HGVs on the road to net zero

How battery electric trucks can decarbonise GB road freight

May 2023

Summary

Transport & Environment UK commissioned **Element Energy** (an ERM Group company) to examine the techno-economic feasibility of accelerating the adoption of battery electric trucks with static charging infrastructure across England, Scotland and Wales (Great Britain). The study evaluates a wide range of common operational profiles and develops optimal combinations of battery size, depot-based charging infrastructure, opportunity-charging at pick-up/delivery sites and (for those use cases that would need it) high-power public charging infrastructure. A large number of vehicle duty cycles have been studied, capturing (from a comprehensive dataset) a large and representative spread of different HGV operations, including those pushing the extremes of payload and journey distances.

The study does not assess the techno-economic feasibility of other battery electric technologies and options such as dynamic public charging (e.g. overhead catenary Electric Road Systems), battery swapping or "pony-express" vehicle swapping, nor does it consider other zero tailpipe emission technologies such as fuel-cell vehicles or the role of alternative fuels – it only considers battery electric trucks with static charging and only compares their technical and commercial viability with diesel-powered, conventional truck operations.

This report summarises the findings of the technical study and provides actionable recommendations for UK policymakers and fleet managers to speed up the transition in ways that could not only support decarbonisation, net zero, energy security and air quality agendas but also cut costs, strengthen technology leadership, boost economic growth, and enhance profitability for operators.

The first phase of the research assessed logistics operations that would not be reliant on public charging infrastructure and thus could, with the right policy environment, potentially be electrified very quickly. The second phase covered use cases that will need public truck charging infrastructure.

Back-to-base use cases

Phase one of the study shows that in this decade – well ahead of the UK Government's 2035/40 phase-out dates for diesel trucks – 65-75% of Britain's rigid HGVs and 30-35% of articulated HGVs could operate sustainably and productively with battery electric trucks without significant reliance on future public charging infrastructure. Together, these back-to-base use cases capture over half of HGVs and currently account for around 25-35% of all HGV greenhouse gas emissions.

Long-distance, heavy-duty use cases

Phase two of the study shows that GB long-distance, heavy duty 40-44t articulated HGVs could be able to perform their operations using battery electric vehicles and appropriate static charging infrastructure with technology set to be available from 2024. Battery electric HGVs are projected to become cost competitive with diesel equivalents for many long-distance, heavy-duty use cases around 2030, even with any potential payload losses and charging downtime fully considered. We emphasize here that we do not assert that battery electric HGVs with static chargers are the only solution for long-distance, heavy-duty trucking but our study results certainly indicate that this provides one highly cost effective and rapidly scalable solution for decarbonising such operations.

Roughly half of GB HGVs and two thirds of GB HGV emissions are from vehicles that would require some form of charging outside their home depot to complete longer trips. Most charging will occur at depots (for all HGV types including 40-44t artics), but a public charging network will be needed.

Recommendations for policymakers

The research has firmly indicated that a battery-electric truck future for the HGV fleet is an achievable objective. It has also shown that this transition is likely to be achievable, in terms of the business case to support new truck purchases, well ahead of the existing 2035 and 2040 UK phase-out dates for sales of new non-zero emission HGVs. But we are in a climate emergency and a volatile global economy, so the researchers have also looked at a wide range of near-term policy interventions that could accelerate and bring forward that transition and thus make an even stronger contribution to carbon budgets and air quality improvements while boosting economic growth and energy security. If all eight recommendations were implemented, the modelling indicates that TCO parity dates for battery electric HGVs of all types and use cases would typically be brought forward by 2-5 years, depending on the specific circumstances, a change which could significantly increase the number of zero emission HGVs on Britain's roads in 2030.

1. **Strengthen the phase-out dates policy by introducing interim ZEV mandates.**
Supply side regulation in the form of ZEV mandates is essential to ensure there are sufficient zero emission trucks available to meet the likely demand.
2. **Support supply chain development for battery electric trucks.**
Strengthening and expanding our supply chain and positioning it for the coming global transformation to battery electric trucks could and should be a much stronger pillar of UK automotive industrial strategy.
3. **Provide more effective vehicle acquisition incentives.**
The current high upfront costs of battery electric trucks highlight the need for more effective vehicle acquisition incentives (than current Plug-In Truck and Van Grant levels), which the Government should urgently explore and propose.
4. **Support the roll-out of private charging infrastructure for depot-based fleets.**
Regulation must mandate and support sufficient, smart and cost-effective charging infrastructure supply for depot-based commercial vehicle fleets and remove the various existing barriers to rapid deployment.
5. **Lower the early-years risks to public truck charging infrastructure providers.**
If private sector balance sheet investment could be leveraged against a zero/low interest loan from government, this would improve the internal rate of return during the early years of potentially low

utilisation and help to reduce the level of risk to the private investor.

6. **Fund truck public charging at major warehouses and develop planning policies to further incentivise charging infrastructure at logistics hubs.**

Tax breaks and other policies that would incentivise multiple stakeholders and landowners in warehousing areas to install charging infrastructure could help overcome issues caused by low land availability in warehousing areas. Planning rules could be adjusted to incentivise and remove barriers to charge point installation and shorten lead-times.

7. **Consider changes to maximum vehicle weight and length regulations.**

A one-metre increase in allowed vehicle length and two-tonne increase in allowed gross vehicle weight would allow operators to switch from the heaviest 44 tonne diesel HGVs to 44 + 2 tonne battery electric HGVs without loss of payload, deterring adoption. Opportunities to trial such interventions and assess fully their real-world impacts exist through current and planned demonstration programmes.

8. **Review and amend where appropriate driver hours regulations and rest stops**.

Some targeted flexibility in the driver hours regulations and working-time definitions could allow more drivers to make use of a fixed number of charging locations without resulting in additional downtime.

These specific recommendations arise directly from this study's assessment of the potential benefits of accelerating the uptake of battery electric trucks. But there are a range of potential complementary measures that would serve to further accelerate the decarbonisation of the sector and its transition away from fossil fuels. For example, the deployment of alternative fuels, the electrification of auxiliary loads and the use of the latest aerodynamic / rolling resistance features can all play important roles during the transition period towards 100% zero-emission vehicles.

Endorsements

The above summary has been prepared by Transport & Environment with the assistance, guidance, support and endorsement of an advisory group of expert stakeholders, collectively known as the UK Platform for Battery Electric Trucking.

Signatories include:

- Andy Eastlake, Chief Executive Office, Zemo Partnership
- Celine Cluzel, Partner, Element Energy an ERM Group Company
- Phil Greening, Centre for Sustainable Road Freight
- Justin Laney, John Lewis Partnership
- Peter Harris, Vice President - International Sustainability, UPS
- Sam Clarke, Chief Vehicle Officer, GRIDSERVE

Further information

Richard Hebditch
UK Director
Transport & Environment
richard.hebditch@transportenvironment.org
Mobile: +32(0)4 83 08 48 91
Square de Meeûs, 18, 2nd floor | B-1050 | Brussels | Belgium
www.transportenvironment.org | @transenv | fb: Transport & Environment

Table of contents

1. Introduction

T&E is Europe's largest NGO working on transport – its vision is a zero-emission mobility system that is affordable and has minimal impacts on our health, climate and environment. It does so via influencing EU, global and national policies regulating transport activities. T&E represents 60 organisations from 26 countries across Europe, mostly environmental groups and campaigners working for sustainable transport policies at national, regional and local level. Altogether its members and supporters represent more than 3.5 million people. Its network of national offices includes the UK.

The switch to electric cars in the UK is well underway and sales of new conventional cars should end within a decade. In contrast, the shift to electric trucks has barely commenced. However, the government has confirmed its intention to phase out sales of new smaller combustion-powered trucks less than 26 tonnes (by 2035). All new (non-zero tailpipe emission) combustion truck sales should end by 2040 such that, by 2050, the vast majority of the UK HGV fleet will be zero emission vehicles and the UK will be in a very strong position to achieve its net zero climate goal for the road freight sector.

The UK is keen to be seen as a leading world nation through ambitious climate policy. Being outside the EU presents a huge opportunity for the UK to adopt more progressive policies than currently applied or proposed in the EU. As an innovator of progressive policies to decarbonise transport, the UK can provide a model of what could be implemented elsewhere in the world. Accelerating the transition to a zero emission UK HGV fleet as far as possible will help achievement of cumulative GHG (carbon) budgets, reduce dependence on oil and, in all likelihood, improve the competitiveness of UK hauliers.

The early years of this decade have seen the development and commercialization of an ever-expanding range of battery electric trucks (BETs), across all vehicle segments and in all the major developed markets including the UK. Established truck makers such as Daimler, Leyland Trucks/DAF, Renault Trucks, Scania, MAN and Volvo Trucks are focused on bringing many more battery-powered trucks to the mass market over the next few years. Many see them playing a dominant role in decarbonising the road freight sector in our battle to reach net zero by 2050 or sooner, as exemplified by this recent statement from Milence, a joint venture between Daimler Truck, TRATON GROUP, and the Volvo Group:

"In the coming years, battery-electric trucks will prove to be a competitive and efficient choice for transport companies looking to rapidly reduce their climate impact. With the right charging infrastructure in place, battery-electric trucks will be a leading option for many transport applications, including long haulage."

