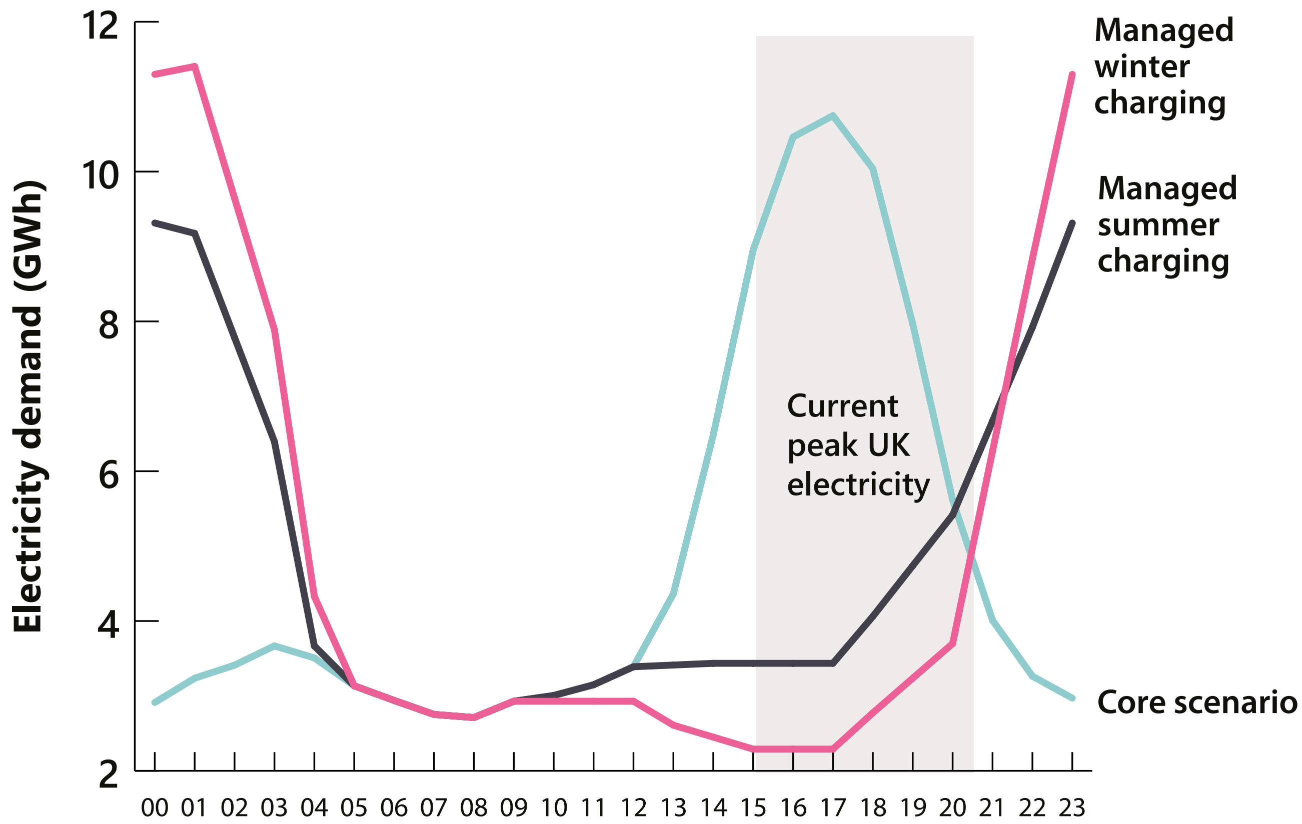


Figure 16 - 2050 overnight charging profiles

Shared access charging

This section looks at how charging at different locations could impact the infrastructure required and the profile of daily electricity demand. The locations discussed are not specific geographic locations, rather types of locations such as depots or different shared access options. Shared access charging is any charging away from the fleet's own depot. For example, this could be public chargepoints on motorways, shared hubs located near depots or at other fleet's depots with chargers open for shared access.

At depots, the fleet would need to pay the costs associated with the charging infrastructure, installation and network connection costs. Through this investment the fleets could then access a cheaper unit price for electricity at their site, as they would be buying direct from the energy retailer and could negotiate tariffs that meet their operational needs.

At shared access locations, the developer would need to recoup the same upfront infrastructure costs, meaning a higher unit cost for electricity at these sites. It is also likely the chargepoint provider would add a margin to the unit price to cover their operation costs and to generate a profit. While the unit price of electricity may be higher at shared access sites, there may be cost benefits for fleets to use these locations.

The cost to install chargers at depots, including electricity network connection costs, are not insignificant and can vary significantly site-by-site. This means at some locations the cost to install chargers may outweigh the benefit of cheaper electricity. Additionally, many fleet operators may not own their depot sites, adding a barrier to installing chargers. Therefore, shared access charging may be more prevalent than seen in the Core Scenario, where the majority of charging happens at depots.

