Fleet decarbonisation review

Pendle Borough Council

Beatrice Sampson and Joseph Walters

Final report

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energysavingtrust.org.uk

Contents

1. Executive summary

Pendle Borough Council (PBC) formally declared a Climate Emergency in 2019, with the target to be 'carbon neutral' by 2030. PBC have a Climate Emergency Working Group, and have adopted a Climate Emergency Action Plan 2020-2025. Within the Action Plan, the key strategic objective for this project is 'Reduce emissions from the Council's transport fleet', and the relevant actions are:

- 'Introduce electric vehicles into the Council's transport fleet and explore options for biogas from recycled vegetable oil',
- 'Introduce an electric Mayoral vehicle'.

PBC commissioned Energy Saving Trust to assess how to decarbonise the fleet vehicles, and understand what the optimum route to delivery would look like. This project analyses PBC's operating data to determine the best route to decarbonisation, including costs and greenhouse gas (GHG) emissions savings.

PBC operate a mixed fleet based from the Fleet Street Depot, consisting of cars, light commercial vehicles (LCVs or vans), heavy commercial vehicles (HCVs), and refuse collection vehicles (RCVs).

Key findings and opportunities

In the financial year 2023/24, PBC provided the details for 75 fleet vehicles: 13 cars, 36 LCVs, 10 HCVs (mostly sweepers), and 16 RCVs. Fuel data was available for almost all vehicles, and mileage data available for most. Telematics data was also available for some of the LCVs, and most of the HCVs and RCVs.

In 2023/24, PBC's fleet drove around 383,000 miles, used around 2,520 MWh of energy, and emitted around 664 tonnes of GHG emissions, 388 kg of nitrogen oxide (NO_x) emissions, and 4.3 kg of particulate matter (PM).

The energy efficiency (mpg) of many of the fleet vehicles is lower than we would expect, meaning that there are some opportunities to reduce GHG emissions immediately, and prior to any major fleet renewal. Improving the driving efficiency of fleet vehicles could typically achieve around 5% fuel savings, although where there have been no previous interventions, this can be as high as 15%. This

In 12 months, the PBC fleet:

Drove around **383,000 miles**

Consumed over **2,520 megawatt hours** of fossil fuel energy

Produced **664 tonnes** of GHG emissions

Scope to reduce annual GHG emissions by around **550 t** with BEVs would be equivalent to a range of 33t-100t annual emissions reductions and £14,000 to £43,000 annual cost saving.

With most of the fleet up for renewal in 2026, PBC have the opportunity to decarbonise a significant proportion of the fleet, ahead of the 2030 carbon neutral target. Based on assessment of the PBC fleet, and available zero-emission technologies, battery electric (BE) will be the most suitable alternative in most cases. Battery electric vehicles (BEVs) have high energy efficiency and zero tailpipe emissions, and where suitable to current usage patterns offer the best option for decarbonisation. However, this has to be cost-effective and practical. We have reviewed the fleet in detail to establish where this approach will work.

To achieve the best outcomes, several structural actions are required – starting with the establishment of an 'energy transition team', adaptation of fleet replacement cycles, a BEV focused purchasing policy, and allocation of sufficient funds, as well as use of whole life costing (WLC) methods to help justify expenditure. It is also essential to invest in infrastructure prior to electric vehicles arriving.

Our evaluation of the fleet data and energy consumption shows that most vehicles on this fleet could be replaced by existing BE products that would be at least as operationally effective as diesel models. The financial case varies, so whilst BEVs are always cheaper to run if charged at the depot, whole life costs (which include capital and running costs) vary from cheaper than diesel to more expensive than diesel, depending on vehicle category and mileage. However, comparisons between electric and hydrotreated vegetable oil (HVO) are usually much more favourable to BEVs due to the cost premium on HVO.

Some vehicles on fleet are not yet suited to electrification (namely the sweepers and 22t RCVs), however we expect there will be wider availability by 2026, and certainly by the end of the decade. A small number of vehicles may need to be replaced with diesel models at the 2026 replacement, with their subsequent replacements likely to be electric. However, as these vehicles will be kept for seven years to 2033, PBC should consider this carefully, as this is beyond the carbon neutral target of 2030. Vehicle electrification potential is summarised in Table 1-1 and the estimated costs and relative costs of the transition based on WLC modelling are shown in Table 1-2. Vehicle numbers only consider those on fleet as of 31 March 2024.

Table 1-1 Operational suitability of PBC fleet sectors to transition to battery electric

Fleet Category	No. of vehicles	No. of vehicles suited to BE in 2024	No. of vehicles requiring additional confirmation	No. of vehicles where 2024 BE availability not yet suitable
Car	9	9	-	-
LCVs up to 3.1t	7	7	-	-
LCVs 3.1-3.5t	16	16	-	-
Utility/Pick-up	3	-	3	-
12t skip loader	1	1	-	-
7.5t gully tanker	1	-	1	-
Sweepers	6	-	1	5
15-18t RCV	7	5	2	-
22t RCV	7	-	-	7

It is evident that of the vehicles where replacement is planned, the vast majority can be replaced by an electric equivalent, based on our assessment of the available data. A small number would need more clarification (either because of high usage patterns or because of a lack of data) and 12 currently don't have a suitable electric equivalent available in today's market, although we expect this to change.

Table 1-2 Likely cost and emissions savings from electrification

Fleet category	Ave estimated annual *cost* or (saving) per BEV	Total annual *cost* or (saving) for the fleet	Ave estimated annual GHG saving per BEV	Total annual GHG saving for the fleet
Cars	*£460*	*£4.2k*	1.6 t	14 t
LCVs	(£590)	(£15.4k)	3 t	79 t
12t skip loader	-	-	4 t	4 t
Sweepers	-	-	19 t	114 t
15-18t RCVs	(£8.5k)	(£59.5k)*	24 t	168 t
22t RCVs	-	-	24 t	168 t
Total	**/**	**(£70k)**	**/**	**547 t**

*Assuming costs for 15t RCVs are same as the 18t WLC analysis in Section 9.4.

Most existing PBC diesel vehicles can be replaced by BEVs at a cost saving on a WLC basis, with the main exception being the small fleet of hatchback cars due to their low utilisation. Those fleets for which we have not been able to accurately analyse the WLC (as these are specialised vehicles which may not yet be suitable to transition to BE) are likely to incur costs, although we cannot accurately determine this for the fleet replacement in 2026.

With a clear path to decarbonisation through electrification, efforts need to be made to invest in electric vehicle charging infrastructure (EVCI). Overnight availability to charge means that infrastructure only needs to be low impact AC charging (22 kW for HCVs and RCVs and 7.4 kW or less for vans and cars). A total spare connection size of 370 kVA is needed for the whole fleet as BE to be charged, if it is managed on a smart system. Rapid (DC) charging would significantly increase the demand for power, but the presence of one or several 50 kW DC charge points could add flexibility to operations, for daytime top-up charging for example.

It is likely PBC will need to upgrade the electrical capacity of its depot in order to meet the demand for BEV charging. This work is undertaken by the Distribution Network Operator (DNO), which pays for assets external to PBC locations. There is likely to be an additional cost for infrastructure needed within PBC locations as well. Installing charging infrastructure for the fleet is a large project, but will outlive the vehicles (and infrastructure and capacity upgrades will only be needed once).

Summary of recommendations

Topic	Recommendation	Notes	Section
Transition	Establish a BEV transition team to oversee electrification projects.	PBC have a Climate Emergency Working Group which may fulfil this role.	-
Data	Improve data collection and management.	Install telemetry systems on those vehicles currently without.	4.4
Efficiency	Improve vehicle usage efficiency.	Use the improved data collection to accurately report on driver performance and improve driving efficiency.	4.2 and 6.3
Car fleet	Replace diesel and petrol cars with BEVs as these come up for renewal.	All cars on fleet can be replaced with currently available BE versions, the hatchbacks may incur a cost but the saloon may save costs.	7
LCV fleet	Replace diesel LCVs with BEVs as these come up for renewal.	All LCVs on fleet can be replaced with currently available BE versions, and at a cost saving.	8
RCV fleet	Replace the 15t and 18t RCVs with BEV when these comes up for renewal.	The smaller RCVs can be replaced with currently available BE versions, and at a cost saving.	9.4
RCV fleet	Assess the suitability of available BE 22t RCVs when these come up for renewal.	At the moment there is not a suitable BE replacement for the 22t RCVs, so PBC will need to assess what vehicles are available when these need replacing.	9.4
HCV fleet	Replace the 12t skip loader with BEV when this comes up for renewal.	The skip loader can be replaced with currently available BE versions, although this may incur a cost.	9.2
HCV fleet	Assess the suitability of available BE sweepers when these come up for renewal.	At the moment there is not a suitable BE replacement for sweepers, so PBC will need to assess what vehicles are available when these need replacing.	9.3
EVCI	Establish overnight locations for the PBC fleet vehicles.	A BEV will need to have a defined base where a charge point can be installed.	10
EVCI	Assess home charging for vehicles based at employees' homes.	Where vehicles are kept at employees' homes, PBC will need to assess the provision of a home charging point, or nearby charging facilities for vehicles.	10
EVCI	Assess impact of other electrification projects.	EVCI needs to be addressed alongside other electrification projects such as moving to heat pumps.	10
EVCI	Liaise with the DNO to determine site capacity and upgrades.	PBC's depot is likely to need a capacity upgrade, which is done through the DNO.	10
EVCI	Install EVCI for the PBC fleet vehicles, with smart capacity.	An electric fleet needs to be able to be charged, before acquiring the vehicles.	10

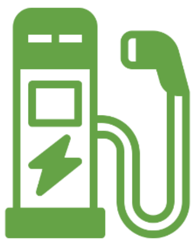
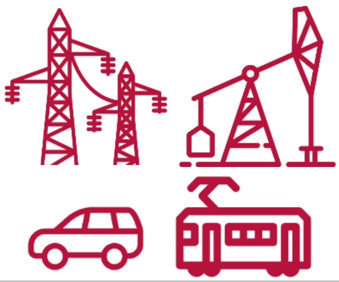
2. Emissions and energy use

2.1 Greenhouse gases

The carbon dioxide (CO_2e) footprint (often shortened to carbon footprint) details an estimate of the tonnage of carbon dioxide that PBC's fleet has emitted in 2023/24. This is based mainly on the fuel data provided, and on mileage data where fuel was unavailable.

The 'e' in CO_2e stands for 'equivalent' and indicates that the estimate includes the other reportable GHGs emitted by the fleet (nitrous oxide and methane) expressed in terms of their carbon dioxide equivalence over 100 years. For example, nitrous oxide (N_2O) has a global warming potential (GWP) 265 times that of carbon dioxide and one tonne of N_2O is therefore equivalent to 265 tonnes of CO_2 (GHG Protocol, GWP Values, AR5). The GWP of methane (CH_4) is 28. In the UK, GHG emissions are usually reported under Scopes 1 to 3 (Figure 2-1). Scopes 1 and 2 are reportable, whereas Scope 3 is discretionary. There is also Out of Scope (OOS) emissions, which in this context covers the combustion of biofuels in internal combustion engines.

Figure 2-1: Summary of GHG reporting Scopes relevant to road transport emissions

Scope 1	Scope 2	Scope 3
		
The fleet you directly operate Owned, leased, hired	Electric vehicle electricity generation	Transmission, distribution, extraction, refining.
Tank to Wheel (TTW), direct emissions, operational emissions	Well to Tank (WTT), indirect emissions, upstream emissions	
Well to Wheel (WTW)		

2.1.1. Summary of PBC fleet GHG emissions

Table 2-1: WTW GHG reporting – fleet size, mileage, GHG emissions and energy consumption

Fleet category	Vehicles	Annual mileage	WTW GHG (tonnes)	Energy (MWh)
HCV - RCV	16	65,842	372	1,529
HCV - Rigid	10	29,576	146	492
LCV	36	217,220	118	398
Car	13	70,576	27	96
Total	**75**	**383,214**	**664**	**2,515**

The WTW GHG footprint of the fleet (Figure 2-2 and Table 2-1) is based on the fuel and mileage data provided by PBC. We have calculated this footprint using the year-appropriate GHG conversion factors published by BEIS/DESNZ. It also includes an estimate of the GHG emissions from burning adBlue in the diesel exhaust systems of HCVs. The methodology used complies with international GHG reporting standards (WRI GHG Protocol) and with UK's SECR Reporting Guidelines which apply to UK public bodies. We have not included the lifecycle GHG emissions associated with the manufacture and disposal of the vehicles, which are classed as out of scope.

Fleet numbers in Table 2-1 reflect the number of vehicles contributing to emissions in 2023/24 rather than the current active fleet size.

Figure 2-2: Greenhouse gas emissions by Scope (includes OOS)

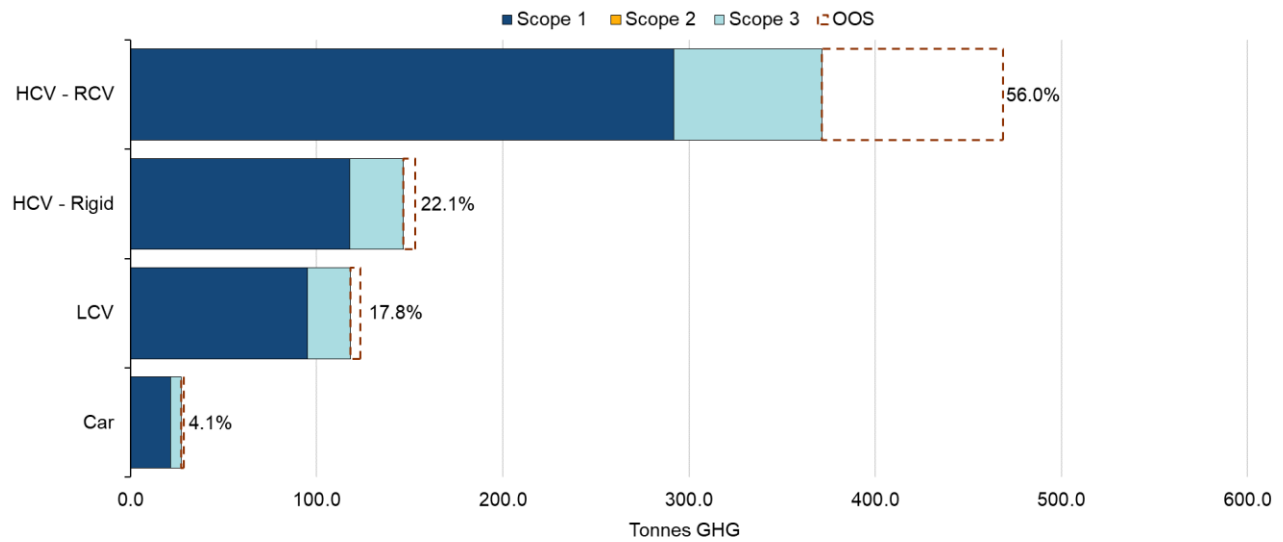


Table 2-2 provides a breakdown of the WTW GHG emissions by reporting Scope. Scope 1 is the most important because it is the fossil-fuel GHG emissions for which PBC are directly responsible. The vehicles burning the fuel are fully controlled and operated by PBC and all aspects of their use from specification, usage, driving standards and monitoring are its direct responsibility. No other organisation can reduce these emissions. There are no Scope 2 emissions as PBC do not yet have any electric vehicles on fleet.

Table 2-2: GHG reporting by Scopes – Scope 1 and 2 are mandatory, Scope 3 and OOS are discretionary

Fleet category	Scope 1 GHG (tonnes)	Scope 2 GHG (tonnes)	Scope 3 GHG (tonnes)	Out of Scope GHG (tonnes)
HCV - RCV	292	0	80	97
HCV - Rigid	118	0	29	7
LCV	95	0	23	5
Car	21	0	6	1
Total	**526**	**0**	**137**	**110**

Table 2-3 shows that 78% of GHG emissions come from the HCV fleet (RCVs and Rigids) which undertake 25% of the fleet's mileage. Cars contribute only 4% of fleet emissions despite covering 18% of mileage and similarly LCVs emit only 18% of the fleets GHG emissions, despite covering over 56% of the mileage.

This clearly shows the greatest potential for emissions reduction is in the heavy vehicles, and so it may be worth the higher level of investment to achieve this. In a fleet of this nature, relatively small improvements in efficiency can result in many tonnes of GHG emissions saved.

Table 2-3 Analysis of fleet size, mileage, GHG emissions and energy use

Fleet category	% number	% mileage	% WTW GHG	% kWh of energy	WTW $kgCO_2e$ per vehicle	S1 $kgCO_2e$/km per vehicle
HCV - RCV	21.3%	17.2%	56.0%	60.8%	23,222	2.754
HCV - Rigid	13.3%	7.7%	22.1%	19.5%	14,647	2.477
LCV	48.0%	56.7%	17.8%	15.8%	3,286	0.272
Car	17.3%	18.4%	4.1%	3.8%	2,106	0.189

2.1.2. Battery electric vehicle emissions

BEVs have no Scope 1 GHG tailpipe emissions from directly burning fuel. They do, however, have GHG emissions associated both with the generation of electricity (Scope 2 GHG emissions), with its transmission and distribution (Scope 3 GHG emissions) and with the operation of the plant as well as the extraction and transport of fuels (Scope 3 GHG emissions).

2.2 Emissions that affect air quality

Every litre of fuel burnt, or mile driven by an ICE vehicle, is associated with emissions which have an adverse impact on human health. The emissions generated include hydrocarbons (HC), non-methane hydrocarbons (NMHC), carbon monoxide (CO), nitrogen oxides (NO_X – nitrogen monoxide NO and nitrogen dioxide NO_2) and particulate matter (PM). Vehicle emissions measure NO_X because NO in the presence of sunlight and ozone (O_3) forms NO_2, a regulated pollutant.

Emissions of these gases are much harder to estimate than GHG emissions. This is because they depend on vehicle mileage, how the vehicle is driven, speed, load, usage cycle, the standard of maintenance, fuel type, Euro emission category, engine technology and the effectiveness of the exhaust clean-up system.

We have determined the data in Table 2-4 using average vehicle emissions adjusted for the area of operation as published by the National Atmospheric Emissions Inventory. This analysis is based on vehicle mileage and cannot be determined from fuel data alone, so where mileage driven is missing, emissions cannot be calculated.

Table 2-4: Estimated annual emissions of nitrogen oxides (NO_X) and particulate matter (PM_{10} and $PM_{2.5}$)

Fleet category	NO_X (kg)	PM (kg)
HCV - RCV	111	1.7
HCV - Rigid	50	0.8
LCV	219	1.7
Car	8	0.1
Total	**388**	**4.34**

A more accurate assessment of the vehicle air quality impact would require the use of the COPERT V5 model and much more detailed usage data about each vehicle. Some fleets may have much higher emissions due to slow operating speeds, low engine temperatures, and stop/start operation which results in the Euro VI exhaust clean up technology being switched off by the engine management system to avoid emissions of ammonia and other noxious substances; this is not reflected in the above figures.

Each year in the UK, between 28,000 and 36,000 deaths can be attributed to a combination of $PM_{2.5}$ exposure and NO_2 exposure (Public Health England, March 2019). In England alone, the cost burden to society of these two pollutants over a ten year period (to 2025) is estimated as being in the range £5 billion to £20 billion, depending on how many diseases with links to poor air quality are included in the estimate (Public Health England, 2018).

NO_2 is strongly linked to childhood asthma and less strongly associated with adult asthma, diabetes, lung cancer, low birth weight, and dementia. Particulates are strongly associated with coronary heart disease, childhood asthma, stroke and lung cancer. There is less strong evidence of an association between particulates and chronic obstructive pulmonary disease, diabetes, and low birth weight. Recent research in London has further linked both $PM_{2.5}$ and NO_2 to increased mental health service use among people recently diagnosed with psychotic and mood disorders.

Research has also linked particulates with dementia and the World Health Organisation (WHO) fact sheet on air pollution states that there is no known safe level of particulate pollution: "*Small particulate pollution has health impacts even at very low concentrations – indeed no threshold has been identified below which no damage to health is observed.*"

The WHO Guidelines were revised in September 2021 and the WHO has encouraged all countries to work towards the new recommended levels and for decision-makers to use the Guidelines "*as a tool to steer their legislation and policies*".

The previous (2005) WHO Guidelines were already much stricter for fine particulate matter ($PM_{2.5}$) than the UK legal limits for this type of pollution (10 $\mu g/m^3$ compared to 25 $\mu g/m^3$), and the new WHO Guidelines are even tighter, at 5 $\mu g/m^3$ as an annual mean limit. The new WHO Guidelines also include a huge reduction in annual mean NO_2 compared to the UK legal limit; 10 $\mu g/m^3$ compared to 40 $\mu g/m^3$ permitted by current legislation. The WHO estimates that 80% of global deaths relating to $PM_{2.5}$ could be avoided if current air pollution levels were reduced to the new WHO 2021 Guideline level.

Nitrogen dioxide (NO_2) emissions which originate primarily from transport have a direct impact on public health, something that should be considered in broader corporate social responsibility policies and influence decision making beyond the immediate financial case. Air quality presents a very strong argument for any decarbonisation transition to focus on vehicles with zero tailpipe emissions, wherever possible.

3. Fleet profile

When reviewing the PBC fleet, we have used a benchmark of 31 March 2024. The data provided by PBC comprised a total of 77 vehicles, two of which were not included in the GHG analysis in Section 2 but are in the fleet analysis, and 20 which were not included in the fleet, either due to being de-fleeted during 2023/24, as they were short-term hires or third-party spares, or due to errors in VRM registration.

The following charts describe the 57 vehicles on fleet as of 31 March 2024. Figure 3-1 shows the age breakdown of the fleet, Figure 3-2 shows the emissions band rating (LCV and car fleets only), and Figure 3-3 shows the Euro class of the vehicles on fleet. The HCV and LCV fleets are entirely diesel-fuelled (a few have also been using HVO), and all except one of the cars are petrol fuelled (the Mayor's car is diesel). There are no zero-emission or hybrid vehicles on fleet.

The PBC fleet is mostly leased, with the next replacement scheduled for 2026. The HCV – Rigid fleet consists mostly of sweepers, with one skip loader, and one gully tanker. The RCV fleet is a majority of 18t Resource Recovery Vehicles (RRVs, kerbside recycling) and 22t RCVs. The LCV fleet is quite mixed, varying from sub-2t up to 3.5t, with a majority of 3.5t chassis cabs and tippers. The car fleet is a majority of small hatchbacks, and of note is the Mayor's car, a 2017 diesel Mercedes-Benz E Class.

