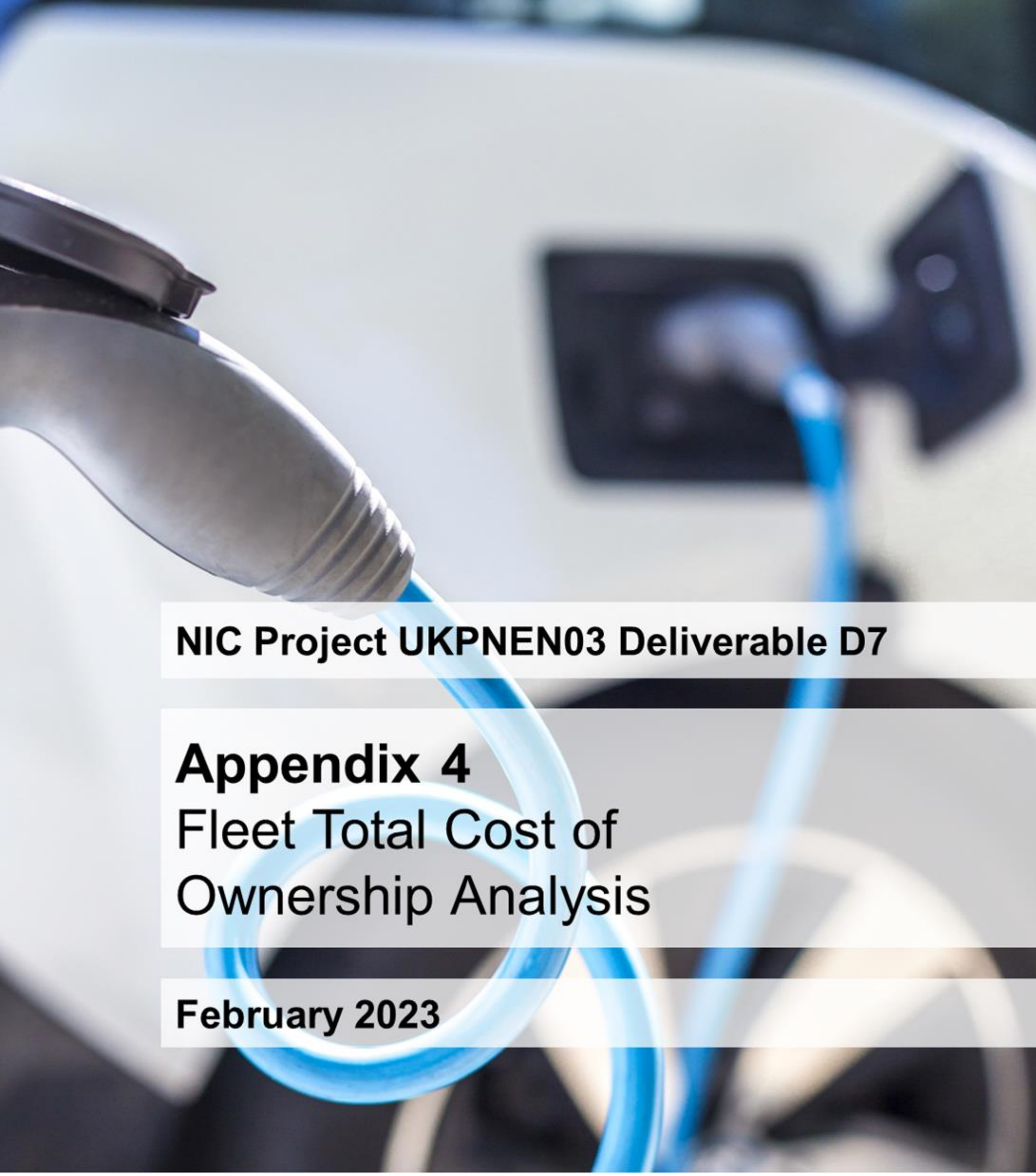


NIC Project UKPNEN03 Deliverable D7

Appendix 4
Fleet Total Cost of Ownership Analysis

February 2023

Optimise Prime

HITACHI Inspire the Next | Uber | Scottish & Southern Electricity Networks | centrica | Royal Mail | UK Power Networks

Contents

1 TCO Model Introduction

1.1 Purpose

The Total Cost of Ownership (TCO) compares the cost of acquiring and operating an internal combustion engine (ICE) vehicle fleet against an electric fleet over its lifetime and is a key component of the business case for transition to electric vehicles (EVs) for most organisations.

The purpose of TCO modelling is to demonstrate a like for like, complete cost comparison, and to explore the influence of historical and future changes in the key variables.

While at the outset of Optimise Prime it was expected that in most scenarios an EV fleet TCO should be at least at parity with an ICE fleet, if not lower, changes to external factors over the course of the project have made this picture more nuanced. The TCO models presented in this section explore the impacts of such changes, including increases of electricity and fuel prices, vehicle costs, as well as changes to government policies. The influence of the methods trialled under Optimise Prime (profiled connections, flexibility provision and smart optimisation) will also be discussed.

1.2 Approach

Optimise Prime approached all TCOs presented here with one generally overarching approach, with some differences resulting from varying characteristics of the three fleet types, as outlined below.

The key components of each TCO model are:

- Total capital expenditure (CAPEX)
- Operating expenditure (OPEX)
- Relevant revenue streams. Includes the resale value of vehicles, as well as additional revenue generated from the provision of flexibility services to the DNO (Table 1).

This section provides an overview of the main TCO components and the sources of the assumptions for each of the project partners. While efforts were made to use real partner data as much as possible for the TCO inputs, in some cases this was not possible because of partner confidentiality or the data was deemed not representative. For example, special negotiated vehicle prices which would lead to lower CAPEX for project partners were replaced by regular market benchmarks to represent a more realistic CAPEX cost that would be achievable by an average-sized fleet.

Table 1 – Overview of TCO components and data sources

Input data	Data sources
CAPEX	
Vehicle acquisition (if vehicles purchased)	Manufacturer list price
Charge Point (CP) acquisition	Manufacturer list price
Distribution network connection	UK Power Networks' cost estimation
LCT acquisition (if relevant)	Manufacturer list price
OPEX	
Vehicle lease cost (if not purchased)	Assumed to be 2% of list price per month
Electricity	Published flat and Time-of-Use tariffs
Public charging	Published membership fees
Maintenance (vehicle)	Published vehicle maintenance cost data
Maintenance (CP)	Published maintenance cost data
Control software	Assumed 10% of CP cost
Insurance	Published average vehicle insurance data

Input data	Data sources
CAPEX	
Tax	Published excise duty rates[1]
Tolls	Transport for London (TfL) Low Emissions Zone, Ultra Low Emissions Zone, Congestion Charge and Zero Emission Zone data
Revenue	
Vehicle resale value (if vehicles purchased)	Published data on vehicle end of life value
Flexibility	UK Power Networks' LV flexibility value data
Third party flexibility management fee	Market benchmark for an aggregation fee
Onsite electricity generation	Calculated using Depot Planning Model

For both ICE and EV fleets there are two possible ownership strategies:

- **Outright purchase –** the vehicle acquisition is a CAPEX cost, with any end-of-life value of the vehicle treated as a revenue stream for resale
- **Leasing –** the vehicle costs are all treated as OPEX costs.

EVs require charging infrastructure, which could be installed at a depot or a driver's home, either through outright acquisition or a leasing method. Additionally, the fleet could also use public charging infrastructure, requiring membership of one or more CPO schemes. CPs require maintenance and could also require a control software package to enable smart charging, adding further costs and potential revenues from flexibility to the TCO assessment.

The outputs of the TCO model include:

- Cumulative TCO over the selected time period for both ICE and EV fleets
- Net Present Value (NPV)
- Internal Rate of Return (IRR) for investment in electrification.

If LCTs such as solar PV are installed, there is also the potential to consume electricity generated onsite rather than from the grid, and to export excess production to the grid at a given rate per kWh exported. These also open possibilities for EV fleets to generate revenue which can result in a positive net benefit on the TCO.

The TCO scenarios explored are as follows:

- **Royal Mail's** TCO considers nine depots in the trials individually because some of the assumptions are location specific (e.g. connection costs, applicability of Congestion Charge, mileage driven). These results are then consolidated to show the TCO across all nine depots. The TCO is calculated over eight years[2] and assumes the outright purchase of vehicles and charging infrastructure. The impact of network connection upgrade costs, changes in vehicle and fuel prices, congestion charges and potential flexibility revenues are discussed. The benefits of solar PV installation are quantified for one of the depots (Islington), which has an existing rooftop installation.
- **Centrica's** TCO is based on a five-year leasing model for the vehicles and the infrastructure. Results are shown for a single vehicle and extrapolated to the whole of the British Gas fleet. This was possible because home-based installations, unlike depots, do not attract location-specific connection costs. However, as British Gas' fleet electrifies fully, it is expected that approximately 60% of drivers will rely on public charging, due to the feasibility of installing a CP at every home. The TCO explores the impact of different mixes of charging scenarios, as well the recent changes in electricity and public charging prices.

[1] The TCO was calculated before the changes to vehicle excise duty announced in the 2022 Autumn Statement

[2] The eight-year TCO timeframe is one of the Royal Mail inputs and was chosen to best show the results of early electrification investment due to the 2030 ban for ICE vehicles.

- In the case of **Uber**, the decision to transition to EV is an individual decision for each of the drivers and the TCO balance may change depending on the individual circumstances of the driver. For example, daily mileages driven, a driver's access to finance, their ability to install a home CP, as well as their vehicle choice can all have unique impacts on their TCO. The assessment of Uber TCO employed a persona approach and explored different scenarios for the most representative driver personas constructed based on behavioural questionnaires and feedback from Uber.

The following sections present TCO results for these three trials. In addition to the financial impact, greenhouse gas emission (carbon dioxide equivalent – CO_2e) savings resulting from the transition are calculated based on operational emissions (excluding other lifecycle emissions resulting from the production and disposal of the vehicles and the infrastructure).

2 Total Cost of Ownership for depot-based fleets – an example from Royal Mail

2.1 Overview of the Royal Mail TCO Model

The Royal Mail TCO aims to illustrate the cost of a fully electrified fleet versus a fully petrol or diesel fleet, using the examples of the nine Royal Mail depots in the trials. Unlike Centrica's TCO, no extrapolations were made to other depots as the cost components related to depot distribution network connection reinforcement are location specific. The model focused on both the investment required for each fleet and the impact each would have on CO_2e emissions.

Royal Mail vehicles are currently being charged exclusively at their depots with no public or home charging. The depots in scope differ in size, based on vehicle numbers, vehicle type, average yearly mileage per vehicle, and existing ASC, allowing the impact of these variables to be assessed.

The aim of the TCO is to reach conclusions applicable to other depot-based fleets, while retaining the important characteristics of the Royal Mail depots. For example, the mix of vehicles has been simplified to two comparable vehicle types only: Peugeot Partner, Peugeot Expert and their electric equivalents.

Each Royal Mail depot is based in Greater London where EVs are exempt from the congestion charge until 2025. From 2025, all vehicles were assumed to be subject to congestion charges, removing this source of cost saving for the EV transition. The model did not explore any potential changes to road taxes currently under policy review. It has been assumed that all vehicles in the model will operate in the congestion charge zone, although in reality this would vary by depot and vehicle route. This assumption emphasises the impact of clean air legislation, which is expected to become more prevalent in the UK (see section 2.4.5).

2.2 Assumptions

Certain assumptions were necessary to be able to compare scenarios of 100% ICEV fleet and 100% EV fleet in the TCO model. The assumptions are based on inputs from the Royal Mail trials, publicly available data or benchmarks.

Table 2 shows the assumptions common across all TCO models presented in this section and Table 3 those that are specific to Royal Mail.