Fleets will need to understand what their mix of own infrastructure and shared infrastructure may be and how this will impact their operations. This is investigated further in the eFREIGHT 2030 Accelerating the Transition: Business models for eHGV scale-up report and be explored by fleets using the Pre-feasibility eHGV Financial Assessment Tool.

In this work we have looked at the cases of 25% and 50% of over 40t eHGVs charging fully at shared access locations, making the assumption that they do not have access to depot charging. The focus of this analysis was on HGVs over 40t, as we have the most comprehensive historical fleet movement data available for these vehicles.

Therefore, fleet operators should engage with network operators, landlords, chargepoint providers and installers now to understand the feasibility and costs of installing chargers at their depots.

Charging outlets required for over 40t eHGVs Core scenario vs 50% eHGVs without depot charging

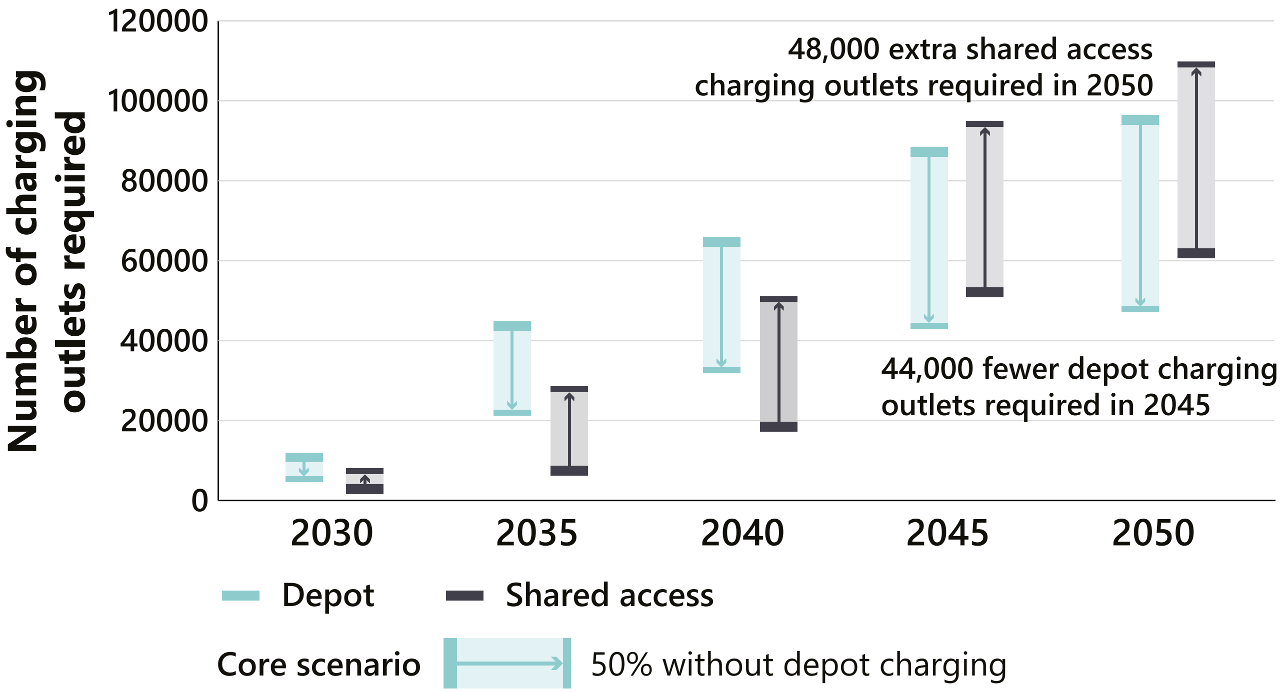


Figure 17 - Charging outlets by scenario

Figure 17 shows how the number of charging outlets at different locations could change significantly if 50% of eHGVs did not have access to depot charging. More shared access charging could save UK fleet operators between £1 billion and £2 billion on upfront costs for chargers between now and 2050, with additional savings for fleets from installation and network connection costs.

However, charging at shared access locations would likely increase the day-to-day operating costs of eHGVs, due to higher electricity costs. The trade-offs between costs and operations will differ fleet by fleet and location by location.

The location of charging not only impacts the costs for fleets, but also the time of day of electricity demand and the strain on the electricity network. When charging at shared access locations, eHGVs would mostly charge during their working shift. This could be during driver breaks, drop-offs or pick-ups. In some cases, additional stops may be needed en-route to top up the battery. These stops would likely increase electricity demand during the middle of the day, as shown in Figure 18.

Higher shared access charging may decrease the eHGV peak demand in the evening as more charging would happen during the day, meaning less is required when the eHGV returns to base. Though some form of managed charging may still be needed during peak times.

Electricity network operators need to understand the potential mix of depot vs shared access charging, as this will influence the location and time of eHGV demand.