New entrants and specialist manufacturers such as Dennis Eagle, Tesla, Tevva and Volta are bringing innovative new concepts to the urban/short-haul, municipal and long-haul vehicle markets. Radically improved business operating models, battery chemistries and charging systems are also evolving at pace. While some pioneering logistics organisations are already exploiting the commercial opportunities that battery electric trucks can provide, many others are not yet ready to make the switch. As well as concerns around vehicle purchase costs, driving range and possible payload loss, there are also "chicken and egg" concerns about the (lack of) availability of HGV-accessible high power public charging infrastructure.

Transport & Environment UK commissioned **Element Energy** (an ERM Group company) to examine the techno-economic feasibility of accelerating the adoption of battery electric trucks with static charging infrastructure across England, Scotland and Wales (Great Britain). The study evaluates a wide range of common operational profiles and develops optimal combinations of battery size, depot-based charging infrastructure, opportunity-charging at pick-up/delivery sites and, for those use cases that would need it, high-power public charging infrastructure. A large number of vehicle duty cycles have been studied, capturing (from a comprehensive dataset) a large and representative spread of different HGV operations, including those pushing the extremes of payload and journey distances.

An important limitation of the study's scope, that must be acknowledged, is that it does not attempt to assess the techno-economic feasibility of other battery electric technologies and options such as dynamic public charging (e.g. overhead catenary Electric Road Systems), battery swapping or "pony-express" vehicle swapping, nor does it consider other zero tailpipe emission technologies such as fuel-cell vehicles or the role of alternative fuels – it only considers battery electric trucks with static charging and only compares their technical and commercial viability with diesel-powered, conventional truck operations.

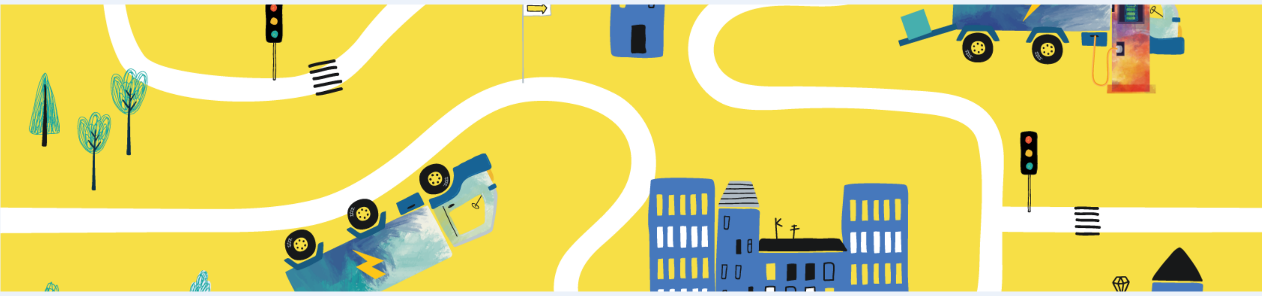
This report summarises the findings of the technical study and provides actionable recommendations for UK policymakers and fleet managers to speed up the transition in ways that could not only support decarbonisation, net zero, energy security and air quality agendas but also cut costs, strengthen technology leadership, boost economic growth, and enhance profitability for operators.

The outcomes of this study are intended to provide robust evidence to encourage the Department for Transport to implement a range of new policies and other support mechanisms to accelerate the switch to battery electric trucks for UK hauliers.

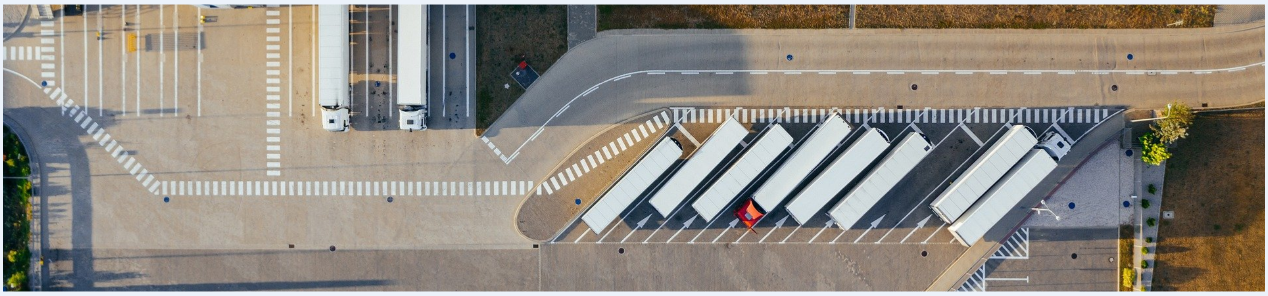
INFO BOX: Other recent T&E HGV electrification studies

T&E has made extensive study of decarbonising freight in the UK and EU. Recent activity includes:

2020:
Unlocking electric trucking in the EU: Methodology (July 2020)
Unlocking electric trucking in the EU: recharging in cities (July 2020)
How to Decarbonise the UK Freight Sector by 2050 (December 2020)



2021:
Unlocking electric trucking in the EU: recharging along highways (April 2021)
Phasing out the sale of polluting trucks in the UK (October 2021)



2022:
Flicking the switch on truck charging (January 2022)
Why long-haul trucks can be battery electric (February 2022)
Addressing the heavy-duty climate problem (September 2022)

2. Main study findings

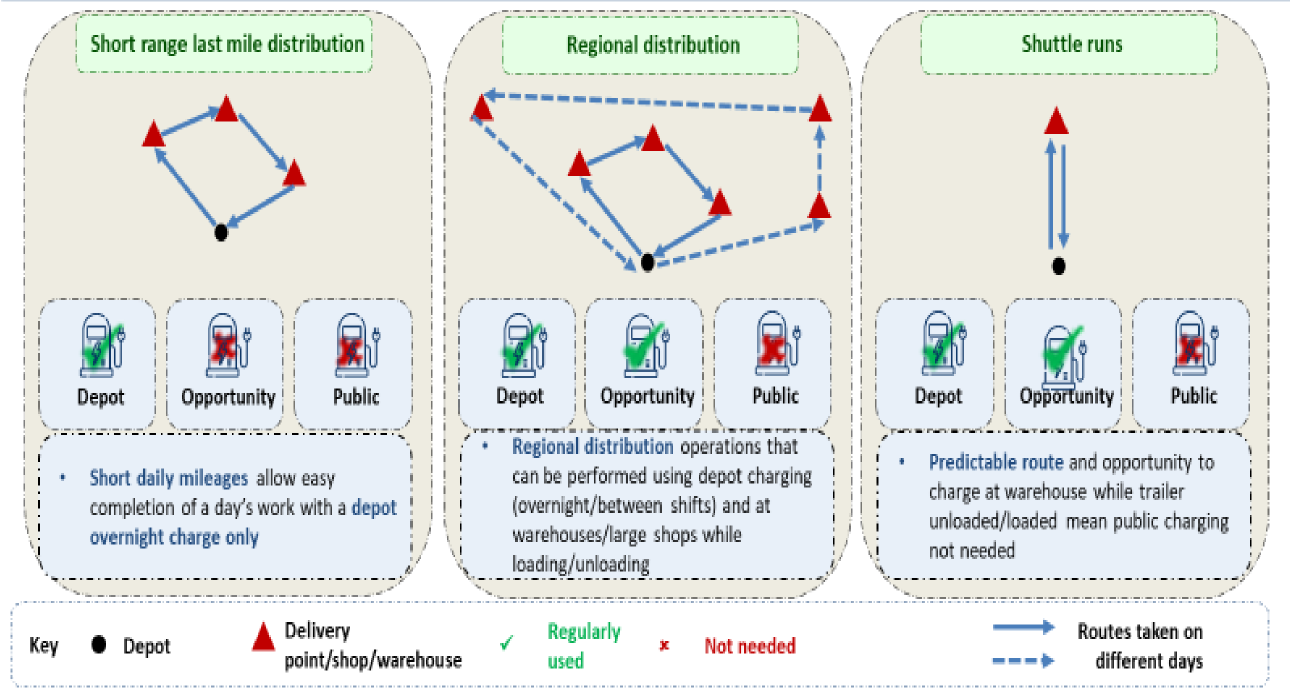
2.1 Back-to-base use cases

The first phase of the research assessed logistics operations that would not be reliant on public charging infrastructure and thus could, with the right policy environment, potentially be electrified very quickly. The second phase covered use cases that will need public truck charging infrastructure. For each HGV usage profile Element Energy examined, costs were analysed to assess when BETs become the more cost-effective option (vs diesel).

Phase one of the study shows that in this decade, well ahead of the UK Government's current 2035/40 phase-out dates, 65-75% of the Great Britain's rigid HGVs and 30-35% of our articulated vehicles ("artics") could be able to operate sustainably and productively as battery electric trucks without significant reliance on future public charging infrastructure. Together, these back-to-base use cases capture over half of GB HGVs and currently account for around 25-35% of all GB HGV greenhouse gas emissions.

The early electrification of back-to-base use cases is a golden opportunity for policymakers and commercial visionaries to de-risk the transition for fleet operators and close the cost gap with diesel for the larger HGVs via a balanced "demand" (user incentives and depot charging infrastructure support) and "supply" (ZEV mandates) approach.