Figure 3-1: Breakdown of the PBC fleet by age

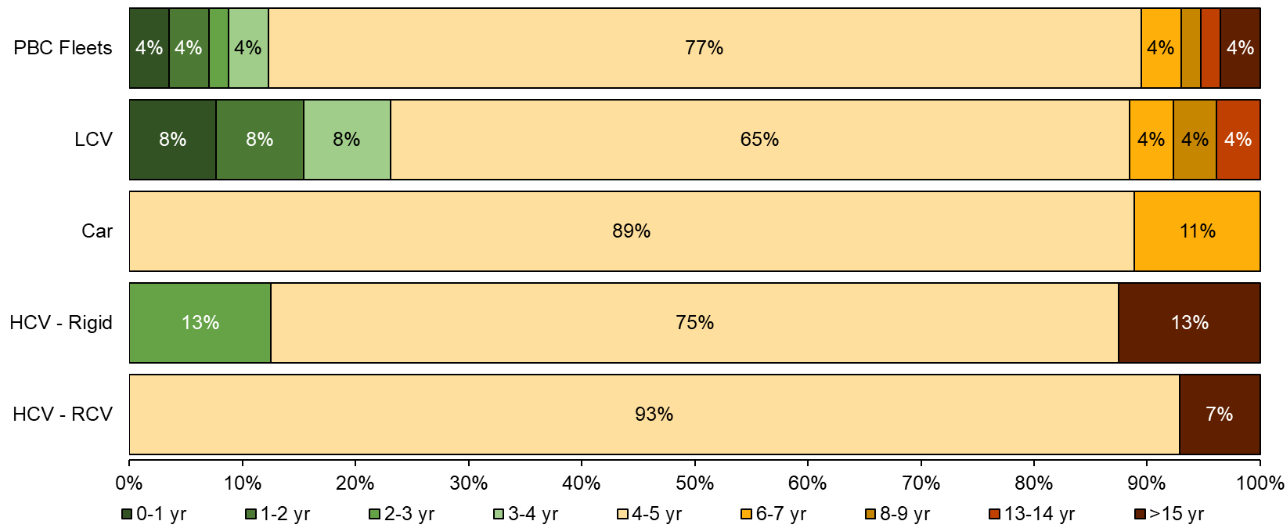


Figure 3-2: Breakdown of the PBC fleet by emission band

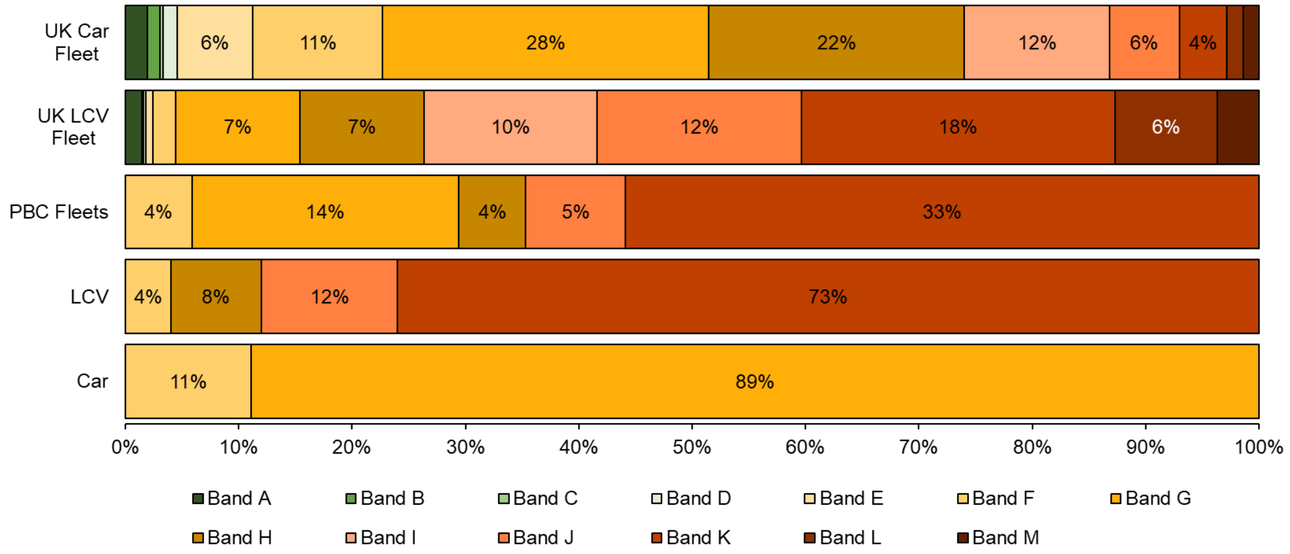
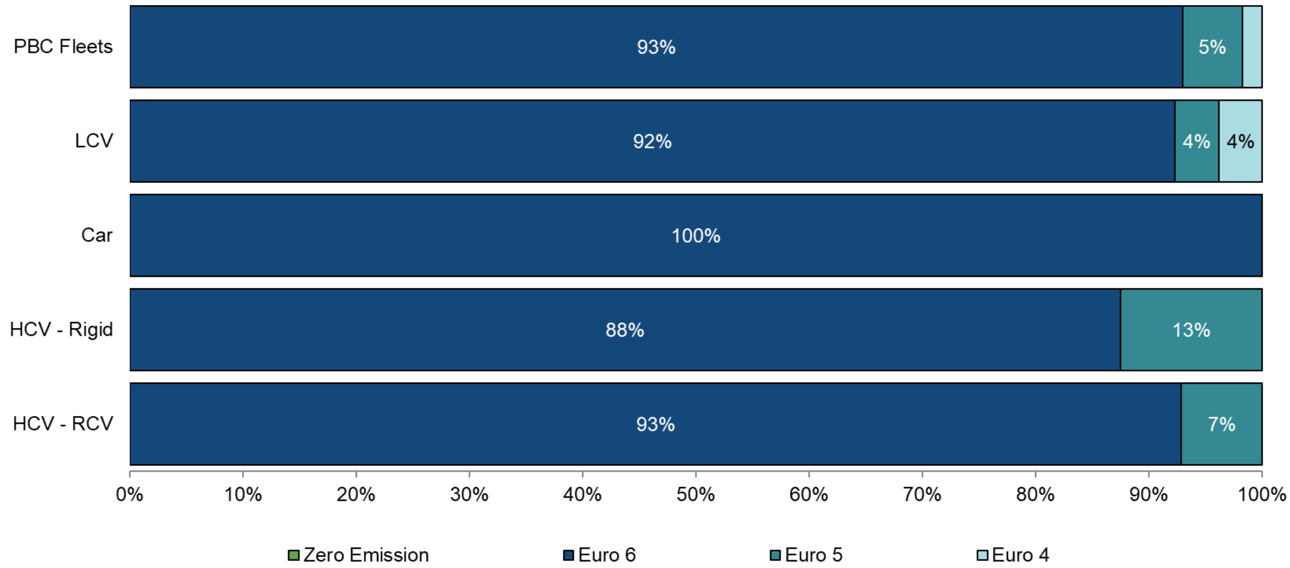


Figure 3-3: Breakdown of the PBC fleet by Euro Class



4. Fleet data management

Central to any well-managed fleet is good data management. Fleet operators must have up-to-date, comprehensive, accurate and accessible data on all the vehicles in use by their organisation, their drivers, their energy consumption (litres or kWh) and the business mileage driven. This applies regardless of the ownership of the fleet (purchase, lease, spot hire, etc.).

For commercial vehicles, it is also important to have information about the work done (eg load carried, jobs completed, etc) so that the performance of a fleet and its environmental impact can be linked back to the service it delivered and form part of a suite of driver, vehicle and fleet performance indicators.

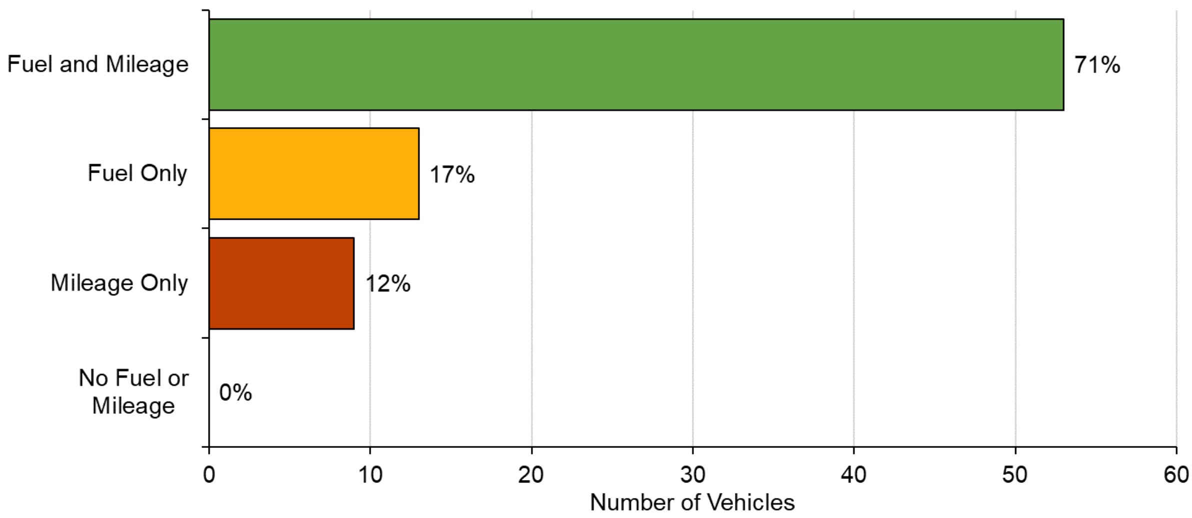
Systems are widely available to accurately monitor bulk fuel tank drawings recording both litres and mileage, record off-site fuel purchases using fuel cards, manage fleet workshops, manage the fleet itself, track all vehicle movements and link to the vehicles' internal information network, known as the CANBUS.

The quality of these commercial systems is variable. Some have not kept pace with developments in technology, and there is often a failure, or inability to fully integrate the data from all the different sources. For example, combining accurate mileage from CANBUS-linked tracking data with actual fuel dispensed from bulk tanks to give accurate energy efficiency (mpg, miles/kWh, Wh/km).

4.1 Description of the data available

PBC provided the vehicle fleet list, comprehensive fuel data from the Fuelmate invoices system and Wagons HVO fuel system, and mileage data from the Quartix telemetry system and mileage reports. Vehicles were present within different files, so we have collated the data together to form the full picture of the PBC fleet, which in total came to 77 vehicles. We were also able to access MOT mileage recordings for most of those vehicles without mileage data recorded. Figure 4-1 shows the quality of the data set provided. This is a good data set, however there are areas where data management could be improved.

Figure 4-1: Quality of the data set (including MOT mileage)



Fuel data was available for 66 vehicles, from Fuelmate invoices and Wagons HVO usage. The Fuelmate invoice data required some cleaning, in that there were erroneous VRMs within the fuel recordings. Where possible we have either corrected or assigned an erroneous VRM to a vehicle known as on fleet (for example correcting DU69NH0 to DU69NHO, or BK65MFH to BK65NFH). We are aware PBC hold some 'wildcard' fuel cards for short term or spot hire vehicles, however no 'wildcard' fuel data was included in the invoices. Although drivers could be more careful when recording their vehicle VRM when refuelling, this is a reasonably good fuel data set.

Mileage data came from a variety of sources, and was available for 38 vehicles. We were able to complement this with MOT recorded mileage for 24 vehicles, totalling 62 vehicles with mileage data. For the majority of vehicles with both fuel and mileage data, the resulting mpg values are as expected for the type of vehicle. There are however six instances in the 3.1-3.5t LCV fleet where the mpg is unreasonably high (between 50-120 mpg). As the mileage data for these comes from the Quartix telematics system, it is possible the fuel data is underreported, perhaps with use of the 'wildcard' fuel cards.

There were four VRMs within the fuel data set which we could not reconcile to a known vehicle on fleet. We have kept these vehicles within the GHG analysis, but excluded them from the PBC fleet profile analysis. The vehicles are DC66XWH, RK21YXC and YT63XZA, all 3.5t LCVs, and FJ70WKO, a 16t RCV. Together these vehicles used 3,621 L of diesel, the majority being used for YT63XZA (2,776 L) and FJ70WKO (825 L). It is possible both these vehicles may have been third party spares or short-term hires. DC66XWH and RK21YXC only drew 10 L of fuel each, so these may be errors in the VRM recording.

There were also five VRMs which were included in the fleet listing provided, but which emerged as not being on fleet (and having never been). We would recommend reviewing the recording system to ensure only correct vehicles on fleet are reported.

PBC has Quartix telematics installed in 13 of the 3.5 t LCVs, 5 of the 4.5 t sweepers, 1 18 t sweeper, 2 15 t RCVs, 4 18 t RCVs, and 7 22 t RCVs, totalling 32 vehicles with daily mileage data available, just under half of the fleet. This daily mileage data is invaluable in informing the transition to a zero-emission fleet, and will be further analysed in Sections 8.4, 9.3, and 9.4 specific to each vehicle fleet.

The data provided by PBC is of a fair standard, including fuel recordings, telemetry data, and mileage data. We would recommend improving the accuracy of VRM recording when vehicles are refuelled, to ensure the correct VRM is input into the system. Mileage was also not available for all vehicles, and accurate fuel and mileage needs to be recorded for all vehicles used by PBC. We would recommend extending the installation of the telematics system into all PBC vehicles, to ensure a smooth transition to zero-emission vehicles, based on accurate daily energy use.

4.2 Using data to improve energy efficiency

While the main reason to improve the energy efficiency data is to inform the move to zero emission vehicles, organisations that introduce tight monitoring of fuel use and a focus on fuel efficiency (mpg) have achieved reductions of 5% to 15% in fossil fuel use, depending on how weak fuel management was to begin. A 5% reduction in fuel use at PBC would save around 33t of GHG emissions and over £14k per year (2023/24, using BEIS/DESNZ conversion factors, excluding VAT).

With accurate energy efficiency monitoring in place and targets established, driver training that focuses on efficiency can be an effective and immediate way to save money by reducing fuel consumption and GHG emissions. As BEVs are introduced, it can also be used to ensure drivers make full use of the energy recovery capabilities of BEVs.

A system, generally based on telematics, needs to be established to monitor driver behaviour and efficiency. This will allow drivers to understand their efficiency performance, and include incentives for drivers to improve their efficiency. Without incentive or additional motivation, not all will engage or identify with the need to reduce emissions and fuel costs. However, it will identify where training should be prioritised.

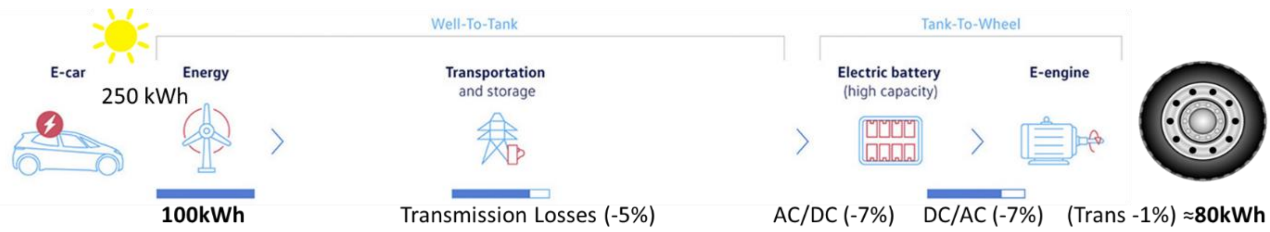
4.3 The importance of accurate data

Accurate energy usage and energy efficiency (mpg) is critical when trying to determine the future energy requirements of a zero-emission battery electric fleet.

Figure 4-2: Energy efficiency of an internal combustion engine vehicle

Internal combustion engine vehicles (ICEVs) are 25% to 30% efficient (Figure 4-2) with the losses (mostly heat and friction) occurring in the engine and transmission. This excludes any losses prior to fuel input into the vehicle (during processing and distribution). Smaller ICE vehicles like cars and car-derived vans should achieve a higher level of efficiency, especially if they are not used in a start-stop urban environment. ICE hybrids can achieve efficiencies of 30% to 35% because they make use of energy recovery when braking and energy assist when accelerating. Most diesel engine vehicles are at their most efficient when cruising at 50-60 mph.

Figure 4-3: Energy efficiency of a battery electric vehicle



Business vectors created by macrovector
Other Images VW: Battery or fuel cell? That is the question

Electric vehicles are about 80% efficient (Figure 4-3) with most of the losses occurring in the conversion of AC to DC from the grid to the battery and then back from DC to AC for the electric motor, even when including electricity transmission losses. As a result, BEVs will typically use between one quarter and one third of the ICEV's energy, which gives us an indication of the battery size we will need for the replacement BEV and, therefore, whether a suitable vehicle is available.

The tracking data of the ICEV, if combined with accurate energy consumption, should allow daily variations in energy use (kWh per day) to be determined. Aggregated across the fleet, this can be modelled to provide an indication of the peak overnight charging demand and the site maximum import capacity (MIC) required at the locations where those vehicles are based.

With only fuel data, only mileage data or inaccurate data, only part of the picture is available, and the analysis has to be based on 'average' daily performance of similar vehicles, which may not reflect the PBC operating environment.

4.4 Recommendations for improving data at PBC

As part of the move to a zero emission fleet, we would recommend that PBC carries out a comprehensive review of the IT systems linked to fuel use, vehicle tracking data and charging infrastructure, as well as driver and fleet management, to ensure that all these data sets can be integrated into a single system for the fleet management, energy management, operating departments and the drivers to use.

Ensuring the telematics system gives accurate fuel and mileage information, and extending it to all fleet vehicles, would enable PBC to monitor its vehicles energy usage and efficiency (mpg), enabling clear communication in both reducing the GHG emissions of the current fleet, and enabling the transition to zero emission vehicles (ZEVs). There are additional desirable outcomes that can be achieved from fitting and operating telematics units in all vehicles within the fleet:

- Ease of integration with other systems such as vehicle safety checks, cameras and other data sources (this may or may not require specific external fleet management software for the optimum results).
- Live reporting of performance against KPIs – dashboards (this may be possible directly on the telematics package or from a telematics API feeding into fleet management software). This would include fuel, emissions and driver scores.
- A driver interface to ensure drivers are directly aware of their performance at any point making conversations about driver performance easier.
- Interaction with BEVs so that state of charge and energy consumption can be viewed in real time.

It would also be beneficial for PBC to find an automated way to bring different data sources together. Integrated fleet management packages exist (albeit to varying standards) that can combine fuel purchase, driving licences, compliance, vehicle checks, maintenance, CANBUS fuel and driver performance data all in one place, selectable by vehicle registration. When set up correctly, all data sources automatically feed into this one place and automated dashboard reporting can be directed to bring appropriate live feedback to different people within the organisation. FORS, the compliance organisation, has approved software that achieves this, and many other options exist, although care must be taken to set any new system up to its potential and not to simply just add yet another data source or system to check.

Subsequent consideration should also be given to how data is presented 'live' at different levels of the Council, reviewing what dashboard reporting is visible to whom and at what level. This should also include direct communication with drivers.

5. Options for decarbonisation

5.1 Battery electric vehicles

Battery electric vehicles are 100% electric, powered by a battery which is charged by an external power source. BEVs have no tailpipe emissions, and the emissions depend on the source of electricity used to charge. This electricity can be 100% renewable, but even if charged from the UK grid, BEVs will reduce emissions by around 70-80% (today) compared to diesel and petrol. Furthermore, as the UK grid decarbonises the emissions of BEVs will reduce, without any changes needed to the vehicles. A BEV acquired today and operated for 7-10 years is likely to reduce emissions by 90-95% over its lifetime, based on current UK grid decarbonisation targets. BEVs require the installation of charging infrastructure, and a robust charging strategy in place to ensure the vehicles are plugged in and charging when not in use.

Where BEVs are operationally viable, the efficiency of this technology and the benefit of zero tailpipe emissions, means that it will always have an advantage over other existing technologies. However, at present it may not be possible for every existing ICE vehicle to be replaced by a BEV, especially for HCVs and specialist vehicles. Whilst in the long term we expect there to be a wide availability of BEVs suitable for all applications, it may be worth investigating alternative approaches for reducing vehicle emissions in the short term.

5.2 Hydrogen fuel cell electric vehicles

Hydrogen is a potential zero-emission form of energy storage, which can be used in a fuel cell electric vehicle (FCEV) to produce electricity, which drives the vehicle. FCEVs produce no tailpipe emissions, and refuelling with compressed hydrogen gas is similar to conventional petrol and diesel fuel refuelling.

Although hydrogen is the most abundant element on Earth, it rarely occurs naturally and accessibly, so it needs to be produced. Globally, the most common production method is steam methane reforming, which has a high carbon intensity of 9 $kgCO_2e/kgH_2$. Hydrogen is also produced from the gasification of coal (22-26 $kgCO_2e/kgH_2$), and from electrolysis of pure water (9.5 $kgCO_2e/kgH_2$ with UK grid electricity). The only zero emission way of producing hydrogen is by electrolysis using curtailed renewable energy generation, which may be a viable method of energy storage in a decarbonised energy system. There is also development into steam methane reforming with carbon capture and storage (CCS), although this remains at demonstration/pilot stage only, and is not yet proven technology[1].

Whilst there is a potential role for zero-carbon hydrogen in decarbonising heavy transport, it is not yet clear whether this will be the best pathway for PBC vehicles for the following reasons:

[1] Hydrogen production methods are often referred to by colour, although there is no national or international standard for this. Generally, steam methane reforming is 'grey' hydrogen, coal gasification is 'black' hydrogen, steam methane reforming with CCS is 'blue' hydrogen, and electrolysis using renewable energy is 'green' hydrogen (note there is no colour for electrolysis with grid electricity).

- A hydrogen fuel cell uses more than three times the electrical energy than charging a battery, for the same amount of energy to arrive at the wheels of the vehicle. This means more than three times the energy needs to be generated, and this comes at both a financial and environmental cost.
- When well to wheel factors such as distribution and transport of the hydrogen are taken into account, the energy use of the fuel cell increases to four to six times that of a battery electric equivalent (Zemo Partnership, 2021).
- The lower efficiency of producing hydrogen for fuel cells not only means extra cost but is likely to divert renewable power away from the grid, thus slowing broader decarbonisation.
- FCEVs have costly additional components and maintenance requirements compared to a BEV.
- FCEVs cost significantly more to purchase than BEVs and unlike them, do not (yet) offer any savings from reduced energy consumption to offset the higher costs when compared to diesel vehicles.
- PBC would need reliable local third-party hydrogen refuelling infrastructure, along with a back-up plan in the event that the refuelling supply becomes unavailable.

Whilst FCEVs may provide a solution for those vehicles which cannot be decarbonised using BEVs, the technology is not yet widely available, and it is unclear whether it will be by 2030.

5.3 Compressed natural gas

Some vehicle manufacturers offer compressed natural gas (CNG) powered vehicles as an alternative to diesel. Vehicles are powered by spark ignition engines (similar to petrol engines) and fuel is often grid gas that is compressed at a suitable facility, which relies on a sufficiently high-volume gas supply.

Advantages of this approach are:

- Favourable road fuel duty (half that of diesel, fixed until 2032).
- This can result in a favourable WLC for some intensively used vehicles if gas prices are at reasonable levels.
- Possibly better air quality performance than diesel, though evidence is limited and some even points to worse air quality emissions.

However, the downsides could include:

- Operational vulnerability if there is only one local supply (or costly infrastructure installation) – sites will need to shut down at times for maintenance.
- Limited choice and supply of vehicles.
- Low consumption across a fleet or small part of the fleet makes it difficult to find a cost effective supply of fuel.
- Gas price volatility in recent times has led to higher than expected refuelling costs.

Biogas (or biomethane) is an attractive low carbon fuel, that yields genuine emission reductions, with many transparent waste sourced feedstocks available in the UK and Europe. For most UK vehicle use cases, biogas is not put directly into vehicles, but is the result of paying a premium when refuelling with mains sourced gas for substitute biogas to be injected into the grid. Whilst substantial carbon emissions reductions are achieved, these are also counted within the mains gas carbon intensity factors. This means that mains emissions have to be reported alongside the savings to avoid double counting. Further planned changes to GHG reporting protocols could mean that the savings produced when refuelling on mains gas but paying for remote biogas injection, are not attributable to the fleet in future.

If a hypothetical locally produced supply is available separate from the mains (for example a local food waste collection), then biogas related emissions savings can all be claimed in full by the fleet operator.

In these circumstances several questions will need to be asked before committing to use:

- What is the likely cost per unit and potential for cost volatility?
- How reliable is the supply and is there a locally accessible alternative if it fails?
- Is it more efficient to use the biogas to simply generate power for battery electric? The process of production, cleaning and compressing gas, then burning it at 30-35% efficiency in a vehicle needs to be compared to the cost and efficiency and emission profile of using the same gas to generate electricity at >90% efficiency, then using it to power a BEV at 85% efficiency.

We have observed that CNG is in decline as a fuel used by local authorities, and some recent fuel contract renewals have been prohibitively expensive. When grid gas is used there are some downsides to consider, even if biogas is injected into the grid elsewhere.

Powering food waste collection vehicles with energy harvested from food-waste is an attractive proposition. Whether there would be a sufficiently reliable and cost-effective local solution is yet to be seen. However, the end of combustion engine sales will mean that even if this can prove viable, it will only be a transition fuel over a small number of replacement cycles. The most likely niche would be for vehicles that cannot currently be replaced with BEVs, but this may not be enough to deliver value for money.

5.4 Hydrotreated vegetable oil

There has been recent growing interest in use of this 'drop-in' diesel replacement fuel. Hydrotreated vegetable oil (HVO) is produced by hydrocracking or hydrogenating vegetable oil using hydrogen and high pressure, and can be used as a direct drop in for conventional diesel. The main oil feedstock is used cooking oil (UCO), which the Renewable Fuels Assurance Scheme (RFAS) classify as a waste product. This waste classification means that all carbon dioxide emissions at use (tailpipe) are classified as 'out of scope', as are all emissions associated with crop production. The only emissions included in the carbon footprint for HVO are those from the HVO production, transportation, and non-CO_2 emissions at the tailpipe.