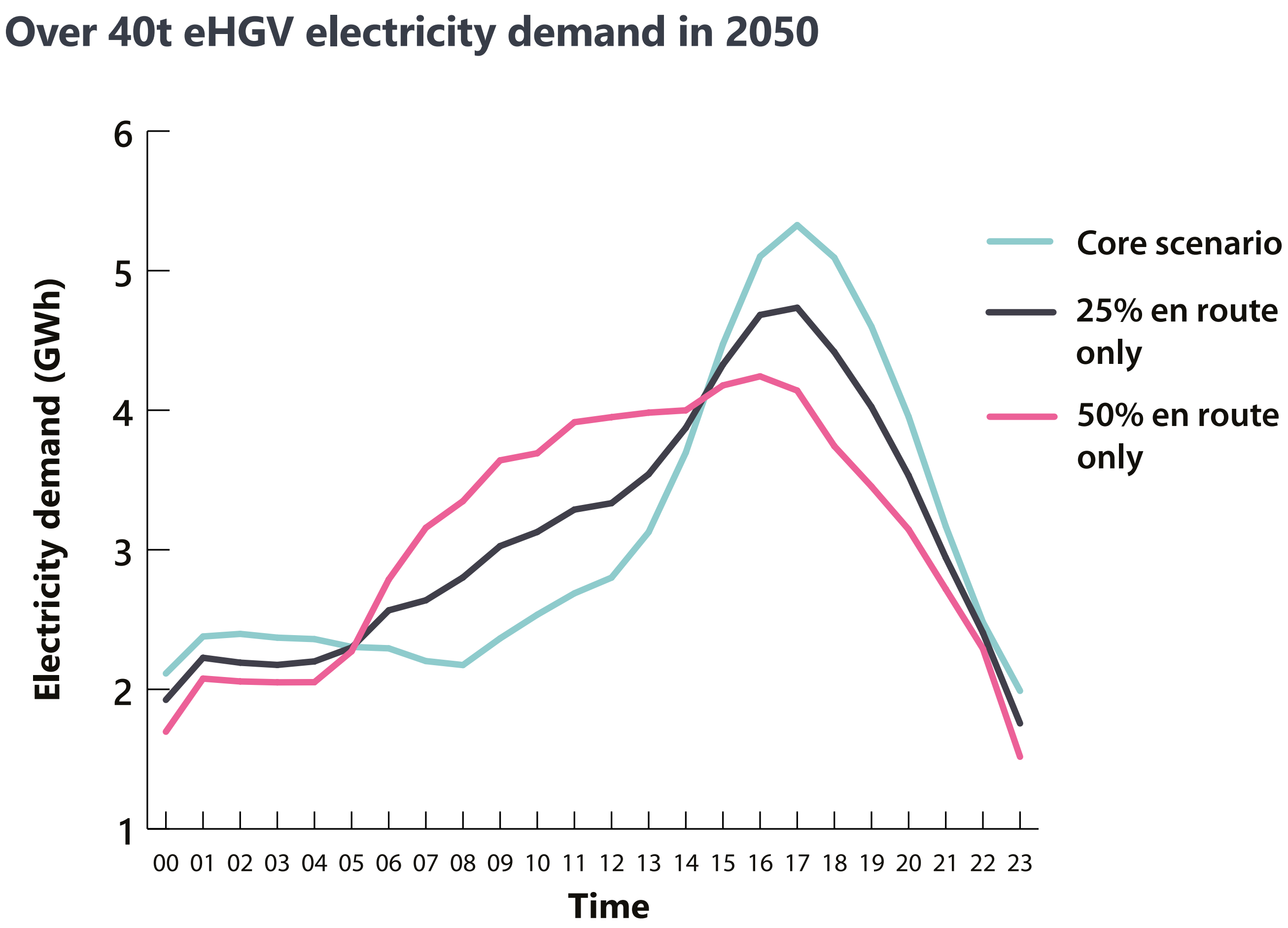


Figure 18 - Demand profile by scenario

Vehicle-to-Everything (V2X)

eHGVs have large batteries that could also be used as a form of energy storage, discharging unused energy for other purposes when not needed by the eHGV for driving. This unused electricity stored in eHGVs could go back to the electricity grid at peak times, to buildings nearby or to other vehicles on site. Vehicle-to-Everything (V2X) is a term used to encompass all of these options (and more).

V2X could allow fleets to gain additional revenue from selling electricity back to the grid during peak times. It may also mean less electricity network reinforcement could be needed if peak electricity demands were reduced.

Figure 19 shows the potential amount of energy stored in eHGVs while at depots in 2050 (in pink), alongside the energy available for V2X (in blue). This assumes that the maximum discharge power is the same as the depot outlet charging power (150kW) and that eHGVs will not drop below 20% state-of-charge (SoC) during V2X.