Different price scenarios have been chosen to show the impact of changes in market rates observed since 2021 on the TCO models:

2021 Stable Prices
A scenario where prices for electricity and diesel are relatively low and stable. Prices increase over an eight year view by a stable 2% inflation rate (the level of inflation that the Bank of England sets as a goal).

2022 Stable Prices
A scenario showing how the prices for electricity and diesel increased considerably at the beginning of 2022, but assumes a stable 2% inflation rate thereafter for comparison with 2021

2022 Variable Prices
A scenario where prices for electricity and diesel increase considerably during first three quarters of 2022 before government interventions come into play. The eight year model is then based on electricity prices adjusted to Cornwall Insight predictions and diesel prices adjusted to price variances based on historical data. Other OPEX costs are increased by the current

inflation rate, which is then adjusted across the future years based on Bank of England predictions (where available, then assuming the 2% inflation target for last few years of the model).

Table 2 – TCO key assumptions[3]

Key assumptions	Inputs	Source	Cost type
Fuel cost petrol (£/l) 2021	£1.31	Gov stats 26/09/2022 https://www.gov.uk/government/statistics/weekly-road-fuel-prices	OPEX
Fuel cost diesel (£/l) 2021	£1.35	Gov stats 26/09/2022 https://www.gov.uk/government/statistics/weekly-road-fuel-prices	OPEX
Fuel cost petrol (£/l) 2022	£1.66	Gov stats 26/09/2022 https://www.gov.uk/government/statistics/weekly-road-fuel-prices	OPEX
Fuel cost diesel (£/l) 2022	£1.76	Gov stats 26/09/2022 https://www.gov.uk/government/statistics/weekly-road-fuel-prices	OPEX
Fuel eight year view with 2022 variable prices	Prices increased based on UK historic data of petrol/diesel price at pump 2023-2030: 5%	Gov stats 26/09/2022 https://www.gov.uk/government/statistics/weekly-road-fuel-prices	OPEX
Electricity cost 2021 (£/kWh)	£0.15	Benchmark Price (powercompare.com) 2021	OPEX
Electricity cost 2022 (£/kWh)	£0.22	Benchmark Price (powercompare.com) 2022	OPEX
Electricity cost 2023 (£/kWh)	£0.58	£0.68 Average Price for one year commercial contract as per 23/09/2022 (powercompare.com)	OPEX
Electricity – eight year view with 2022 variable prices	Prices increased by Cornwall Insight Predictions on wholesale prices 2023: - 15% 2024: - 24% 2025: - 21% 2026: -14% 2027: -5% 2028: -11% 2029: +6% 2030: +6%	Cornwall Insight	OPEX
Inflation	2%	Bank of England - https://www.bankofengland.co.uk/monetary-policy-report/2022/august-2022	OPEX/ CAPEX
Inflation – eight year view with 2022 variable prices	Variable 2023 - 9.6% 2024 - 2.6% 2025 - 1.0% 2026-2030 - 2%	Bank of England - https://www.bankofengland.co.uk/monetary-policy-report/2022/august-2023	OPEX/ CAPEX

[3] Prices used in this analysis were last updated in September 2022. It should be noted that there have been significant changes in electricity and fuel prices since this time which may impact upon future TCO analysis

Key assumptions	Inputs	Source	Cost type
AdBlue (£/km)	£0.0030	Based on £1.50/l and 1l per 500km From Royal Mail Group reference	OPEX
Daily congestion charge (£) – pre 2025	ICE -£15 EV -£0	https://tfl.gov.uk/modes/driving/congestion-charge/paying-the-congestion-charge = 18/02/2022	OPEX
Daily congestion charge (£) – 2025 onwards	ICE -£15 EV -£15	https://tfl.gov.uk/corporate/transparency/freedom-of-information/foi-request-detail?referenceId=FOI-0573-2021 18/02/2022	OPEX
Carbon emission (kg CO2/L of diesel	2.66807	https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021 - 18/02/2022	-

Table 3 – Depot key assumptions

Key assumptions	Inputs		Source	Cost type
ICE vehicle cost (£)	**Peugeot Partner**	-	Specific value redacted due to commercial confidentiality	CAPEX
	Peugeot Expert	-		
ICE fuel efficiency (l/km)	**Peugeot Partner**	**0.06**	https://www.peugeot.co.uk/ based on WLTP[13] 18/02/2022	OPEX
	Peugeot Expert	**0.073**		
ICE maintenance costs (p/m)	**Peugeot Partner**	**£3.44**	Benchmark price https://www.commercialfleet.org/tools/van/running-costs	OPEX
	Peugeot Expert	**£3.44**		
EV vehicle costs (£)	**Peugeot ePartner**	-	Specific value redacted due to commercial confidentiality	CAPEX
	Peugeot eExpert	-		
	Mercedes eVito	-		
EV power efficiency (Wh/km)	**Peugeot ePartner**	**262**	https://www.peugeot.co.uk/ based on WLTP	OPEX
	Peugeot eExpert	**294**		
	Mercedes eVito	**370**		
ICE insurance costs (£/vehicle/year)	-		Specific value redacted due to commercial confidentiality	OPEX
EV insurance costs (£/vehicle/year)	-		Specific value redacted due to commercial confidentiality	OPEX
EV maintenance costs (p/m)	**Peugeot ePartner**	**£1.91**	Benchmark price https://www.commercialfleet.org/tools/van/running-costs/	OPEX
	Peugeot eExpert	**£1.89**		
	Mercedes eVito	**£1.89**		
ICE and EV resale value after eight years (% of purchase price)	**10%**		Benchmark Average % https://www.kbb.com/new-cars/best-resale-value-awards https://www.forbes.com/sites/jimgorzelany/2019/03/25/heres-why-electric-car-resale-values-are-on-the-upswing/#3229eefc6af3 Cost consistent for ICE/EV	Revenue
CPs purchase and installation costs (£/unit)	**Commercial Double Socket Charger**	-	Specific value redacted due to commercial confidentiality	CAPEX

Key assumptions	Inputs		Source	Cost type
CPs maintenance costs (£/Unit/Year)	**Commercial Double Socket Charger**	-	Specific value redacted due to commercial confidentiality	OPEX
Weighted Average Cost of Capital (WACC)	**5%**			NPV
Flexibility (£/MWh)	**Product B:** **Utilisation** **Product A:** **Availability** **Utilisation**	 **£549.45** **£120.70** **£326.33**	Benchmark price (Utilisation price based on awarded UK Power Networks tenders available on Piclo https://picloflex.com/ - see Section 3.2.4.7 for detail)	Revenue
Solar PV generation	**Solar Panels**	**62**	Based on Islington Depot N1 7ED - Google Maps 23/02/2022	CAPEX
	SP Rating (Watts)	**450**	Benchmark Average % Honey M - DE08M.08(II) | Trina Solar 21/02/2022	
	Price per kWp	**£800**	Hitachi market knowledge	
	Annual kWh generation per kWp	**900**	Hitachi market knowledge	Revenue

Table 4 details electricity network connection assumptions, which are based on the findings from initial connection analysis explained in section 3.6.3.3, of Deliverable D4 where 20 Royal Mail depots were analysed in order to ascertain the peak load from future electrification plans across depots. The results of load analysis were then assessed by UK Power Networks and estimated costs of connection were provided. This TCO analysis used the base case and smart case to illustrate the differences:

- **Base:** where all CPs are used simultaneously at the time of peak background load (i.e. the worst-case scenario).
- **Smart:** where charging times and speeds were managed to below the ASC where possible.

The connection upgrade cost for Camden, Dartford and Victoria are calculated using the average ASC exceedance (kW) across 20 depots due to the lack of data for these locations.

These estimates were deemed sufficient for illustrative purposes in this TCO assessment. However, they may not be fully reflective of the current situation in the depots due to changes in underlying assumptions. For example, a 1:1 ratio of vehicles to sockets was originally assumed, and so in the worst-case scenario all vehicles would be charging at the same time. However, Royal Mail's strategy changed so that new depots would have a 2:1 ratio of vehicles to sockets, thus reducing the CAPEX of CPs. This strategy would need to be supported by operational changes and would result in a lower demand than the base case scenario because not all vehicles will be able to charge at the same time. The assumptions behind connection reinforcement costs were revisited in this final project deliverable, alongside the discussion of benefits of profiled connections.

When applying this TCO to other fleets and locations, it is key to consider that connection costs are location dependent and are heavily dependent on constraints on the local distribution network. While an average from the trials sample of depots has been used here, the cost for another depot could be significantly higher if upgrades to network assets were required.

Table 4 – Network connection costs

Depot	Network Connection (£) Base Case	Network Connection (£) Optimised Smart Charging Case	Source	Cost Type
Mount Pleasant	£0	£0	UK Power Networks	n/a
Camden	£42,253	£0	Average cost across 20 depots analysed	CAPEX
Bexleyheath	£100,000	£0	UK Power Networks	
Islington	£85,000	£0	UK Power Networks	
Victoria	£42,253	£0	Average cost across 20 depots analysed	
Orpington	£168,000	£2,000	UK Power Networks	
Premier Park	£85,000	£0	UK Power Networks	
Dartford	£42,253	£0	Average cost across 20 depots analysed	
Whitechapel	£0	£0	UK Power Networks	n/a

Table 5 – Fleet assumptions

Depot	No. Vehicles	Assumed Vehicles		Assumed number of dual socket CPs (2:1 Vehicle: Socket ratio)
		100% ICE	100% EV	
Mount Pleasant	192	192 Expert	192 eExpert	48
Camden	37	19 Partner	19 ePartner	10
		18 Expert	18 eExpert	
Bexleyheath	23	23 Partner	23 ePartner	6
Islington	38	26 Partner	26 ePartner	10
		12 Expert	12 eExpert	
Victoria	12	3 Partner	3 ePartner	3
		9 Expert	9 eExpert	
Orpington	28	21 Partner	21 ePartner	7
		7 Expert	7 eExpert	
Premier Park	111	84 Partner	84 ePartner	28
		27 Expert	27 eExpert	
Dartford	128	72 Partner	72 ePartner	32
		56 Expert	56 eExpert	
Whitechapel	36	14 Partner	14 ePartner	9
		22 Expert	22 eExpert	

The vehicle numbers presented in Table 5 represent the mix of Royal Mail vehicles on the ground, while being representative of the choice of comparable vehicles available in the market. The aim is a representative TCO comparison, ignoring any preferential vehicle purchase conditions available exclusively to Royal Mail due to the size of their fleet. (Calculations steps can be found in Annex 6.2).

2.3 Results

Table 6 and Table 7 summarise the TCO results for a fully ICE vs. fully electric fleet across the nine depots under the 2022 variable prices scenario. Table 6 shows a base case scenario with higher network connection CAPEX costs, while Table 7 shows a smart charging scenario, in which the requirement for additional capacity is substantially reduced.

The NPV was calculated over eight years assuming a cost of capital of 5%. In the base case scenario, the NPV for the nine depots was £2,599,445, representing the overall benefit of the transition to EV over that period. In the scenario with smart charging and the resulting lower connection CAPEX this value increases to £3,162,204 (~22% improvement in the project's NPV).