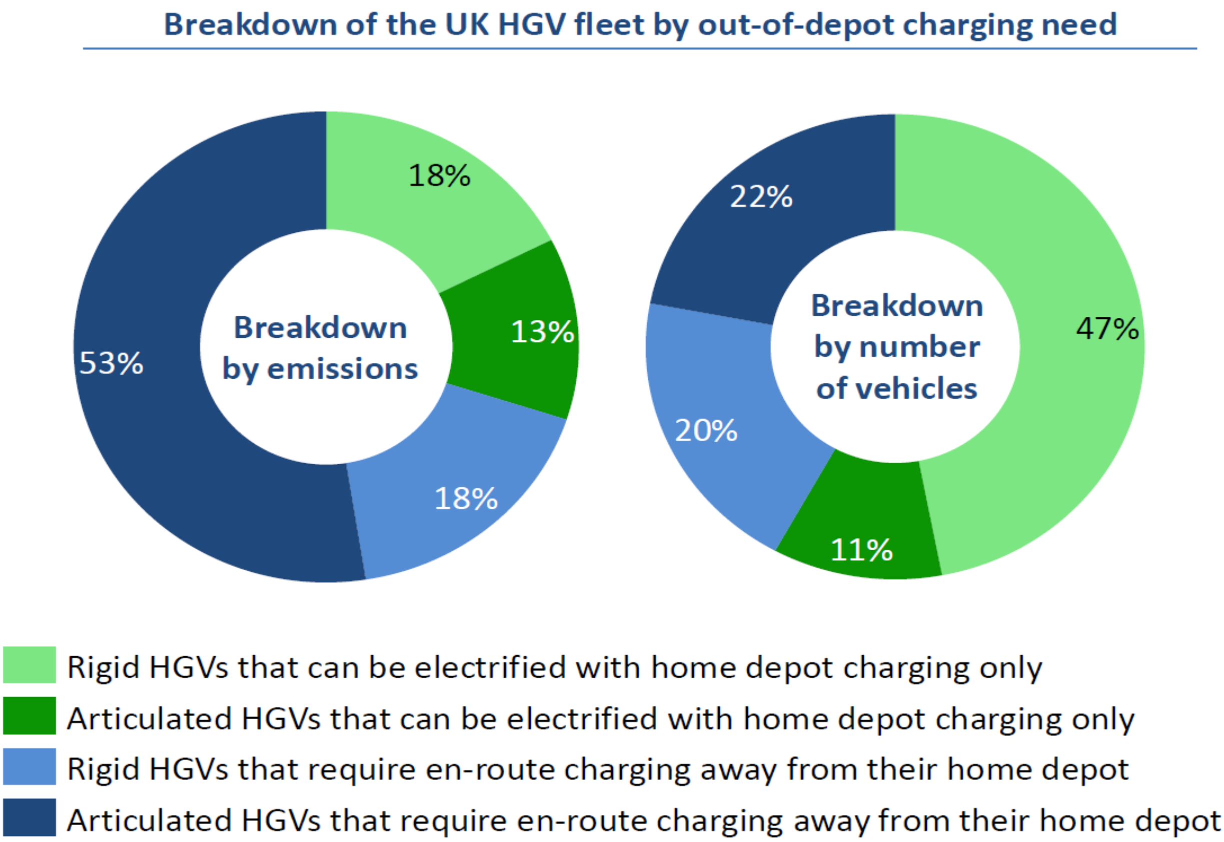
Example use cases that can be completed on a single daily charge or have good opportunity charging options at their own depot between shifts, or at 3rd party warehouses while loading or unloading



2.2 Long-distance, heavy-duty use cases

Phase two of the study shows that GB long-distance, heavy duty 40-44t five or six-axle articulated HGVs could be able to perform their operations using battery electric vehicles and appropriate static charging infrastructure with technology set to be available from 2024. Battery electric HGVs are projected to become cost competitive with diesel equivalents for many long-distance, heavy-duty use cases around 2030, even with any payload losses and charging downtime fully considered. We emphasize here that we do not assert that battery electric HGVs with static chargers are the only solution for long-distance, heavy-duty trucking but our study results certainly indicate that this provides one highly cost effective and rapidly scalable solution for decarbonising such operations.

Roughly half of GB HGVs and two thirds of GB HGV emissions are from vehicles that would require some form of charging outside their home depot in order to complete longer trips. Most charging will occur at depots (for all HGV types including 40-44t artics), but a public charging network will be needed, and a set of additional policy measures could enable battery electric HGVs to significantly reduce emissions from long-distance, heavy-duty trucking in the 2020s.



3. Methodology

Previous work by T&E has shown that battery electric trucks represent the optimal net zero, air quality and commercial solution for city, urban and regional delivery HGVs doing predominantly back-to-base operations and that these vehicles have the potential to reach Total Cost of Ownership (TCO) parity with diesel in the short term. These **use cases that do not require public charging** involve vehicles completing their daily operations using a combination of charging at their own depot and at third party warehouses while waiting, loading or unloading. This category includes activities such as:

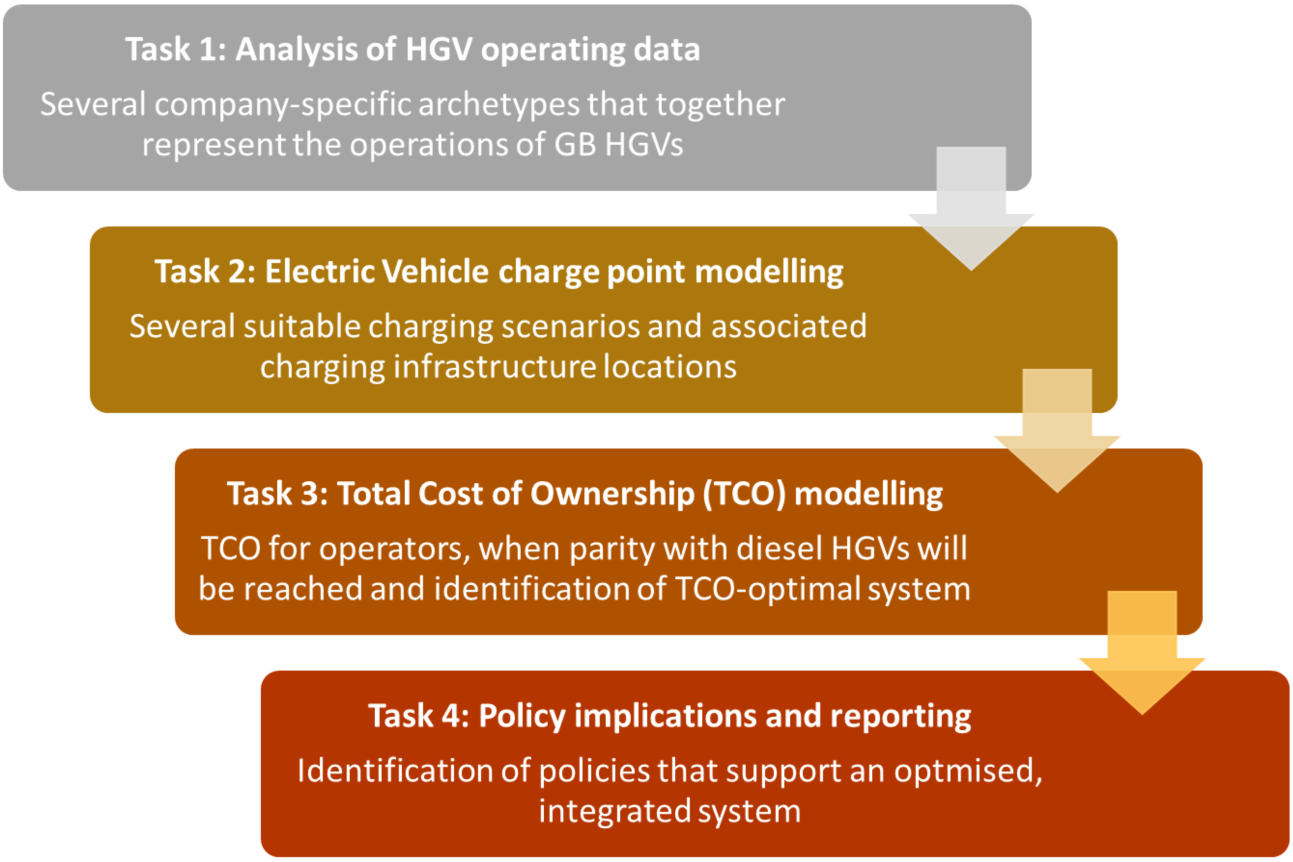
- **short-range last mile distribution** - short daily mileages allow easy completion of a day's work with a depot overnight charge only.
- **regional distribution** - operations that can be performed using depot charging (overnight/ between shifts) and at warehouses/large shops while loading or unloading.
- **shuttle runs** - predictable and relatively short-distance routes with opportunity to charge at warehouse while trailer unloaded or loaded mean public charging is not needed.

This latest study (carried out by Element Energy) was commissioned to understand the TCO-optimal specification of GB charging infrastructure and battery sizing based on detailed duty cycle analyses. The study brings authoritative evidence on the charging & TCO questions. For each of the city, urban and regional vehicle categories, the study considers their distinct duty cycles and optimises the trade-offs between battery and infrastructure costs to minimise TCO, while meeting all existing operational vehicle requirements. This study moves beyond the average figures for truck activity used in previous work and assesses in detail the implications of the distinct duty cycles to develop an integrated strategy for both private/depot-based infrastructure and vehicles. This should enable the Department for Transport to develop dedicated policies to accelerate the switch to BETs, make the diesel truck phase out dates more readily achievable and set an example for the rest of Europe.