Total stored energy and the amount available for V2X

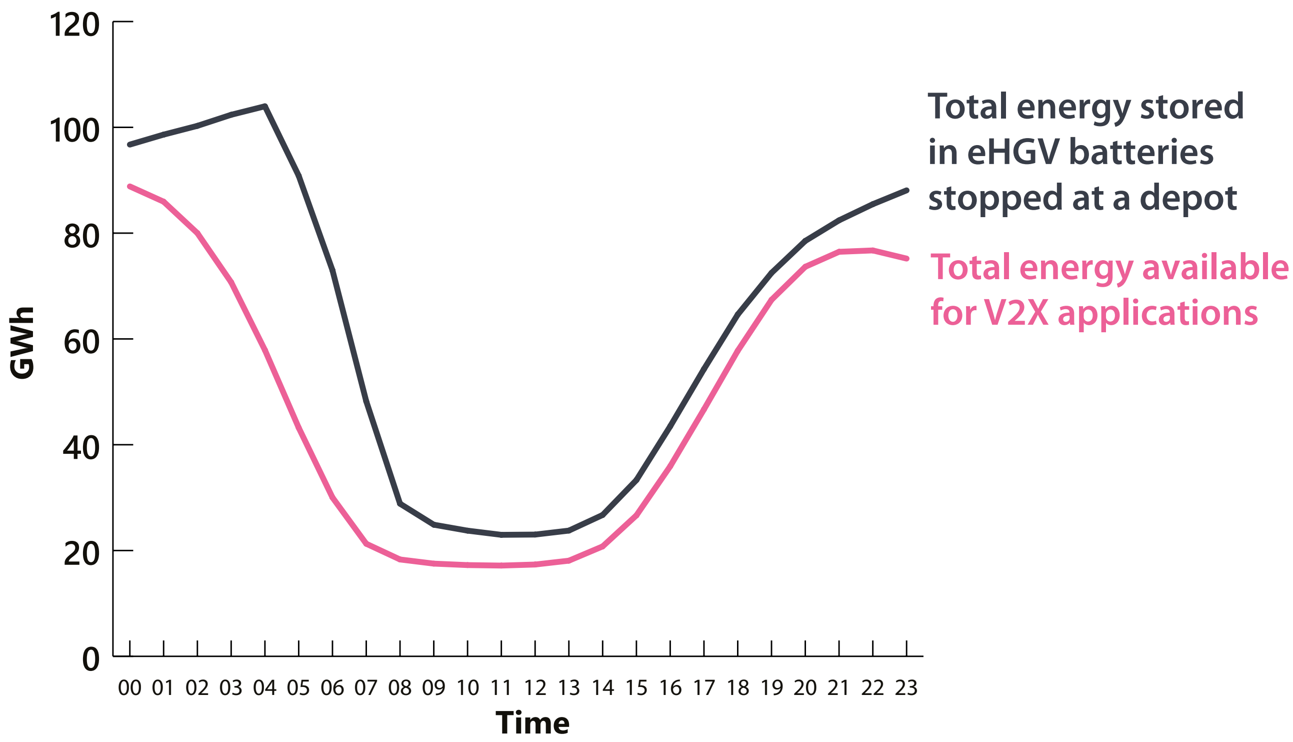


Figure 19 - V2X capacity available in 2050

The actual energy available in the future will depend on the discharge power for V2X chargers and the daily driving patterns of eHGVs. Even so, this shows a large capacity for V2X applications from eHGVs throughout the whole day. In peak times for grid demand there could be around 50GWh of available energy stored in eHGVs at depot locations, increasing further overnight.

If eHGVs discharge during peak times, either back to the grid or to other vehicles, this could lead to an increased level of peak demand for eHGVs overnight. This is because the eHGVs will need to get back to the full battery level, with additional energy needed to account for the amount discharged, all during a shorter timeframe overnight.

Electricity network operators, chargepoint operators and fleet operators should work together to determine the potential for V2X based on fleet operations for eHGVs, what constraints may exist in V2X chargepoints and how V2X could benefit the wider network.