Table 6 – Eight years view costs for 100% ICEV and 100% EV depots – Base Case

Cost \Depot £'000	Whitechapel	Camden	Bexleyheath	Islington	Mount Pleasant	Victoria	Orpington	Premier Park	Dartford	Total
CAPEX ICE	774	765	404	744	4,607	269	537	2,122	2,608	12,830
OPEX ICE	1,719	1,748	1,047	1,710	9,837	557	1,520	5,071	5,925	29,133
REVENUE[4] ICE	-87	-86	-46	-84	-520	-30	-61	-240	-294	-1,448
TOTAL ICE	**2,405**	**2,427**	**1,405**	**2,370**	**13,924**	**795**	**1,996**	**6,954**	**8,238**	**40,515**
CAPEX EV	1,016	1,082	719	1,136	5,589	385	936	3,128	3,605	17,596
OPEX EV	1,247	1,274	768	1,255	7,036	406	1,088	3,712	4,323	21,108
REVENUE EV	-107	-109	-65	-110	-591	-36	-81	-320	-375	-1,795
TOTAL EV	**2,156**	**2,247**	**1,423**	**2,281**	**12,034**	**754**	**1,943**	**6,520**	**7,553**	**36,909**
NPV (8-year)	**191**	**123**	**-52**	**37**	**1,522**	**24**	**-10**	**272**	**494**	**2,599**
IRR (8-year)	**37%**	**21%**	**-2%**	**9%**	**60%**	**14%**	**4%**	**17%**	**26%**	

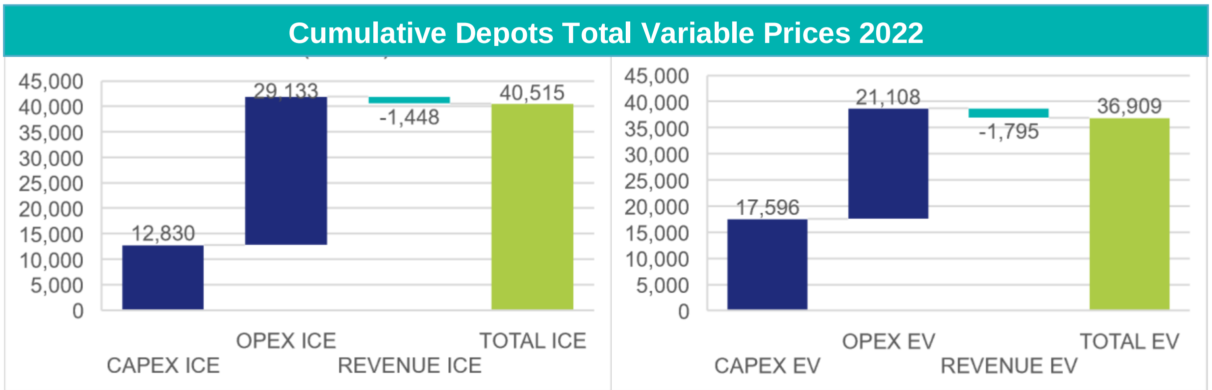
Table 7 – Eight years view costs for 100% ICEV and 100% EV depots – Smart Charging

Cost \Depot £'000	Whitechapel	Camden	Bexleyheath	Islington	Mount Pleasant	Victoria	Orpington	Premier Park	Dartford	Total
CAPEX ICE	774	765	404	744	4,607	269	537	2,122	2,608	12,830
OPEX ICE	1,719	1,748	1,047	1,710	9,837	557	1,520	5,071	5,925	29,133
REVENUE ICE	-87	-86	-46	-84	-520	-30	-61	-240	-294	-1,448
TOTAL ICE	**2,405**	**2,427**	**1,405**	**2,370**	**13,924**	**795**	**1,996**	**6,954**	**8,238**	**40,515**
CAPEX EV	1,016	1,040	619	1,051	5,589	343	770	3,043	3,563	17,033
OPEX EV	1,247	1,274	768	1,255	7,036	406	1,088	3,712	4,323	21,108
REVENUE EV	-107	-109	-65	-110	-591	-36	-81	-320	-375	-1,795
TOTAL EV	**2,156**	**2,204**	**1,323**	**2,196**	**12,034**	**712**	**1,777**	**6,435**	**7,511**	**36,347**
NPV (8-year)	**191**	**165**	**48**	**122**	**1,522**	**66**	**156**	**357**	**536**	**3,162**
IRR (8-year)	**37%**	**30%**	**15%**	**23%**	**60%**	**42%**	**27%**	**22%**	**29%**	

Figure 1 illustrates that running costs for both, an EV and an ICEV over the eight-year period exceed the initial cost of vehicle purchase. However, the EV OPEX is considerably lower in comparison to ICEV OPEX.

[4] In Tables 6 and 7, revenue represents the resale value of vehicles after eight years, assumed to be 10% of the initial purchase price for both ICEV and EVs. Anecdotal evidence suggests that EVs depreciate at a lower rate, however this is dependent on the model and range, and reliable market data is not available at present.

Figure 1 – Comparison of CAPEX and OPEX between ICEV (left) and EV (right) fleets



In the base case charging scenario for all nine depots, the initial comparison between 100% ICEV and 100% EV fleet suggests that running a fully electrified fleet is cheaper than an ICEV fleet. However, the results are not consistent. Table 6 illustrates not only that Total ICEV and EV cost varies between depots, but they differ to varying degrees. In two depots (Bexleyheath and Orpington), the EV fleet turns out to be more expensive than an ICEV fleet.

One of the reasons for this variation could be higher network connection costs. When costs in the smart charging scenario are investigated (Table 7), in all cases the network connection is reduced dramatically and overall EV fleet costs are less across all nine depots. However, network connections costs are not the only factor impacting the TCO results. Other variables such as vehicle costs, mileage, congestion charges, flexibility, as well as network connections, will be explored further in the following sections.

Connection costs will be explored further in section 2.4.4. Vehicle price impact on fleet will be discussed in the section 2.4.3.

In order to present the most realistic scenarios which could be used as benchmarks for fleet electrification, the following results are explored further for three differently sized depots:

- **Small** (Bexleyheath – 23 vehicles);
- **Medium** (Premier Park – 111 vehicles); and
- **Large** (Mount Pleasant – 192 vehicles) depots.

2.4 Factors impacting the TCO

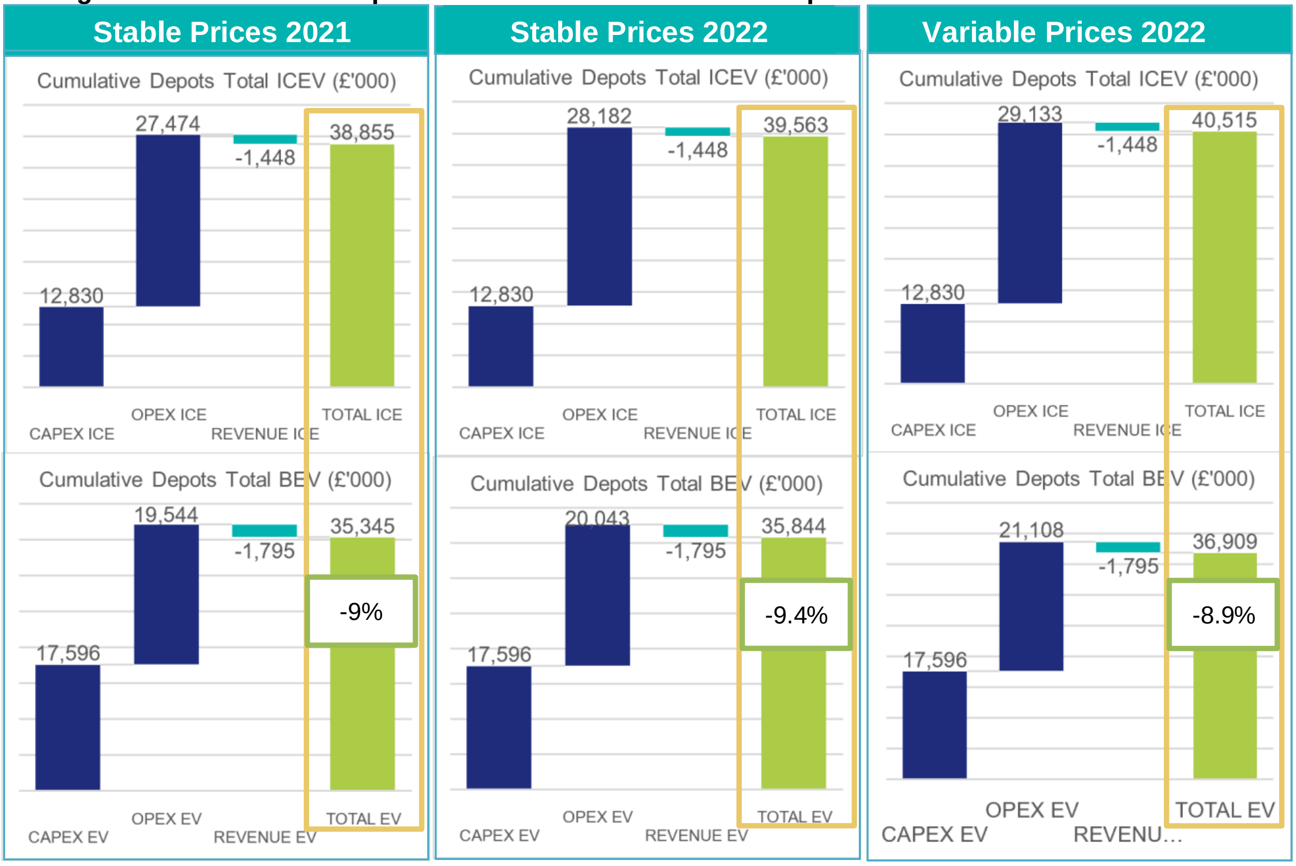
2.4.1 Electricity and Fuel Prices

The same average per kWh electricity cost was assumed for all depots, based on market benchmarks (£0.15/kWh for stable prices 2021, £0.22/kWh for stable prices 2022 and £0.68/kWh for reviewed variable prices 2022). The benefits from ToU tariff optimisation are discussed separately in 2.4.7.

Due to the significant increase in energy prices across 2022, it was deemed necessary to check whether this had any impact on potential fleet electrification based on the Royal Mail model. This may be particularly significant considering that electricity prices increased by ~50% at the beginning of 2022 to over 100% in the third quarter, while the diesel price increased from £1.35 to £1.76 between 2021 and 2022, a comparatively smaller rise of 30%.

In the base case scenario, the TCO model over eight years shows the cumulative costs of a fully electrified fleet are cheaper in all price scenarios than an ICEV fleet by an average of 9%, despite EV CAPEX costs being more expensive than ICE vehicles (Figure 2).

Figure 2 – Cumulative Depots Total ICEV vs BEV across all price scenarios



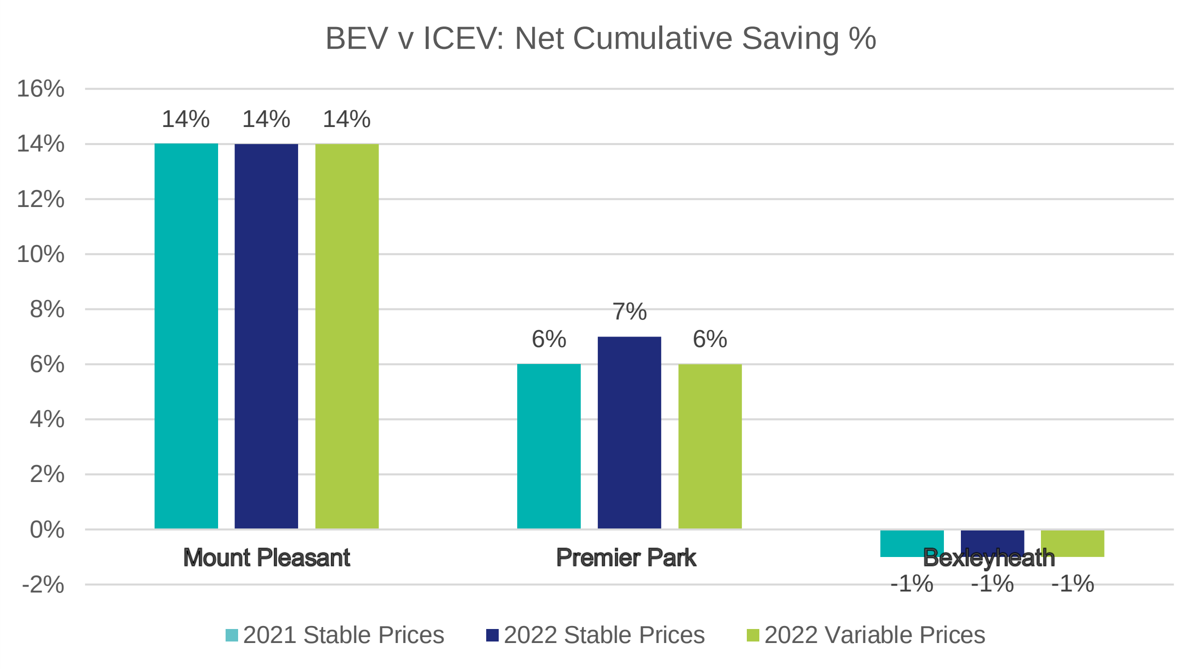
The results presented in Figure 3 show the eight-year cumulative net savings of EV versus ICEV fleet, including fuel and electricity prices across all three pricing scenarios, for the small, medium and large depots. Figure 3 confirms that changes across prices did not have significant impact on the business case for fleet electrification. In fact, variances in the cumulative saving over eight years across the three depots were minimal. This was also the case when average yearly mileages per vehicle were increased and decreased (all depots had different mileages).