The research did not limit itself to only back-to-base operations, though. It also assessed the vehicle and infrastructure requirements for battery electric trucks with static charging infrastructure to be able to compete with and displace new diesel trucks in use cases **where public charging is needed**; for long haul articulated HGV duty cycles and by highly variable rigid HGV duty cycles to deal with long distances travelled between opportunity charging locations, e.g:

- **general haulage (tramping)** – do different routes each day and will need a nationwide public charging network, ideally with charging during driver breaks.
- **rural distribution** - variable rural duty cycles will only need public charging on particularly long days – so will not themselves drive a business case for public charging infrastructure.
- **trunking with long distances between end points** too far spaced for BET driving range demands chargers in specific strategic locations for charging during driver breaks.

An overview of the research approach is shown in the following diagram. The remainder of this section provides a brief description of the specific research tasks.



3.1. Analysis of HGV operating data

This task developed several archetypes that together represent the real-world operations of HGVs. This covered the full spectrum of activity, including city, urban, municipal, regional and long-haul duty cycles. The analysis was carried out in three defined steps:

1. **Categorisation by vehicle weight and duty cycle patterns**, using telematics data obtained from previous work, supported by and checked against official survey data. The exact breakdown of the archetypes developed is based on common distinct duty cycle patterns identified, considering differences in trip lengths, frequency of stops, stop lengths and daily distances. This produced sectoral archetypes, each consisting of a vehicle type, an average day duty cycle, a challenging day duty cycle (e.g. 80th percentile in terms of energy demand), and an absolute worst case day duty cycle.
2. **Assignment of drive cycles to each archetype**: For each archetype, the travel segments between stops have been assigned an appropriate drive cycle. This allows calculation of time taken and battery energy consumption between stops for the different vehicle sizes and duty cycles. This approach is necessary as average fuel consumption figures by truck size do not capture the "worst case" operational days or the factors that can affect fuel consumption, such as payload carried. Furthermore, quantification of the on-route charging opportunities requires knowledge of the battery state of charge (SOC) at each stop. Modelling the SOC accurately requires knowledge of the full duty

cycle including the distances and drive cycles between stops.

3. **Fleet operator interviews and development of company-specific archetypes**: Element used interviews with several fleet operators to add to each archetype a description of the journey type and of what occurs at each stop, thereby converting national level archetypes - which lack key details such as whether a stop location is suitable for charging - into results from which detailed infrastructure and vehicle designs can be established. Collectively, these company-specific archetypes represent a very wide range of real-world operations for GB HGVs. The interviews also addressed some key operational assumptions such as the practicalities of destination charging and the opportunities and barriers that occur at a fleet level and that are not illustrated by an analysis at individual truck level. For example, fleet operators using a mixture of electric and diesel trucks in the short term could ensure that electric trucks are always dispatched first and so are more heavily utilised than other trucks in the fleet, improving their TCO benefits. Furthermore, in the short-term diesel trucks could be used for the absolute "worst case" routes as the fleet electrifies and technology develops.

3.2. EV charge point modelling

The three steps of this task identified the charging infrastructure needed to support the archetypes:

1. **Infrastructure scenario development**. Sizing and specifying several charging scenario/battery size combinations that could support the driving profiles, for example, depot charging only and depot charging with destination charging at certain locations. The battery and charging infrastructure are sized based on the "worst case day" duty cycle for each archetype.
2. **Determination of charging locations**. Having determined the specifications of charging infrastructure for various scenarios, the next step is to identify the areas where this infrastructure should be deployed. The details of each archetype such as depot, warehouse and shop locations are used to map out the infrastructure and understand how destination type links to charging infrastructure needs. Focusing on company archetypes rather than national databases at this stage allows greater specificity about how the infrastructure could be used and where it is needed.
3. **Scale the company-specific archetype findings to a national level**. This subtask determines the destination and depot charging infrastructure requirements in GB cities and urban areas.

3.3. Total Cost of Ownership (TCO) modelling

This task models the TCO of battery electric trucks and infrastructure for the archetypes and scenarios developed and determines the cost-optimal combination of battery size and charging infrastructure for each. The analysis determines the TCO for first and second buyers and how this is likely to change between now and 2050. This allows quantification of the policy measures needed to meet the 2035/2040 phase out dates, considering the latest known regulatory developments. It consisted of these steps:

1. **Data aggregation and alignment of assumptions**. Preparation of a clear and transparent list of key assumptions for the TCO analysis, drawing on up-to-date databases on HGV TCO components.
2. **TCO modelling of archetypes identified in previous sections**. Determination of the TCO for each of the archetypes and charging scenarios, projected forward to 2050. This includes producing electricity (charging) cost projections, equal to the base electricity price (using official projections) plus the

markup needed to obtain a strong IRR over a 15-year business case for the charging infrastructure.

3. **Identification of the TCO-optimal system configuration for each archetype**. Identifying the system that optimises the trade-offs between battery cost and infrastructure cost from a truck total cost of ownership point of view.
4. **Comparison between archetypes and with diesel TCOs**. Identifying when TCO parity with diesel is expected to be achieved for the different archetypes.
5. **Sensitivity analysis**. Since battery electric trucks have yet to be widely commercialised, significant uncertainties exist over future costs. This subtask investigated the impact of key sensitivities on the overall conclusions, including battery price, battery lifetime, relaxation in space and weight allowance limits, resale value of diesel HGVs, cost of electricity, annual mileage, ownership lifetime, required payback times for infrastructure, and increased vehicle utilisation.

The model calculates TCO from first principles and allows battery right-sizing and optimisation of the infrastructure for each archetype. Inputs to the model fall into four main categories:

1. Duty-cycle information specific to each archetype:
    a. Drive cycle for an “average day”, a “bad day” and a “worst case” day.
    b. The “worst case” is used to size the battery and infrastructure for any operational day.
    c. Charger utilisation per day to determine the infrastructure cost per vehicle.
2. Weather related inputs
3. Vehicle and infrastructure parameters
4. Cost data:
    a. Fuel costs for both electricity and diesel.
    b. Current and projected future battery pack and power electronics costs for BETs.
    c. OEM transition costs, reflecting non-component costs of the transition to BET manufacture – this accounts for the difference between the sum of individual component costs (with markup) and the prices that BETs are currently being quoted for.
    d. Diesel engine costs and vehicle glider costs.
    e. Charger and grid connection costs.
    f. Calibration checks of vehicle capital cost values for both BET and diesel vehicles with real world values from fleet operators.
    g. Vehicle downtime (for charging while not otherwise stationary anyway).
    h. Payload loss (productivity impacts where battery weight reduces payload carried)

The model then calculates the optimal combination of battery size (in kWh) and charge point power (kW) but crucially it also considers the impact of the uncertainty around future fuel prices on the date when battery electric HGVs will reach TCO parity with diesel equivalents. The TCO of diesel HGVs is sensitive to diesel prices, and the TCO of battery electric HGVs is sensitive to commercial electricity prices. The date at which battery electric HGVs reach TCO parity with diesel therefore depends on how diesel and electricity prices change in future, which is inherently uncertain. To capture this, a range of different electricity price scenarios and diesel price scenarios were considered, reflecting the range of possible future electricity and diesel prices. The TCO breakeven date has been determined for each combination of scenarios.

The researchers have used conservative assumptions and careful sensitivity analysis to ensure their key findings are robust, including:

- No disruptive new battery technologies, just incremental improvements in existing battery technologies and no improvements in battery lifetime. Assumptions around battery energy density have been carefully checked against public data on the performance of current and near future (2024) battery electric HGV models; in reality further, and potentially substantial, improvements in energy density, longevity and/or cost are all possible, e.g. from new chemistries such as Lithium-Sulphur, Sodium-Ion, Lithium-Air and Solid State batteries.
- 2024 OEM models will have the capability to drive for 4.5 hours at full load, which is the longest a driver is legally allowed to travel before taking a break, and then recharge sufficiently to continue/complete their duties using MW charging during mandatory driver 45-minute breaks. This allows completion of long-haul operations while recharging entirely during existing operational downtime.
- Conservative assumptions around infrastructure costs, chargers and grid connections.
- No aerodynamic / vehicle mass improvements are assumed; in reality, these will likely improve the business case for BETs by allowing smaller batteries.
- Electricity costs kept at historically high levels until 2030. In reality, reforms of the current electricity market may cause electricity costs to fall before 2030 by decoupling the electricity price from the natural gas price. Furthermore, fleet operators may be able to access cheaper electricity prices overnight using smart tariffs and corporate power purchase agreements. None of these have been assumed, again making the results conservative.
- No change in operator behaviour. The researchers have assumed operator behaviour remains unchanged whereas operations may change if cost savings exceed impacts on loss of time or payload.

Key sensitivities used to confirm the robustness of the results include:

- Battery prices and fuel prices – even with the most pessimistic assumptions around fuel prices and battery prices, the key conclusions are not changed: city, urban and regional deliveries with rigid HGVs are already on the cusp of being cheaper with BETs, and BETs reach TCO parity with diesel across all use cases studied by the early 2030s – even with the conservative assumptions mentioned above.
- Diesel vehicle life – diesel vehicles are OPEX intensive rather than CAPEX intensive, and so the lifetime assumed for a diesel vehicle has minimal impact on the annual total cost of ownership.