6. Watt next? Recommendations and conclusions

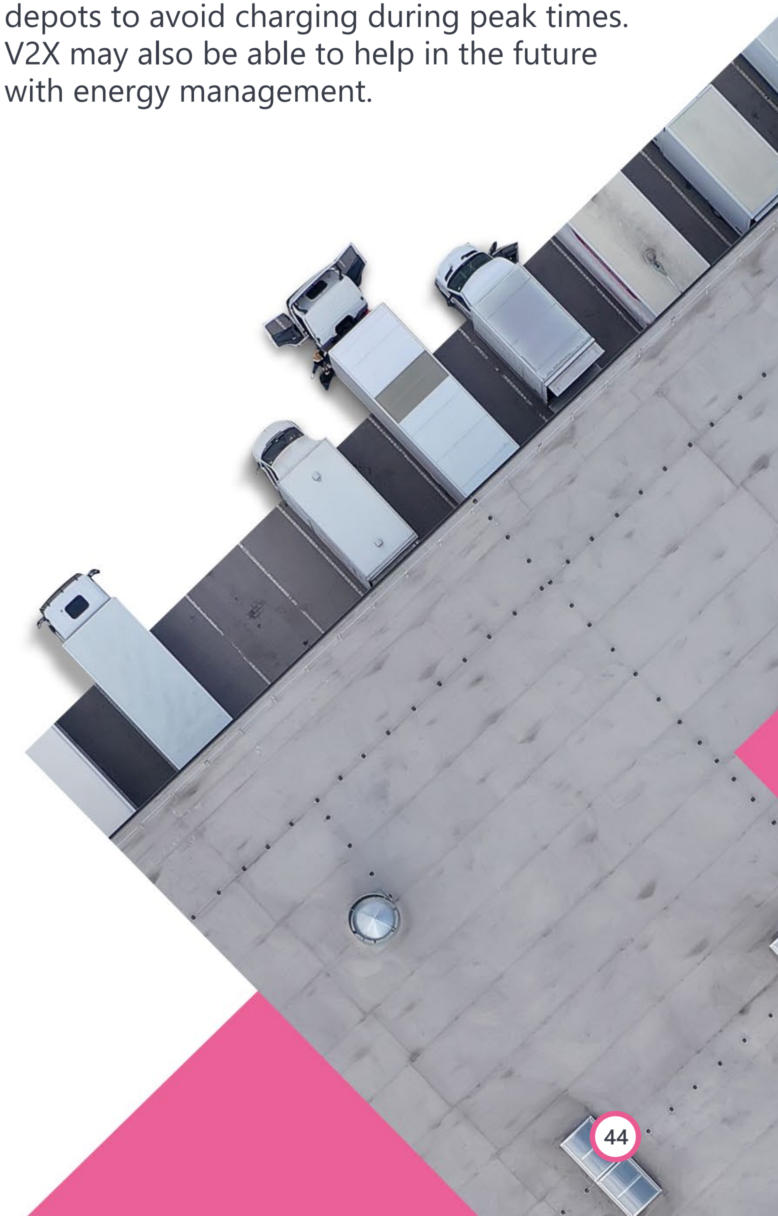
As part of the Zero Emission HGV and Infrastructure Demonstrator (ZEHID) programme, and the eFREIGHT 2030 consortium, Energy System Catapult is leading the evidence gathering, analysis, and insight to ensure these large-scale trials generate the knowledge needed to overcome barriers, inform stakeholders, and support a commercially viable pathway for decarbonising road freight. This report has covered the Catapult's national whole systems modelling, exploring possible futures for the UK HGV fleet, charging infrastructure, energy demands, and emissions reductions. The analysis has drawn on input from consortium workshops, which helped establish agreed assumptions about current market conditions and future trends.

This analysis indicates eHGVs may dominate as the zero-emission vehicle of choice from a TCO perspective, given the high costs of hydrogen HGVs. Many segments of eHGV could reach TCO parity with diesel over the next five years, not accounting for infrastructure costs. However, the long-haul 40t+ eHGVs may take longer to reach parity due to high upfront costs and the need to charge at shared access locations, where energy costs are higher. Given long-haul 40t+ HGVs are the highest emitters, these should be a target for further intervention to encourage their uptake.

A range of incentive packages were investigated, focussing on reducing the upfront cost of eHGVs. This has shown that targeting incentives at the heaviest HGVs could bring forward their uptake significantly. If carefully considered there could be mechanisms for this to be at no extra cost for the UK government compared to continuing the current plug-in grant. One option includes a carbon tax, which could be a government cost neutral way to incentivise eHGV uptake and could lead to a significant uptake of eHGVs. The downside of this is that it would add a cost burden to fleets, and likely disproportionately effect smaller operators, so detailed design would need to take these factors into consideration.

To support the uptake of eHGVs, chargepoints need to be installed and the electricity network needs to be reinforced, at a time when other parts of the economy are also electrifying and placing new demands on the networks. This will likely need to happen at a rapid rate, with the potential for eHGV electricity demand in 2035 to exceed the current electricity demand in Wales. By 2035 around 200,000-230,000 charging outlets may need to be installed.

The split of depot vs shared access charging is still unknown but could have significant impacts on infrastructure (such as location and charger power) and times of eHGV electricity demand (avoiding peak times). Even with around 25%-50% of eHGVs solely using shared access charging, some form of managed charging may still be needed at depots to avoid charging during peak times. V2X may also be able to help in the future with energy management.



Key Findings

They key messages from this report are shown below, with key findings around the HGV fleet shown in blue and findings around the infrastructure in grey.

HGV Fleet

Given our modelling assumptions **eHGVs are likely to dominate** as the zero-emission vehicle of choice across all HGV types, including long-haul journeys. In the short term HVO could be widely adopted for long-haul HGVs. However, hydrogen HGVs could have a far higher TCO compared to eHGVs, limiting their uptake.

Long-haul HGVs may require further incentives to encourage eHGV uptake. These vehicles account for the **highest portion of emissions** out of all HGV types and reducing their emissions is likely to be critical to meet carbon budgets.