The reportable emissions reduction achievable by using HVO varies by source, and the BEIS/DESNZ GHG conversion factors are updated year on year. In general, due to the exclusion of tailpipe emissions from HVO reporting, a reduction in emissions of 80-90% is achievable compared to diesel. However, as quoted on the BEIS/DESNZ conversion factors, "All fuels with biogenic content, such as (average biofuel blend) diesel and petrol and all electricity consumption should have the biogenic CO_2 emissions reported, to ensure a complete picture of an organisation's emissions is created". Instead of the 80-90% carbon reduction sometimes quoted from adopting HVO, the combined TTW, WTT and out-of-scope emissions figure, shows a much more modest reduction in carbon intensity (around 10-20%).

Table 5-1 Carbon intensity of HVO, diesel and electricity (DESNZ Conversion Factors, 2023)

Fuel or energy	Unit	Scope 1 kg CO_2e	Scope 2 kg CO_2e	Scope 3 kg CO_2e	Out-of-scope kg CO_2e	**Total reportable (excl. OOS)**
Biofuel HVO (UCO)	kg/litre	0.0356	-	0.357	2.43	**0.393**
Diesel (average biofuel blend)	kg/litre	2.48	-	0.611	0.14	**3.09**
Electricity (UK grid)	kg/kWh	-	0.207	0.0856	-	**0.293**

NOTE: DESNZ "Conversion Factors Methodology" states that the DfT factors published on the Renewable Fuel Statistics website take precedence over these DESNZ values.

The BEIS/DESNZ Conversion Factors Methodology points users to the DfT Renewable Transport Fuels Obligation (RTFO) data when determining GHG emission reductions from HVO. Users must be clear about the source of the claimed reductions in GHG emissions, what these figures include in and out of scope, and make sure they use the right factor for the year in question.

In the UK and Europe, where UCO is classified as a waste product and has few approved secondary uses, it is much easier to trace its origin back to its producer than non-European UCO. Fundamentally, we must be certain that the UCO used as a feedstock for HVO is in fact a waste product. In south-east Asia and the Americas, where almost all of the UCO imported into Europe originate, UCO has been used as animal feed (mixed with grain) and so in some cases it is not a true waste product, as it has a permitted use.

The high price that UCO suppliers are achieving because of its 'waste' classification in Europe, is resulting in a distortion of the world market: UCO is diverted from less financially rewarding markets and is replaced with other farmed crops which may include palm oil and soy. The greater demand for palm oil and other types of crop-derived oil contributes to further global deforestation, and other indirect land use change (ILUC) leading to reduction in biodiversity, a loss of ecosystem services and further increases in GHG emissions.

Although it has low reportable GHG emissions, HVO is still a combustion fuel, meaning air pollution emissions are still produced, and it is not a zero-emission technology. HVO should only be seen as an interim solution, and we would caution its use if the price premium is affecting the move to true zero emission technology.

6. Using BEVs to achieve a zero-emission fleet

Where a fleet is operationally viable for replacement with BEVs, then this will provide the most energy efficient, zero tailpipe route to large emission reductions. The process to maximise their uptake in a fleet such as PBC's is described in this section.

6.1 Establish a transition team

The successful transition of the fleet to zero-emission will require PBC to establish a collaborative team encompassing fleet management, the main vehicle operating departments, estates, energy management, human resources (for grey fleet), procurement and finance. The robust appraisal of need and utilisation, changing vehicle procurement to a model based on whole life cost, funding the new fleet, putting in place the charging infrastructure to support new BEVs and addressing issues like home-based charging, will require input and resources from all the groups identified above. Governance and reporting structure with full senior management team engagement will also prove vital to the project's success.

The move to zero tailpipe emissions is a once in a generation transformation and is not just a project for the fleet team. The decarbonisation of the fleet should be occurring in parallel with a move away from the use of fossil fuels, such as natural gas or oil for heating buildings which will usually involve a move to electric heat pumps. All electrification projects need to be integrated, as site supplies and infrastructure will need to cope with the demands of heat pumps, PV generation (and possibly export), battery storage and vehicle charging. There is also the possibility that the battery capacity in the BEVs could provide site or grid services during peak periods.

6.2 Identify suitable BEV options

The factors to consider when selecting a suitable BEV include:

- Typical daily journey length and load – longest daily trip, maximum load.
- Single-charge range – avoiding charging during the working day, if possible, due to lower costs and grid emissions overnight.
- Opportunities to charge during the day – useful for top up charging if battery range is exceeded.
- Carrying capacity – seats in cars; weight and volume in LCVs and HCVs.
- Towing capacity – with BEVs under 3.5 tonnes, this can be limited in some cases.
- WLC – cost over the operational lifetime.
- Grant funding available – any funding to cover WLC difference or EVCI.

We have undertaken an initial analysis of the principal elements of the PBC fleet using the data provided (see Sections 7-9). Using 2023/24 as a guide to likely future fleet usage and activity, there is excellent and immediate scope for the phased transition to BEVs to begin within upcoming vehicle replacement schedules.

6.3 Driver training

Driver training that focuses on efficiency can be an effective and immediate way to save money by reducing fuel consumption and GHG emissions. It may also reduce service, maintenance and repair (SMR) costs and bring significant safety benefits.

Even when driven badly, BEVs can still reduce emissions, but driver training will produce confident drivers who can maximise BEV usage and minimise emissions. Training will address changes to driving technique associated with features like regenerative braking as well as issues such as range anxiety and the correct use of charging technology. Without training, BEVs can be underused, may not deliver the expected cost savings, and may not deliver the expected functionality and range. Training will support the successful introduction of BEVs, which in turn can bring significant cost savings and emission reductions.

Improving driving efficiency can also offer significant cost reductions within the current ICE vehicle fleet usage. Every 1% reduction in fuel use at PBC can save around 6.5 tonnes of GHG emissions and almost £3k annually. Combined with rewards and incentives for efficient driving, driver training should be a cost-effective means to reduce emissions, costs, and enable a smooth fleet decarbonisation.

Rewards and incentives could take several forms., and it is worth consulting with drivers which method would provide the greatest motivation. The most effective method will depend on the nature of the employment arrangements and culture within the current operation. We have seen the following methods used to good effect, generally used in isolation to each other (although there is no reason why some measures cannot be combined):

- Fuel savings above a specified level (ideally based on the current level of efficiency) shared with efficient drivers (usually 50:50) as a form of reward or bonus pay.
- Fuel savings above a specified level shared with either a driver's choice of charity, or all savings across the fleet to a designated charity.
- A driver league table is set up. All fleet fuel saved is pooled and an agreed proportion of the financial savings are allocated to the drivers who finish in the highest league positions, based on their aggregate score over a defined period of time (a week or a month).

Where driver league tables are concerned, they can work even better if they incorporate a range of factors, such as customer feedback (even if the 'customer' is in-house), punctuality, presentation, vehicle cleanliness, accident rate, minor damage cost, fuel consumption (mpg) and telematics scores. League tables can also be used to identify the best drivers and they could be considered 'lead drivers' or 'fuel champion' and could be asked help to promote good driving and fuel-saving initiatives across the fleet. Similarly league tables can be used to identify training needs and demonstrate progress and improvement amongst those who are performing less well.

Clear, regular channels of communication for achievements and goals will maximise the potential benefits of an incentive scheme. It is very likely that a well-executed incentive scheme would deliver significant fuel savings.

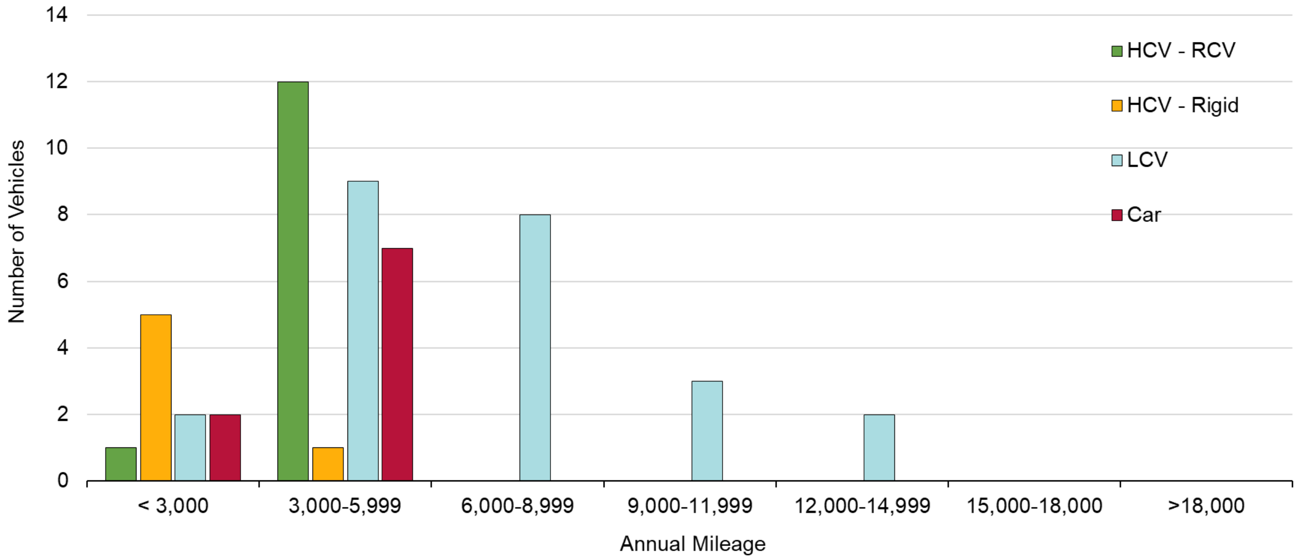
6.4 Review vehicle utilisation

It is important to identify and review the requirement for vehicles with a low level of use, such as those driving under 6,000 miles a year (average 25 miles a day, 240 working days). There may be a good reason for low utilisation, such as maintenance issues, or the nature of duties. However, it may be a consequence of departmental 'silos' preventing the shared use of a resource that spends a lot of the week parked, when other similar low-mileage vehicles from other departments are also being used infrequently.

Low mileage has an adverse impact on the WLC of BEVs because the low mileage results in much lower cost savings from the reduction in energy use. When purchased and even if retained for the full battery warranty period (typically eight to ten years) some low usage vehicles may not recover their higher capital cost, and if mileage is very low, some may not be able to offset the additional GHG emissions associated with their manufacture in that period, thus minimising the environmental benefits of the transition in those cases.

Figure 6-1 shows the mileage undertaken by PBC vehicles that operated for the full year in 2023/24. There were 10 vehicles used for less than 3,000 miles per annum, and a further 29 were used for between 3,000 and 6,000 miles per annum. Some of the vehicles (particularly the HCVs) are spare vehicles, which explains the low mileage. In the LCV and car fleets, it would be beneficial to assess the reasons for the low mileage, and whether vehicles can be shared.

Figure 6-1: Mileage profile of the fleets (only vehicles on-fleet all year and with mileage).



When a vehicle is used for 3,000 miles a year at an average speed of 30 mph, then it would only be driving for an average of less than 30 minutes per working day over the course of the year, which would suggest that there may be a more efficient way of rearranging or sharing duties and operating fewer vehicles. There may be scenarios where resources could be pooled across departments to ensure better utilisation and value for money. PBC should review how internal vehicle costs are allocated to departments to see if they could be improved to encourage better sharing of vehicles across the organisation. If a department pays for an under-utilised vehicle directly from its budgets, it may be more inclined to use pooled or shared vehicles if they are offered cheaper.

Reducing the numbers of vehicles on the fleet will reduce the capital required to electrify and will remove the lowest usage vehicles that offer the lowest potential emissions savings and the longest payback from carbon emissions embedded in the production of vehicles and batteries.

6.5 Adapt the fleet replacement cycles to BEVs

It appears that PBC have a robust replacement schedule for fleet vehicles, with few vehicles over seven years old. We understand the majority of the fleet is up for renewal in 2026. Ongoing improvements in emission technology and standards mean that today's Euro 6/VI(d) fossil fuel ICE vehicles will be superseded by cleaner ICE models with (Euro 7/VII) which is now under consideration for introduction in 2025/26. Typically, PBC replaces vehicles every seven years.

Unlike diesel vehicles, keeping BEVs for longer does not have a negative impact on GHG emissions due to deterioration in diesel engine performance. Indeed, as the UK grid decarbonises, BEV GHG emissions will fall year on year, without the need to make any changes to the vehicles. This means that higher BEV procurement costs can be deferred over a longer period of ownership, without adverse environmental impact, and it also makes best use of the energy and resources used to make the battery. This approach is further supported by the long operational life and simplicity of electric drive train components which have been used across a wide range of transport modes, for example trains and trams, for over 100 years. Most batteries can be serviced, and faulty cells replaced, to extend their operational life at full capacity.

With electric RCVs and HCVs, it may be necessary to take a different approach to the replacement cycle with the chassis, drive train, battery and rig all being treated as separate and independently replaceable components.

To maximise the return on the investment in BEVs, we recommend aligning replacement cycles with the vehicle's battery warranty, although if a battery is well maintained its life could be a lot longer than its warranty period. This may mean planned replacement cycles of eight or, in some cases, ten years.

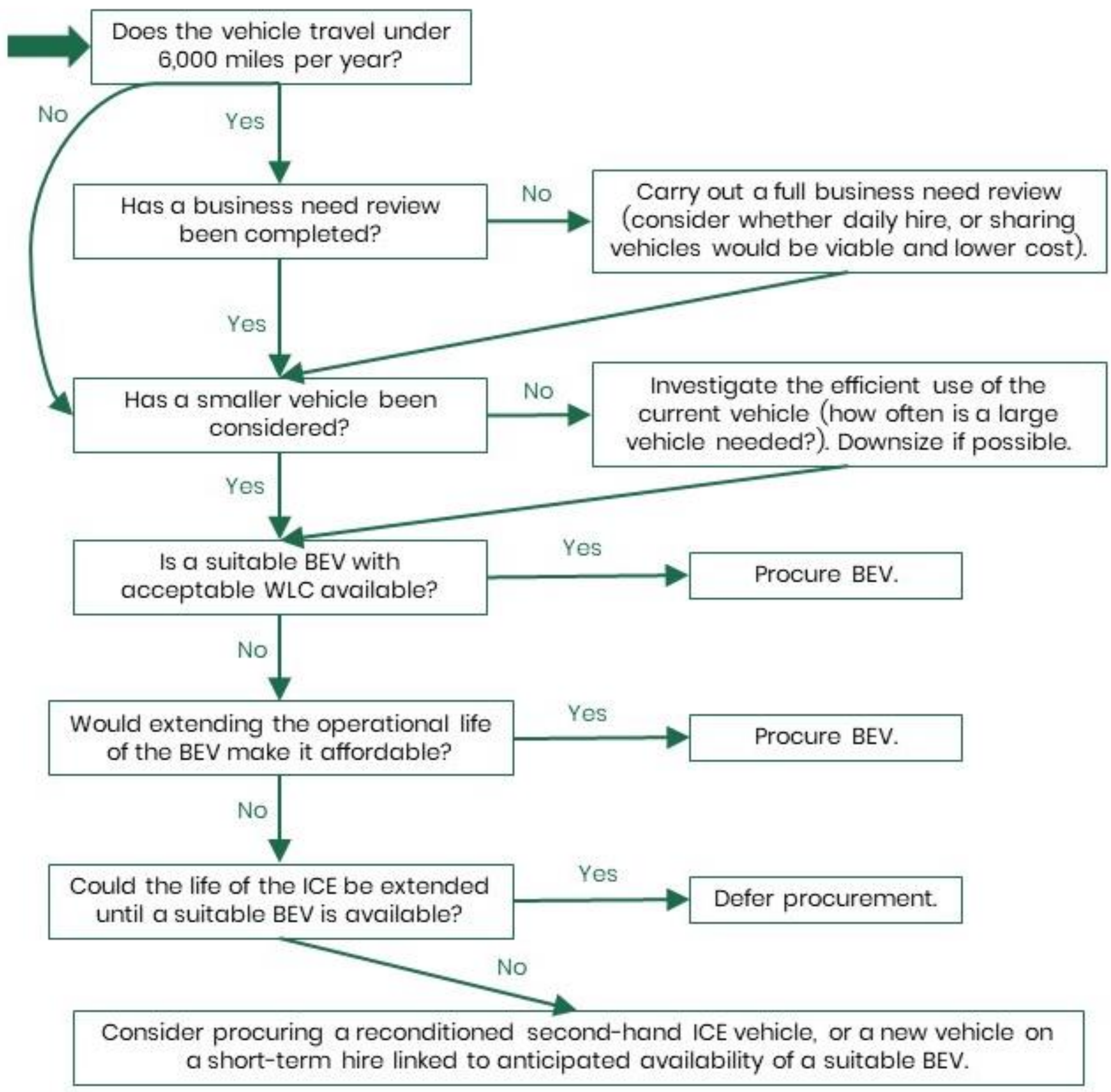
6.6 Introduce a BEV procurement policy

The assumption should be that from now, all ICE vehicles will be replaced with zero emission models as part of the standard fleet replacement programme and BEVs should be the preferred zero emission technology. It is very occasionally appropriate to use a plug-in hybrid electric vehicle (PHEV) or an ICE range-extended electric vehicle (REEV) where a BEV is not practical, and the PHEV or REEV offers real GHG reductions because there is a significant opportunity to use it in electric-only mode. However, experience suggests that PHEVs can offer the worst of both worlds, limiting the range of the BE zero-emission mode due to additional weight of the petrol engine and increasing the fuel consumption of the petrol engine, due to the weight of the batteries and electric motor.

Other technologies such as Hydrogen Fuel Cell (H2FC), Hydrogen ICE (H2ICE), Hydrogen-Diesel Dual-Fuel, Biomethane (BioCNG/LNG) and HVO (BioDiesel) should only be considered where there is no suitable BEV technology available, or expected to be available, by 2030.

It is recommended that procurement follows the process in Figure 6-2 which starts with a review of the need for a vehicle and a check to see if it can be downsized.

Figure 6-2: BEV procurement process.



Where current assets are underutilised, replacements should be robustly challenged because of the high capital/lease cost of BEVs. A well utilised, right-sized BEV can save money. An underutilised, overweight BEV costs extra money.

6.7 Use a whole life cost analysis model

A WLC model calculates all of the predicted costs of owning and operating a vehicle over its operational life, including the capital/lease, servicing, vehicle excise duty and the fuel or energy cost. Fixed costs such as fleet management overheads, telemetry and fleet insurance could also be included, although they do not vary based on fuel or energy type.

Over a BEV's operational life, the reduction in energy cost compared to diesel vehicles may partially or completely offset the higher purchase or lease cost, and can result in an overall cost saving. The current disruption in the energy markets caused by high gas and oil prices means it is very difficult to predict the long-term price of electricity, gas, petrol and diesel to 2030 and beyond. To mitigate for this, we advise the use of conservative (and certainly not best case) figures when WLC modelling and using long run averages of energy cost increases when predicting increases in future years. It appears likely that prices are not expected to remain at current levels on mid or long-term horizons.

BEVs are mechanically simpler than diesel vehicles, with significantly fewer components in the drivetrain and without a complex transmission and exhaust system. As a result, maintenance costs are much lower – often quoted at 20-50% less. Over an extended operational life of eight to ten years, the saving may be even greater, as ICE vehicles can incur significant costs in later years. The failure of one ICE vehicle component can be very expensive - for example, replacing a gearbox or an exhaust catalyst system. The saving from reduced maintenance costs can further help to offset the higher purchase cost or add to overall cost savings.

This approach is also valid for investment in vehicle improvements that may yield GHG emissions savings, for example, for electric bin lifters.

A detailed explanation of how to use WLC is available in Appendix C. Some leasing companies and the Crown Commercial Service Fleet Portal also provide an estimate of whole life cost.

6.8 Carbon accounting

Implementing GHG emission reductions may have associated costs and deciding what costs are acceptable and where to invest, to achieve the maximum and best value GHG reductions, can be achieved by putting a price, or value, on every tonne of GHG (tCO_2e) emitted or saved.

Many companies use a carbon price for project appraisal, including ASDA, Novartis, BP, and Shell. Some also use an 'internal price' or 'carbon fee' which is a charge that is made to departments based on their GHG emissions. Companies in this group include Microsoft, Apple, Disney, and Ben & Jerrys. The funds raised are then used to reduce GHG emissions, either by funding GHG reduction schemes within the same company, or by the purchase of independently accredited carbon offsets.

A shadow price for carbon can reflect the societal cost of GHG emissions (externalities) or it can assess the mitigation cost linked to specific targets. A review published by BEIS: "Carbon values literature review (2021)" concluded that, for the UK, the use of a "target consistent price path" was most appropriate because the country has stringent GHG reduction targets and there are significant uncertainties over the use of a price linked to societal cost. As a result, BEIS and His Majesty's Treasury (HMT) have produced a target consistent shadow carbon price to be used in policy appraisal at a national level.

Following the announcement by the UK Government of new, more ambitious, Nationally Determined Commitments (NDCs), a review of the target consistent UK shadow carbon price was carried out by BEIS and HMT (October 2021).

That review resulted in a significant increase in the UK shadow carbon price from £72 a tonne to £248 a tonne in 2022 and from £81 a tonne to £280 a tonne in 2030 (see Appendix B, Table B-1: Central Carbon Value (BEIS 2021)). The increase between 2022 and 2030 reflects the greater impact of emitting a tonne of GHG in 2030 on the UK's ability to reach its new NDCs.

7. Moving to a zero-emission car fleet

7.1 Overview of the car fleet

There were nine cars in the PBC data, eight small hatchbacks (Vauxhall Corsas), and one high-end saloon, the Mayor's car. Table 7-1 summarises the average fleet mileage and energy use per day, to assess the suitability of BEVs in terms of single-charge range. The car fleet does not appear in the telematics data, so we have based BEV suitability on the fleet average and fleet maximum annual mileages.

To estimate the daily BEV energy, we have used the current ICEV mileage, the fleet average mpg ICEV energy efficiency, and that a BEV would use 30% of the ICEV energy. Fuel data was available for the hatchback cars only, and all mileage data was based on MOT records. The hatchback fleet has an average mpg of 30, and the saloon has an mpg of 29. Daily values are estimated based on 240 working days a year.

There is a wide range of BE cars now available, suitable for PBC usage, as shown on EV database. Based on the average mileages, all of these vehicles can transition to BEV without any single-charge driving range or functionality concerns.

Table 7-1: Overview of the PBC car fleet for electrification

Fleet	Qty	Fleet average			Fleet maximum			Example BEV	
		Annual mileage	Daily mileage	Daily BEV energy	Annual mileage	Daily mileage	Daily BEV energy	Battery size	Single-charge range*
Hatchback	8	3,799	15.8	6.6 kWh	5,817	24	9.1 kWh	50 kWh	120-270 miles
Saloon	1	3,071	12.8	6.1 kWh	/	/	/	70 kWh	200-400 miles

*Real world range, from EV database.

7.2 Whole life cost - cars

In the following graphs, we have undertaken a WLC analysis comparing equivalent vehicles to those on fleet with some suitable BEV examples. The full WLC analysis methodology is available in Appendix C. These figures are for illustration purposes only, real costs will depend on specific PBC operation. As the majority of PBC vehicles are leased, we present the WLC analysis on a four-year lease basis only[2]. The car fleet has very low mileage, so we have done the WLC analysis on a 6,000 and 10,000 miles per year basis, except for the Mayor's car which we have only compared on a 6,000 miles a year basis as this mileage is unlikely to change.

[2] We understand PBC replaces its vehicles every seven years, however the framework we use for leasing costs has a maximum four-year term.

7.2.1. Hatchbacks

Figure 7-1 shows the WLC analysis for hatchback cars, comparing the petrol Vauxhall Corsa and the electric Vauxhall Corsa-e.