Some examples of Element Energy's main assumptions (all for 2030) are:

- Electricity 22p/kWh (will be lower if by 2030 wholesale price is set by renewables, not gas)
- Diesel costs £1.40-1.55 per litre – infrastructure costs for bunkered diesel supplies excluded
- Batteries cost £80-130 per kWh (well above projected costs for car batteries)
- 22 kW DC chargers cost £2,700 each, 350 kW DC chargers cost £135,000 each (installed)
- £200/kW average grid connection costs (sites close to existing grid could be below £100/kW)
- Battery specific energy 230 Wh/Kg

3.4. Policy implications and reporting

As well as producing a formal detailed report, this task used the above tasks to derive policies that:

- Help overcome the "chicken and egg" problem by encouraging the integration of vehicle and infrastructure specification.
- Encourage an optimised system that mitigates the risk of deploying infrastructure that is over-sized and underutilised or relies on vehicles that are prohibitively expensive.
- Bridge the TCO gap with diesel in the short term, enabling a scale up that will achieve the necessary cost reductions in the medium and long term.
- Account for the differences between GB cities and regions that require different local policies.
- Account for the key opportunities at a fleet level.

INFO BOX: Summary of research methodology

1 Fleet operator interviews

Over 20 fleet operators were interviewed, covering a wide range of both rigid and artic use cases. This involved discussion of the vehicle duty cycles (including trip distances, stop times, variation between days) and the opportunities for charging, including length of stops, practicalities of installing charging infrastructure at stop locations.

2 Archetype development and screening

Based on the interviews a set of archetypes were constructed. Each archetype describes the operation of a particular HGV use case. The archetype consists of a detailed description of the mileages, time at stops, the practicalities of charging and opportunities for sharing infrastructure at each stop. Each of these factors is described for a "worst case" day as well as an "average day" and a "bad day" to ensure that the infrastructure modelling of the following step reflects the full range of operational scenarios for each use case.

Archetypes with duty cycles that could be completed without public charging were then selected for inclusion in this study. A subsequent study will focus on use cases that do require public charging.

3 Infrastructure and TCO

For each archetype, we calculated an energy use profile and battery state of charge profile for the "average", "bad" and "worst case" days. This was used to determine the charging infrastructure and battery size required for a BEV to perform the same real world operation as a diesel vehicle.

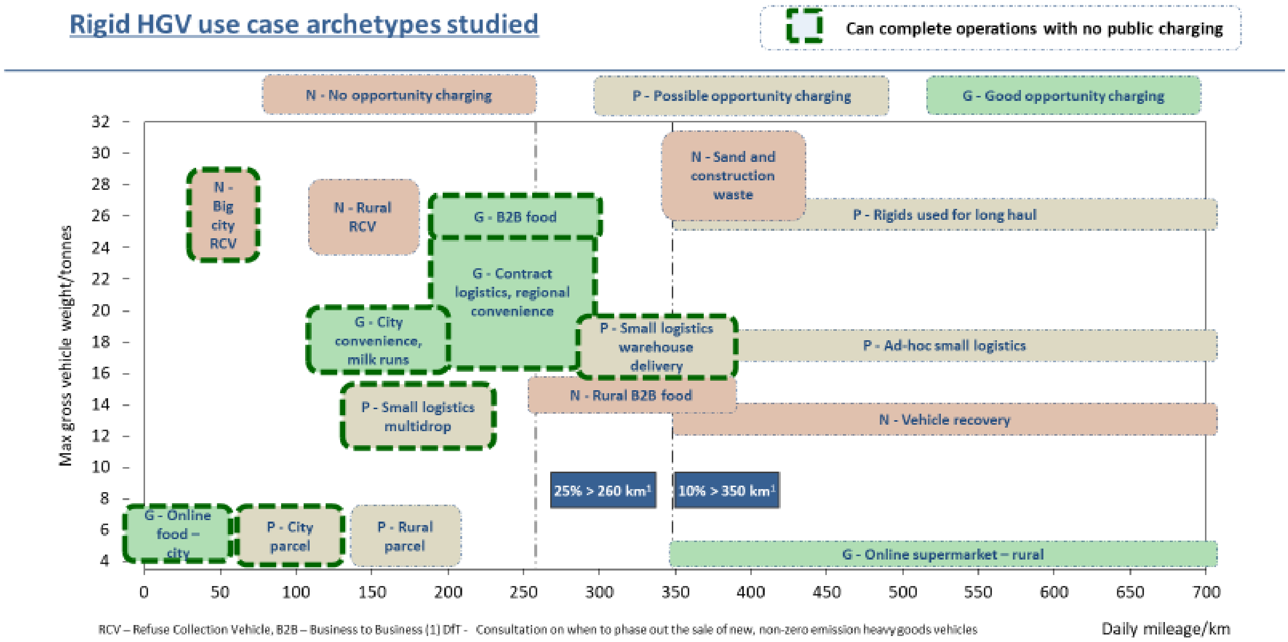
This was then used to calculate the Total Cost of Ownership (TCO) for each use case.

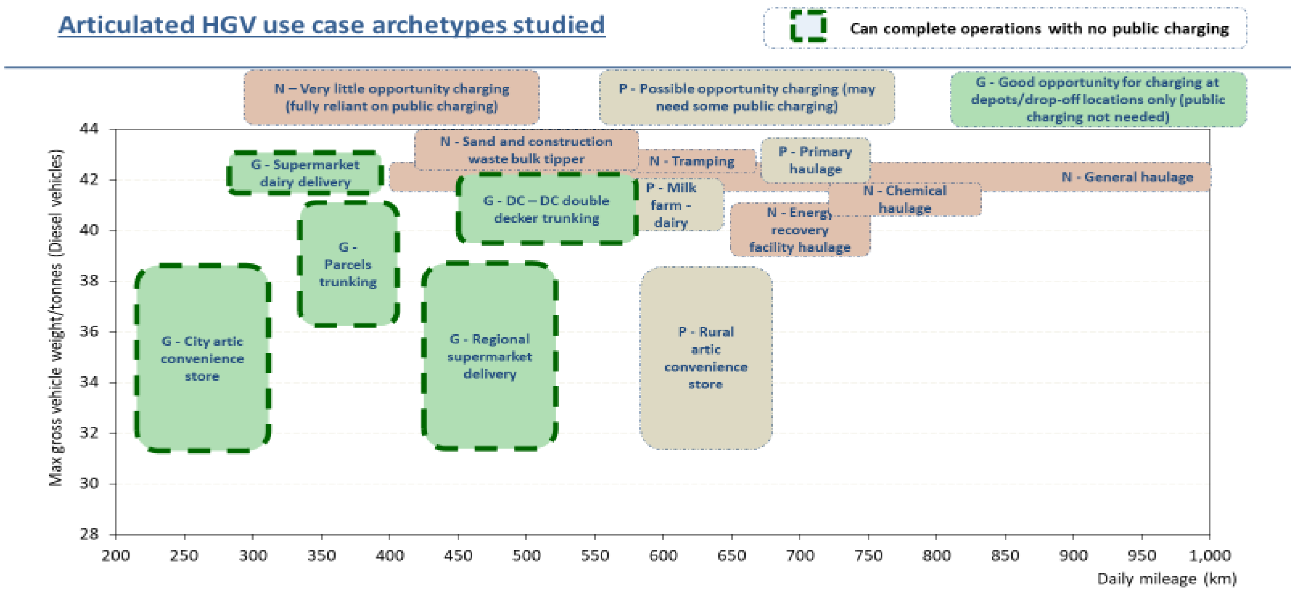
4. Detailed results of the study

4.1. Duty-cycle archetypes

The study developed a wide range of archetypes for common GB HGV operational duty-cycles, both for where public charging infrastructure would be needed and for those that could be completed without it.

The full range of archetypes developed and Element Energy's assessment of their suitability for operating with or without public charging infrastructure is shown in the diagrams below, the first covering rigid HGV duty-cycles and the second detailing those more commonly completed by articulated HGVs.





A report by TRANSPORT & ENVIRONMENT

4.2. TCO modelling results – back-to-base use cases

For the first phase of the research, the TCO analyses were carried out across a range of scenarios for each back-to-base use case archetype to identify if and when operators purchasing a new BET for that use case would see its likely TCO fall below that for a diesel truck. The likelihood that this TCO breakeven date occurs in any given year is proportional to the number of different combinations of electricity and diesel price scenarios that lead to a breakeven date within that year. There are some years where there is a high probability of the TCO breaking even because this happens under a wide range of scenario combinations – for example, a combination of a central electricity scenario and central diesel price scenario results in a very similar breakeven date to a combination of a high electricity price and high diesel price. Conversely, very early or late TCO breakeven years are very unlikely because they require a very low electricity price scenario and a very high diesel price scenario or vice versa.

To reflect this scenario-based modelling approach, the diagrams in the following sections present the results as heatmaps where the darkness of the square reflects the probability that the TCO will break even (for vehicle purchases) in that year. This reflects the number of combinations of diesel/electricity fuel price scenarios that result in the TCO breaking even in that year.