Most eHGVs could have a **competitive TCO with diesel by 2030** (excluding infrastructure costs), before the ICE sales bans in 2035 and 2040. However, the HGVs travelling over 400km per day could struggle to reach TCO parity, without additional action.

HGV Fleet

Targeted incentives

Removing incentives from lighter zero-emission HGVs and redistributing incentives to long-haul, 40t+ HGVs, could result in an **earlier increase in eHGV uptake** for these long-haul vehicles, without significantly halting uptake of lighter eHGVs.

The earlier switch to eHGVs of the highest emitting vehicles **increases the likelihood of meeting carbon budgets.**

This would **accelerate the need for charging and electricity network infrastructure rollout**.

Carbon tax incentives

Taxing carbon emitting fuels for HGVs and using the revenue to incentivise eHGV uptake could be a **fully funded** way for the UK government to **promote eHGV uptake, especially for long-haul vehicles**.

However, a **significant cost would be shifted to fleets** through higher taxes. Additionally, these taxes could disproportionately **affect smaller operators**.

The implementation would need to be considered carefully, and incentives may need to be more evenly spread over time.

Supply chain incentives

Certainty around eHGV vehicle demand for OEMs could result in a **reduction of upfront costs** for eHGVs.

This mostly supports eHGV uptake in the **long-haul, 40t+ eHGV segment**.

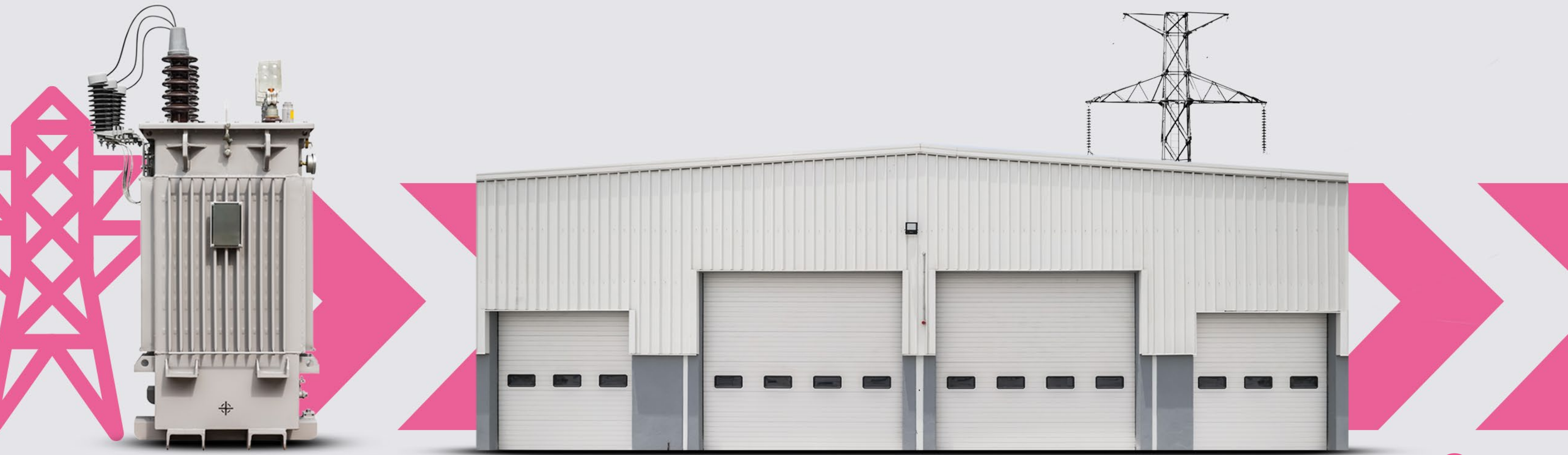
This scenario does not reach the carbon budget in our modelling, and **further incentives could still be needed** to make long-haul, 40t eHGVs cost competitive.

Infrastructure

eHGV electricity demand in 2035 could exceed the current electricity demand in Wales, and in 2045 it could exceed the current electricity demand in both Wales and Scotland. **This is a significant amount of electricity to add to the electricity network.**

To accommodate eHGV uptake, 70,000-90,000 charging outlets may need to be installed over the next five years, increasing to 200,000-230,000 by 2035. **This would require a swift charger rollout.**

Without further interventions, the **HGV market may not reach its carbon budget**, based on the HGV trajectory in the 7th Carbon Budget. However, **targeting incentives towards higher emitting HGVs may help** achieve the carbon budget.



Infrastructure

Managed charging

Without some form of managed charging, **eHGV electricity demand may peak at the same time as the wider UK peak.**

Using **slower power chargers** where possible **could significantly reduce the peak** electricity demand.

Where the grid is currently constrained, or in the future as electricity demand grows, **smarter versions of managed charging may be needed** to move demand away from peak times. This could **delay charging until later in the evening or encourage charging during times of high renewable generation.**

Increased shared access charging

Increased shared access charging is likely to **increase the cost of electricity** for fleet operators. However, it **may still save them money overall** depending on the cost to install charging at their depots, which can be very site specific.