Figure 7-1: WLC analysis for hatchback cars, 4-year lease, 6,000 and 10,000 mpa

Table 7-2: WLC analysis for hatchback cars, 4-year lease, 6,000 mpa

Vehicle	Fuel	WLC (excl. CP)	WLC (excl. CP) per mile	GHG (tonnes)	Shadow carbon price	WLC (incl. CP)	Lowest cost
Vauxhall Corsa 1.2 Turbo GS	Petrol	£22,053	£0.92	10.1	£2,564	£24,617	X
Vauxhall Corsa e GS 50 kWh	Electric	£25,774	£1.07	1.0	£246	£26,020	

Table 7-2 shows the estimated WLC for the four-year lease term at 6,000 mpa, the equivalent cost per mile, and four-year GHG emissions, and the shadow carbon price (CP)[3] of those emissions. Using an illustrative 6,000 mpa, this example shows that the electric Corsa would reduce GHG emissions by an estimated 9.1 tonnes per vehicle compared to the petrol Corsa over a four-year operational life and 24,000 miles.

Over the four-year lease and at 6,000 mpa, the electric Corsa could cost around £3.7k more per vehicle compared to the petrol Corsa. Comparative savings would be greater at higher annual mileage, or smaller at lower annual mileage. The comparison between 6,000 and 10,000 miles per year shows that as annual mileage increases the BEV moves closer to cost parity.

[3] Shadow carbon pricing places a monetary value on carbon emissions released, and serves as a means of including emissions into pricing schemes. At present, this cost is not collected.

7.2.3. Saloon – Mayor's car

Figure 7-3 shows the WLC analysis for saloon cars, comparing the diesel Mercedes E Class and the electric Polestar 2, BMW i4, and Tesla Model 3.

Figure 7-2: WLC analysis for saloon cars, 4-year lease, 6,000 mpa

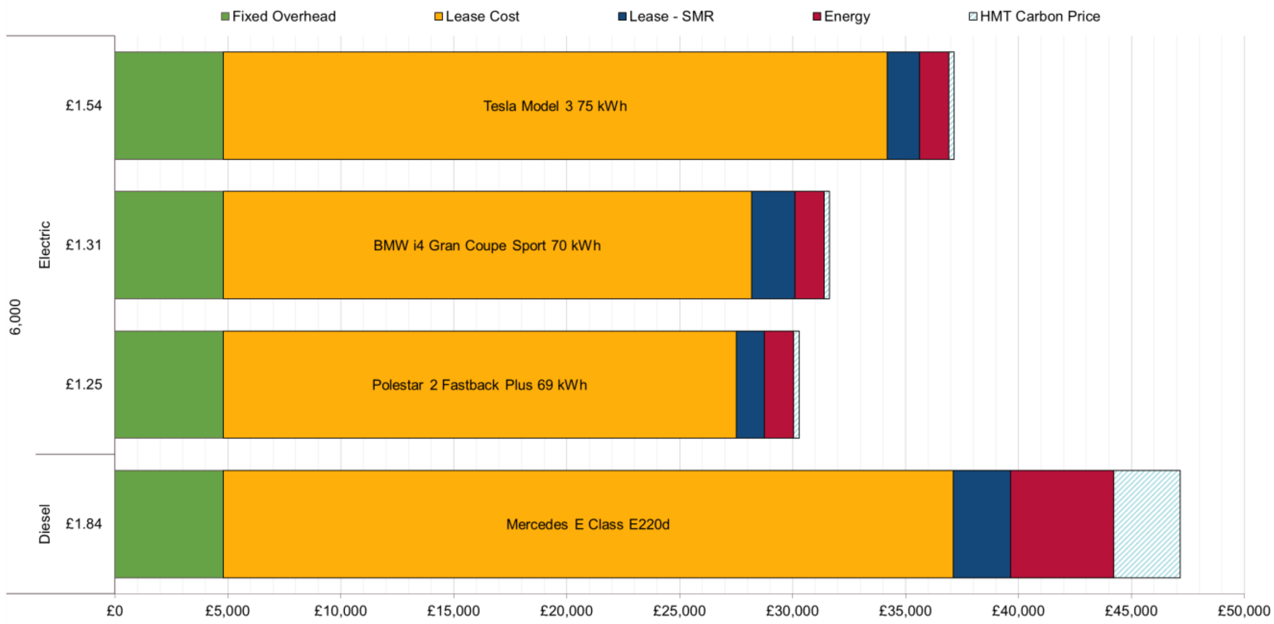


Table 7-3: WLC analysis for saloon cars, 4-year lease, 6,000 mpa

Vehicle	Fuel	WLC (excl. CP)	WLC (excl. CP) per mile	GHG (tonnes)	Shadow carbon price	WLC (incl. CP)	Lowest cost
Mercedes E Class E220d	Diesel	£44,223	£1.84	11.5	£2,926	£47,149	
BMW i4 Gran Coupe Sport 70 kWh	Electric	£31,390	£1.31	1.0	£246	£31,636	
Polestar 2 Fastback Plus 69 kWh	Electric	£30,046	£1.25	1.0	£246	£30,292	X
Tesla Model 3 75 kWh	Electric	£36,910	£1.54	1.0	£246	£37,156	

Table 7-4 shows the estimated WLC for the four-year lease term at 6,000 mpa, the equivalent cost per mile, and four-year GHG emissions, and the shadow carbon price of those emissions. Using an illustrative 6,000 mpa, this example shows that the electric vehicles would reduce GHG emissions by an estimated 10.6 tonnes per vehicle compared to the diesel Mercedes E Class over a four-year operational life and 24,000 miles.

Over the four-year lease and at 6,000 mpa, any of the electric models could save compared to the diesel Mercedes E Class. The Polestar 2 could save around £14.2k, the BMW i4 could save around £12.8k, and the Tesla Model 3 could save around £7.3k. Comparative savings would be greater at higher annual mileage, or smaller at lower annual mileage.

7.3 Replacement plan – cars

There are no vehicles in the car fleet that cannot be replaced with currently available BEVs, and so the recommended transition schedule is based only on the age of the vehicles, and PBC's seven-year retainment period.

Table 7-4 considers the first replacement cycle to BEV, and does not take into account lead times on vehicle orders, which can be up to 12 months. The annual GHG saving is the saving achievable per year from the 2023/24 baseline, by transitioning the vehicles for the year specified. The WLC analysis has been annualised (WLC divided by the number of life years - four for lease, based on our analysis), and Table 7-4 shows the annualised cost or saving from transitioning the vehicles for the year specified. The costs are for illustration only, they do not take into account specific PBC operation, a seven-year retention period, or future changes in purchase or lease prices for BEVs.

Table 7-4: Recommended BE car transition schedule

	2024	2025	2026	2027	**Total**
Hatchbacks	-	-	8	-	**8**
Saloon*	1	-	-	-	**1**
Annual GHG saving (tonnes)	1.4	-	12.8	-	**14.2**
Annualised WLC cost (£k)	-	-	7.4	-	**7.4**
Annualised WLC saving (£k)	3.2	-	-	-	**3.2**

*Costs compared to the BMW i4.

Transitioning the car fleet to BEVs can save around 14 tonnes of GHG emissions annually. Although the BE saloon could have a WLC saving compared to ICE, the additional cost of the hatchbacks could make switching to BEVs more expensive. Due to the low mileage of the car fleet, PBC should evaluate the requirement for all vehicles – less vehicles with higher mileage will make the switching to BE cars more cost effective.

As part of the transition to BEVs, we would highly recommend implementing driver training. This is to ensure employees feel comfortable driving the BEVs, can drive efficiently to improve single-charge range, and are capable of using charging infrastructure (whether public or PBC owned).

8. Moving to a zero emission LCV fleet

8.1 Overview of the LCV fleet

For the year 2023/24, 36 LCVs appeared in the PBC data in total, ten of which are no longer on fleet (whether de-fleeted or short-term hires). We have therefore analysed the 26 remaining LCVs, summarised in Table 8-1. Telematics data was available for 13 of the large LCVs, which provides an accurate assessment of BEV suitability in Section 8.4. For the remaining small LCV, medium LCV, and utility vehicle fleets we have based BEV suitability on the fleet average and maximum annual mileages.

To estimate the daily BEV energy, we have used the current ICEV mileage, the fleet average mpg ICEV energy efficiency, and that a BEV would use 30% of the ICEV energy. Fuel data was available for 21 vehicles, and mileage data was available for 24 vehicles (including 8 based on MOT mileage). The only two vehicles without mileage were the two brand new utility vehicles, YC24HNW and YH24KNS. Annual averages are based only on the vehicles on fleet all year 2023/24, and daily values are estimated based on 240 working days a year. Based on the average mileages, all of these vehicles can transition to BEV without any single-charge driving range concerns.

Table 8-1: Overview of the PBC LCV fleet for electrification

Fleet	Qty	With telematics	Av mpg	Fleet average			Fleet maximum		
				Annual mileage	Daily mileage	Daily BEV energy	Annual mileage	Daily mileage	Daily BEV energy
Up to 2.6 t	3	/	40	4,125	17.2	6.1 kWh	6,459	26.9	9.8 kWh
2.6 – 3.1 t	4	/	39	6,907	28.8	10.2 kWh	11,156	36.4	15.3 kWh
3.1 – 3.5 t	16	13	21*	7,510	31.3	18.6 kWh	13,177	54.9	44.1 kWh
Utility/ Pickup**	3	/	34	6,861	28.6	11.8 kWh	12,482	52.1	19.6 kWh

*Excluding six values with unreasonably high mpg (between 50 and 120).
**Including representative data from two de-fleeted vehicles.

8.2 Small LCVs and car derived vans up to 2.6 t

The three small LCVs on fleet comprised of two Citroen Berlingo and one Vauxhall Combo. Electric versions of these vehicles are available, along with some other examples shown in Table 8-2.

Table 8-2: Examples of electric LCVs up to 2.6 tonnes

Make	Model	Battery (kWh)	Real world range (miles)	Max payload (kg)	Max trailer unbraked/ braked (kg)	Max load volume (m^3)
Renault	Kangoo E-Tech	44	140	760	750/1,500	4.2
Maxus	eDeliver 3	35/52	80/130	900	750/1,200	4.8
Stellantis	eBerlingo/ePartner/ Combo-e	50	150	800-1,000	750/750	3.8/4.4
Toyota-Stellantis	Proace City	50	150	800	750/1,500	3.8/4.4

8.2.1. Whole life cost – small LCVs

Figure 8-1 shows the WLC analysis comparing equivalent vehicles to those on fleet with some suitable BEV examples. The full WLC analysis methodology is available in Appendix C. The analysis is based on a four-year lease at 6,000 and 10,000 miles a year. These figures are for illustration purposes only, real costs will depend on specific PBC operation.

Figure 8-1: WLC analysis for small LCVs, 4-year lease, 6,000 and 10,000 mpa

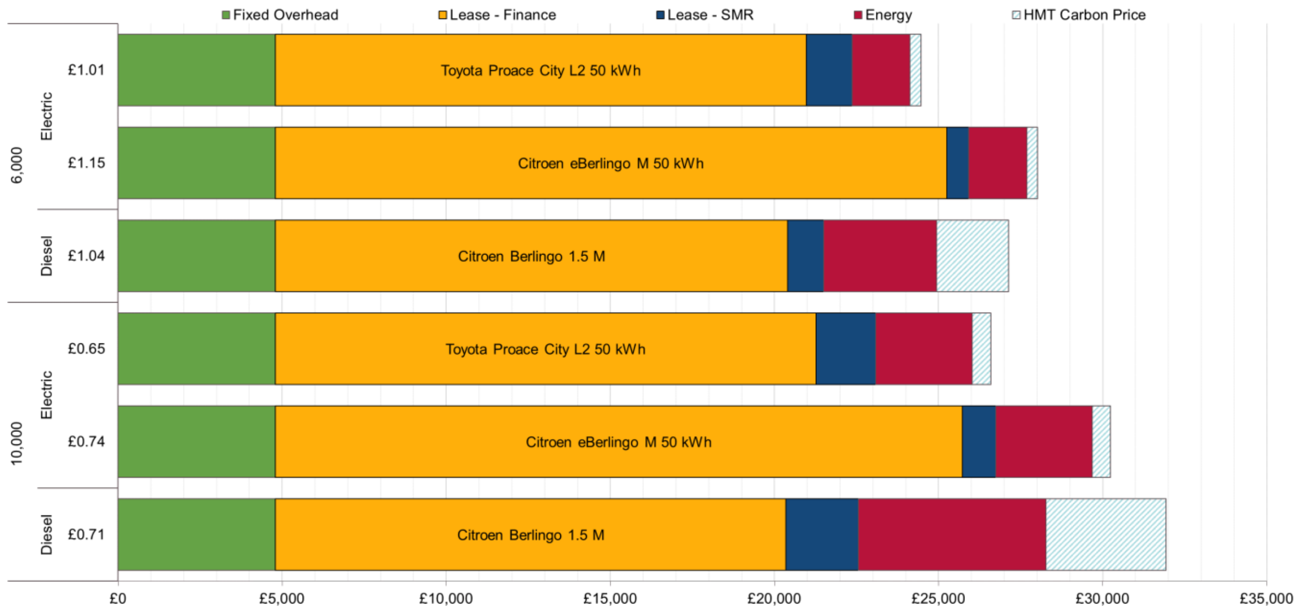


Table 8-3: WLC analysis for small LCVs, 4-year lease, 6,000 mpa

Vehicle	Fuel	WLC (excl. CP)	WLC (excl. CP) per mile	GHG (tonnes)	Shadow carbon price	WLC (incl. CP)	Lowest cost
Citroen Berlingo 1.5 M	Diesel	£24,935	£1.04	8.6	£2,195	£27,130	
Toyota Proace City L2 50 kWh	Electric	£24,132	£1.01	1.3	£336	£24,468	X
Citroen eBerlingo M 50 kWh	Electric	£27,684	£1.15	1.3	£336	£28,020	

Table 8-3 shows the estimated WLC for the four-year lease term at 6,000 mpa, the equivalent cost per mile, and four-year GHG emissions, and the shadow carbon price of those emissions. Using an illustrative 6,000 mpa, this example shows that the electric vans would reduce GHG emissions by an estimated 7.3 tonnes per vehicle compared to the diesel Berlingo over a four-year operational life and 24,000 miles.

Over the four-year lease and at 6,000 mpa, the electric Berlingo could cost around £2.7k more per vehicle compared to the diesel Berlingo, but the electric Proace could save around £800 per vehicle. Comparative savings would be greater at higher annual mileage, or smaller at lower annual mileage.

8.3 Medium LCVs 2.6 – 3.1 t

The four medium LCVs on fleet comprised of two Vauxhall Vivaro, one Peugeot Expert and one Volkswagen Transporter. The electric Vivaro-e and eExpert are available, and VW have the electric ID Buzz. Table 8-4 shows some examples of available electric medium vans.

Table 8-4: Examples of electric LCVs 2.6 – 3.1 tonnes

Make	Model	Battery (kWh)	Real world range (miles)	Max payload (kg)	Max trailer unbraked/ braked (kg)	Max load volume (m³)
VW	ID Buzz	77	190	600	750/1,000	3.9
Maxus	eDeliver 7	77	120	1,100	750/1,500	6.7
Stellantis	eDispatch /eExpert/ Vivaro-e	50/75	110/170	900-1,000	750/1,000	5.3/6.6
Toyota-Stellantis	Proace Medium	50/75	110/170	1,200/1,000	750/1,500	5.3

8.3.1. Whole life cost – medium LCVs

Figure 8-2 shows the WLC analysis comparing equivalent vehicles to those on fleet with some suitable BEV examples. The full WLC analysis methodology is available in Appendix C. The analysis is based on a four-year lease at 6,000 and 10,000 miles a year. These figures are for illustration purposes only, real costs will depend on specific PBC operation.

Figure 8-2: WLC analysis for medium LCVs, 4-year lease, 6,000 and 10,000 mpa

Table 8-5: WLC analysis for medium LCVs, 4-year lease, 6,000 mpa

Vehicle	Fuel	WLC (excl. CP)	WLC (excl. CP) per mile	GHG (t)	Shadow CP	WLC (incl. CP)	Lowest cost
Peugeot Expert 2.0 L1	Diesel	£30,129	£1.26	9.9	£2,508	£32,637	
Toyota Proace M 75 kWh	Electric	£29,568	£1.23	1.8	£448	£30,016	X
Peugeot eExpert L1 50 kWh	Electric	£33,552	£1.40	1.8	£448	£34,000	

Table 8-5 shows the estimated WLC for the four-year lease term at 6,000 mpa, the equivalent cost per mile, and four-year GHG emissions, and the shadow carbon price of those emissions. Using an illustrative 6,000 mpa, this example shows that the electric vans would reduce GHG emissions by an estimated 8.1 tonnes per vehicle compared to the diesel Expert over a four-year operational life and 24,000 miles.

Over the four-year lease and at 6,000 mpa, the electric Expert could cost around £3.4k more per vehicle compared to the diesel Expert, but the electric Proace could save around £550 per vehicle. Comparative savings would be greater at higher annual mileage, or smaller at lower annual mileage.

8.4 Large LCVs 3.1 – 3.5 t

The 16 large LCVs on fleet comprised a mix of panel vans, tippers, and chassis cabs. The majority of vans on fleet were Iveco Daily (12), also with Vauxhall Movano (3) and Mercedes-Benz Sprinter (1). There is a wide variety of large electric vans now available, with most bodies now available too. Table 8-6 shows some examples of available electric large vans.

Table 8-6: Examples of electric LCVs 3.1 – 3.5 tonnes

Make	Model	Battery (kWh)	WLTP range (miles)	Max payload (kg)	Max trailer unbraked/ braked (kg)	Max load volume (m^3)
Ford	eTransit	70/90	160/210	1,700/1,400	750/750	15
Maxus	eDeliver 9	50/70/90	110/130/180	800-1,300	750/1,500	11
Stellantis	eRelay /eBoxer/ Movano-e	75/110	150/260	600-1,400	-	15
Iveco	eDaily	35/75/110	70/140/190	2,200	750/3,500	18

8.4.1. Telematics analysis for large LCVs

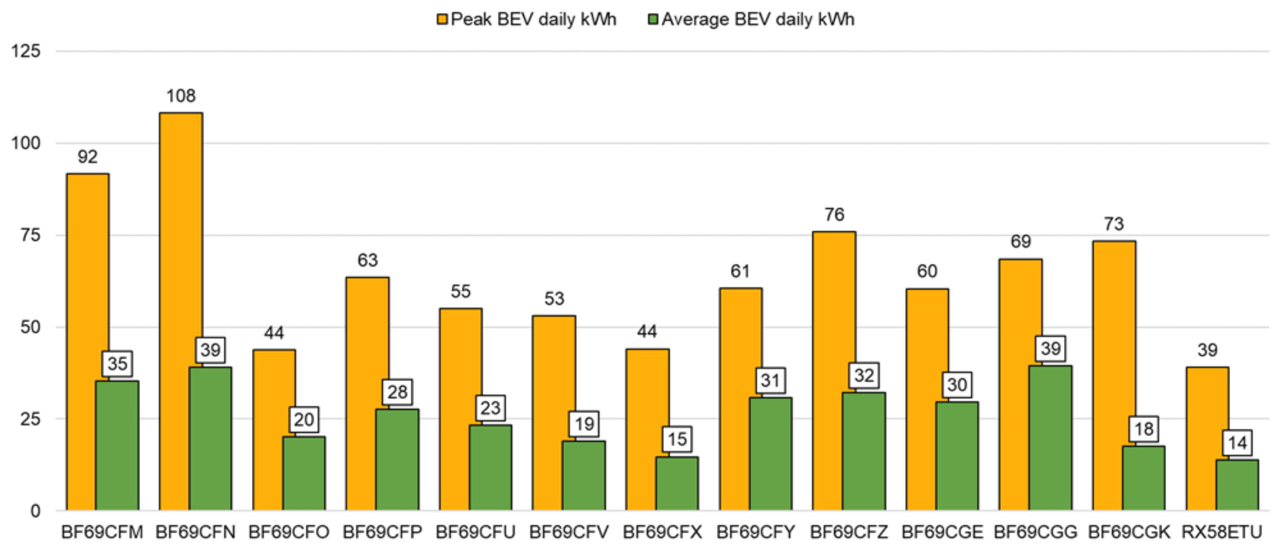
There were 13 LCVs on the PBC fleet for which daily mileage data was available. The average efficiency for these 13 vehicles is recorded at 17.8 mpg based on total annual mileage and total annual fuel consumption data.

The utilisation of LCVs could be more consistent, with annual mileages ranging from 2,875 to 13,177, with an average annual mileage of 7,419 miles across the 13 vehicles. For example RX58ETU only completed 2,875 miles in 2023/24, which suggests that its activity need to be reviewed before ordering a replacement.

The 13 LCVs had a combined working day average of 26 kWh of equivalent likely BEV energy consumption, based on the number of working days for each vehicle from the daily mileage data.

Figure 8-3 summarises the estimated average and peak energy consumptions for each of the 13 LCVs, identified by registration number. This assumes that a BEV will use 30% of a diesel vehicle's energy and that 2023/24 operations offer a sufficiently accurate indication of future activity. Negative and values less than 1 mile were removed from the data set to provide a more realistic picture of daily use and energy consumption, and we have assumed that a litre of fuel burnt produces the equivalent of 10.6 kWh of energy.

Figure 8-3: Average and peak energy consumption for 13 LCVs with telematics



Looking at peak energy consumption, all but three LCVs always fall below the 75 kWh threshold of commonly available capacity electric LCVs. Table 8-7 highlights the number of days in which this analysis shows an electric LCV would exceed common BEV battery capacities available today.

Table 8-7: Suitability of BE LCVs for the PBC fleet

VRM	Days <35 kWh	Days over 35 kWh	Days over 50 kWh	Days over 75 kWh	Notes
BF69CFM	246	176	35	5	110 kWh BEV suitable, 75 kWh BEV may be suitable with efficiency and shift changes
BF69CFN	219	170	42	15	110 kWh BEV suitable, 75 kWh BEV may be suitable with efficiency and shift changes
BF69CFO	249	13	0	0	50 kWh BEV suitable
BF69CFP	250	66	12	0	75 kWh BEV suitable
BF69CFU	219	28	2	0	75 kWh BEV suitable
BF69CFV	242	16	2	0	75 kWh BEV suitable
BF69CFX	251	5	0	0	50 kWh BEV suitable
BF69CFY	201	85	3	0	75 kWh BEV suitable, 50 kWh BEV may be suitable with efficiency and shift changes
BF69CFZ	223	89	4	1	75 kWh BEV likely suitable
BF69CGE	260	21	2	0	75 kWh BEV suitable, 50 kWh BEV may be suitable with efficiency and shift changes
BF69CGG	202	215	7	0	75 kWh BEV suitable
BF69CGK	255	22	10	0	75 kWh BEV suitable
RX58ETU	171	1	0	0	50 kWh BEV suitable, mileage very low and need for vehicle should be reviewed

Three of the LCVs would not exceed the single charge capacity of a 50 kWh electric LCV. Seven of these vehicles would not exceed the single charge of a 75 kWh BEV, and BF69CFZ only exceeded this value once in the year (76 kWh). The remaining two vehicles, BF69CFM and BF69CFN, exceed 50 kWh regularly, and 75 kWh occasionally, but always use less than 110 kWh which is a newly available battery size. It may be possible to reduce the daily mileages of these vehicles by splitting shifts with other lower mileage vehicles, but if not there are now BEV options available.

Therefore, it would likely be operationally viable to replace all 13 LCVs on the fleet with electric vehicles (providing their usage is deemed sufficient to justify replacement at all) with minimal or no in shift charging needed. With the three highest mileage large LCVs captured in the telematics analysis, this would indicate that all of the large LCV fleet can transition to BE with available options now. Many of the vehicles would not need charging every night, which could give further flexibility in terms of their operation.

8.4.2. Whole life cost – large LCVs

Figure 8-4 and Figure 8-5 show the WLC analysis comparing equivalent vehicles to those on fleet with some suitable BEV examples. The full WLC analysis methodology is available in Appendix C. The analysis is based on a four-year lease at 6,000 and 10,000 miles a year. These figures are for illustration purposes only, real costs will depend on specific PBC operation.