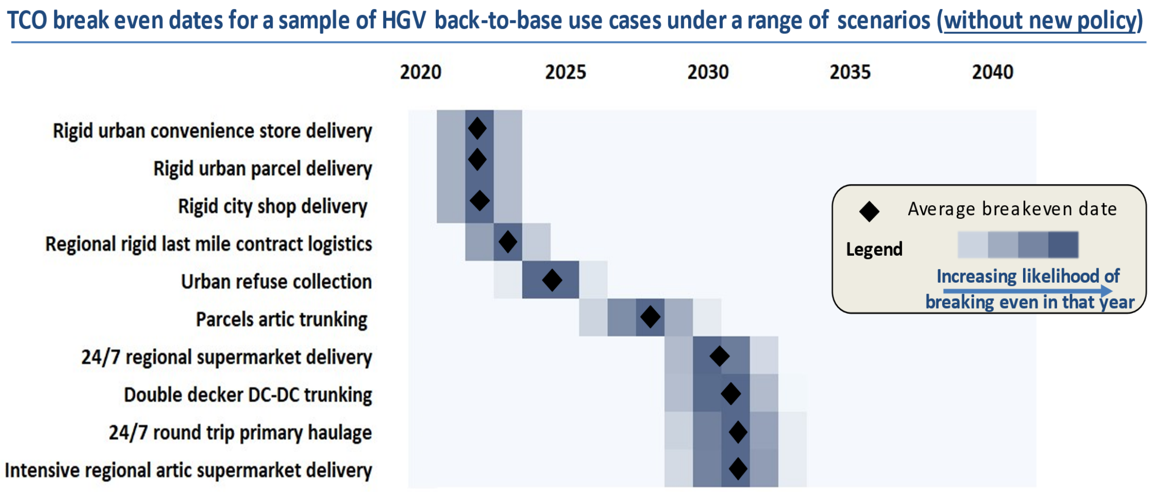
4.2.1. Without new policies

The modelling indicates that urban deliveries with predictable daily mileages will likely reach TCO parity first – batteries are small and can be right sized, reducing vehicle capex. Regional deliveries with significant downtime (which can be used for top-up charging) reach TCO parity around the end of this decade – this includes some artic HGV duty cycles. Intensive regional artic HGV duty cycles benefit from the projected incremental increases in battery energy density and vehicle range over the coming decade, reducing their need for top-up charging and infrastructure costs and enabling likely TCO parity before 2035. Sharing of rapid chargers at warehouses can make BETs cost competitive with diesel several years earlier – and could be an important enabler of wider electrification (e.g. of vans).

Even under scenarios projecting significant delays in battery cost reductions, the modelling suggests that BETs are likely to achieve TCO parity with diesel across the board by the early 2030s, and in rigids performing city, urban and regional deliveries by the mid-2020s.

It should be noted, however, that these dates assume battery and infrastructure right-sizing – choosing a BET with more range than is needed by the operation will result in a higher upfront cost and delay the TCO parity date. OEMs are, in general, already offering a range of battery sizes but it is acknowledged that exact battery right-sizing on a vehicle-by-vehicle basis is unlikely.

Conversely, it bears repeating here that these parity dates are projected based on generally conservative assumptions, including no aerodynamic improvements to vehicle efficiency, only incremental improvements in existing battery technology and conservative infrastructure cost assumptions. Assumptions on battery energy density and vehicle performance have been carefully checked against the specifications of current and future announced (2024) OEM models and found to agree very well.



4.2.2. With new policies

A package of policy measures has been developed that would close the TCO gap over the first owner's usership period and bring forward the above baseline TCO dates. As an example, one of the new policies modelled involved enhanced purchase subsidies for BETs, of up to £45,000 for rigid HGVs > 7.5t and up to £125,000 for artics (the current UK maximum grant is £25,000). If such a subsidy regime were in place, the modelling projects TCO parity dates would be brought forward by around three-five years to typically the mid-late 2020s for the back-to-base artic HGV use cases. Note that subsidies such as this could be gradually phased out, as battery costs and the overall business case improves, and are only needed in the short term to help kick start adoption – since, as shown above, all the use cases studied are indicated to be cost competitive without subsidy by 2035.

Across the range of policy measures assessed (and discussed more fully in the recommendations section of this report), all the use cases studied could be made cost competitive for back-to-base BETs in the 2020s.

4.2.3. Sensitivities

The modelling indicates that the TCO trade-off between a long-range BET and a shorter-range BET with greater need for warehouse charging is insensitive to battery cost changes. The assumed vehicle lifetime influences the TCO comparison between large batteries without warehouse charging and smaller batteries with warehouse charging. BETs are still projected to reach cost parity with diesel trucks for rigid HGV regional deliveries during the 2020s – even if the projected battery price reductions are substantially delayed. Further improvements in battery cycle life by 2030 are likely to allow increased vehicle lifetime and drive further TCO reductions.

4.3. TCO modelling results – long distance, heavy-duty use cases

For the second phase of the research, the TCO analyses were carried out in a slightly different way. Rather than model the TCO break even dates for specific use cases, the TCO analyses were grouped to derive, for any specific year (date of first purchase/use of the vehicle) the overall proportion of GB new 6x2 tractor unit HGV sales (i.e. those able to operate at up to 44 tonnes) that would have lower TCO if BETs than

would be the case for their diesel equivalents.
To inform the TCO modelling and operational assumptions, the researchers first examined Department for Transport data on HGV journey profiles. Their analysis concluded that most driver shifts include time spent picking up and dropping off goods, reducing distance travelled during the shift (and hence en-route charging requirements) while also often providing additional downtime for charging. Nine hours of continuous motorway driving with only one 45-minute break in the middle represents the most demanding driver shift in terms of range and recharging time requirements. However, time spent loading and unloading, combined with GB's geography, mean that well over 90% of articulated HGV driver shifts do not involve two consecutive periods 4.5 hours of non-stop motorway driving separated by just 45 minutes of downtime – instead the vehicles drive shorter distances, often with more downtime. This both provides more opportunities for vehicles to charge and reduces the amount of en-route charging needed as the vehicles travel a shorter distance before returning to depot – meaning the battery would generally not need to be recharged to close to 100% capacity in any single 45-minute break, an important consideration as, in general, batteries recharge more slowly as they get closer to 100% full.

Additional downtime costs have been included for double shifted vehicles to account for the possibility that the vehicles sometimes perform back-to-back shifts with no time in between the first driver returning to depot and the second driver leaving, or that early-stage public charging infrastructure leads to some sub-optimal stopping locations. The total cost of ownership results presented include the effects of some productivity loss due to charging downtime, but the analyses suggest that even where the vehicle operation does feature some productivity loss owing to small amounts of additional downtime for charging, the costs are small compared to the fuel cost savings from battery electric vehicles.

The analyses also indicate that around half of GB 44 tonne HGV operations could be run with 42 tonne 4x2 tractor units (five-axle artics) with no loss of payload. This has significant implications for the switch to battery electric because battery packaging constraints are far less significant for 4x2 tractor units than the 6x2's needed for operations above 42 tonnes overall vehicle weight.

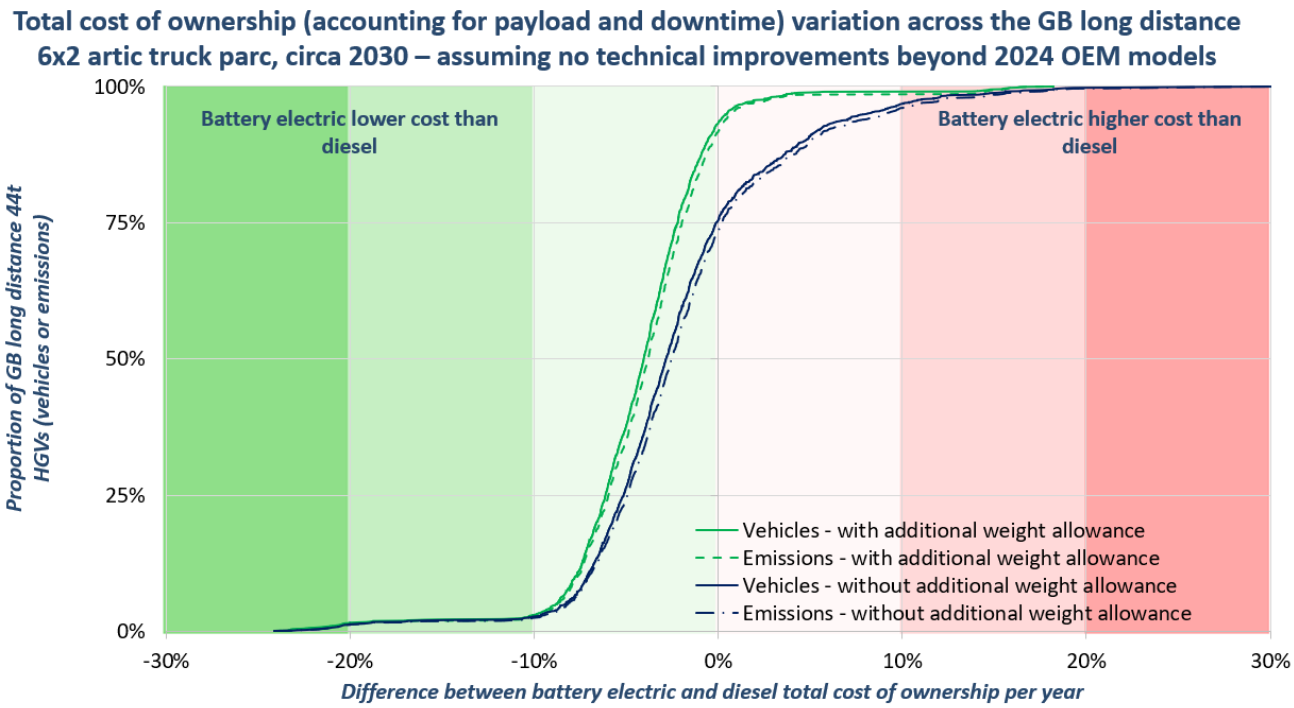
4.3.1. Without new policies

The modelling indicates that more than half (perhaps up to three-quarters) of long distance, heavy-duty 44t HGV use cases are likely to be cost competitive with battery electric vehicles by 2030, even if vehicle range and payload does not improve after 2024 and there are no major new policy interventions. The 44t artic use cases that are projected to achieve the greatest overall TCO benefits by 2030 are those that rarely (or never) weigh out, and hence are not impacted significantly by any payload reductions, as well as those that source most of their energy from depot charging (either overnight or rapid charging between shifts), which will be lower cost than an early-stage public charging network with low utilisation.