This low variance between 2021 and 2022 stable prices scenario might be due to electricity prices still being cheaper than diesel prices to fuel a van, but also because there is control over the electricity tariff when the EVs are charged in a depot. In the 2022 stable prices scenario, even though the tariff price increased by 50% from £0.15 in 2021 to £0.22 in 2022, electricity was still comparatively cheaper than domestic and public charging prices which affect both Centrica and Uber TCOs.

Furthermore, despite the fact the electricity price cap was increased in April and October 2022, the commercial price would still be negotiated for a fixed yearly rate and so would not be impacted significantly by market changes for the duration of the contract. Nonetheless, after major changes in energy prices between Q1 and Q3 of 2022, the assumptions for this TCO assessment were updated to reflect a more realistic overview on the eight years TCO outputs.

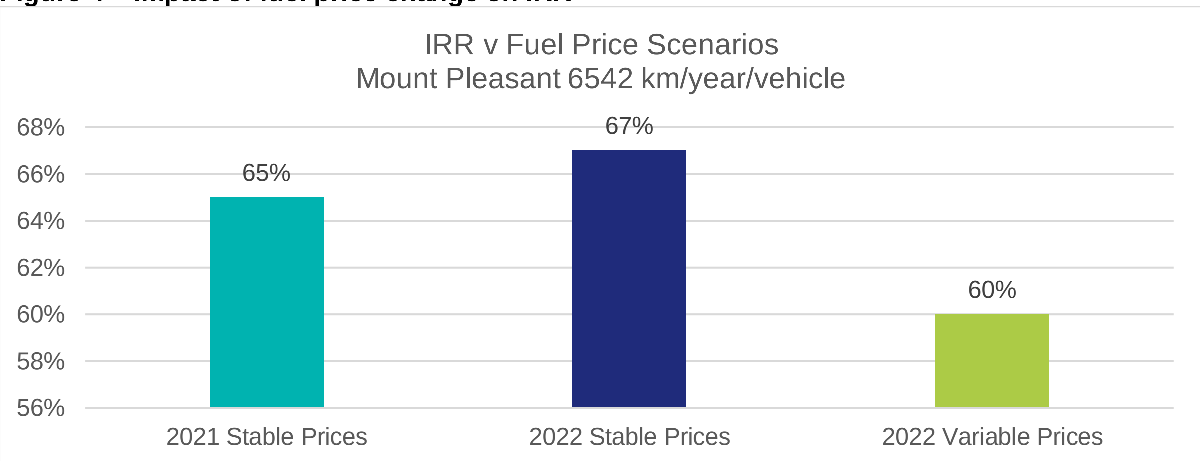
Therefore, even with the considerably higher electricity prices in 2022 and 2023, the latest variable prices 2022 scenario is based on Cornwall Insight electricity price predictions which assume wholesale price will start decreasing after 2023, while the diesel price is predicted to increase about 5% year on year, based on UK historical data.

Figure 3 – Impact of fuel price change on Net Saving %



Electricity and fuel prices had a slightly higher impact on IRR than on cumulative net saving. In the Mount Pleasant example – which is the depot with the highest IRR, the increase in prices reduced the eight-year IRR from 67% in the 2022 stable prices scenario to 60% in the 2022 variable prices case (Figure 4). Therefore, even though in this case the electrified fleet is cheaper than the ICE alternative, with the dynamic increase in electricity prices, the return on investment will most likely take longer than previously expected based on more stable market conditions. In addition, in this scenario a typical distance travelled of 6,542 km/year/vehicle was considered. As mileage also has a significant impact on IRR and therefore the TCO as a whole, its impact will be discussed in the next section.

Figure 4 – Impact of fuel price change on IRR

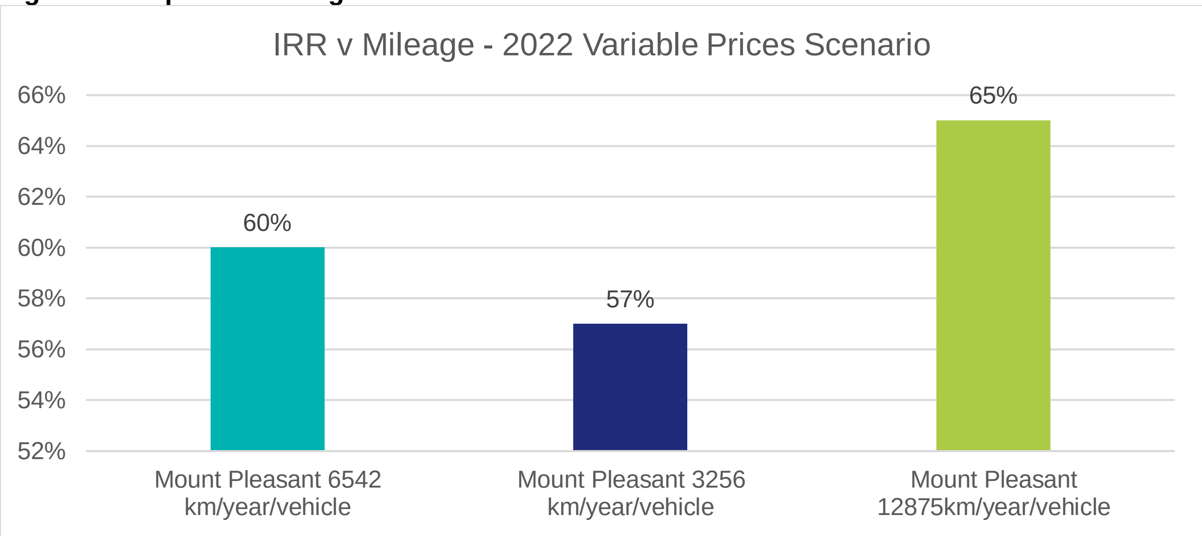


2.4.2 Mileage

Based on the Mount Pleasant depot, with a typical distance travelled of 6,542 km/year/vehicle, the IRR in the 2022 variable prices scenario was 60%, as shown in Figure 5. However, if this distance is reduced to 3,256 km/year/vehicle, as in Bexleyheath, which has the lowest distance across the depots, then the eight-year IRR drops to 57%. The IRR changes significantly with the changes in miles driven per year by a single vehicle. If the national average mileage based on all Royal Mail depots is applied (12,975 km/year/vehicle) the IRR increases to 65%.

The conclusion is that while electricity price difference has a larger negative impact on IRR than on cumulative net savings, IRR can also be significantly influenced by the distance travelled by the vehicles: the higher the distance driven per depot, the higher the IRR. The mileages driven by fleet vehicles, therefore, can lead to overall lower OPEX costs of EVs.

Figure 5 – Impact of mileage on IRR



2.4.3 Vehicle Prices

Figure 6, Figure 7 and Figure 8 illustrate the breakdown of costs for the ICEV and EV fleets. The most significant difference between ICEV and EV CAPEX is at the smallest Royal Mail depot, Bexleyheath (75%), and the most minor difference was assessed at the largest depot, Mount Pleasant (22%).

One of the biggest drivers of this difference is vehicle type. For Mount Pleasant, calculations were solely based on Expert vs eExpert vehicle type. For Bexleyheath, calculations were based on Partner vs ePartner. The price differential between ICEV and EV is significantly higher for the smaller Partner vehicle. Premier Park's fleet includes both types of vehicles, however with a larger number of the Partner/ePartner models the depot aligns more closely with Bexleyheath in terms of CAPEX.

Figure 6 – Mount Pleasant – Fleet cost breakdown based on Expert/eExpert – Base case

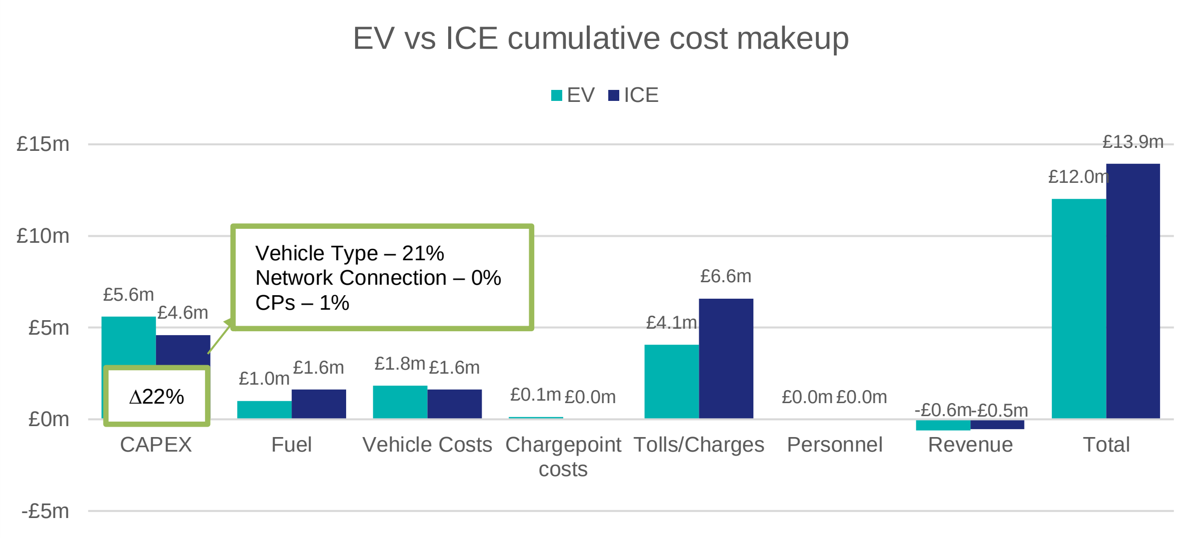


Figure 7 – Premier Park – Fleet cost breakdown based on mix of Partner/ePartner and Expert/eExpert – Base case