Figure 8-4: WLC analysis for large LCVs (panel van), 4-year lease, 6,000 and 10,000 mpa

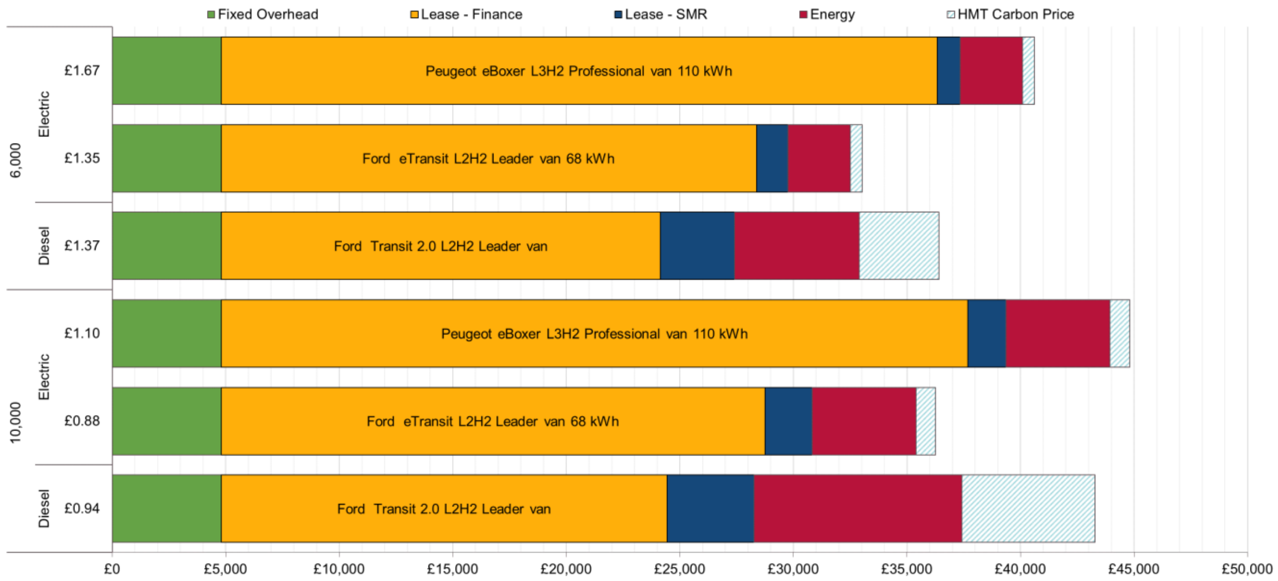


Table 8-8: WLC analysis for large LCVs (panel van), 4-year lease, 6,000 mpa

Vehicle	Fuel	WLC (excl. CP)	WLC (excl. CP) per mile	GHG (tonnes)	Shadow carbon price	WLC (incl. CP)	Lowest cost
Ford Transit 2.0 L2H2 Leader van	Diesel	£32,898	£1.371	13.8	£3,511	£36,409	
Ford eTransit L2H2 Leader van 68 kWh	Electric	£32,505	£1.354	2.1	£523	£33,028	X
Peugeot eBoxer L3H2 Professional van 110 kWh	Electric	£40,089	£1.67	2.1	£523	£40,612	

Table 8-8 shows the estimated WLC for the four-year lease term at 6,000 mpa, the equivalent cost per mile, and four-year GHG emissions, and the shadow carbon price of those emissions. Using an illustrative 6,000 mpa, this example shows that the electric vans would reduce GHG emissions by an estimated 11.8 tonnes per vehicle compared to the diesel over a four-year operational life and 24,000 miles.

Over the four-year lease and at 6,000 mpa, the electric Ford Transit could save around £400 per vehicle compared to the diesel Transit, but the electric Boxer (with a larger 110 kWh battery) could cost around £7.2k more per vehicle. Comparative savings would be greater at higher annual mileage, or smaller at lower annual mileage.

Figure 8-5: WLC analysis for large LCVs (chassis cab), 4-year lease, 6,000 and 10,000 mpa

Table 8-9: WLC analysis for large LCVs (chassis cab), 4-year lease, 6,000 mpa

Vehicle	Fuel	WLC (excl. CP)	WLC (excl. CP) per mile	GHG (tonnes)	Shadow carbon price	WLC (incl. CP)	Lowest cost
Iveco Daily 2.3 chassis cab 3450 WB	Diesel	£45,666	£1.90	13.8	£3,511	£49,177	
Ford eTransit chassis cab L3 68 kWh	Electric	£32,169	£1.34	2.1	£523	£32,692	X
Iveco eDaily chassis cab 3450 WB 74 kWh	Electric	£62,889	£2.62	2.1	£523	£63,412	

Table 8-9 shows the estimated WLC for the four-year lease term at 6,000 mpa, the equivalent cost per mile, and four-year GHG emissions, and the shadow carbon price of those emissions. Using an illustrative 6,000 mpa, this example shows that the electric vans would reduce GHG emissions by an estimated 11.8 tonnes per vehicle compared to the diesel over a four-year operational life and 24,000 miles.

Over the four-year lease and at 6,000 mpa, the electric Daily could cost around £13.5k more per vehicle compared to the diesel Daily, but the electric Transit could save around £17.2k per vehicle.

8.5 Utility vehicles/pickups

The three utility vehicles on fleet comprised of two Isuzu D-Max, and one Ford Ranger, all four-wheel drive. There is only one double cab battery electric pick-up model currently available to order, the two-wheel drive Maxus T90. This offers the layout and ground clearance of the utility vehicles on PBC's fleet, but lacks four-wheel drive capability. The battery capacity is 88.5 kWh, which should give a real-world range in excess of 150 miles.

We are still awaiting four-wheel drive BE utility vehicles in the UK (they are available elsewhere such as the United States and Asia), though there have been announcements, for example from Ford and VW. One vehicle on fleet is from 2017, which we would expect to be replaced this year. If PBC need four-wheel drive capability then we recommend keeping that vehicle on fleet if possible rather than replacing with diesel, and reevaluating the state of the market in the next 12 months. The remaining two vehicles are new from 2024. By the time these vehicles are up for replacement in 2031 we would expect an electric four-wheel drive vehicle to be available.

8.6 Replacement plan - LCVs

There are no vehicles in the LCV fleet that cannot be replaced with currently available BEVs, and so the recommended transition schedule is based only on the age of the vehicles, and PBC's seven-year retainment period.

Table 8-10 considers the first replacement cycle to BEV, and does not take into account lead times on vehicle orders, which can be up to 12 months. The annual GHG saving is the saving achievable per year from the 2023/24 baseline, by transitioning the vehicles for the year specified. The WLC analysis has been annualised (WLC divided by the number of life years - four for lease, based on our analysis), and Table 8-10 shows the annualised cost or saving from transitioning the vehicles for the year specified. The costs are for illustration only, they do not take into account specific PBC operation, a seven-year retention period, or future changes in purchase or lease prices for BEVs. In each case we have compared diesel to the cheaper of the BEV options analysed. The utility vehicles are included in the GHG saving but not in the WLC cost and saving.

Table 8-10: Recommended BE LCV transition schedule

	2024	2025	2026	2027	2028	2029	2030+	**Total**
Small LCVs up to 2.6 t	1	-	1	-	-	-	1	**3**
Medium LCVs 2.6 – 3.1 t	-	-	1	2	-	1	-	**4**
Large LCVs 3.1 – 3.5 t	1	-	15*	-	-	-	-	**16**
Utility/pickups	-	1	-	-	-	-	2	**3**
Annual GHG saving (t)	5.2	1.8	61.3	4.2	-	2.1	4.3	**79**
Annualised WLC cost (£k)	-	-	3.6	-	-	-	-	**3.6**
Annualised WLC saving (£k)	0.3	-	18	0.3	-	0.15	0.2	**19**

*This includes 2 LCVs with larger batteries, and 5 chassis cab vehicles.

Transitioning the LCV fleet to BEVs can save around 79 tonnes of GHG emissions annually. A BE LCV fleet could potentially save costs for PBC in all LCV categories, though if larger battery models are needed these may incur a cost.

9. Moving to a zero emission HCV Fleet

9.1 Overview of the HCV fleet

For the year 2023/24, 28 HCVs appeared in the PBC data in total, six of which are no longer on fleet (whether de-fleeted, third-party spares, or erroneous VRM). We have therefore analysed the 22 remaining HCVs, summarised in Table 9-1. Telematics data was available for 19 HCVs (RCVs and sweepers), which provides an accurate assessment of BEV suitability in Sections 9.3 and 9.4. For the remaining HCVs without telematics, we have based BEV suitability on the fleet average and maximum annual mileages.

To estimate the daily BEV energy, we have used the current ICEV mileage, the fleet average mpg ICEV energy efficiency, and that a BEV would use 30% of the ICEV energy. Fuel data was available for 21 vehicles (including four which used HVO), and mileage data was available for 19 vehicles. BT58FUV (gully tanker) had no fuel or mileage. Annual averages are based only on the vehicles on fleet all year 2023/24, and daily values are estimated based on 240 working days a year.

Table 9-1: Overview of the PBC HCV fleet for electrification

Fleet	Qty	With telematics	Av mpg	Fleet average			Fleet maximum		
				Annual mileage	Daily mileage	Daily BEV energy	Annual mileage	Daily mileage	Daily BEV energy
12 t skip loader	1	/	/	/	/	17.3 kWh	/	/	17.3 kWh
7.5 t gully tanker	1	/	/	/	/	/	/	/	/
4.5 t sweeper	5	5	1.5	1,824	7.6	72.8 kWh	3,185	13.3	84.1 kWh
18 t sweeper	1	1	1.1	2,796	11.7	145 kWh	2,796	11.7	145 kWh
15 t RCV	2	2	2.4	4,452	18.6	108.1 kWh	5,104	21.3	109.1 kWh
18 t RCV	5	4	1.5	3,598	15.0	117.3 kWh	4,291	17.9	143.1 kWh
22 t RCV	7	7	1.7	4,271	17.8	145.3 kWh	4,775	19.9	156.8 kWh

9.2 Skip loader

An increasing number of manufacturers are offering BE rigid HGVs. Most can be specified with different types of body, suited to many different operations.

At the end of 2022 the UKs first electric skip loader started work with Recycling Lives in Preston, Lancashire (Figure 9-1). This is an 18 t Renault E-Tech D Wide 4x2 BEV truck. It has a 265 kWh battery and Renault's own modelling suggests that carrying a 50% load it could achieve a range of 200-210 km (124 to 130 miles) with external temperatures at five degrees Celsius.

Figure 9-1: Electric skip loader from Recycling Lives

In the 12 tonne HCV category, although choice is more limited than 18 tonne and above, there is the DAF Trucks XB Electric available in a 12 tonne version. This is available with battery sizes from 140 to 280 kWh, giving around 100 to 200 miles of single charge range.

Lancashire-based Electra also offer various configurations of rigid electric HCVs, with multiple body types and battery options. Whilst not an OEM, the vehicles are based on OEM gliders (warrantied chassis of base vehicles, manufactured the OEM without engine, gearbox, and exhausts, ready for equipping with electric drive and batteries). Electra have the eCargo available in a 12 t version, on an Iveco base chassis, and with battery sizes 140 to 315 kWh.

PBC operate one 12 t skip loader, MF71AAK. No telematics data was available for this vehicle and no mileage was available, so daily miles are not visible. The fuel data provided would indicate that this vehicle would use under 20 kWh per day as a BEV, if used 240 days a year. However, it is not clear how much the daily usage varies. This means that PBC would need to identify peak daily usage, before being able to specify the most cost-effective battery configuration, or indeed have confidence that a BEV could undertake all the existing duties of this vehicle without the need for potentially disruptive in-shift top up charges.

Based on a seven-year replacement, the skip loader on fleet would need replacing in 2028. There are suitable BEV options available now to replace this vehicle, and we would expect there to be a wider choice in 2028. As this sector is still developing, it is likely that the low usage of this vehicle would mean switching to BEV now (in 2024) would incur a higher cost, however by 2028 this is likely to change as the market for BEV HCVs increases and vehicle costs decrease.

9.3 Sweepers

Increasing numbers of options are emerging for electric sweepers. Nottingham City Council is operating a fleet of eight small electric sweepers from Boschung and City of Edinburgh Council is operating a large electric sweeper from Bucher.

Companies like Whale (tankers and gully cleaners) and Johnston/Bucher sweepers have used electric drive kits from the Dutch company EMOSS to convert donor vehicles. The Green machine Ze500 is another small fully electric sweeper that has recently emerged on the market with a useable battery capacity of up to 46 kWh.

Scarab have the Ravo R5E, which is an 11.5 t sweeper with 100 kWh battery. The Schmidt Swingo 200 (of which PBC operate five) also offer the electric e-Swingo 200 for daily duties, suited to inner cities and pedestrianised areas with a battery size of 75 kWh. Schmidt also have the eCleango 550, an 11.5 t with 100 or 150 kWh battery.

PBC have six sweepers on fleet, five 4.5 t and one 18 t. All six sweepers are up for replacement in 2026. Whilst there are possible BEV options available to replace all of these vehicles, capability is currently limited and focused on urban applications, due to small battery capacity (particularly for the smaller 4-5 t vehicles). The 18 t one may be viable to replace with currently available technology, but in all cases we would recommend trialling the vehicles available. The sweeper market is comparatively new and in development, and by 2026 there should be a wider variety of vehicles available, with lower costs and higher energy storage.

9.3.1. Telematics analysis for sweepers

There are five 4.5 t and one 18 t sweepers on the PBC fleet for which daily mileage data was available. The average efficiency for these vehicles is recorded at 1.4 mpg based on total annual mileage and total annual fuel consumption data.

1.4 mpg is low for this kind of fleet, indicating there may be scope for improvement through interventions to assist driver efficiency. For this analysis we will accept that higher energy consumption means that estimates for electric sweeper energy consumption will have more contingency, and that actions to improve and measure efficiency will be taken.

The utilisation of sweepers is very high, but could be more consistent, with annual mileages ranging from 960 to 3,184, and an average annual mileage of 1,953 miles across the six vehicles. Each sweeper produces an average annual 21 tonnes of GHG.

An electric sweeper is likely to use between 25-30% of the energy of a diesel equivalent during operation (the latter is more likely in colder conditions and at speeds where a diesel vehicle would be more efficient). We have used the 30% figure, to make allowances for adverse conditions and ensure some caution within our conclusions.

PBC's sweepers had a combined working day average of 135 kWh of equivalent likely BEV energy consumption, based on the number of working days for each vehicle from the daily mileage data.

Figure 9-2 summarises the estimated average and peak energy consumptions for each of the sweepers, identified by registration number. This assumes that a BEV will use 30% of a diesel vehicle's energy and that 2023/24 operations offer a sufficiently accurate indication of future activity. Negative and values less than 1 mile were removed from the data set to provide a more realistic picture of daily use and energy consumption, and we have assumed sweeper data has been recorded in km, and we have converted to miles accordingly. We have assumed that a litre of diesel burnt produces the equivalent of 10.6 kWh of energy.

Figure 9-2: Average and peak energy consumption for six sweepers with telematics

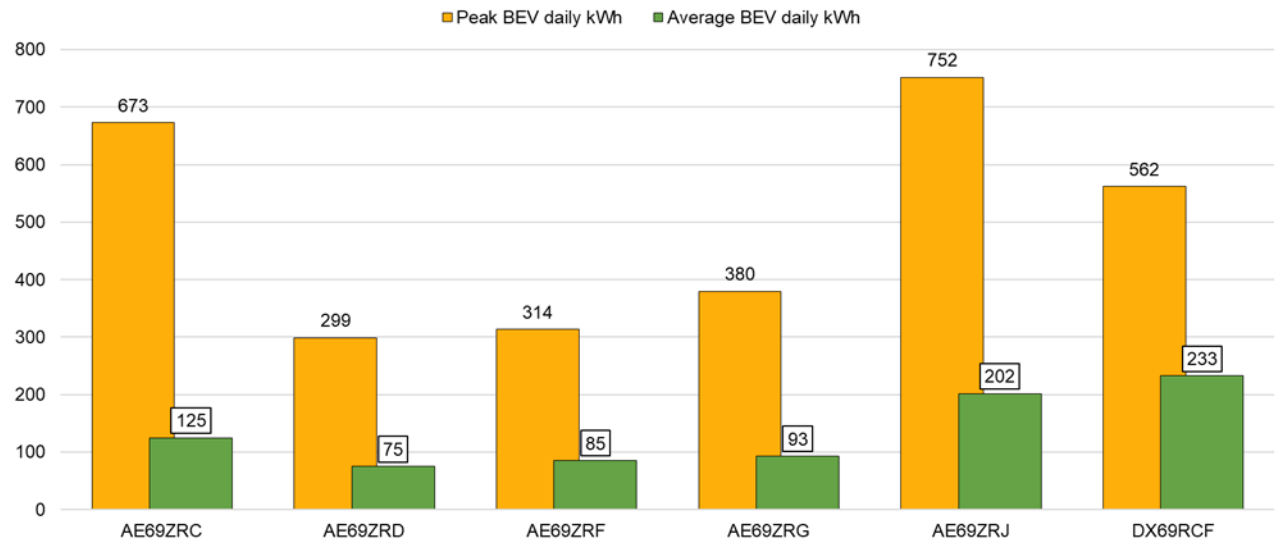


Table 9-2: Suitability of BE 4.5 t sweepers for the PBC fleet

VRM	Days <65 kWh	Total days over 65 kWh	Total days over 125 kWh	Total days over 185 kWh	Notes
AE69ZRC	40	114	64	30	Electric sweeper not yet suitable, further analysis needed
AE69ZRD	85	142	29	2	Electric sweeper not yet suitable, further analysis needed
AE69ZRF	54	144	35	5	Electric sweeper not yet suitable, further analysis needed
AE69ZRG	46	146	41	3	Electric sweeper not yet suitable, further analysis needed
AE69ZRJ	16	71	62	49	Electric sweeper not yet suitable, further analysis needed

Table 9-3: Suitability of BE 18 t sweepers for the PBC fleet

VRM	Days <270 kWh	Total days over 270 kWh	Total days over 300 kWh	Total days over 360 kWh	Notes
DX69RCF	92	61	31	13	300 kWh truck mounted sweeper may be suitable with efficiency and shift changes.

The sweeper fleet has a very high level of usage and a very high energy intensity. For the 4.5 t sweepers, the currently maximum available 75 kWh battery would not be sufficient, unless it is possible for the vehicles to be recharged during the working day. The 18 t sweeper may be possible to replace with a BEV, although this would need to be verified by trialling one.

The energy efficiency of this fleet is remarkably low, so we would recommend PBC investigate the telematics calibration, as well as the fuel and mileage recordings for this fleet, to ensure all data is correct. Driver training that focuses on energy efficiency could deliver substantial savings in this fleet, and would make the switch to BEVs more operationally feasible.

When these vehicles are up for replacement in 2026, PBC should reevaluate the electric vehicles available and the whole life cost differential at this time. If it is possible to defer procurement for 1-2 years there may be a greater availability by 2028. PBC should consider carefully that if these vehicles are replaced by diesel in 2026, these will be on fleet until 2033 – three years after PBC's net zero target date. If PBC decides to fuel these vehicles with HVO, due diligence should be made as to the out of scope emissions, considering whether the use of HVO will contribute to a real positive impact on the climate emergency.

9.4 RCVs

There is now a wide range of electric options for RCVs, whether direct from the OEMs, or through specialist converters to electric drivetrain. In moving to BEV, it may be a better solution to look at the chassis and body separately. The Electra eStar platform is configurable to suit any body style, and is available with 140 to 420 kWh battery ranges. The eCargo is available up to 19 t GVW, with battery range 140 to 315 kWh. Electra also offer the eCompact, on a Dennis Eagle base chassis, in 19 t, 27 t and 32 t, with battery range 140 to 420 kWh. The City of London (Veolia) and Manchester City Council (Biffa) now have substantial fleets of the 19 tonne (2-axle) and 27 tonne (3-axle) Electra RCVs (Figure 9-3) in operation.

Figure 9-3: One of the City of Manchester's Electra/Mercedes 26 t 300 kWh electric RCVs

The Dennis Eagle eCollect, is a 300 kWh battery electric version of the company's popular 26 tonne 'narrow' model. Well over 100 are already in service with many councils including Nottingham, Newport, Cardiff, Oxford, Powys, Dundee, York, Cambridge, Sunderland, and Islington.

The Mercedes-Benz eEconic is available in 19 t or 27 t variants, and up to 336 kWh battery. Volvo have the FL electric up to 17 t and 280 to 565 kWh battery, and the FE electric up to 27 t and 280 to 375 kWh battery. Renault Trucks have the E-Tech D electric up to 16 t and 200 to 565 kWh battery, and the E-Tech D wide 19 t to 26 t and 280 to 375 kWh battery. Finally, DAF have the XB electric in

12 t, 16 t, and 19 t, 140 to 280 kWh battery, and the XD electric in 18 t, 26 t (and above), with 210 to 525 kWh battery.

Romaquip have recently launched the RQ-E, an electric resource recovery vehicle (RRV), based on a DAF glider chassis. Electra and Terberg have also produced an electric RRV based on the Electra eCargo chassis, available as 12.5 t or 14 t, with 140 or 210 kWh batteries.

An alternative to buying a new electric RCV is offered by the UK company Refuse Vehicle Solutions (RVS) who have entered into an agreement with EMOSS to use its technology to convert donor RCVs from diesel to electric. The old vehicle chassis, cab and waste collection rig are refurbished, new electric bin lifts are fitted, and the diesel drive train is replaced by an EMOSS electric drive, with the option of a 200 kWh or 280 kWh battery. Examples are in service with Islington Council and Chichester District Council.

PBC operate two 15 t RCVs, five 18 t RCVs, and seven 22 t RCVs – all Dennis Eagle, except for the two 15 t DAF Trucks. We understand that the 18 t vehicles do the recycling rounds, and 22 t the non-recycling and garden rounds. 26 t vehicles are more usual to find in Council fleets, but at PBC these would not be viable due to size restrictions, and 22 t offer sufficient load capacity whilst still being able to access Pendle's streets. There are also two vehicles which do rural rounds. All RCVs travel less than 50 miles a day, and have allocated parking bays at the PBC Fleet Street Depot. There is however potential for the waste transfer station to move to the County Council location, which would add 60 miles a day of mileage between the PBC and County Council locations.

Whilst there is a wide range of options for replacing the 15 t and 18 t RCVs with BEVs, the 22 t category is slightly unusual, meaning there is currently not yet a viable alternative. PBC could consider whether any smaller or larger vehicles would be viable (smaller would need to consider payload and larger would need to consider vehicle dimensions over weight). Otherwise, we would recommend reevaluating the state of the market when the vehicles are up for replacement in 2026, as by then there may be a viable alternative available.

9.4.1. Telematics analysis for RCVs

There are 13 RCVs between 15t and 22t on the PBC fleet for which daily mileage data was available. The average efficiency for these vehicles is recorded at 1.7 mpg based on total annual mileage and total annual fuel consumption data.

The utilisation of RCVs is reasonably consistent with a few lower-mileage vehicles, with annual mileages ranging from 2,681 to 5,103, and an average annual mileage of 4,038 miles across the 13 vehicles. Each RCV produces an average annual 34 tonnes of GHG.