If more eHGVs use shared access charging this can help **reduce the peak demand** on the grid. However, some form of **managed charging may still be needed** to reduce this peak further.

Some eHGVs may need to **stop more often or for longer** than their diesel counterparts in order to charge only using shared access locations.

V2X

V2X could provide fleet operators with a **revenue stream and enhance overall grid flexibility and storage.** However, most V2X chargepoints and eHGVs are **still in a trial phase** for the sector.

While the **peak availability** of energy for V2X may be **overnight**, there could still be a **significant amount of energy** available **throughout the day.**

The **energy available for V2G will depend heavily on the supporting infrastructure.** Where this is not available, or fleet operators wish to reduce complexity, **other implementations such as V2V or energy storage may be able to make some use of this energy.**

Recommendations

This work has formed a set of recommendations for fleet operators, the UK government, electricity network operators and chargepoint operators.

Fleet operators

Fleet operators are at the forefront of the transition as they adopt eHGVs. They should therefore familiarise themselves with eHGV technology, the electricity markets, and charging infrastructure so they can make informed decisions for their future operations and long-term investments. Fleet operators committing to transition to eHGVs in large quantities may allow OEMs to secure supply of batteries at a lower cost therefore lowering overall costs for fleet operators.

Careful assessment of current fleet operations is required to determine which journeys are suitable for electrification, how payload constraints may affect deployment, and what role depot charging can play. Fleet operators should investigate ways to reduce the cost of electricity for eHGVs, as energy costs are a significant part of the TCO. This could be through on-site generation and/or storage, variable tariffs or power purchase agreements (PPAs) to reduce the cost of charging at a depot, or by negotiating competitive tariffs at shared access locations.

Flexibility in charging schedules, such as utilising overnight or off-peak periods, will also be essential in lowering energy expenditure and avoiding pressure on the grid. Furthermore, early engagement with DNOs and NESO will be critical to ensure that the necessary infrastructure is in place when required, given the time it takes to reinforce the electricity network.

Policy makers and regulators

The role of the UK government is equally significant in supporting and accelerating the adoption of eHGVs. The government should prioritise incentive packages for HGV segments which face the greatest barriers to achieving cost parity with diesel. More specifically, the UK government should consider targeting greater incentives at long-haul 40t+ HGVs whilst reducing incentives to smaller HGVs. Reducing incentives for smaller eHGVs may not significantly limit eHGV uptake in the short term and a slightly later uptake in eHGVs may allow time for more electricity network reinforcement. By targeting the highest emitters like the heaviest HGVs on the longest routes, the HGV sector will be more likely to reach the targets set out by the 7th Carbon Budget.

Support must extend beyond vehicle purchases to include the high costs associated with installing and connecting charging infrastructure, without which the total cost of ownership benefits may be undermined. Ofgem should also work closely with electricity network operators to ensure that grid constraints do not become a barrier to adoption, providing resources for rapid reinforcement where necessary.

Measures investigated in the Carbon Tax Incentives Scenario could be considered, where tax is applied to carbon emitted ICE fuel to discourage uptake. The associated revenue could be redirected to incentivise eHGV uptake in a cost neutral manner for the government. The tax would need to be considered carefully not to punish fleet operators who cannot switch to eHGVs due to electricity network constraints or smaller SME fleets with tighter operating margins. The knock-on impacts on the costs to fleets' customers would also need to be taken into account.

In the longer term, policies such as scrappage schemes may be required to remove older diesel HGVs from circulation and ensure progress towards net zero by 2050.

Electricity network and chargepoint operators

Electricity network operators and chargepoint providers will play a fundamental role in enabling the infrastructure to support eHGV deployment. To do so effectively, close collaboration with fleet operators will be essential to understand the scale of the required eHGV uptake, timing of charging requirements, as well as the balance between depot and shared charging solutions. Electricity network operators should begin the infrastructure planning immediately, so the capacity is in place when needed, as there could be a significant increase in eHGVs over the next five to ten years. Electricity network operators should also understand the impacts of eHGV demand alongside wider road transport and other electrifying demands, to avoid high peak electricity demands in the future and enable co-ordinated planning.

The chargepoint operators should engage with fleet operators to understand the requirement of charger power ratings at their depot, so the right chargers are available for eHGVs. There is also a need to understand the level of depot charging capacity available and what level of shared access charging there may need to be, as these locations will need different charging solutions. Options for quickly connecting high powered chargers (for over 1MW connections) should be explored, developed and communicated where eHGVs may need rapid charging, even overnight. In addition, innovative solutions such as managed charging and vehicle-to-grid (V2X) should be explored to mitigate peak demand pressures and make best use of available capacity.