The TCO modelling indicates that overall costs are likely to still be slightly more favourable (up to around 10%) for diesel 44t trucks in 2030 in use cases that are frequently weight limited and hence would tend (as BETs) to be impacted by reduced productivity (because each vehicle has a lower overall payload capability due to the weight of the battery and thus operators need more of such vehicles to carry the same overall weight of goods). Use cases that are likely to need to source a high proportion of their energy from public charging infrastructure fall into this category, too. At the most extreme end of the spectrum, where diesel trucks TCOs are still likely to be quite substantially more favourable than BETs in 2030, by perhaps 10-30%, are niche operations such as two-driver long haul use cases with two drivers in the vehicle most of the time and extremely limited downtime. This situation also applies to 44t use cases with very low annual mileages and hence limited scope for fuel cost savings (also rare for new vehicles).

4.3.2. With new policies

Various additional policy measures have been developed that would serve to further increase the proportion of new 44t BETs that could cost-competitively complete their use cases in a 2030 base year. A comprehensive discussion of these policies is included in the recommendations section of this report. As an example of how policy changes might influence the TCO calculations, the figure below presents the modelling outputs for a policy to allow six-axle BET artics to operate at up to 46t maximum weight. This would enable many of the operators that regularly weigh out (at 44t with diesel vehicles) to move to battery electric by 2030 and increase the overall proportion of new 6x2 tractors that could run as BETs to around 90% by that time. Such a policy would also provide greater confidence to operators that rarely weigh out to make the transition to BETs and allow operators of HGVs in remote, rural areas with limited infrastructure to choose a longer range, larger battery BEV without payload loss.



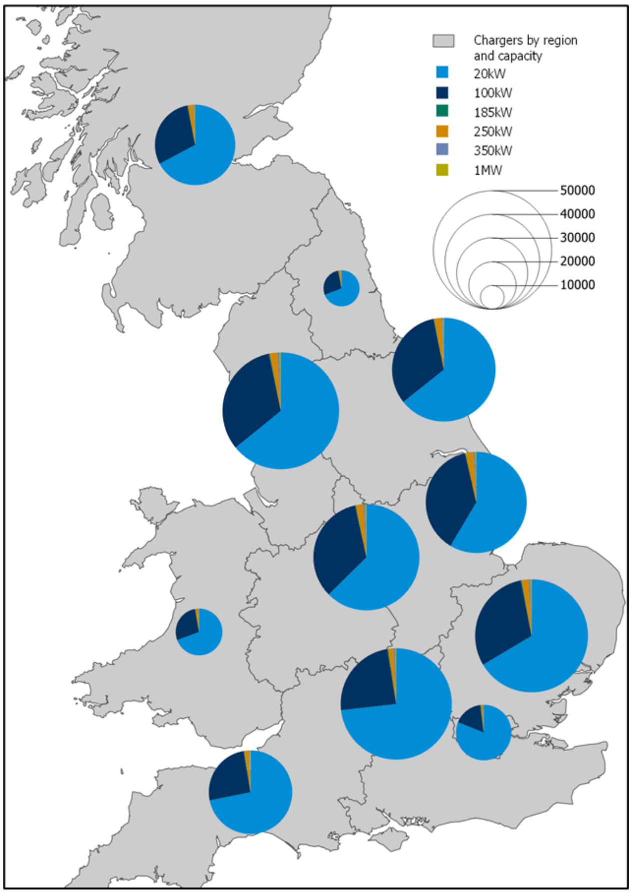
4.3.3. Battery and charging infrastructure optimization

Infrastructure availability will be a key factor determining the speed of decarbonisation of the GB HGV fleet. With the caveat that their study only considered "big-battery" options for HGVs, not more radical battery size-minimization strategies such as Electric Road Systems, battery swapping or "pony-express" tractor unit swapping, Element Energy's research suggests firmly that most HGV charging will occur at the operator home depot, including for most six-axle articulated vehicles.

The research indicates that around two thirds of GB rigid HGVs would be able to complete their operations by charging entirely at their home depot. Half of the GB fleet of 44 tonne, six-axle artic HGVs would be likely to source 85% or more of their energy from depot charging (or for tramping vehicles, overnight truck-stop charging) and over 80% would probably source at least 70% of their energy in these ways.

Depot charging predominates in the modelling as there is no “chicken-and-egg” problem for depot chargers - they can achieve high utilisation immediately after installation (through being used every night for an overnight charge), making them a highly cost-effective solution. Public chargers, on the other hand, require aggregation of demand from many vehicles to achieve good utilisation – and hence, in the early years, will have lower utilisation and be more expensive to charge at than depot chargers – hence operators would be commercially driven to charge at their own depots as much as possible.

Depot chargers and public overnight chargers deliver the majority of the charging needs, but en-route chargers are a critical enabler of long-distance operations including for most 44 tonne artics. The research indicates that a total of around 400,000 truck chargers would be needed by 2050, with 93% of those being depot-based and 97% being 100 kW or less for (generally) overnight charging. For context, there are already estimated to be around 400,000 home or workplace chargers installed for cars or vans in the UK and over 40,000 public charge points (including around 2,500 >100 kW). The researchers have also mapped data on existing HGV movements and depot locations to highlight regional differences in the balance of particular HGV charger types needed by 2050 (see figure below).



The research indicates that the total installed charger capacity needed to power the modelled fleet of BETs varies greatly by region, with high concentrations around London, Birmingham and Manchester. These are places where the existing electricity grid tends to be strongest, such as Barking & Thurrock in east London, Sandwell in the West Midlands, and Halton & Trafford in the North West.

A comparison of charging power needs to local population has highlighted places where truck power requirements most vary from the underlying domestic needs. For example, Eden, in Cumbria, is sparsely populated but hosts several long-haul truck-stops. Some other hotspots (where truck charging would add significantly to local grid demand) reflect the pure intensity of logistics activity in the local economy, especially in the southern East Midlands.

The TCO modelling strongly suggests that the first HGV operations to electrify (primarily rigids) will charge entirely at their home depot. This is because these short distance back-to-base operations do not need to wait for a public charging network to be in place in order to electrify, and also have the most immediately competitive total cost of ownership with diesel. As a result, the fastest ramp-up for charging demand will occur in areas with a high concentration of rigid vehicle depots. Areas with a high proportion of rigid HGVs – particularly London – will require a higher proportion of their infrastructure to be in place by 2030, owing to the higher uptake expected for rigid battery-electric HGVs in the 2020s. It will be important that sufficient grid capacity is in place ahead of time so that power availability does not limit the speed of electrification for early movers in such areas.

For public, en-route charging, the modelling suggests two main types will be needed – a mix of 350 kW and 1 MW chargers delivering roughly half each of the overall energy needed by GB HGVs using public charge points. Each charger type would have a distinct role - 350 kW chargers would provide small top-ups during loading and unloading at warehouses, as well as top-ups during driver 45-minute breaks for regional delivery vehicles (which includes many articulated HGVs) – such breaks also often occur near warehousing areas. The reinforcements required for 350 kW charging near warehouses would also be needed to support depot charging near warehouses and could be performed at the same time. This reflects the fact that most HGV depots are near warehousing locations. The research indicates that around 800 of the 350 kW chargers would be required to meet 2030 GB HGV charging demand, primarily at destinations.

1 MW chargers would serve vehicles with high out-of-depot energy demands and limited downtime. They would also play a role for vehicles performing deliveries and collections at small sites (such as farms) that will not be able to support charging infrastructure, meaning that the vehicle cannot "sip" charge during trailer loading / unloading and instead will need to charge just once in the middle of the shift, during the driver break. 1 MW chargers would also play an important role for international road freight, because although these vehicles account for only a small proportion of HGVs present in Great Britain at any one time, they will be much more reliant on public charging than domestic HGVs. The modelling further suggests that the total number and spatial distribution of 1 MW chargers required in 2030 broadly corresponds to one-three 1 MW chargers in each Motorway Service Area and truck stop, rising to one-ten at each location by 2050, corresponding to a peak demand of around 6 MVA at any one location.

4.3.4 Sensitivities

"Monte Carlo" multi-scenario modelling reveals that the cost impact of uncertainties around the assumptions of 2030 parameters is limited, even if battery technology did not improve beyond 2024 (a highly unlikely scenario in its own right).