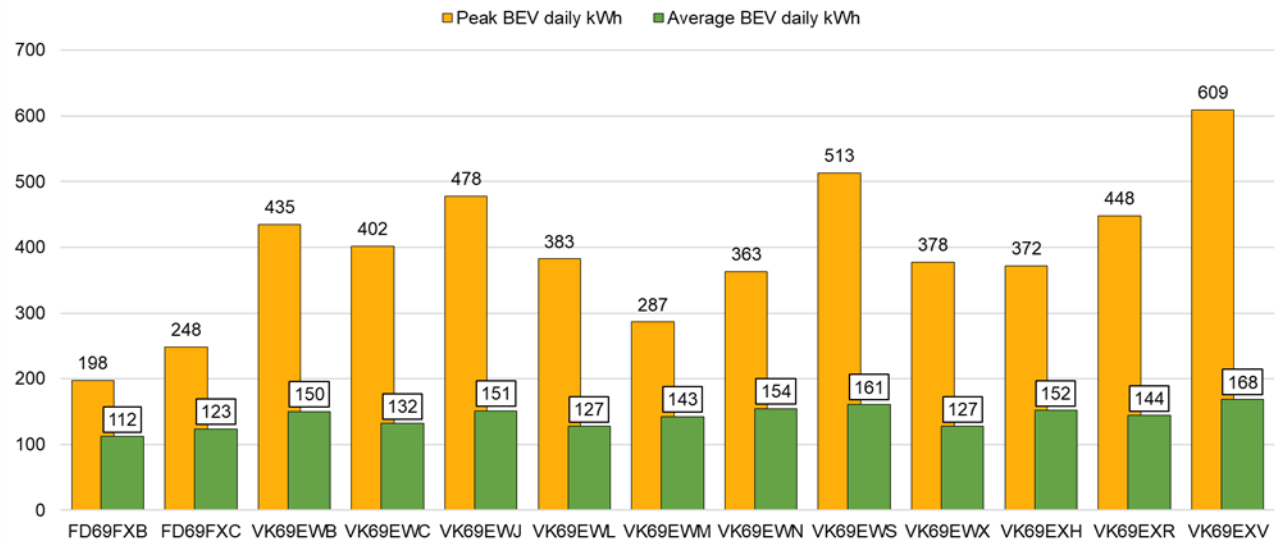
An eRCV is likely to use between 25-30% of the energy of a diesel equivalent during operation (the latter is more likely in colder conditions and at speeds where a diesel vehicle would be more efficient). We have used the 30% figure, to make allowances for adverse conditions and ensure some caution within our conclusions.

PBC's RCVs had a combined working day average of 142 kWh of equivalent likely BEV energy consumption, based on the number of working days for each vehicle from the daily mileage data.

It was not clear from the data provided whether or not RCVs are allocated to specific routes or sets of routes, although data suggested some patterns of energy consumption visible for some vehicles. For example, particular days of the week where energy consumption was likely to be high, suggested some allocation of vehicles to the same routes. If all vehicles are used across all routes, it would mean that all vehicles have a potential high peak of energy consumption, as they all could be used on longer or more energy intensive routes. This would have the effect of making vehicles look less favourably disposed to electrification than they would be if allocated to specific routes, keeping the same vehicles allocated to those energy intensive routes.

Figure 9-4 summarises the estimated average and peak energy consumptions for each of the 13 RCVs, identified by registration number. This assumes that a BEV will use 30% of a diesel vehicle's energy and that 2023/24 operations offer a sufficiently accurate indication of future activity. Negative and values less than 1 mile were removed from the data set to provide a more realistic picture of daily use and energy consumption, and we have assumed RCV data has been recorded in km, and we have converted to miles accordingly. We have assumed that a litre of diesel burnt produces the equivalent of 10.6 kWh of energy.

Figure 9-4: Average and peak energy consumption for 13 RCVs with telematics



If taken at face value, it is possible to look at peak energy consumption and dismiss the use of eRCVs on all but three vehicles (assuming an eRCV with a usable battery capacity of 300 kWh). The remaining 10 vehicles are likely to exceed a single charge of 300 kWh during a day at some point in a year.

However, closer inspection of data suggests that only five of vehicles are likely to exceed the 300 kWh threshold on more than 10 days in a year, and only one of those exceeded 360 kWh on more than 10 days. There is therefore scope to electrify eight of the 13 vehicles based on current use. It may also be viable to transition the remaining vehicles with some alterations to rounds, and/or use of larger battery vehicles (though this comes at a cost premium). If necessary, remaining diesel RCVs can be kept for the longer routes where required until a suitable BE option is available. Table 9-4 highlights the number of days in which this analysis shows an eRCV would exceed the common battery capacities of eRCVs available today.

Table 9-4: Suitability of BE RCVs for the PBC fleet

VRM	Days <270 kWh	Total days over 270 kWh	Total days over 300 kWh	Total days over 360 kWh	Notes
FD69FXB	246	0	0	0	300 kWh eRCV suitable
FD69FXC	219	0	0	0	300 kWh eRCV suitable
VK69EWB	249	7	4	1	300 kWh eRCV may be suitable with efficiency and shift changes
VK69EWC	250	15	8	2	300 kWh eRCV may be suitable with efficiency and shift changes
VK69EWJ	219	17	11	4	300-400 kWh eRCV may be suitable with efficiency and shift changes
VK69EWL	242	19	11	1	300-400 kWh eRCV may be suitable with efficiency and shift changes
VK69EWM	251	5	0	0	300 kWh eRCV suitable
VK69EWN	201	13	3	1	300 kWh eRCV may be suitable with efficiency and shift changes
VK69EWS	223	23	16	6	300-400 kWh eRCV may be suitable with efficiency and shift changes
VK69EWX	260	4	4	2	300 kWh eRCV may be suitable with efficiency and shift changes
VK69EXH	202	6	5	3	300 kWh eRCV may be suitable with efficiency and shift changes
VK69EXR	255	13	12	4	300-400 kWh eRCV may be suitable with efficiency and shift changes
VK69EXV	171	36	28	16	eRCV may not yet be suitable, further analysis needed

9.4.2. Whole life cost – 18 t RCVs

We have analysed the WLC for the 18 t RCVs, as these are viable for replacement with currently available models, and are the second-largest fleet. These costs are for illustration only, but the other RCV weights are likely to follow a similar cost pattern. We have estimated costs for the replacement of a typical diesel 18 t RCV with an eRCV and have used the average energy efficiency data (mpg) from PBCs RCVs in 2023/24 to determine the energy cost savings and GHG emissions. Any new diesel vehicles are not expected to have significantly better energy efficiency than current models, as both old and new fleet meet the Euro VI emission standard and the engine technology is very similar.

Because a BEV drive train has far fewer wearing parts, it is inherently more reliable. Some manufacturers even offer a ten-year battery warranty. Therefore, we have modelled the life of the BEVs over 10 years and the ICE vehicles over seven years with a second new ICE fleet for the last three years (costs are proportionate to this). What is not included in this model is the cost of rig refurbishment during the operational life of any RCVs, or the additional cost of future diesel RCVs associated with meeting the new Euro VII emission standard in 2026/27.

Within our WLC analysis we have also included HVO, which is based on the same diesel models with a cost premium for the fuel, and hydrogen fuel cell, although as fuel cell vehicles are rare and bespoke, prices are only our best approximation.

We understand PBC lease their vehicles, however as we do not have access to viable lease pricing data we have based our analysis on a purchase basis. We would recommend PBC undertake a cost analysis on a whole life basis with their leasing provider when procuring new vehicles.

Table 9-5: Electric 18 t RCV fleet – factors used in the WLC energy model.

RCV factor	Diesel	HVO	BEV	FCEV	Notes
Fleet size	5	5	5	5	Fleet data
Fleet annual mileage	15,391	15,391	15,391	15,391	Fleet data
Project life	10 years	10 years	10 years	10 years	BEV lifespan
Vehicle lifespan	7 years	7 years	10 years	10 years	OEM advice & fleet
Annual mileage/vehicle	3,078	3,078	3,078	3,078	Fleet data
Energy efficiency	1.54 mpg	1.54 mpg	9.38 kWh/mile	1.80 miles/kg	EV and FCEV derived from diesel
Cost of energy/fuel	£1.23/L	£1.42/L	£0.20/kWh	£10/kg	Ex VAT
Annual Inflation to 2030	2%	2%	1%	-5%	Per year

The cost savings from eRCV chassis maintenance are significant but the cost of maintaining the rig will be similar for both vehicle types. The energy/fuel costs for April 2024 are used as the base year but an annual inflationary increase has been applied. Future carbon taxes have not been considered but may be significant. Electricity prices are based on a high of £0.27/kWh and overnight low tariff of £0.07/kWh. If the fleet is only charged in a low cost window, electricity prices can be reduced further. Reductions in electric energy costs may also be achieved through generation and may be likely given the current 'spike' in energy prices.

Table 9-6: Net capital cost of diesel, electric and FCEV RCVs.

Cost summary	Diesel	HVO	BEV	FCEV	Notes
Vehicle capital cost	£250,000	£250,000	£430,000	£625,000	OEM data
Residual value (chassis)	-£17,500	-£17,500	-£21,700	-£43,750	All 5%
ULEV grant funding	/	/	-£25,000	£0	OZEV grant scheme
Residual value (battery)	/	/	-£24,000	-£6,000	Estimated as 20%
Net vehicle cost	£232,500	£232,500	£359,300	£575,250	
Over 10-year project	£332,143	£332,143	£359,300	£575,250	Including lifespan
Fleet net capital cost	**£1,660,714**	**£1,660,714**	**£1,796,500**	**£2,876,250**	Whole fleet

The higher capital cost of the eRCV fleet is apparent in Table 9-6 and even if the ICE fleet is renewed at seven years and the costs associated with the additional three years included over ten years, the BEV vehicles still have a significant additional capital cost of over £130,000 for the fleet. The residual value of the batteries could be higher than our estimate (they should have a second life in energy storage and can be refurbished) and it is quite possible that in 2030 (and 2033), an electric chassis will be worth much more than a diesel chassis, and possibly even have significant residual life.

Table 9-7: 18 t RCV fleet WLC, 10-year lifespan.

Cost summary	Diesel	HVO	BEV	FCEV	Notes
Fleet net capital cost	£1,660,714	£1,660,714	£1,796,500	£2,876,250	From previous table
Fleet energy cost	£648,763	£746,077	£311,387	£587,550	Includes inflation
Fleet adBlue cost	£12,420	£12,420	/	/	No inflation
SMR (ex tyres) cost	£600,000	£600,000	£420,000	£600,000	OEM estimate
VED + Road User Levy	£29,175	£29,175	£0	£0	DVLA V149/1 - 2020 Policy
CAZ levy	£0	£0	£0	£0	No local CAZ proposed
Whole life cost	**£2,951,072**	**£3,048,387**	**£2,527,887**	**£4,063,800**	

We would expect electric RCVs to reduce the energy cost of an RCV by about £337k compared to diesel, and £435k compared to HVO over 10 years. They would also eliminate the need for 'adBlue' exhaust additive and would be zero-rated for Vehicle Excise Duty and Road User Levy. Other savings arise from reduced chassis maintenance costs, although these may be offset by more body and lifter maintenance costs later in the life of the eRCV when kept for ten years.

There is overall an estimated saving of around £423k for the whole 18 t fleet (£85k per vehicle) from operating an eRCV (over 10 years), compared to diesel. Compared to HVO, the saving increases to £520k (over £100k per vehicle). With our best estimates, FCEVs would increase fleet costs on a WLC basis, although energy cost savings may be possible. This makes eRCVs the most cost effective route to decarbonising the fleet.

It should be noted that with the current volatility and unpredictability of fuel and energy prices, any modelling of future costs could be subject to significant variation in either direction. However, whilst we remain close to an all-time high electricity cost there is the strong possibility of a return to more favourable rates, especially as the influence of renewables increases.

Emission reductions from a switch to eRCVs is summarised below.

Table 9-8: Ten-year energy use and GHG emissions of a diesel, HVO, electric and hydrogen RCV fleet.

Energy use and GHG	Diesel	HVO	BEV	FCEV	Notes
Energy consumption (kWh)	4,814,621	4,814,621	1,444,386	4,910,015	
Scope 1 TTW kg CO_2e	1,140,392	176,761	/	/	BEIS/DESNZ factors
Scope 1 TTW AdBlue kg CO_2e	3,606	3,606	/	/	BEIS/DESNZ factors
Scope 2 Generation kg CO_2e	/	/	92,951	315,974	UK grid - predicted
Scope 3 T&D kg CO_2e	/	/	8,660	29,438	UK grid - predicted
Scope 3 WTT kg CO_2e	276,826	42,908	27,735	94,283	BEIS/DESNZ factors
Project GHG emissions	**1,420,824**	**223,275**	**129,346**	**439,695**	Over 10-year life

Over the ten-year lifetime of the eRCV fleet, total GHG emissions will reduce by almost 1,300 tonnes (91%) compared to diesel, and by 94 tonnes (42%) compared to HVO. The eRCVs have no Scope 1 emissions and all the GHG emissions are Scope 2, from the generation of electricity and Scope 3 from transmission and distribution (T&D) losses as well as 'WTT' emissions at the generator – all of these will fall over the lifetime of the project, as the UK grid decarbonises. Local generation of electricity by PBC using a wind turbine or PV array would help to reduce electrical energy costs (typically to around 6p/kWh equivalent) and shield PBC from future fluctuations in electricity costs.

If PBC replace all 14 RCVs with eRCV equivalents (when viable options are available), then annual emissions would reduce by around 330 t compared to operating diesel vehicles. With eRCVs, annual emissions would be around 140 t less than if the whole fleet switched to using HVO.

9.4.3. Air quality improvements

The diesel RCV engine has significant emissions of both NO_x and PM and these must be controlled using a selective catalytic reduction system (SCR) for the NO_x and a particulate trap for the PM. Both these technologies struggle to work well at the low exhaust temperatures associated with low speeds and with intensive stop/start operations. The SCR may switch off as it can release ammonia at low temperatures and the particulate trap may need to be regenerated by driving the vehicle at sustained speed.

Table 9-9 below has been determined using the COPERT5 model for a Euro VI diesel operating at an average speed of 15 km per hour reflecting semi-urban stop-start operation. This is a vehicle specific model and very different from the 'Average UK HCV' values presented earlier in this report.

Vehicles powered by HVO still emit tailpipe pollutants, possibly at a marginally lower rate than fossil diesel, although independent research is limited.

Table 9-9: Air quality emissions for the 18 t RCV fleet over the 10-year project life.

Air quality (project life)	Diesel	HVO	BEV	FCEV	Notes
Nitrogen oxides (NO_x) kg	313	313	0	0	NAEI COPERT5 (15 km/hr)
Particulate matter (PM) kg	2.1	2.1	0	0	NAEI COPERT5 (15 km/hr)

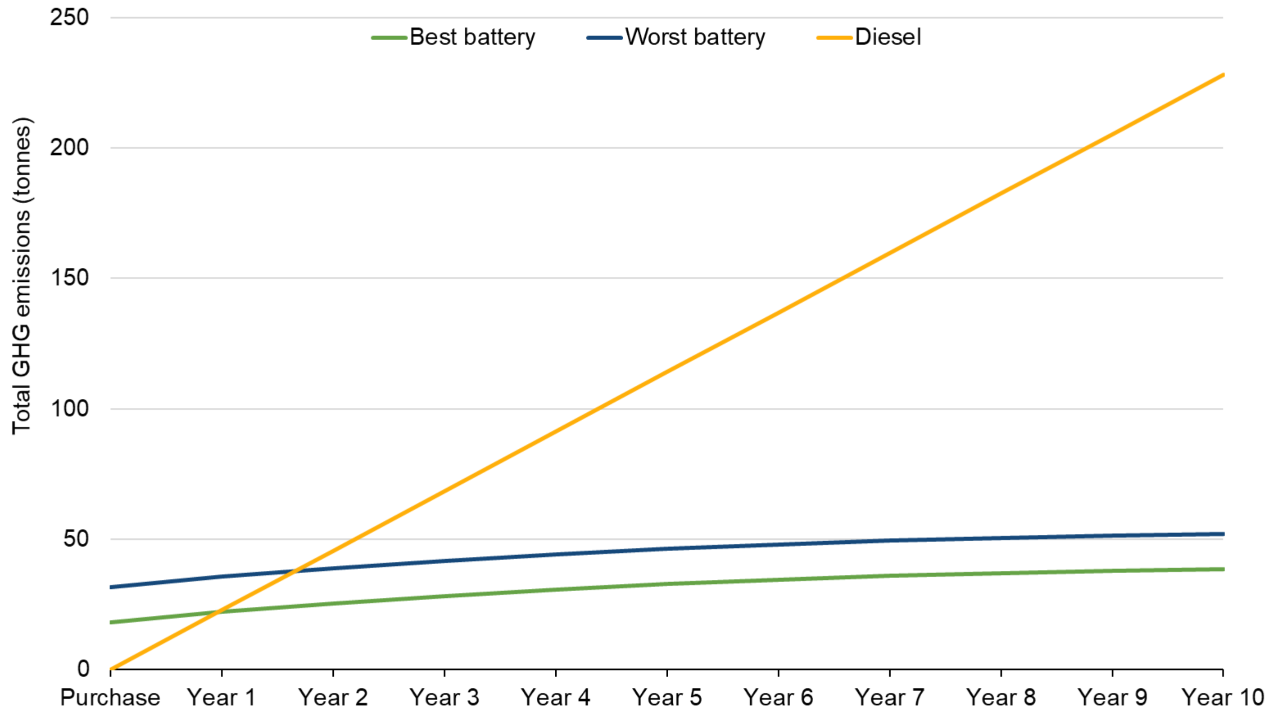
9.4.4. Offsetting the GHG embedded in the battery

One concern often expressed when evaluating BEVs is the embedded GHG in the battery associated with the manufacture of the battery cells. Research by the Swedish Environmental Research Institute in cooperation with the Swedish Energy Agency has identified the variation in GHG emissions associated with each kWh of capacity (Lithium-Ion Vehicle Battery Production, 2019) depending on the GHG intensity of the manufacturing process.

In 2019, the range was from 61 $kgCO_2e$/kWh to 106 $kgCO_2e$/kWh. Figure 9-5 demonstrates that even with the most GHG intense battery (worst battery) the electric RCV offsets the GHG embedded in its manufacture within 18 months - when the yellow line of cumulative diesel emissions crosses the green lines of cumulative EV emissions. In the case of the 'best battery' this occurs after about a year of use based on CLIENT mileage and current diesel efficiency.

During 2019-2023, many battery manufacturers around the world have moved to using renewable energy for the production process which would place their batteries in the 'best' category. Even if the battery manufacturing plant is 100% net zero, there are still GHG emissions associated with the extraction, processing and transport of the raw materials required for manufacture of the battery.

Figure 9-5: Cumulative GHG emissions, 300 kWh battery, 10-year life, UK grid, PBC RCV operation.



9.4.5. Treating the principal components as separate assets

Electric motors, batteries, vehicle chassis and refuse/recycling rigs all have different operational lives. Most heavy-duty electric motors can operate with minimal servicing for 20 years or more (based on experience in trains and trams) and can be easily refurbished – two new bearings and a rewind of the coils.

Batteries can be serviced by replacing faulty cells and, when they are no longer economic to refurbish, they can still be used in a battery storage array as the reduced storage capacity – and therefore range – is not an issue. The chassis and cab can be fully refurbished, and the refuse rig replaced. All of which means that simply replacing the whole vehicle at seven years – common practice for diesel RCVs – is likely not the optimal ownership strategy for an electric RCV fleet. Longer retention may also be complemented by refurbishment and second life of many components.

9.5 Replacement plan - HCVs

The transition schedule in Table 9-10 is based only on the age of the vehicles, and PBC's seven-year retainment period. There are vehicles within the HCV fleet that are not yet suitable for electrification, and replacement for these may need to be deferred until later in the decade.

Table 9-10 considers the first replacement cycle to BEV, and does not take into account lead times on vehicle orders, which can be up to 12 months. The annual GHG saving is the saving achievable per year from the 2023/24 baseline, by transitioning the vehicles for the year specified.

We have not included a WLC analysis in this table, as only the 18 t RCVs were analysed. Due to the high usage of the RCV fleet, it is likely that the rest of the RCVs would follow a similar pattern to the 18 t, resulting in substantial cost savings for PBC. The sweepers may incur costs, as these vehicles are still quite new and specialised, meaning very high purchase and lease prices for these vehicles at present. Whilst there is a variety of choice for the skip loader, the low usage of this vehicle means the reduced energy costs may not make up for the higher lease cost. Only two vehicles would be expected to be replaced in 2024, and by the main replacement year of 2026 (and later), BEV costs will have substantially reduced, and the market will have developed, as we have seen this already in the last 2-3 years.

Table 9-10: Recommended BE HCV transition schedule

	2024	2025	2026	2027	2028	2029	2030+	**Total**
12 t skip loader	-	-	-	-	1	-	-	**1**
7.5 t gully tanker*	1	-	-	-	-	-	-	**1**
4.5 t sweeper	-	-	5**	-	-	-	-	**5**
18 t sweeper	-	-	1	-	-	-	-	**1**
15 t RCV	-	-	-	2	-	-	-	**2**
18 t RCV	1	-	4	-	-	-	-	**5**
22 t RCV	-	-	7**	-	-	-	-	**7**
Annual GHG saving (t)	24	-	378	48	4	-	-	**454**

*No data.

**Subject to vehicle availability, may need to be deferred until 2028-2030.

10. Electric vehicle charging infrastructure

10.1 Introduction to charging infrastructure

10.1.1. Charging an electric vehicle fleet

The majority of BEV fleets can be fully recharged overnight, or during long periods of inactivity, except (for example) emergency services and 24/7 delivery vehicles. BEVs should generally be matched to the service being delivered, so that a normal working day can be completed on a single charge - although there are exceptions where high-mileage services also offer frequent top-up charging opportunities (such as an inter-site delivery or bus service). It Is also possible to consider daytime top-up charging using rapid chargers.

Battery charging is not a linear process, meaning that charge times can vary. If a vehicle returns to a 7.4 kW charger needing 74 kWh of energy to replenish its battery, it will take longer than the theoretical 10 hours to fully recharge it (74 kWh/7.4 kW=10 h). When a battery is depleted, there is little internal resistance to the flow of current (Amps), and so energy can be quickly transferred to the battery. However, as it reaches 80%-90% state of charge, the internal resistance increases, and the charging system has to increase the voltage to maintain the current. There is a maximum voltage above which damage to the battery will occur, so the flow of energy to the battery has to reduce, and the battery charge rate slows down.

For vehicles with battery sizes up to 75 kWh, a 12-hour charging window usually provides enough time in which to recharge the battery from a fully depleted state of charge (SoC) (only 10% residual charge in the battery) using a basic 7.4 kW charger. Only cars and vans specified with a greater range or load carrying capability and therefore larger 100+ kWh batteries, may need longer than 12 hours to fully recharge at 7.4 kW from 10% SoC.

10.1.2. Charging speed and hardware

There are two basic types of charging infrastructure. Alternating Current (AC) and Direct Current (DC). Electricity that comes from the grid, or a private wire electrical supply, is always AC, but BEV batteries store power as DC.

AC (fast) charging

When using an AC charge point, the vehicle must convert the electricity to DC. On board the vehicle is a conversion system known as the 'onboard charger', which converts the power and feeds it into the vehicle's battery. The output of AC charging systems ranges from 3.4 kW up to 43 kW but is usually 7.4 kW or 22 kW. Charging speed is dictated by the vehicle, and as most BE cars and vans available today have a maximum AC charge rate of 7.4 or 11 kW, there can be little benefit of a higher power (22kW) AC unit, except for larger vehicles like HDVs and buses. These types of charge points are usually found in domestic properties, commercial sites for overnight charging, and destination charging locations.

Traditionally, with AC, limited information was exchanged between the vehicle and the AC charge point, as the on-board hardware and software manage the charging process. As a result, the AC charger would not know the SoC of the battery or the battery capacity. The Open Smart Charging Protocol aims to change this when it is widely adopted by both vehicle manufacturers and charge point suppliers. Without this, AC systems cannot use information about the vehicle's SoC and battery size to develop an optimal charging strategy.

DC (rapid) charging

If a vehicle is using a DC charge point, the conversion system is within the charge point itself. This means the power bypasses the vehicle's on-board conversion system and flows directly into the battery. To do this safely and without damaging the batteries, the DC charge point must communicate with the vehicle's battery management system and understand the size of the battery and its SoC. DC charge points are therefore "smarter" than AC units, and management of DC charging can be more sophisticated, making use of battery size and SoC data.

The output of DC charge points ranges from 20 kW up to 600 kW (or more). DC charge points are classified as rapid (20 kW – 100 kW) or ultra-rapid (100 kW and above). Like AC charging, the speed of charge is dictated by the vehicle, and is concurrent with battery size. As vehicles with larger batteries are introduced to the market, the charging speed of these vehicles is increasing. These types of charge points are usually found at motorway service stations, on-street in urban areas, and at depots housing larger vehicles such as electric refuse vehicles.