Conclusion

The decarbonisation, and likely large-scale electrification, of the HGV sector presents both challenges and opportunities for all involved. With strategic planning by fleet operators, appropriately targeted incentives and policies from government, and timely infrastructure delivery from electricity network operators and chargepoint providers, the transition to eHGVs can be accelerated. This will reduce emissions from one of the hardest to decarbonise transport sectors, while ensuring that the UK logistics industry remains competitive and at the same time sustainable in a Net Zero future.

7. Appendices

Definitions and abbreviations

Climate Change Committee (CCC)

An independent statutory body established under the UK's Climate Change Act 2008. Its purpose is to advise the UK and devolved governments on emissions targets and to report on progress towards meeting these targets.

Distribution Network Operator (DNO)

A DNO is the company responsible for managing and operating the local electricity network that connects the main transmission grid to homes and businesses.

Electric Heavy Goods Vehicle (eHGV)

A HGV that is powered by an electric motor and draws energy from a rechargeable battery pack instead of an internal combustion engine, contributing to zero-tailpipe-emission freight transport.

ESME Road Freight

The ESME Road Freight model assesses low carbon road freight options with detailed and wide-ranging powertrain data and operating profiles to assess fleet implications and infrastructure requirements. More details of the model can be found here and the modelling assumptions for this work can be found here.

Hydrotreated Vegetable Oil (HVO)

HVO is a drop-in diesel replacement that significantly reduces net CO_2 emissions and can be used in existing diesel engines without modification. It is a biofuel made from vegetable oils, animal fats, or used cooking oils.

Long-haul

While there is no set definition of a long-haul journey, within this report long-haul HGVs refer to those travelling over 400km per day.

National Energy System Operator (NESO)

The purpose of the National Energy System Operator is to manage and plan the UK's electricity and gas networks. NESO has a range of strategic planning obligations, such as the:

- Strategic Spatial Energy Planning (SSEP)
- Regional Energy Strategic Plans (RESPs)
- Centralised Strategic Network Plan (CSNP)

Original Equipment Manufacturer (OEM)

An OEM is the company that manufactures a vehicle (e.g. Renault, DAF).

Seventh Carbon Budget

The 7th Carbon Budget is a UK government legally binding limit on the total amount of greenhouse gas emissions over time, based on recommendations from the Climate Change Committee (CCC).

Shared charging

Within this report, shared charging is any location away from base. For example, for a fleet their depot will be their base and anywhere away from their depot would be a shared charging location. This could be at a motorway service station, at a drop-off/pickup location or at another fleet's depot. Charging locations are discussed further below.

Total Cost of Ownership (TCO)

The TCO is a financial estimate that helps consumers and enterprises determine the direct and indirect costs of a product or system over its entire lifespan. For vehicles, this includes purchase price, fuel/energy, maintenance, insurance, and residual value.

Vehicle parc

Vehicle parc is the total number of vehicles in use at a given time, essentially the total vehicle population.

Vehicle-to-Everything (V2X)

V2X is an overarching term for technology that allows energy to be transferred to and from an electric vehicle's battery. Vehicle-to-Grid (V2G) is a specific V2X application for exporting power back to the main electricity network, but V2X also includes several other applications for using the stored energy.

Zero-Emission Vehicle (ZEV)

A Zero-Emission Vehicle (ZEV) is a vehicle that produces no tailpipe emissions, such as carbon dioxide.

Vehicle categories

Within the ESME Road Freight model, HGVs are split into different categories. These are categorised based on axle configuration and weight.

For axle configuration, vehicles are split into rigid and articulated. A rigid vehicle is a single, long vehicle that doesn't bend in the middle. Whereas an articulated HGV is two parts (a tractor and a trailer) connected by a pivot, allowing it to "articulate" or bend when turning. In this report, articulated has been shortened to artic in some circumstances.

Within the rigid and articulated categories, the vehicles are broken down further into the number of axles, where an axle is a central shaft or rod that rotates the wheels and bears the load of the vehicle and its contents. Some graphics are shown below providing an example for each type of axle configuration.

The rigid vehicles are split into weight categories of:

- 3.5t-7.5t (2 axle-rigids only)
- 7.5t-18t (2 axle-rigids only)
- 18t-26t
- Over 26t

2 Axle rigid

3 Axle rigid

4 Axle rigid

The articulated vehicles are split into weight categories of:

- Under 40t
- Over 40t (referred to as 40t+ in the report)

2 Axle artic

3 Axle artic

Charging locations

Within this report, base locations are generally depots, with charging away from the HGVs own depot being at some sort of shared access location. The types of locations with some basic modelling assumptions can be seen below.

Depot

Lowest power rating (150kW)

Most trucks will make some use of these

Short haul trucks only use these

Electricity provided at cost

Shared access semi-public

Medium power rating (300kW)

These are found at sites visited by trucks such as warehouses or ports

Electricity provided with small mark-up

Shared access public

Highest power rating (600kW)

These are found predominantly at motorway services or similar sites and are open to use by any fleet

Electricity provided with the largest mark-up

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