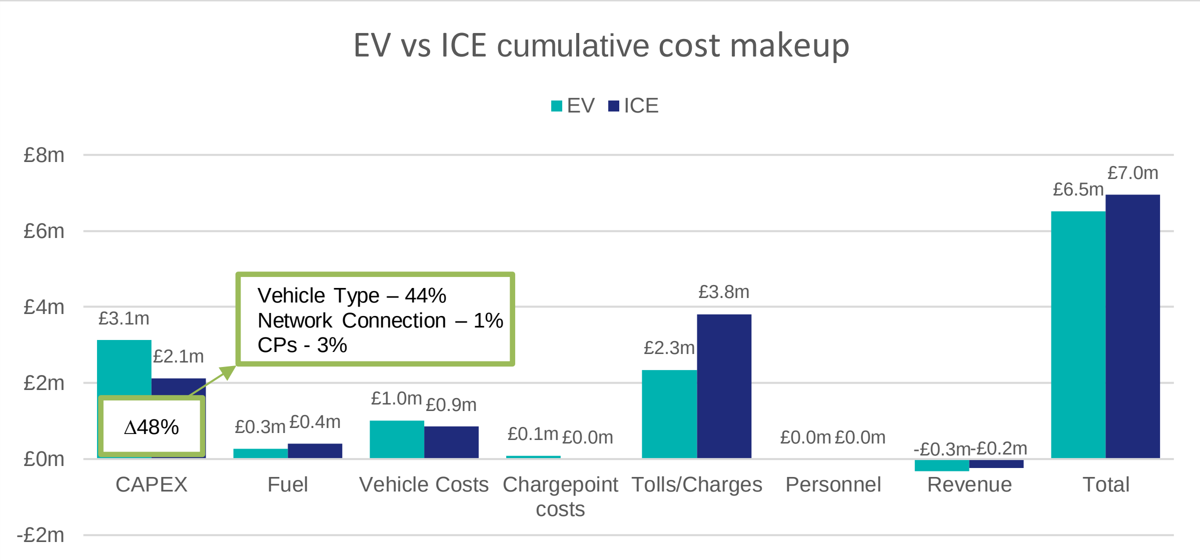
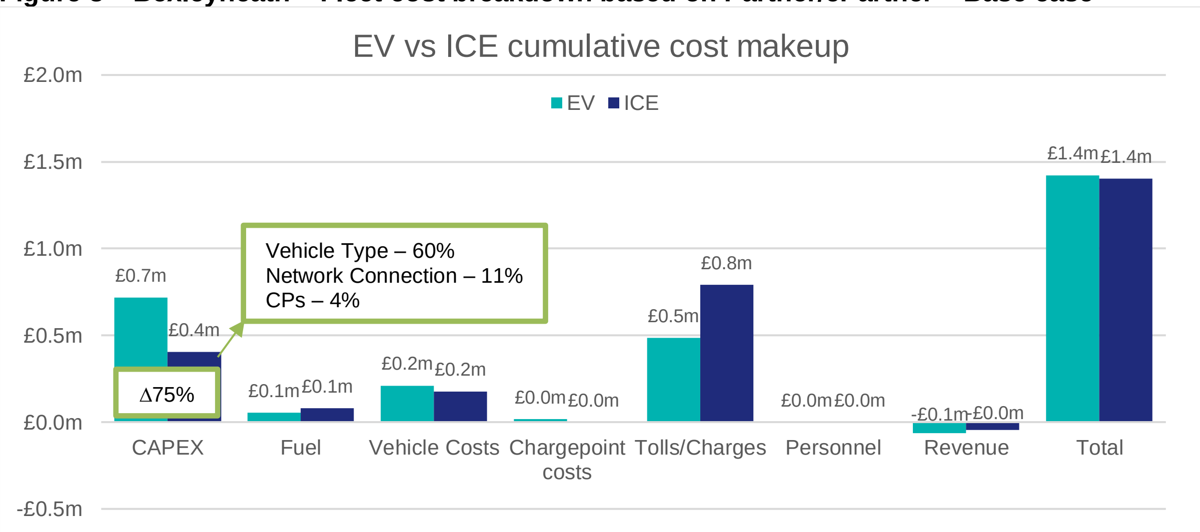


Figure 8 – Bexleyheath – Fleet cost breakdown based on Partner/ePartner – Base case



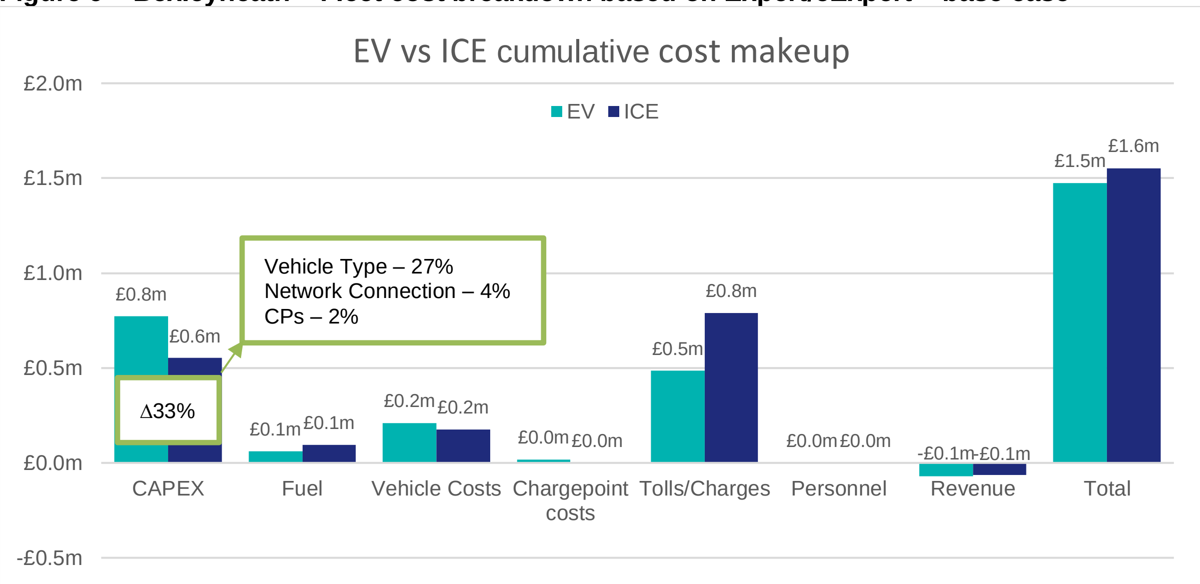
Bexleyheath exclusively has Peugeot Partner/ePartners and for this model there is a significantly greater difference in cost between the EV and ICEV vehicles than between the EV and ICEV Experts.

The sensitivity of TCO result to the price differential was explored. For example, at Bexleyheath, if EVs were up to 37% more expensive than equivalent ICEVs there would be a favourable TCO for switching to EVs in the base case scenario. The NPV over eight years would increase from -£51,603 to -£31,423 and IRR would be neutral at 0%. Combining this with smart charging to eliminate connection reinforcement, the NPV increases to £68,577 while IRR reaches 20%.

The TCO model demonstrates that for the ICEV and EV TCO to break even, the EV price cannot be more than 37% more expensive than ICEV[5]. Moreover, based on all nine Royal Mail depots experiencing 27% cheaper OPEX for an EV fleet than for ICEV OPEX, the EV TCO remains favourable with EV CAPEX up to ~75% more expensive compared to ICEV CAPEX, even without introducing cost saving measures from smart charging.

As shown in Figure 9, vehicle price is not the only CAPEX consideration. In this case for Bexleyheath, the Expert/eExpert vehicle price differential is assumed instead of the Partner/ePartner combination. The difference in CAPEX is now reduced from 75% to 33% and the TCO over eight years becomes cheaper for the electrified fleet. Although in this scenario, vehicle purchase price difference still accounts for the majority of the overall CAPEX difference (27% out of 33%), the network connection cost becomes a second significant factor. This will be investigated further in the next section.

Figure 9 – Bexleyheath – Fleet cost breakdown based on Expert/eExpert – base case



2.4.4 Connection cost

Another major impact on CAPEX cost for EV fleets is the electricity distribution network connection costs to upgrade the electrical supply into depots. This cost can vary significantly between depots and can be highly unpredictable. For example, as Mount Pleasant has historically been a large commercial site, the existing ASC to the location is sufficient to support an EV fleet there without the need to upgrade the connection. However, Bexleyheath and Premier Park have smaller existing supply connections and so both would require connection upgrades, resulting in higher CAPEX for both sites (Table 4).

[5] The % might change depending on vehicle type and its efficiency, as well as network connection costs which is location specific.

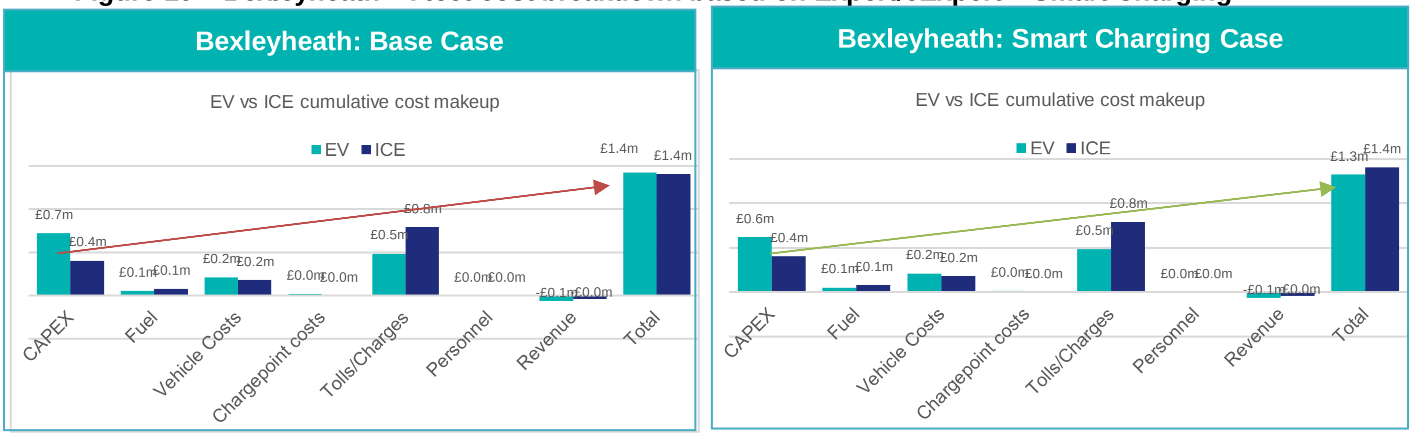
The extra connections costs modelled to reflect the requirement for a network connection upgrade at these sites also had varied impacts on the TCO assessment; the impact on TCO was larger at Bexleyheath than Premier Park. This difference can be explained by the connection costs constituting varied proportions of the total CAPEX costs for each site. Even though both depots have similar connection costs in the base case (for Bexleyheath £100,000 was modelled and for Premier Park £85,000) for Bexleyheath this cost accounts for 15% of the overall CAPEX, whereas at Premier Park connections costs account for only 2% of the total CAPEX. As a result, this has a proportionally larger impact on the overall TCO of the site contributing largely to the EV fleet being more expensive at Bexleyheath than ICE fleet. At Premier Park, the opposite was found. The connection cost estimates were calculated by UK Power Networks based on each depot's expected load, location and existing ASC.

Smart charging, by reducing the peak load from EVs, can allow fleets to avoid having to upgrade their electrical supply. If smart charging was implemented across Premier Park and Bexleyheath depots, for example, neither site would require a network connection upgrade to achieve full electrification as reinforcement would not be necessary for full fleet electrification as Table 4 shows. Avoiding network connection costs can have a significant benefit on the overall TCO at a site. At Bexleyheath, for example, avoiding network connection costs would result in a favourable TCO for the EV fleet where – if network connection upgrade costs are included – the EV fleet would be more expensive.

Figure 10 shows Bexleyheath fleet electrification based on Partner/ePartner vehicle type with smart charging. In this case, the eight-years EV Fleet TCO would be lower than ICEV.

In the Base Case with £100,000 extra CAPEX costs, the Net cumulative Saving in 2030 is at -1%. If smart charging is deployed and the peak load of EV charging is shifted to relieve network constraints, the Net Cumulative Saving would increase to a positive 6%. In this particular case the requirement of connection costs or mitigation through smart charging can make or break the case for the investment into EV fleet.