Charge points

EVCI can be designed to suit your specific fleet operation. Fast charge points (AC) can have single or dual sockets, and can come with charging cables tethered (cables affixed, largely for domestic charging) or untethered (just the sockets). Rapid charge points (DC) can have either one, two, or three charging ports. There are different connector types available, depending on the charge point type and vehicle: rapid charge points use CHAdeMO, CCS or Type 2, and fast charge points use Type 1, Type 2, Commando, or 3-pin plug. BEVs are generally supplied with cables and connectors to be able to use most untethered charge points. However, if installing tethered charge points, the cables need to be compatible with the vehicles operated. Charge points can be post mounted, wall mounted, mobile, part of an overhead gantry system, stand alone, satellite posts and more. It is important to consider specific site requirements when procuring hardware.

The simplest layout is to install one charge point per vehicle, so that each vehicle has a dedicated parking space and charge point. This allows the charging load to be spread over the downtime available, reducing the maximum import capacity needed (more on this in Section 7.3). It also enables the use of 'pre-conditioning', either heating or cooling the vehicle in preparation for its use, while still attached to the power supply.

It may however be necessary (either due to cost or space available) to implement a charge point sharing system between low-mileage vehicles, whereby two or even three vehicles could share a single charge point on a rota basis. If this is implemented, it is imperative that the vehicle be plugged in when required, and this may need dedicated staff resource. It is also important that sharing charge points does not lead to procuring larger battery vehicles - it is better from a cost and environmental perspective to have more charge points and smaller batteries.

10.1.3. Smart charging and load management

Smart charging

Smart charging is a system whereby the BEV and charge point share a data connection, and the charge point shares a data connection with an operating system. Basic ('dumb') charge points simply allow a BEV to plug in and receive a charge. Smart charge points are connected to a cloud network, either through Wi-Fi, ethernet or 3G/4G/5G. This allows the charge point to monitor, manage, and restrict use remotely, to optimise energy consumption. In a smart charging system, the chargers will react with the changes in the grid system in order to not overload or unbalance the grid, whilst still ensuring the vehicles are charged as needed. Smart charging allows you to set your charging preferences, which may include:

- Desired charge level
- Minimum charge level
- Charge-by time

Smart charging is essential as BEV uptake continues to exponentially increase. There are many benefits to fleet operators looking to implement smart charging systems within their workplace, such as those outlined in Table 10-1.

Table 10-1: Benefits of smart charging

Feature	Benefit
Cost saving	An energy tariff specifically designed for BEVs will have lower off-peak rates, and smart charging can ensure charging happens during these off-peak hours, without needing to physically plug or unplug the vehicles.
Convenience	Smart charging requires little effort – when the vehicle is returned to a site, or an employee's home, the BEV can just be plugged into its smart charge point. The smart functionality ensures the vehicle is charged by the time set by the user.
Environmental benefits	Smart charging can ensure BEVs are charged when renewable energy generation is more abundant in the grid, helping to further reduce their carbon emissions.
Balancing grid demand	Most BEV users plug in their vehicles at the end of the working day, corresponding with peak demand on the grid. Using smart charging, the BEV can still be plugged in when it is returned to the depot, or the employee's home, but the charge point then manages and adjusts the vehicle's charging to a time when electricity demand is lower.

Load management

The simplest form of load management is static load management, or static load balancing. Using smart charging, charge point operators can distribute power to different charge points on the network to ensure that the total incoming supply capacity cannot be exceeded. Charge points will analyse the vehicle charging demand and available capacity of the supply, and distribute the power based on the maximum capacity of the connection.

For example, if a site has a maximum 20 kW of available capacity, and four cars are plugged in to four 7.4 kW chargers, the static load management will distribute the available 20 kW over those four chargers, each receiving 5 kW rather than the 7.4 kW. If all four chargers were to charge at 7.4 kW, the system would be overloaded. If two of the cars then leave, the remaining two will continue to charge now at 7.4 kW, as 2x7.4=14.8 kW is below the 20 kW available. The 'static' nature of this type of load balancing means that the system only knows that its defined power is available (in this case 20 kW). It is possible to set different power levels at different times, but the system cannot respond automatically to changes in availability over the site.

Dynamic load balancing is more complex and can handle dynamic changes in power availability over the site. This can be beneficial for sites which have other electrical requirements on the same circuit as the charge points. The load balancing system will take into account other electrical circuits when vehicles are charging. For example, if vehicles are plugged in during the day time and the building supply is powering the lighting at the same time, the vehicles will receive a reduced rate of charge. As the lighting system is turned off, more power will be available for the electric vehicles to use, and the charge rate will increase.

Load management can prevent the need for potentially expensive increases in connection capacity and prevent peak loads that result in extra charges. The operation of a fleet would not be restricted as a result of load balancing through slower charging, as the vehicles can retire to charging points when shifts have ended and charge overnight during downtime hours.

10.1.4. Charge point management and back office

Smart charge points are managed through a 'back office' system. The charge points are connected to a cloud-based platform through SIM cards within the units, through a Wi-Fi connection, or through an ethernet cable. This system enables the operator to manage the charge points remotely to schedule charging, observe live charging sessions, obtain management information data, set tariffs, see and fix live faults, and a variety of other features.

A comprehensive system, including a fleet platform, should be considered when installing EVCI. Similar to the hardware, there are a variety of platforms and fleet portals to choose from. A number of hardware OEMs have their own back office system, but following the Open Charge Point Protocol (OCPP) charge points can also be managed by a different system to the hardware manufacturer. This means an organisation can tailor the back office and fleet management system to suit their requirements, some examples of which are listed in Table 10-2.

Table 10-2: Charge point fleet platform back office features

Feature	Breakdown
Integration	• Integration with telematics systems already in use. • Integration with employee's energy provider and home charge points to calculate true charging cost. • Business platform integration. • Energy trading to buy electricity at flexible tariffs. • Operable with multiple hardware OEMs.
Reimbursement	• Automatic reimbursement for home charging through charge point tracking. • Reimburse employees directly through back office platform. • Home and public charge costs directly reimbursed through energy provider invoicing.

Feature	Breakdown
Reporting	• View CO_2e savings to help monitor net zero targets. • View all costs of charging in one place, including split bills from home, work, and public charging. • View charging sessions (kWh, session times). • Download management information reports. • Track business and personal mileage.
Scheduling and accessibility	• Set charging times for vehicles to make use of off-peak electricity tariffs and manage site electrical supply. • Multi-user access. Ability to make EVCI available to different fleets (grey fleet, company cars, main fleet).

10.1.5. Installation considerations

One of the first things to consider when planning a charge point installation is the electrical supply to the site, and whether this will need increasing, in order to provide charging capacity for BEVs and any other potential electrification projects (such as heating). Electrical supplies can be installed or upgraded through either a distribution network operator (DNO) or through an independent distribution network operator (IDNO)[4]. The recent Access SCR rules changed the payment requirements for capacity upgrades, so that customers requiring increased capacity no longer have to pay the grid upgrade costs (though do still pay 'extension assets' - the works to provide the site with a new/upgraded connection). This has reduced the cost for capacity upgrades significantly, making EVCI installations more feasible.

Installing solar PV and stationary batteries can also be a means to increasing the site's capacity for BEV charging, whilst reducing its emissions from electricity generation. This can also be a quicker and more cost-effective solution if a grid upgrade is not feasible in the area, or if there is a long waiting list.

If charge points are to be installed in batches, rather than all at once, then it is important to future proof the installation. EVCI needs to be planned, so that all groundworks can be completed up to the furthest charge point location, installing retention sockets[5] where charge points are not yet needed but will be. As further charge points are installed, the installer pulls cables through the ducting to the required location. This ensures groundworks are only needed once, saving on costs, materials, and potential disruption.

10.1.6. Charge timing and tariff

During the working week, demand on the UK grid is highest in the early morning and late afternoon. During this time the GHG intensity of the grid may also be high, due to the use of fossil-fuel based generation (generally gas) used to meet the high demand (Figure 10-1). Ideally, vehicles

[4] DNOs operate within certain regions of the UK whereas IDNOs operate local electricity distribution networks anywhere in the UK. They both share the same obligations and performance standards. Generally IDNOs will distribute electricity from either DNOs or the transmission network to smaller areas.

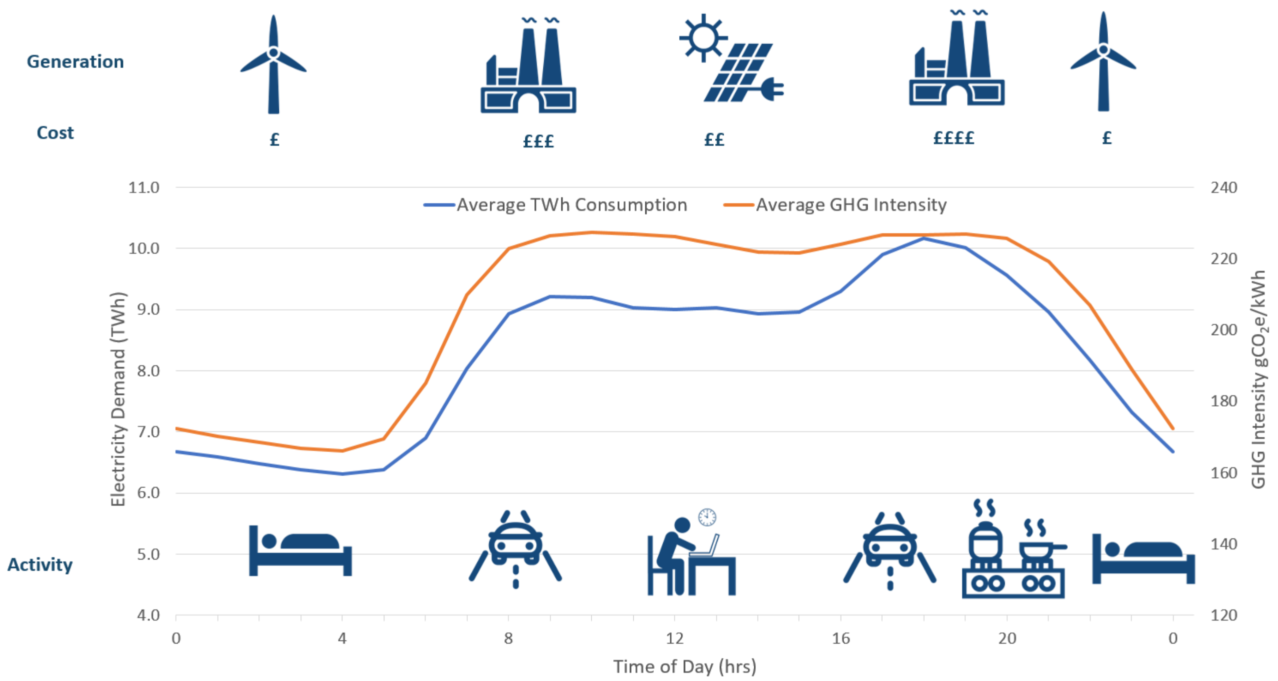
[5] Retention sockets are metal plugs which form the foundation of the charge point and are also used for traffic lights, lamp posts, and other street furniture.

should be charged overnight, to avoid increasing peaks in demand and avoid using high-GHG electricity.

However, avoiding these peaks entirely leaves a narrow window of six or seven hours in which to charge vehicles, which may require the use of higher power charge points, rather than lower-cost 7.4 kW AC points. The reduction in GHG emissions from avoiding the high intensity periods is typically 10%-15% over the entire charging period, and this will diminish in importance as the grid decarbonises. The higher cost of electricity during peak periods may have a bigger impact and prove to be a greater incentive to charge vehicles at off-peak, low cost and low GHG periods.

During the summer months, on-site or private wire PV generation can be used during the late afternoon and early evening to charge vehicles that have returned, at a time when the site load is falling as people go home. Using the PV to displace grid import at this time will have a significant cost saving and will maximise the charging window, however selling the power to the grid might be better in terms of revenue income and reduction in overall grid GHG emissions as it will prevent fossil fuel generation being needed.

Figure 10-1: UK grid relationship between consumption, cost, generation and GHGs (data: Mon-Fri, 2021)



(Based on graphic by Char.gy)

When implementing a BEV fleet, it is important to negotiate low off-peak tariffs for electricity at all sites where the BEVs are based. This may mean a new tariff structure, as the highest demand may have shifted from daytime to off-peak use.

It is anticipated that innovative tariffs will become available in the commercial sector as the BEV charging market grows. The National Grid Electricity System Operator (ESO), working with partners, has already developed and published an open system called the "Carbon Intensity API" which makes available the predicted carbon intensity of the grid up to two days in advance, in half hour periods. This forecast could be used to adjust the price paid for electricity by lowering the cost (£/kWh) when renewable generation is high (carbon intensity low) or curtailment of wind generation may occur, and increasing the cost when fossil fuel generation is high (carbon intensity high). This has the aim of modifying customer behaviour as well as being used to directly manage the activity of “smart” appliances, including BEV charging systems. The objective would be to eliminate curtailment of wind generation and match demand to supply throughout the day.

10.1.7. Overcoming capacity issues

An issue at some depots is the lack of local grid capacity, and the upgrade of the local grid can be difficult and expensive. On sites with inadequate capacity, there may be another local substation with spare capacity that can be accessed. In the first instance, the local DNO should be contacted.

Alternatives to DNO capacity upgrades include the use of on-site renewable generation coupled with battery storage, or just the use of battery storage to absorb any spare capacity during the day and then feed it back into the vehicles overnight, combining stored energy with site capacity.

IDNOs may also offer innovative and affordable grid reinforcement or upgrade options, including integration of PV canopies and battery storage with the grid upgrade and charging systems.

10.2 Charging capacity at PBC sites

10.2.1. Assessing site BEV charging capacity

In this section, we will determine what capacity is available at selected PBC sites for BEV charging. PBC provided half-hourly (HH) electrical energy consumption for two sites, with maximum import capacity (MIC) awaited from the DNO. The next section contains charts based on the HH electrical energy consumption, with each chart showing the following consumption data for the period given, displayed as a single week:

- the maximum energy used on-site in any half-hour period (green),
- the average daily consumption (black line),
- the baseload or minimum daily consumption in any half hour period (red),
- the ‘static’ charging capacity (dark blue),
- the ‘dynamic’ charging capacity (pale blue).

The ‘static’ charge capacity is the difference between the maximum recorded site use and the site MIC adjusted by the site power factor. The ‘dynamic’ capacity is a measure of the energy available between the recorded peaks of maximum usage; most of this capacity is generally available overnight when other functions may be switched off.

The ‘static’ capacity is available at all times, and can be used to charge vehicles without any sophisticated demand management controls. Provided the total power (kW) demand of the installed charging points cannot exceed the static capacity, the system is self-limiting. For example, if the static capacity available is 25 kW, then three 7.4 kW (22.2 kW total) charge points could be installed and used at the same time without exceeding site capacity, and with no further management needed. The static capacity is always available, so the only constraint on its use is a desire to avoid higher daytime tariffs and periods of peak demand on the UK grid.

The ‘dynamic’ capacity represents unused capacity that falls between the peaks of daily usage by the rest of the site. At its simplest, this capacity could be accessed by using charge points on timers, but that would require careful management to ensure a significant margin of error between the demand from the charging points and other site loads. More sophisticated demand management systems can ensure best use is made of the dynamic capacity without going over the site's MIC.

A static control system can be used with the static capacity, to regulate the current to the charge points, such that it never exceeds the site's capacity. The dynamic capacity can be added to this based on time of use. In our example of 25 kW static capacity, we could have six 7.4 kW charge points, but if all six are in use at the same time, the power to each would be limited to 3.7 kW. As vehicles become fully charged, they stop charging, and their share of the site's 25 kW capacity is reallocated over the remaining vehicles. This is an efficient strategy and should ensure that all the vehicles are fully charged with the lowest MIC. It can be implemented cost effectively by using one primary controller which can support 10 to 20 drone charge points (the exact number depends on the manufacturer of the charge point system).

A more complex dynamic load balancing system continuously monitors the total site load and adjusts the power made available to the vehicle charge points accordingly. A load balancing system allows all the capacity above the site's baseload to be utilised. This type of control system must be very responsive and work 100% of the time, as a failure to adjust charging capacity in response to an increase in demand elsewhere on the site, could result in a site blackout or penalty charges for exceeding the site's MIC. A demand responsive EVCI may also require a significant upgrade to the building's energy management system and much tighter management of the electrical systems in use within the building.

At each site we have considered the capacity available all year around, but capacity will vary from summer to winter. In the summer, capacity can be constrained by daytime air conditioning demand but may be supplemented by an extended period of PV generation (if installed).

In the winter, heating demand during the day, and potentially night-time storage heaters, will impact on charging capacity, as will extra demand from lighting due to the shorter day length. If installed, PV generation at this time of the year will be limited by the shorter day length and reduced solar intensity.

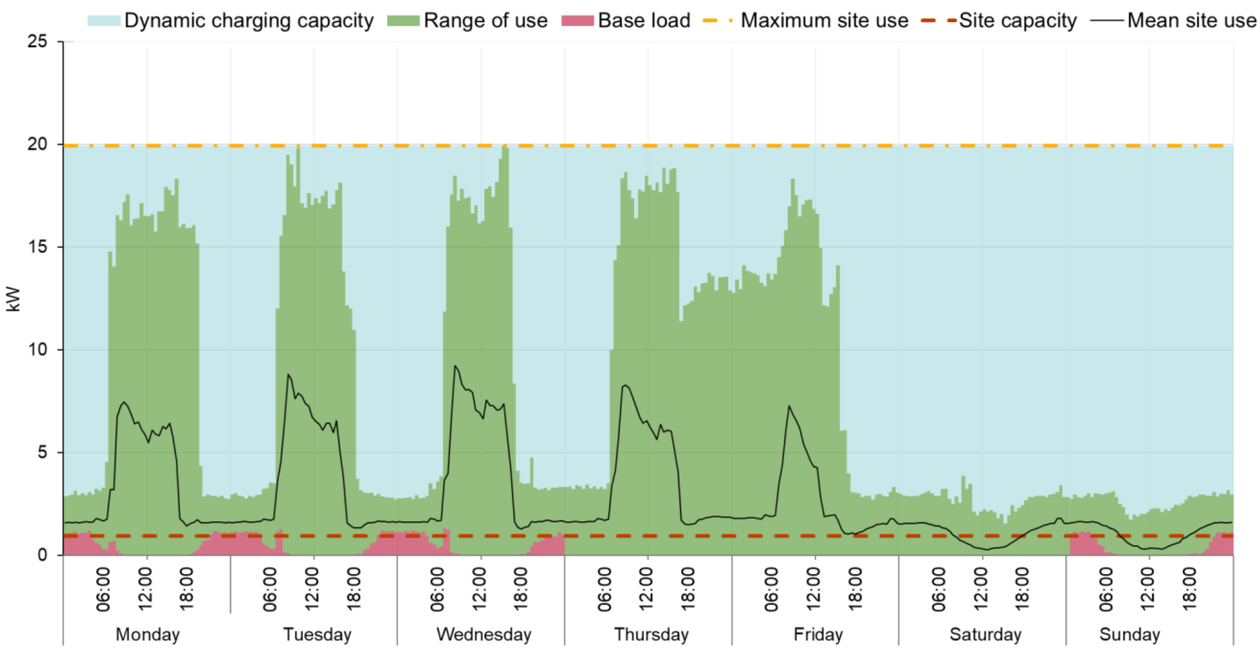
10.2.2. PBC site energy capacity

Fleet Street Cleansing

Table 10-3: Fleet Street Cleansing site information

Site	MIC (kVA)	Assumed power factor	Available capacity (kW)	Notes
Fleet Street Cleansing	1	0.95	0.95	HH data 06/04/2023 to 03/04/2024

Figure 10-2: Fleet Street Cleansing energy consumption profile – 06/04/2023 to 03/04/2024



At Fleet Street Cleansing, usage peaked at 20 kW, though the site's reported maximum available capacity is 0.95 kW. The reported MIC of 1 kVA may be an error, but if this is correct then there is no static capacity available at this site.

There is at least 2.9 MWh of dynamic capacity available per week, though more capacity may be available in the green area, which represents one-off high usage events. There is a clear daytime-nighttime usage pattern, where usage drops between the hours of 6 pm and 6 am, and at weekends. The overnight usage between Thursday and Friday is likely due to a one-off event, as the average shows a similar drop to the other nights of the week.

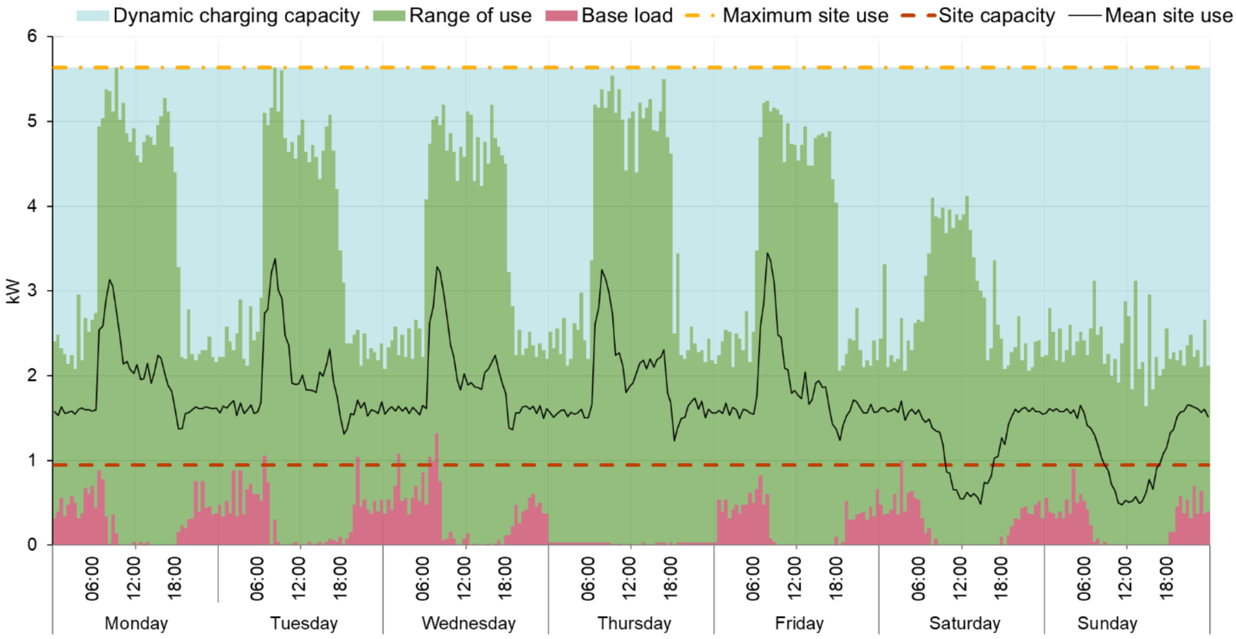
During the off-peak period only (6 pm to 6 am, Monday to Friday) the average dynamic capacity available is 240 kWh. The average dynamic headroom is 20 kW, which is enough for two 7.4 kW charge points to operate concurrently at their full capacity. Dynamic load balancing would be needed to make use of the dynamic capacity, and this could handle more charge points through power sharing. The low usage at this site means there is little dynamic capacity available.

Fleet Street Offices

Table 10-4: Fleet Street Offices site information

Site	MIC (kVA)	Assumed power factor	Available capacity (kW)	Notes
Fleet Street Offices	1	0.95	0.95	HH data 06/04/2023 to 03/04/2024

Figure 10-3: Fleet Street Offices energy consumption profile – 06/04/2023 to 03/04/2024



At Fleet Street Offices, usage peaked at 6 kW, though the site's reported maximum available capacity is 0.95 kW. The reported MIC of 1 kVA may be an error, but if this is correct then there is no static capacity available at this site.

There is at least 660 kWh of dynamic capacity available per week, though more capacity may be available in the green area, which represents one-off high usage events. There is a clear daytime-nighttime usage pattern, where usage drops between the hours of 6 pm and 6 am, and at weekends. The Saturday daytime usage is likely due to a one-off event, as the average shows a similar drop to Sunday.

During the off-peak period only (6 pm to 6 am, Monday to Friday) the average dynamic capacity available is 34 kWh. The average dynamic headroom is 3 kW, which is not enough for a 7.4 kW charger to operate a full capacity. Dynamic load balancing would be needed to make use of the dynamic capacity. The low usage at this site means there is little dynamic capacity available.