The modelled overall variations in TCO between the central set of cost/price assumptions and those relating to the extremes (i.e. that most favour diesel or battery electric vehicles depending on the specific assumptions) amount to around +/- 10%. Given the inherently uncertain, unpredictable nature and volatility of HGV operational costs - fuel prices, driver wages, maintenance/repair costs etc.- this level of TCO risk is generally considered to be within existing and accepted tolerances.

5. Recommendations for policymakers

The research has firmly indicated that a battery-electric truck future for the GB HGV fleet is an achievable objective. It has also shown that this transition is likely to be achievable, in terms of the business case to support new truck purchases, well ahead of the existing 2035 and 2040 UK phase-out dates for sales of new non-zero emission HGVs. But we are in a climate emergency and a volatile global economy, so the researchers have also looked at a wide range of near-term policy interventions that could accelerate and bring forward that transition and thus make an even stronger contribution to carbon budgets and air quality improvements while boosting economic growth and energy security. Their analyses suggest the following policies would be most likely to be both deliverable and have the greatest overall impact on accelerating the shift to battery electric HGVs. These have been split into three broad categories; supply-side measures aimed at truck manufacturers, financial incentives for vehicle operators and infrastructure providers, and regulatory changes to enhance HGV operational capabilities and productivity.

5.1. Encouraging the supply of BETs through regulation and fiscal policy

Recommendation 1 – Strengthen the phase-out dates policy by introducing interim ZEV mandates.
ZEV mandates are essential to ensure there are sufficient zero emission trucks available to meet the likely demand. They are also crucial to bring down the individual BET unit costs thanks to economies of scale.

Recommendation 2 – Support supply chain development for battery electric trucks.
The UK still has some world-leading truck manufacturers and manufacturing facilities, as well as a reputation for excellence in automotive innovation, research, and development. Strengthening and expanding this supply chain and positioning it for the coming global transformation to battery electric trucks could and should be a much stronger pillar of UK automotive industrial strategy.

5.2. Supporting investment in infrastructure and vehicles

Recommendation 3 – Provide more effective vehicle acquisition incentives.
While BETs are today usually more expensive to own and operate than diesel trucks, this situation is set to change radically over the next five to ten years, as costs fall and economies of scale are achieved. The current higher prices highlight the need for more effective vehicle acquisition incentives (than current Plug-In Truck and Van Grant levels), which the Government should urgently explore and propose. It can be noted that several other countries already offer much more generous purchase grants. This enhanced support does not necessarily have to involve new, additional taxpayer funding – other countries have, for example, developed bonus-malus schemes that add a small levy onto the very large number of diesel vehicle purchases and thus provide a much larger (per vehicle) subsidy pot for purchasers of new ZEVs in a way that is overall cost-neutral on industry and the exchequer. Stronger support mechanisms are also needed for smaller operators looking to acquire second-hand battery electric commercial vehicles.

Recommendation 4 – Support the roll-out of private charging infrastructure for depot-based fleets.
Regulation must mandate and support sufficient, smart and cost-effective charging infrastructure supply for depot-based commercial vehicle fleets and remove the various existing barriers to rapid deployment. Specific areas to address include landowner consenting, planning permission, grid infrastructure

upgrades and the additional barriers faced by operators based in rural areas.

Recommendation 5 – Lower the early-years risks to public truck charging infrastructure providers.
Public charging infrastructure may generally have low utilisation in the early years, with utilisation and revenues increasing dramatically over the lifetime of the infrastructure as vehicle uptake increases. If private sector balance sheet investment could be leveraged against a zero/low interest loan from government, this would improve the internal rate of return during early years of low utilisation, and – if repayment rate were dependent on revenues and utilisation – help reduce the level of risk to the private investor caused by uncertainty over utilisation ramp-up rate over the later years of the infrastructure. Encouraging the sharing of truck charging infrastructure with other suitable vehicle types (such as vans and coaches) will further improve overall utilisation and serve to lower investor risks.

Recommendation 6 – Fund truck public charging at major warehouses and develop planning policies to further incentivise charging infrastructure at logistics hubs.
The modelling indicates there is likely to be concentrated demands for HGV charging in major warehousing areas, resulting from both depot charging and en-route charging. The presence of depot charging as well as en-route charging in major areas will make peak power demands in some warehousing areas similar or greater than that of many Motorway Service Areas (MSAs), and, because of the large amount of depot charging, the ramp-up will be faster. Tax breaks and other policies that would incentivise multiple stakeholders and landowners in warehousing areas to install infrastructure could help overcome issues caused by low land availability in warehousing areas. Planning rules could be adjusted to incentivise and remove barriers to charge point installation and shorten lead-times.

5.3. Enhancing HGV productivity and logistical efficiency

Recommendation 7 – Consider changes to maximum vehicle weight and length regulations.
Two changes to the Road Vehicle Construction & Use and Authorised Weight Regulations could significantly accelerate decarbonisation of GB's long-distance heavy-duty HGVs. A one-metre increase in allowed vehicle length and two-tonne increase in allowed gross vehicle weight would allow operators to switch from the heaviest 44 tonne diesel HGVs to 44 + 2 tonne battery electric HGVs without loss of payload deterring adoption. Opportunities to trial such interventions and assess fully their real-world impacts exist through current and planned demonstration programmes including, where necessary, through the application of Vehicle Special Orders and limitations to use only authorized routes.

Recommendation 8 – Review and amend where appropriate driver hours regulations and rest stops.
Some targeted flexibility in the driver hours regulations and working-time definitions could allow charging locations to offer greater freedom of movement for battery electric long-haul trucks. Recent research and trials of a four-day week may indicate, too, that a more generous driver-break regime may enhance overall productivity, driver retention, health and well-being etc – the major hauliers and their trade associations should be encouraged to explore and develop appropriate best practice guidance that would also facilitate charging stops and lower their perceived or actual business productivity impacts. This review could also usefully examine how improving the overall quality and service offerings at truck stops, as part of wider investment and roll-out of charging infrastructure, alongside technologies such as automated charging functionality, could further support driver welfare and productivity.

The above recommendations arise directly from this study's assessment of the potential benefits of accelerating the uptake of battery electric trucks across Great Britain. But there are a range of potential complementary measures that would serve to further accelerate the decarbonisation of the sector and its transition away from fossil fuels. For example, the deployment of alternative fuels, the electrification of auxiliary loads and the use of the latest aerodynamic / rolling resistance features can all play important roles during the transition period towards 100% zero-emission vehicles.

6. Concluding remarks

This research indicates that in this decade, well ahead of the UK Government's current 2035/40 phase-out dates, 65-75% of GB rigid HGVs and 30-35% of our articulated HGVs could be able to operate sustainably and productively as battery electric trucks without significant reliance on future public charging infrastructure. Together, these back-to-base use cases capture over half of GB HGVs and currently account for around 25-35% of all GB HGV greenhouse gas emissions. The fastest ramp-up for charging demand is likely to occur in areas with a high concentration of rigid vehicle depots. Areas with a high proportion of rigid HGVs – particularly London – will require a higher proportion of their infrastructure to be in place by 2030, owing to the higher uptake expected for rigid battery-electric HGVs in the 2020s.

The study also shows that Great Britain's long-distance, heavy duty 40-44t five or six-axle articulated HGVs could be able to perform their operations using battery electric vehicles and appropriate static charging infrastructure with technology set to be available from 2024. Battery electric HGVs are projected to become cost competitive with diesel equivalents for many long-distance, heavy-duty use cases around 2030, even with any payload losses and charging downtime fully considered. Roughly half of GB HGVs and two thirds of GB HGV emissions are from vehicles that would require some form of charging outside their home depot in order to complete longer trips.

The research points to most charging being needed at depots (for all HGV types including 40-44t artics), but a public charging network will also be needed, and a set of additional policy measures could enable battery electric HGVs to get on the road to net zero even faster and start to significantly reduce emissions from long-distance, heavy-duty trucking in the second half of the 2020s.

A battery-electric truck future for the GB HGV fleet is an achievable objective. This research has also shown that this transition is likely to be achievable, in terms of the business case to support new truck purchases, well ahead of the existing 2035 and 2040 phase-out dates for sales of new non-zero emission HGVs in the UK.

But we are in a climate emergency and a volatile global economy, so there is a clear need and opportunity for near-term policy interventions to accelerate and bring forward that transition (by between two and five years in most cases) and thus make an even stronger contribution to carbon budgets and air quality improvements while boosting economic growth and energy security.

Acknowledgements

T&E are indebted to the many organisations and individuals who have contributed to this study and briefing paper. Particular thanks are due to the team at Element Energy (an ERM Group company), Richard Riley and Will Drake, for their expertise, thoroughness and professionalism in meeting the research objectives, and to Brian Robinson at BJR Solutions Ltd for his work to manage the research and draft this paper on T&E's behalf. Finally, we must also acknowledge the expert contributions and guidance provided by the project's advisory group:

Andy Eastlake (Zemo Partnership)
Denise Beedell (Logistics UK)
Ella Brookes & Ellie Davies (Department for Transport)
Jon Regnart (APC)
Justin Laney (John Lewis Partnership)
Lorna McAtear & Russell Fowler (National Grid)
Peter Harris (UPS)
Phil Greening (Centre for Sustainable Road Freight)
Sam Clarke (Gridserve)
Tanya Neech (Scania)