Figure 10 – Bexleyheath – Fleet cost breakdown based on Expert/eExpert – Smart Charging



Removing reinforcement costs through smart charging has a significant positive impact on the TCO, even across the depots where the EV fleet was cheaper in the base case. When all the depots in the study are combined, the Base Case total cost for all depots with 100% EV fleet is £3.6m cheaper than the ICEV fleet. However, if smart charging was deployed unilaterally, this saving increases to £4.2m. Moreover, smart charging improves the NPV over eight years (assuming 5% cost of capital) against the unmanaged charging scenario by on average 21%, due to reductions of modelled network connection costs over the nine project depots from ~£45,000 to ~£2,000, by reducing peak energy consumption.

Table 8 – Potential benefits of smart charging across nine depots

Total NPV [9 RM Trials Depots]	2021 Stable Prices	2022 Stable Prices	2022 Variable Prices
Base Case	£2,581,836	£2,749,250	£2,599,445
Smart Charging	£3,144,595	£3,312,009	£3,162,204
Smart charging - NPV % Increase	22%	20%	22%

When considering a specific depot however, network connection costs are very much dependent on location and the current available capacity. If the Mount Pleasant full EV fleet of 192 vehicles were to be introduced to Bexleyheath (a small depot with 23 vehicles), which currently has a small connection, then network connection cost could be in the region of £1m as significant upgrades would be required. In this case, the network connection cost would have a significant impact on the overall cost of fleet electrification. Network connection costs could make some business cases negative.

Eliminating the need for network reinforcement would not only save money but also reduce the timeline required for the fleet electrification. As examined in section 3.6.3.2 of Deliverable D4, the timescale for reinforcement in the base case scenario could take up to 12 months.

The cost and implementation time benefits of Profiled Connections are discussed in Appendix 1. Profiled Connections (see section 3.6.4 of Deliverable D4) are a new type of connection being trialled by Optimise Prime, where both customers and DNOs can agree on the connection profile that can vary every 30 minutes across the day. This may reduce reinforcement needs for the customer, as the energy demand would be spread across the day, but would also take into consideration the network capacity and the energy required to satisfy the depot's operations. The smart optimisation system can also ensure that all vehicles have sufficient battery charge for the next shift while power usage fits under the ASC profile. More information on Profiled Connection Methodology and Trials can be found in Appendix 1, Section 4.1.

2.4.5 Congestion charge

Additional charges which apply only to ICEVs can be a significant driver for the difference in operational costs. The Royal Mail trials fleets are in the London area and a significant number of the vehicles are required to pay daily congestion charges. However, while charges for the EV fleet are smaller than for the ICEV fleet, the difference reduces after the end of exemption period for EVs in October 2025. This change of policy has a significant impact on the economics of the EV fleet.

For Mount Pleasant, if the congestion charge exemption was extended for EVs across the whole eight year period, the cumulative net saving after eight years would increase from 14% to 43%. The eight year cumulative net saving would also improve at the medium and small-size Royal Mail depots. These figures are based on the base case scenario. Congestion pricing is location specific and not within the control of fleet managers, unlike other elements of the TCO such as vehicle procurement, time of charging (to avoid network connection costs or at low electricity costs) and installing LCTs.

To fully investigate the impact of congestion charges, based on the current legislation, the TCO for an assumed national average depot has been analysed. National average depot is based on 44 vehicles (50:50 split between the available models), 1:2 charger to vehicle ratio, and covers yearly distance of 8,000 miles per vehicle. Figure 11Figure 11 – Comparison of EV and ICEV fleet cost in congestion charge area shows that electrified fleet within the congestion charge zone is cheaper than ICEV fleet, aligning with cumulative results from the nine depots included in the project. The results on Figure 12 show that once fleets are not impacted by the congestion charges an EV fleet can become more expensive than an ICEV fleet, although marginally. This can be explained by the Congestion Charge having an overall OPEX benefit for EV of ~10%.

Figure 11 – Comparison of EV and ICEV fleet cost in congestion charge area

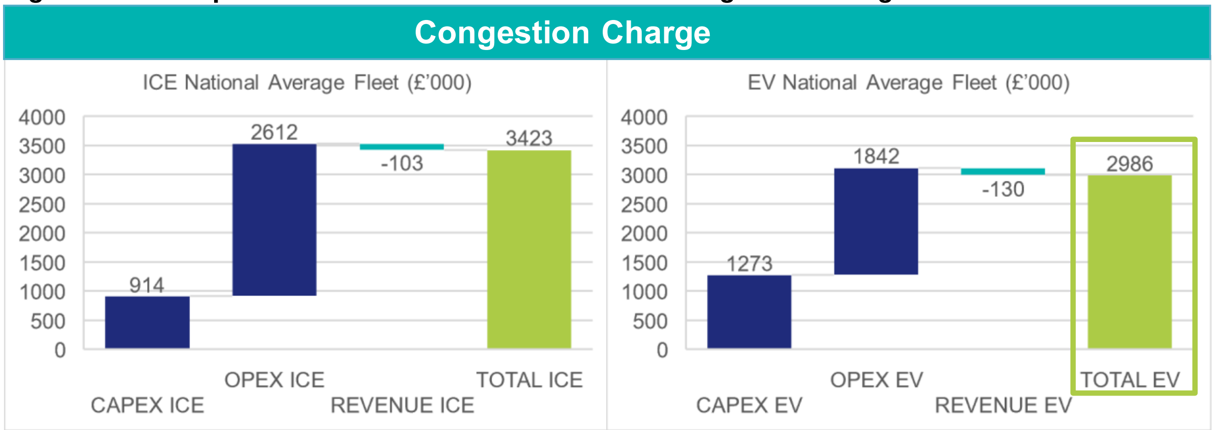
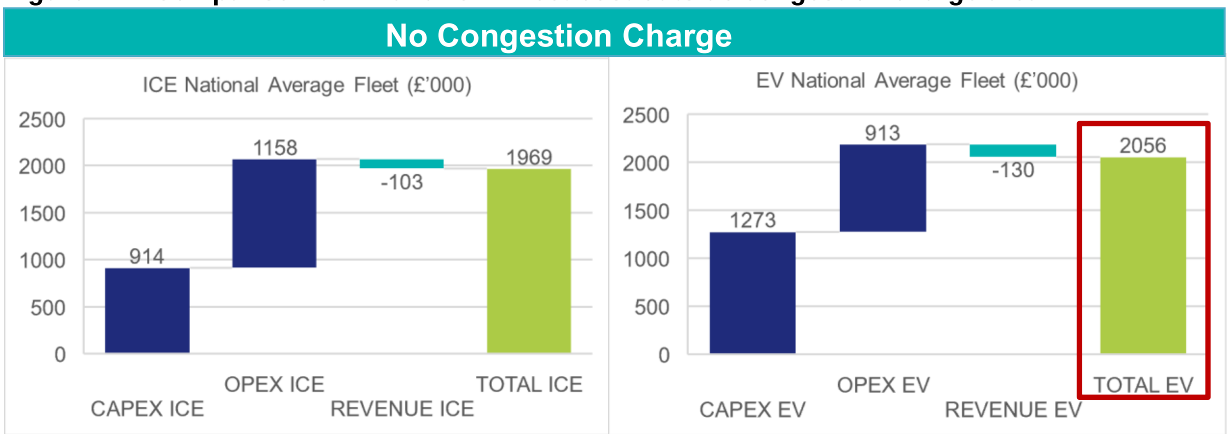


Figure 12 – Comparison of EV and ICEV fleet cost outside congestion charge area



Despite congestion charges, and by extension other levies from which EVs are exempt, being demonstrated to have a significant positive benefit on the investment case for electric fleets, they are not being universally deployed across the UK. Whilst not every fleet will be impacted by congestion charges, it may benefit the wider roll-out of EVs if fleets worked with policy makers to encourage their introduction as a way to justify investments in EVs.

Ultra-low emission zone charges have not been considered, given that the alternative ICEVs are Euro6 compliant and would not be subject to such charges at the time of writing.

2.4.6 CO_2 emissions

The project has assessed what carbon CO_2e savings can be achieved by accelerating the electrification of commercial fleets.

The Royal Mail trials produce on average 80% less CO_2e compared to the ICEV fleet. The results show the CO_2e reduction in operations regardless of the size of the depot.

For Mount Pleasant, the eight year cumulative CO_2e emissions for the ICEV fleet is 1,957 tonnes of CO_2e. 93,190 trees[6] would be required to absorb that volume of CO_2e in comparison

[6] Based on a fully grown tree which can absorb up to 21kg of CO_2 per year

to only 17,333 trees needed to sequester the CO_2e emissions of the EV fleet. For a considerably smaller fleet, at Bexleyheath for example, 4,571 trees would be needed to sequester the CO_2 produced by the ICEV Fleet compared to 905 trees needed for EV fleet CO_2 emissions.

Figure 13, Figure 14 and Figure 15 illustrate the calculated CO_2e savings at the large, medium and small depots.