10.2.3. Summary of site capacity

Table 10-5: Summary of site capacity for two PBC sites

Site	Static				Dynamic			
	Weekly capacity (kWh)	Off-peak capacity (kWh)	Head-room (kW)	7.4 kW charge points	Weekly capacity (kWh)	Off-peak capacity (kWh)	Head-room (kW)	7.4 kW charge points
Fleet Street Cleansing	/	/	/	/	2,900	240	20	2
Fleet Street Offices	/	/	/	/	660	34	3	0
Total	**/**	**/**	**/**	**/**	**3,560**	**274**	**23**	**2**

The two PBC sites which form the Fleet Street Depot have a very low energy usage, and a clear daytime-nighttime pattern. The low usage means that there is little dynamic capacity available to charge overnight. Unfortunately, with both sites having a reported MIC of 1 kVA, there is no static capacity available for electric vehicle charging. We believe this may be incorrect, as the usage would indicate that both sites have a higher MIC than 1 kVA.

It is likely that the fleet depot site will need a capacity upgrade in order to provide charging for BEVs. PBC will need to liaise with their DNO to understand what capacity is available, and how much infrastructure (sub-stations, cabling) would be needed to obtain the required MIC, and what timeframe for installation could be expected. Infrastructure assets that are external to PBC's sites are now paid for by the DNO (through network charges), though any internal assets will need to be paid for by PBC so there may be an additional cost for these upgrades.

The following section estimates how much capacity PBC would need at its depot, for the whole fleet to transition to BEV. It is not unusual for vehicle depots to have a low electrical capacity, as traditionally this would not have been needed. Unfortunately, it does leave and additional barrier to decarbonising the fleet.

10.3 Meeting the demand for BEV charging

10.3.1. Estimating maximum import capacity

The previous section determined the amount of capacity available, and this section considers the amount of energy required for charging the PBC fleet. Due to the different vehicle efficiencies, a BEV will use around 25-35% of the energy of an ICE vehicle (we use an average 30%, see Section 4.3). Based on this, we can estimate the annual energy requirement of a BEV fleet, based on the current fleet's energy usage. The energy efficiency (mpg) of both BEVs and ICEVs varies through the year, depending on ambient temperature and weather conditions, driving styles, auxiliary uses etc. We have estimated an average daily energy requirement based on a 240-day working year, but there will also be variations in daily mileage. Together this makes determining the accurate MIC needed to charge the vehicles (particularly on the most energy intensive day of the year) much harder to estimate accurately.

Table 10-6: Estimated energy requirement of an all-electric fleet (vehicles on fleet 31 March 2024)

Category	Charge point type	Fleet size	BEV fleet kWh/year	BEV fleet kWh/day	kWh/BEV/day (average)	Charge time (average)*
HCV - RCV	22 kW AC / 50 kW DC	14	455,107	1,820	130	5h30 / 2h30
HCV - Rigid	22 kW AC / 50 kW DC	8	131,608	526	66	3h / 1h20
LCV	7.4 kW AC	26	98,325	532	19	2h30
Car	7.4 kW AC	9	14,731	61	7	1h
Total	**/**	**57**	**699,770**	**2,940**	**/**	**/**

*Charge time does not include additional time due to battery internal resistance (Section 10.1).

Based on the composition and utilisation of the fleet, 35 7.4 kW AC charge points would be needed for the car and van fleets, and 22 22 kW AC charge points would be needed for the HCV fleets (assuming one charge point per vehicle). Additionally, PBC may wish to install some rapid 50 kW DC charge points to provide quick top-up charging or in case of operational need. If the low energy use of the car fleet is maintained, ten dual-socket 7.4 kW could be used instead (meaning each vehicle would receive half, 3.7 kW, if both sockets are in use). Charge points could also be shared between low-usage vehicles, particularly in the car and van fleets, though this would require careful management and may demand staff resource to this purpose.

The total maximum demand from 35 7.4 kW units and 22 22 kW units, if used simultaneously, would be 743 kW – the maximum required MIC. Allowing for a power factor of 0.95, this would require a supply of 780 kVA. The low average daily energy requirement of the vehicles suggests they could all be charged in much less than 12 hours with 7.4 kW and 22 kW units (1-6 hours if charged daily), meaning that most of that capacity (which comes at a cost if a capacity upgrade is needed) will be unused for much of the charging period.

With a total daily energy requirement of 2,940 kWh and 12 hours to charge the vehicles, the minimum import capacity required is theoretically 245 kW, or 257 kVA (2940/12=245 kW).

The minimum capacity value assumes that every day of the year, the vehicles return to base needing the same charge. In reality, the SoC of returning vehicles will vary from day to day and throughout the year. It is possible that on some days, several vehicles return with a low SoC due to extended routes, diversions, heavier loads, greater use of ancillaries and adverse weather conditions. The speed at which they can be recharged is limited by the capacity of the charging infrastructure they are connected to, so even if there is spare site capacity, it cannot be used to top-up a vehicle with a very low SoC.

One way of addressing this problem is to take tracking data from all the ICEVs for a period of several weeks, use it to determine the worst case fleet SoC, and use this to estimate the necessary MIC for that worst case scenario, ensuring all vehicles are fully charged at least one hour before they are required (this allows time for the use of pre-conditioning). This process will also identify vehicles that cannot complete the working day with the proposed battery capacity and will need a top-up charge at some time during the day. We have used PBC's available telemetry to undertake this analysis in the following section. Its weakness is that it uses historic data to predict the future.

In the absence of tracking data, we can apply a statistical model and use the same process to determine when the fleet is fully charged, but this process does require some data on which to base the degree of daily variation in the fleet's SoC. Modelling demonstrates that even small variations in the SoC can result in a significant increase in the MIC required - by at least 25%. We can also use this factor to estimate MIC, providing the result is not regarded as anything other than an estimate.

10.3.2. Maximum import capacity strategies

In Table 10-7 we have estimated the capacity required using three charging strategies. The first is the capacity required for all the required charge points to operate simultaneously at full power – this is the simplest option, and many vehicles will be fully charged in less than two or three hours. The issue with this method is when it is used to estimate the increase in capacity needed, it can lead to overestimation of the capacity needed, which would be unused much of the time.

The second is based on the calculated average energy requirement, with a percentage uplift, usually around 25%. This may not be sufficient to cover the seasonal and daily variation in the fleet's energy demands and should be subject to continual review, as more of the fleet is transitioned to BEVs. Experience to date suggests that the greater the variation in energy demand across a fleet, the greater the uplift needed, so a fleet that combines both heavy vehicles and light vans may require an uplift of at least 50%. Although the PBC fleet is quite compact, the telematics available shows a wide variation in daily use, so a 50% uplift may be more appropriate.

The third and final strategy assumes the average capacity will be sufficient throughout the year and that even if vehicles are not fully charged on departure the following day, they will have sufficient capacity to complete their duties. This might be regarded as a high risk, low cost strategy. The MICs estimated are for the whole fleet, and assume that all vehicles are based at the Fleet Street Depot.

Table 10-7: Maximum import capacity identified by the methodologies described

Strategy	Description	Power (kW)	MIC (kVA)*	Notes
1	Simple maximum import capacity	743	780	All chargers work at full power at the same time.
2	Minimum requirement with 50% uplift	368	386	Power is shared over chargers.
3	Minimum requirement	245	257	Power is shared but no headroom for SoC variation.

*Assumes a 0.95 power factor.

To some extent, the strategy chosen may depend on the available capacity in the distribution network:

- If the local grid has significant capacity and there are no other users on the sub-station, then the MIC can be increased incrementally as demand requires, with no risk of another site taking the capacity for their own use.
- If the local grid is severely constrained, there may be no available capacity and then the focus of attention is on the most cost-effective way of providing that capacity, which may not be a grid upgrade and could be installation of PV and battery storage.

For PBC, an all-BEV fleet would have a comparatively low energy demand on an average basis. However, variations in daily use can be high, and daily energy requirement can be high (see following section). Table 10-7 shows the extent to which capacity can be over-estimated if assuming that all chargers will need to run at full power at the same time, which is largely unnecessary due to the downtime available for charging. Our analysis does not take into account potential future changes at the sites captured, or changes to fleet usage. This is why addressing fleet electrification with an all-encompassing electrification team is so important.

10.3.3. Using telemetry and energy peaks

PBC had telemetry data for 13 LCVs, 6 sweepers, and 13 RCVs. We have analysed the daily energy use for each vehicle with data in Section 8.4 (LCVs), Section 9.3 (sweepers) and Section 9.4 (RCVs). Telemetry allows to analyse the difference between fleet average values and actual daily energy usage. With this we can determine the amount of uplift needed to estimate the MIC needed for the Depot, and verify that the hardware recommended meets the vehicles' requirements. The drawback is that we are using historical data to determine future energy usage, and this does not account for potential operational changes.

LCVs

For the LCVs, the peak in energy usage was at 108 kWh for one vehicle on one day, and with a 7.4 kW charge point this would take 15h (approximately) to recharge (assuming the LCV has a sufficiently large battery). LCVs with 110 kWh batteries are available, although on this occasion this vehicle may need a day-time top up – using one of the HCVs' 50 kW DC charge points, a 30 minute charge would add 25 kWh to the vehicle's battery. If PBC acquire 110 kWh LCVs and these are regularly used up to their battery capacity, 22 kW AC charge points may be preferable for overnight charging, (if the vehicle can accept that charge, some are limited to 11 kW AC). However, as these will not be needed regularly, 7.4 kW charge points would seem generally suitable, as long as the higher energy days can be planned for.

The LCV telemetry data shows that in 2023/24 there were 26 vehicle days where the vehicles' energy usage was above 70 kWh, where daytime top-up charging may be needed. These days were quite spread out over the year, and there were no instances of a vehicle having two higher usage days in a row. During the winter months (December to February), average daily usage was 28 kWh per vehicle (almost 50% higher than the average 19 kWh). During the summer (June to August), average daily usage was 26 kWh (40% higher than average). This shows there was not a wide variation in energy use between summer and winter 2023/24, but that there was a wide variation in the fleet usage, with the vehicles with telemetry using significantly more energy than the whole fleet average.

Sweepers

For the sweepers, the peak in energy usage was at 752 kWh for one vehicle on one day, which even with one full daytime recharge would be significantly beyond a 300 kWh battery capacity. The second highest was 673 kWh, and the third highest 562 kWh. There were in total 65 days above 300 kWh. A 50 kW DC charger would take around 6 hours to charge a 300 kWh battery, and a 22 kW AC unit would take around 14 hours. Whilst we would not recommend PBC install charge points higher than 50 kW, due to the high demand on the site capacity, there will need to be some operational changes to the sweeping schedule in order to enable BEV sweepers on fleet, when these are available and cost-effective for PBC to implement.

For the sweepers with telemetry, the average daily energy usage was 124 kWh, almost 90% higher than the 66 kWh average for the fleet as whole (including HCVs without telemetry). During the winter months (December to February), average daily usage was 127 kWh per vehicle (over 90%

higher than the average). During the summer (June to August), average daily usage was 118 kWh (80% higher than average). This shows there was not a wide variation in energy use between summer and winter 2023/24, but that there was a wide variation in the fleet usage, with the vehicles with telemetry using significantly more energy than the whole fleet average.

The sweepers are not easy vehicles to decarbonise, they have a potentially very high energy usage, and the fleet varies widely in terms of daily use. The fact that the fleet average is 66 kWh per working day however, would indicate that there is capacity to make changes to the sweeping schedule to spread energy use more evenly over the working days. This may necessitate changes to work patterns, and may require more staff resource, but would enable a smoother transition to BEVs. At present, BE sweeper technology is limited, so we would recommend revisiting vehicle availability when the fleet is up for replacement in 2026.

RCVs

For the RCVs, the peak in energy usage was at 609 kWh for one vehicle on one day, which even with one full daytime recharge would be beyond a 300 kWh battery capacity. The second highest was 572 kWh, and the third highest 518 kWh. There were in total 102 days above 300 kWh, and 3,044 below 300 kWh. A 50 kW DC charger would take around 6 hours to charge a 300 kWh battery, and a 22 kW AC unit would take around 14 hours. We would not recommend PBC install charge points higher than 50 kW, due to the high demand on the site capacity. Overall this fleet is suitable for replacing with currently available BEV, and for most vehicles charging at 22 kW would likely be sufficient, although PBC may wish to install some 50 kW for the higher usage vehicles, as this provides an additional layer of security, and they can be used for top-up charging for the rest of the fleet.

For the RCVs with telemetry, the average daily energy use was 141 kWh, 8% higher than the whole fleet average of 130 kWh. During the winter months (December to February), average daily usage was 133 kWh per vehicle (2% higher than the average). During the summer (June to August), average daily usage was 140 kWh (15% higher than average). This shows there was not a wide variation in energy use between summer and winter 2023/24, and the RCV fleet did not have such a wide variation in daily usage, meaning average values are more representative for the whole fleet.

The telemetry data shows that the LCV fleet would need a 50% uplift on average minimum MIC, the sweeper fleet would need around a 100% uplift, and the RCV fleet would need around a 20% uplift. Assuming a 25% uplift for the car fleet, altogether, the recommended MIC for the Fleet Street Depot is therefore around 350 kW, or 370 kVA (with a 0.95 power factor). PBC should implement BEV-capable telemetry in switching to BEVs, ensuring energy usage is continually monitored so that this uplift factor can be adjusted to fit the PBC vehicle operation.

Appendix A: Glossary of terms

Abbreviation	Meaning
AC/DC	Alternating current/Direct current
AFR	Advisory fuel rates
BE/BEV	Battery electric/battery electric vehicle
CAZ	Clean Air Zone (England and Wales, excluding London)
CO_2/CO_2e	Carbon dioxide/Carbon dioxide equivalent (GHG)
DBEIS/BEIS	Department for Business, Energy and Industrial Strategy
DESNZ	Department for Energy Security and Net Zero
DNO/IDNO	Distribution Network Operator/Independent DNO
Ebike	Bicycle with a battery powered motor
EV	Electric vehicle (can be BEV, FCEV)
EVCI	Electric vehicle charging infrastructure
FCEV	Fuel cell electric vehicle (hydrogen powered)
GHG	Greenhouse gas - in transport usually CO_2, CH_4 and N_2O
GVW	Gross vehicle weight – Replaced by MAM
GWP	Global warming potential
HH	Half-hourly (electricity data)
ICE/ICEV	Internal combustion engine/vehicle – petrol/diesel/gas
LCV	Light commercial vehicle – van – up to 3.5t MAM
MAM	Maximum authorised mass – replaces GVW
MIC	Maximum import capacity
Mpa	Miles per annum
MPV	Multi-purpose vehicle (people carrier)
NAEI	National Atmospheric Emissions Inventory – Transport Factors
NCAP	New Car Assessment Programme - Safety
OEM	Original equipment manufacturer, e.g. Ford, Nissan, Toyota etc.
OZEV	Office of Zero Emission Vehicles
PHEV	Plug-in hybrid electric vehicle
PM	Particulate matter
PSV	Public service vehicle (bus)
SoC	State of charge
SUV	Sports utility vehicle
TTW/WTT/WTW	Tank to wheel/Well to tank/Well to wheel
ULEV	Ultra-low emission vehicle
ULEZ	Ultra-low emission zone (London only)
VRM	Vehicle registration mark
WLC	Whole life cost
WLTP	Worldwide harmonised light vehicle test procedure
ZE/ZEV/ZEZ	Zero emission/Zero emission vehicle/Zero emission zone

Appendix B: UK grid 2014 to 2030

There are several organisations attempting to predict future carbon intensity of the grid, and these are often updated during the year to reflect changes in policy or grid performance.

Table B-1 shows:

- The BEIS GHG Scope 2 Factor for the year, which is about two years behind real-time emissions because of the verification process. This is used for GHG reporting.
- The real time performance of the grid, in year (or year to date) as calculated from the Elexon data set.
- The Committee on Climate Change (CCC) and BEIS projections (Updated October 2023).
- The average of the CCC and BEIS data sets.
- The HM Treasury Green Book – Central Non-Traded Cost of Carbon Emissions (BEIS 2021).

Table B-1: UK grid future carbon intensity – BEIS Factors, Actual (Elexon), CCC and BEIS Predictions

Year	BEIS GHG Scope 2 Factor	Year on Year Change	Actual in year from Elexon Portal	CCC Balanced Pathway 6th Budget	BEIS 2021 (Table 1)"	CCC - BEIS Average	Central Carbon Value (BEIS 2021)
2014	494.26		415.7				
2015	462.19	-6%	364.2				
2016	412.04	-11%	277.1	269.0	287.6	278	
2017	351.56	-15%	247.1	240.0	257.0	248	
2018	283.07	-19%	227.8	219.0	238.8	229	
2019	255.60	-10%	204.3	193.0	212.9	203	
2020	233.14	-9%	184.94	153.0	159.4	156	£241
2021	212.33	-9%	203.30	151.0	148.7	150	£245
2022	**193.38**	**-9%**	**198.42**	**148.4**	**138.9**	**144**	**£248**
2023	*176.12*			134.5	133.3	134	£252
2024	*160.40*			135.4	145.4	140	£256
2025	*146.09*			125.2	123.0	124	£260
2026	*133.05*			93.3	90.7	92	£264
2027	*121.17*			74.8	75.0	75	£268
2028	*110.36*			64.6	69.4	67	£272
2029	*100.51*			58.1	65.0	62	£276
2030	*91.54*			46.1	51.6	49	£280
2031	*83.37*			37.1	40.8	39	£285
2032	*75.93*			26.5	35.3	31	£289
This data is available from CCC and BEIS until 2050							

When calculating the future emissions of a BEV fleet, it is important to use these predictions, to ensure the potential GHG reduction from the switch to electric power, is fully assessed.

These figures do not take account of the most recent British Energy Security Strategy (April 2022) which envisages a significantly faster growth in off-shore wind, raising the target for 2030 from 40 GW to 50 GW, which may result in even lower average grid emissions by 2030.

Appendix C: Whole life cost in practice

A whole life cost (WLC) model calculates all of the predicted costs of owning and operating a vehicle over its operational life, including the funding method (outright purchase or lease), servicing (often included in a lease), vehicle excise duty (also usually included in a lease), National Insurance Contributions (company cars and salary sacrifice schemes) and the fuel or energy cost. Fixed costs such as fleet management overheads, telemetry and fleet insurance should also be included, although they do not vary based on fuel or energy type.

Calculating the WLC is straightforward, but it becomes complicated when you try to include the treatment of interest on capital and taxes. These vary and are outside the scope of this report; you should consult with your finance team about how to handle the capital deployed and whether there is a preference for purchase or lease. Similarly, VAT is handled differently in the private and public sectors and even between similar public sector bodies – our costings always exclude VAT.

The following factors need to be considered in a WLC model. The (L) indicates when a factor is usually included in a lease agreement and does not have to be considered separately.

Purchase price (L): Most large organisations will be able to obtain a discount, especially if committing to the purchase of several vehicles, or purchasing from one manufacturer for a period.

OZEV grant (L): OZEV offers grants to encourage the take-up of ZEVs. This is accessed by the manufacturer or dealer and will have been deducted from the final price at the point of sale.

Residual value (L): This represents the value of the vehicle at the end of its operational life. The difference between the initial purchase cost and the residual value is known as depreciation. It will vary significantly depending on vehicle type, age, and final condition. Some vehicle types are fully amortised over their operational life and any residual value is treated as a disposal surplus.

With BEVs, the batteries will have a value at the end of the vehicle's life and can be refurbished and reused in energy storage arrays; you might want to consider valuing the batteries separately.

Servicing, maintenance, repair (SMR) and tyre costs (L): Several organisations can provide a forecast of SMR and tyre costs. However, these are usually limited to four or five-year budgets. If you are planning to keep a vehicle for eight or ten years, you will need to base this cost on your experience, or past fleet records.

Vehicle excise duty (VED) (L): This is the annual road use charge; for new cars it is linked to OEM published carbon emissions in the first year but is then a flat rate.

Fleet Management Charge: Many fleet operations include an internal management fee to cover day-to-day management of the vehicle including organising servicing, breakdown cover, fuel cards, driver training and other support services. For some this is a flat rate, but others vary the rate depending on the category of vehicle. This may also include the cost of any additional telemetry installed on the vehicle and the data connection charges.

Insurance: Corporate insurance rarely takes account of the risk of individual vehicles or drivers; instead, it applies a fixed charge for the whole fleet, and will usually reflect previous claims history. How this is apportioned varies but there is merit in linking the charge to the past claims record of the department using the vehicle, so good driving is rewarded and managers are incentivised to act on bad driving.

CAZ/LEZ/ULEZ charges: While ICE diesel vehicles that meet the Euro 6/VI standard currently get charge-free access to clean air zones, this may not be true over their entire operational life. Several towns and cities are considering zero emission zones (ZEZ) and the London ultra-low emission zone (ULEZ) only guarantees Euro 6/VI diesels charge-free access to the zone until 2025.

Table C-1: Whole life cost model – the factors to consider, example values

Factor	Units	Calculation	Example	Notes/observations
Make			Electric	
Model			LCV	
Operational period	years	Y	5	
Annual mileage	miles	AM	10,000	This needs to be realistic.
On-The-Road price	£	A	£25,000	All these costs are included in the lease cost giving a fixed lifetime cost. This is based on the expected condition of the vehicle at the end of the lease and the annual mileage.
ZEV grant if not in OTR price	£	B	Included	
Residual value battery	£	C	£2,000	
Residual value vehicle	£	D	£3,000	
Capital cost or lease cost	£	CC=A-B-C-D	£20,000	
SMR and tyres	£/year	E	£150	Usually included in lease cost
Vehicle excise duty	£/year	F	£0	Usually included in lease cost
Fleet management charge	£/year	H	£550	Same for ICE and BEV
Insurance cost	£/year	I	£500	May be more for BEV
Class 1A national insurance	£/year	J	£0	Only if private use
CAZ/LEZ/ULEZ charges	£/year	K	£0	Any zones in operational area?
Energy/fuel cost	£/year	L	£300	Source real-world figures
Overhead cost	£/year	OC = SUM (E to L)	£1,750	Total annual overhead costs
Whole life cost	£	WLC=CC+(OC×Y)	£28,500	Capital plus overheads (WLC)
Total mileage over period	Miles	TM=Y*AM	50,000	
Cost per mile	£/mile	WLC/TM	£0.57	Use this for evaluation

The GHG emissions of the ICE fleet are straightforward to determine, as they are based on the carbon emitted by burning a litre of fuel and that will stay fairly constant over the lifetime of the vehicle. BEVs are more complicated, as the electricity supply will decarbonise over the next 10 years and that means the GHG emissions of the vehicles will decrease year-on-year.

Wherever possible, use real world figures in the WLC model from your own fleet, or from your own diesel, petrol and electricity supply contracts. ICE vehicles used in urban operations often have significantly higher fuel consumption that the OEM mpg data would suggest and equally, BEV vehicles will be significantly more efficient in urban operation, as their energy efficiency is not impacted by slow stop-go operation but is affected by high speed operation – for example sustained motorway driving.

Table C-2: Costs and emission factors included in the WLC models presented in this report

Item description	Value	Value	Units
Diesel cost (ex VAT) in first year and annual inflation rate	£1.23	+2%	£/litre
Petrol cost (ex VAT) in first year and annual inflation rate	£1.18	+2%	£/litre
Electricity cost (ex VAT) in first year and annual inflation rate	£0.20	+1%	£/kWh
Average GHG emissions of diesel (BEIS 2022)	3.168		$kgCO_2$/litre
Average GHG emissions of petrol (BEIS 2022)	2.775		$kgCO_2$/litre
Average emissions of electricity (CCC/BEIS predictions)	See Appendix B		gCO_2/kWh
Average GHG Shadow Price: HM Treasury Central Carbon Value	See Appendix B		£/tonne
Fleet insurance and fleet management costs	£650	£550	£/year

In 2023/24, we are seeing considerable disruption in energy prices and inflation rate, and it is difficult to predict for how long the higher prices for diesel, petrol, and electricity will be sustained. As the BEV fleet grows, it is expected that diesel and petrol prices will increase, as garages try to recover their fixed costs from reduced fuel sales. We also expect that considering the longevity of the transition project, and certainly by 2030, electricity prices will have returned to pre-2022 levels or lower.

Energy Saving Trust
223-231 Pentonville Rd
London
N1 9NG
Phone: 020 7222 0101