Figure 13 – Mount Pleasant cumulative fleet CO_2e Emissions

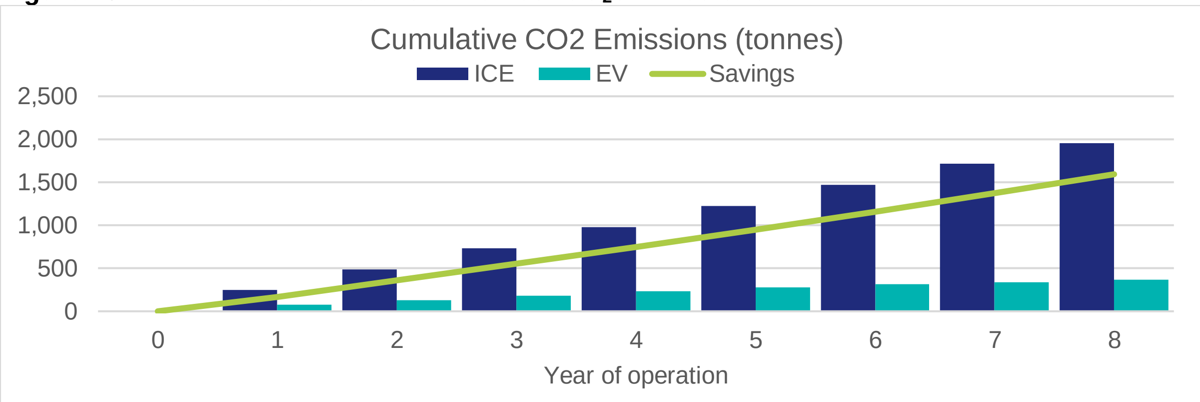


Figure 14 – Premier Park cumulative fleet CO_2e emissions

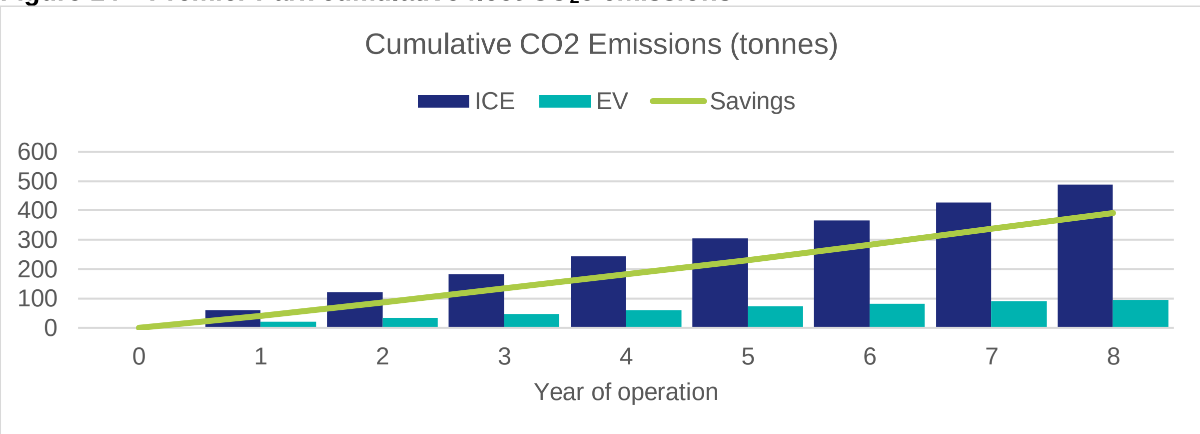
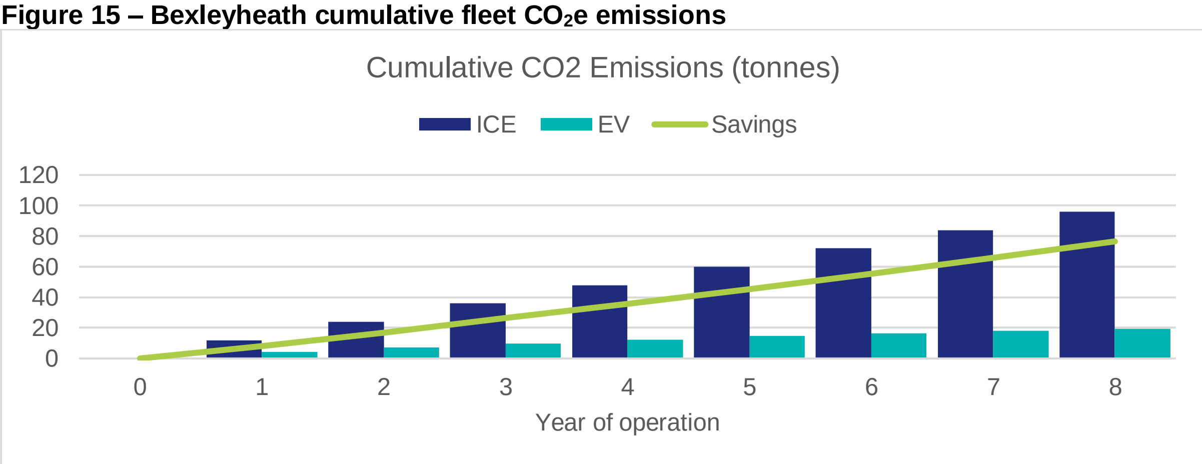


Figure 15 – Bexleyheath cumulative fleet CO_2e emissions



2.4.7 Base case Vs. Smart Charging with ToU Tariff

Smart charging, with the objective of with cost minimisation against a ToU tariff, was investigated against the base case. As previous findings show, smart charging could considerably reduce the overall CAPEX costs of network connections for an EV fleet. Optimising charging against a ToU tariff demonstrates the potential for further OPEX cost reductions.

Early simulations performed in November 2020 for Mount Pleasant indicated that, by shifting load in a cost minimisation scenario from the more expensive to cheapest times for Royal Mail's ToU Tariff, the cost of charging could potentially be reduced by as much as 65%. Applying this saving to the charging cost calculated in the current TCO would reduce the EV OPEX by £655,138 over eight years and improve EV TCO when compared to ICEV by 4% in cumulative net saving from 14% to 18%.

2.4.8 Flexibility

Optimise Prime explored the practicality of using commercial vehicle depots to provide demand turn down to a DNO in response to a request by testing flexibility services across the Royal Mail depots. Provision of such flexibility services could potentially have a positive impact on OPEX for the EV fleet as payments will be received for availability and/or provision of services.

The project has created three energy flexibility products (Products A, B and C), (see Deliverable D3 for the methodology or Appendix 1 for details of the trial outcomes) of which Products A and B were tested at the Royal Mail depots. The intraday product, Product C was tested in the home trials (and was not tested with Royal Mail as the complexity of bidding and dispatching would likely outweigh the benefits on non-aggregated depot loads). The main differences between Products A and B are in relation to procurement timescale and dispatch process. In Product A, capacity is procured by tender, a month ahead and dispatched in real time when needed by the DNO. Product B is tendered for and dispatched as a day ahead schedule. Product A is paid for based on availability and utilisation, while Product B is paid for based on utilisation.

The results from the Royal Mail flexibility trials allowed for certain assumptions to be made to apply flexibility services revenue to the TCO calculations. Therefore, the TCO assumes income from 100% successful turndown compared to bid, 20% CP utilisation and 10% of bids made being dispatched. The trials of flexibility services across the Royal Mail depot-based fleet suggest, as per Figure 16 and Figure 17, that between 7-20% of fleet charging costs could be covered by revenue earned from participating in DNO flexibility markets.

Figure 16 – Revenue from smart charging vs. flexibility product A

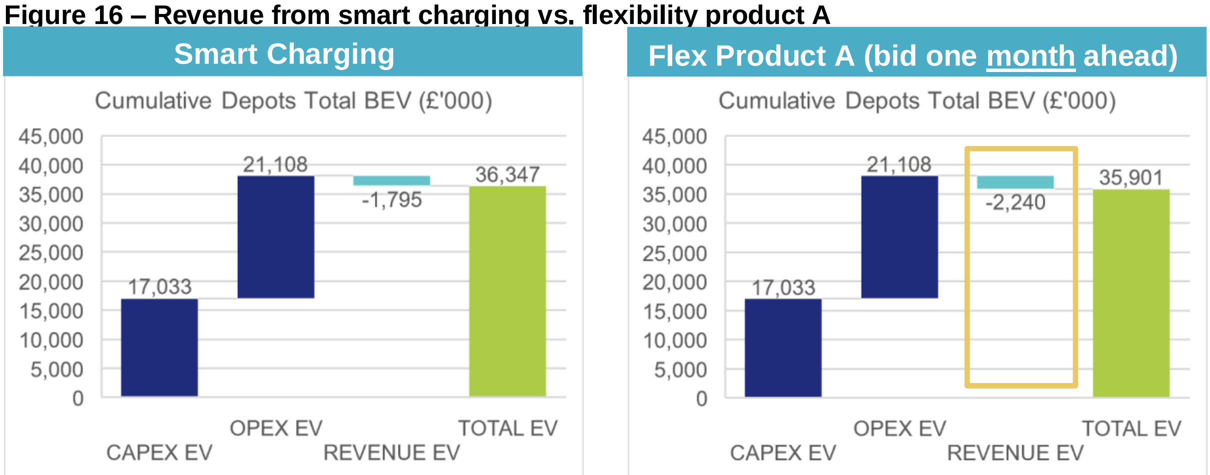
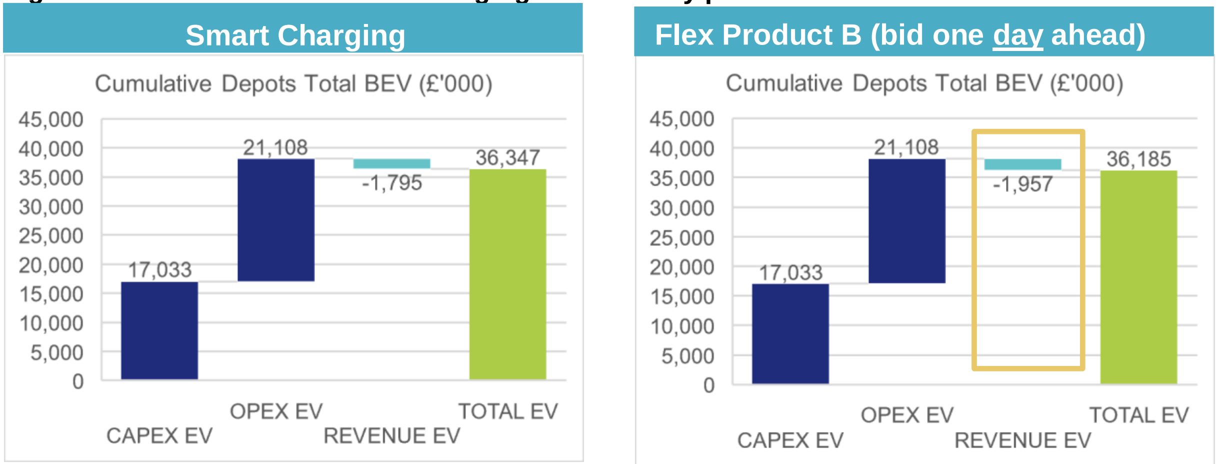


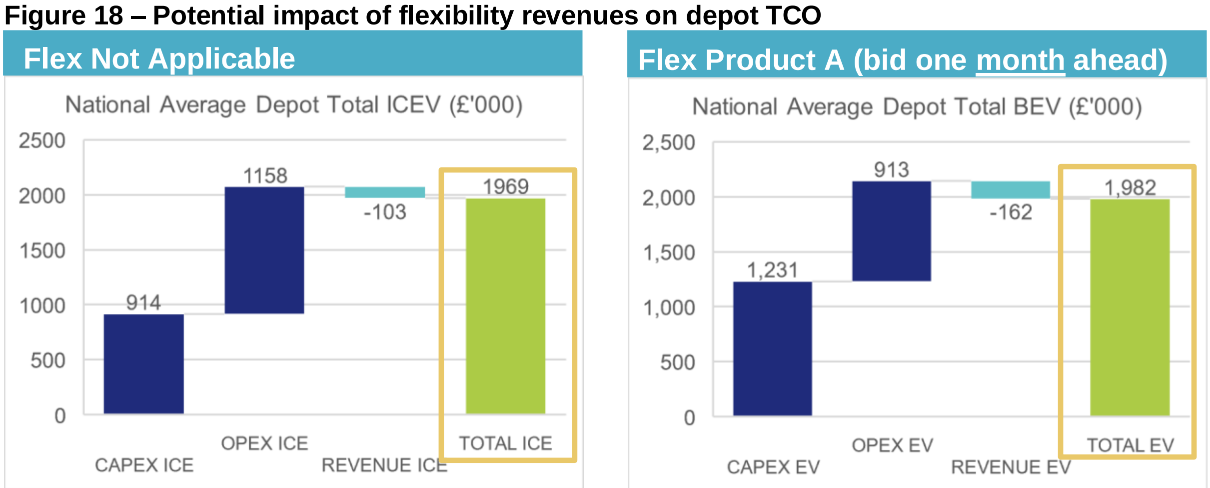
Figure 17 – Revenue from smart charging vs. flexibility product B



Participation in flexibility services might also improve the case for fleet electrification for those depots outside of congestion zones for which EV fleet comes as more expensive than ICEV fleet. As mentioned in section 2.4.5, without the benefit of congestion charge exemption until the end of 2025 over ICEV fleet, the TCO assessment of depots outside of London showed EV fleets to be more expensive than ICEV fleets. Revenue from flexibility services might be a way of mitigating that by offering an additional net benefit for EV over ICE. As shown in Figure 18 the revenue generated through flexibility Product A nearly brings the EV to parity with ICEV. This is based on the DNO dispatching 10% of the bids made.

Input from UK Power Networks and Cornwall Insight suggests that, due to continuous electrification and therefore prediction of higher network constraints, there is a high possibility of more turndown being required than assumed in the TCO models. Therefore, the potential revenue indicated could potentially be exceeded in the future. Further, there is the potential for 'stacking' of multiple flexibility products to create additional revenues, or cycling through products according to the potential revenue opportunity, which would also increase the potential revenue opportunity.

Figure 18 – Potential impact of flexibility revenues on depot TCO



Flexibility trials and the value of flexibility is discussed further in Appendix 1. There are a number of questions that the project is answering that will determine the value of flexibility to a fleet:

- Whether a day ahead or longer-term product is more appropriate for commercial fleet flexibility. While the project has found EV schedules to be broadly predictable, the availability of vehicles cannot be fully controlled. A number of factors, such as schedule changes, workload and seasonal changes in EV efficiency need to be taken into account in making flexibility offers.

- The ability of EV fleets to provide point-in-time demand reductions on request, vs making their demand follow a day long schedule.
- The comparative benefits of products with or without availability payments, given the likelihood and magnitude of flexibility calls.
- The potential revenue from flexibility. Due to the lack of a market within the trials, consideration will be given to the benchmark prices in other flexibility markets – for example a utilisation benchmark price of £549/MWh was calculated based on the data published by Piclo[7] (a flexibility bidding platform) with confirmed bids between 2021 and 2027 that were accepted by UK Power Networks.
- The potential cost of providing flexibility services, and how this scales up with depot size/volume of flexibility available.

Although the specific value of flexibility to a given fleet remains unknown, obtaining additional revenue through the provision of flexibility services may be an attractive option to offset increases in electricity costs. However, offering flexibility is not without cost for the participant, either directly through the systems and processes needed to bid and dispatch, through the impact on operational flexibility, or in the form of the opportunity costs of missing out on charging at a lower electricity price.

2.4.9 Low Carbon Technologies (LCTs)

While trial of LCTs is outside the scope of Optimise Prime, it is evident that technologies such as distributed renewable generation can play an important part of the business case for a depot. While some Royal Mail depots do have solar panels installed, the data on generation was not available to the project and so estimates have been made based on the number of solar panels installed at the Islington depot.

The Islington depot has 62 roof-top solar panels installed. Following assumptions of average rooftop solar panel power and Hitachi market knowledge of the price and installation cost per kWp, calculations show that investment cost for this installation could be on average £21,600, and would generate 24,300 kWh per year at this specific location.

If the power generated by the solar panels is consumed at the depot, the total saving in year one could equal £5,453 (based on the stable prices of £0.22/kWh). This saving would represent 87% of the electricity costs for charging the fleet at the Islington depot. The return on investment for the solar panels would be reached after four years of installation and, given the average of 25 years solar panel lifetime, this could be a viable option for electric commercial fleets to reduce their OPEX by investing in onsite solar. The Royal Mail fleet shows significant variation between depots as to whether EV charging is taking place in the daytime, when solar generation is highest.

If the solar energy generated onsite was to cover 87% of the electric fleet energy requirement, considering increasing energy prices this would have a major effect in minimising the impact of future price increases on fleet electrification. With the most up to date approach of variable 2022 prices, the cost saving through onsite generation could result in a return on investment for solar in just two years. The potential for the use of other Low Carbon Technologies at other depots is explored further in Appendix 2.

[7] Piclo - Confirmed Bid results present up to 15-07-21
https://picloflex-static-public.s3.euwest2.amazonaws.com/landing_page/Piclo_Flex_Confirmed_Bids.xlsx

2.5 Key Learnings and next steps

This section describes the Optimise Prime modelling of the business case for electrification of depot-based fleets. The project has been fortunate to conduct the TCO analysis during a period of high volatility for a number of key value drivers for fleets. This has enabled Optimise Prime to highlight the main factors that influence the fleet TCO and that are currently driving EV affordability. The main conclusions from the analysis so far are summarised below:

At present, whether TCO favours EV or ICEV fleets varies by depot, driven largely by EV type and cost of connection

The difference between EV and ICEV TCOs is not significant and there are a number of OPEX and CAPEX items that can make or break the investment case.

Energy price rises have had some impact on the TCO for depot-based electric fleets, impacting the investment case by around 2%

Electricity prices have increased by around 50% at the beginning of 2022 to over a 100% in 2022 Q3, while diesel and petrol price rises have been around 30% year-on-year. Control over electricity prices through agreed corporate tariffs covering the depots has limited impact of price rises. Future movements in commodity prices could continue to impact the overall investment case unless coupled with other changes such as vehicle cost reductions.

The OPEX savings for EVs even without smart charging can offset a 37% higher price of EVs vs ICEVs at present

While cost parity between EVs and ICEVs is predicted, it is still some way off. Supply constraints, caused by the semiconductor shortage, more aggressive targets for the end of ICEV sales and other commercial factors have especially impacted the LCV market, preventing a reduction in EV prices. OPEX benefits of EVs can offset a higher CAPEX cost, but at present many EVs are still too highly priced relative to ICEV alternatives.

Connection costs are normally a relatively small proportion of the overall fleet electrification costs, but given the small difference in TCO between EV fleet and ICEV fleets, they could still impact investment decisions

Using smart charging to alleviate the need for connection upgrades has been shown to produce benefits in the Royal Mail case. However, the variability in cost of connection between sites can be significant and so it is difficult to generalise the extent to which connection charges impact TCO.

Congestion Charging can provide benefits to EV TCOs, but these benefits are limited by time and location

Within London, the cost of Congestion Charge for ICEV fleets can be significant. However, the current exemption for EVs is planned to end in 2025 limiting its impact on long term TCOs. Other measures penalising ICEV use in London and other areas may be introduced in the future, but the impact of such measures on TCO cannot be predicted. Fleet managers also have little control over Congestion Charges, as delivery fleets like Royal Mail have no option but to enter the zone to make deliveries.

Many of these cost factors are variable and will continue to change due to external, often global, market forces. The application of government tolls, charges, bans and policy incentives will tend to favour EVs over ICEs for some time to come and market researchers[8] predict that the continued deployment of renewable energy may ultimately bring the cost of electricity down.

[8] Cornwall-Insight-GB-Power-Market-Outlook-to-2030_2022Q2-Final.pdf

Furthermore, the analysis also looked at factors that provide a more predictable and durable benefit over the period in question such as the CAPEX and OPEX reductions that smart charging, profiled connections, tariff optimisation and energy flexibility can provide to EV fleets. These factors can be implemented by fleet owners independent of market forces, and together with supplementary schemes such as the roll-out of LCTs could help organisations achieve a positive TCO compared to ICEV in addition to environmental benefits.

3 Total Cost of Ownership for home-based fleets – an example from Centrica

3.1 Introduction

The Centrica TCO aims to model the total costs of owning and operating Centrica's large fleet of British Gas vans, comparing the costs assumed by the business for their diesel and their electric vans. This TCO model forecasts the potential economic effects of electrification at a whole-fleet level and a single vehicle level. The TCO illustrates the key levers that influence the total costs for both the ICEV and EV fleet, showing what factors need to be monitored closely to ensure businesses with similar fleets can transition in a cost-effective manner.

For British Gas' fleet, every engineer is provided with a personal van that they take home each day. Their fleet has the following general characteristics:

3.1.1 The fleet

The British Gas fleet is composed of ~9,500 medium-sized panel vans. The diesel vehicle model used in this analysis is a Vauxhall Vivaro and its zero-emission alternative the Vauxhall Vivaro-e, which is their current electric van of choice. Centrica typically lease their vehicles for six years at a time. However, to try to maximise the applicable value of the modelling work Optimise Prime decided to investigate a short lease-fleet (five years) and a longer lease fleet (eight years). In the context of Centrica's assessment, the five years would be the most valid. It was hoped that analysing two polarised TCO views would yield the most generalisable learnings.

3.1.2 Mileage

Due to the nature of British Gas' work, each van travels long distances completing work at customers' homes. Based on mileages reported in the Optimise Prime Behavioural Surveys (see Appendix 5), and analysed telematics input from the trials, average mileage per driver of 50 miles per day was used (equivalent to the average mileage for the standard shift – see Appendix 2 for further detail on the mileage by shift type). This was deemed appropriate since although drivers reported they can drive more than 120 miles in a day if they are on a call-out shift, the mean distance is much lower.

3.1.3 Congestion and Emissions Charges

Only ~2% of British Gas drivers operate in London within the Congestion Charging zone, which charges £15 per day to enter. An exemption applies for battery electric and hydrogen fuel cell vehicles, although this will cease in December 2025.

Though these ~2% will most likely also be passing through the London Ultra Low Emission Zone (ULEZ), this had no relative impact on their TCO calculations since the Euro 6.2 diesel engines they use in the Vauxhall Vivaros also remain exempt from this charge.

Table 9 – The main inputs and assumptions for Centrica's TCO

Input Type	Input Name	Input Value	Source
Whole-fleet Inputs	Fleet size	9,500 vehicles	Centrica
	Mileage	50miles per day	Centrica's Trials Data
	Total working days assumption	240 days per year	
	Assumed number call-out days	12 per year	Centrica
	Assumed % fleet entering London congestion zone / ULEZ zone	2%	
	Vehicle lease price	See Table 14	Novuna
	Vehicle maintenance cost	£0.04 per mile	Centrica

Input Type	Input Name	Input Value	Source
Diesel Vehicle Inputs *-Vauxhall Vivaro*	Vehicle engine efficiency	0.09 litres / mile	
	Vehicle AdBlue spend	£0.005 per mile	
	Vehicle emissions standard	Euro 6.2	
	Vehicle annual tax cost	£140	
	Vehicle insurance cost assumption*	~£740	
EV Inputs *-Vauxhall Vivaro-e*	Vehicle lease price	See Table 14**Table 14**	Novuna
	Vehicle maintenance cost	£0.03 per mile	Centrica
	Vehicle power efficiency	2.5 miles / kWh	
	Vehicle annual tax spend	£0	
	Vehicle insurance cost assumption*	~£740	
Emissions Assumptions	Diesel CO_2 emissions	2.6 kg CO_2 /litre of diesel	https://www.gov.uk/ government/publications/ greenhouse-gas-reporting-conversion-factors-2021 18/02/2022
	Electricity CO_2 emissions	Operational Emissions model**	Hitachi market knowledge

*Assumed no insurance price difference for EV vs ICEV.
** Optimise Prime has developed a separate model which calculates the approximate carbon emissions per kWh taking into account to gradual decarbonisation of the electricity network.

3.1.4 Centrica's Charging Strategy

Since each driver has their own vehicle and takes it home with them each night, Centrica pursue a home-based charging strategy encouraging drivers to plug-in once they are home on a personal CP. This strategy could allow Centrica to capitalise on lower overall electricity costs associated with home tariffs compared with the higher prices at public charging stations. However, Centrica take full responsibility for procuring, installing and maintaining each personal CP for the driver, which results in additional CAPEX and OPEX for the business. These costs are summarised in Table 10.

Table 10 – Summary of CP costs for Centrica's home-charging fleet[9]

Cost Type	Cost Name	Price (£)
CAPEX (purchase and installation)	Home CP (3.5 to 7 kW)	620
	Installation	325
	OZEV CP installation grant*	-325
OPEX (maintenance, ancillary costs and licenses)	CP failure cost**	350
	Control software	12 (per socket p/y)
	Reimbursement software	72 (per socket p/y)
	Ancillary costs (replacement of leads)	7.5 (per socket p/y)

*As will be discussed later in the report, the OZEV grant is no longer available for fleets like Centrica installing CPs at home. This cost was used in the comparisons between the 2021 scenario for Centrica, and the current (2022) scenario.
** The reported approximated failure rate for CPs was 1%.

To achieve the maximum economic benefits of a home-charging strategy, drivers would need to enrol on a time-of-use tariff and optimise their charging schedule so that their van is charging mostly on cheaper night-time tariffs and avoiding pricier day-time tariffs, particularly during peak hours of between 17:00 and 20:00. Smart charging can yield significant TCO savings when compared to those charging on an unmanaged charging schedule.

[9] Table Source – Centrica

Though home-charging is the primary strategy for Centrica, it is not always possible to install a CP at a driver's home. This is discussed further in the final report and Fleet Electrification Guide, and it can be due to various physical or technical constraints. For example, they may not have a driveway, their driveway may not be near their house, or it may not technically be possible to install an EV charger. If a British Gas engineer is unable to install a home-CP, their only option is to charge using public charging infrastructure. As a result, these drivers find local public charging infrastructure near their house – usually slow CPs from lampposts or in community charging locations – or they must charge on-shift, or on their way home at commercial charging stations. This results in higher costs of electricity, and therefore a less favourable EV TCO.

3.1.5 Timing: the 2021 vs 2022 scenarios

As part of the modelling exercise, it became evident that comparing the economic environment for electrification in 2021, against 2022, could provide useful outputs. Since Optimise Prime has started, the commercial environment for fleet electrification has changed. In addition to the impacts of the COVID-19 pandemic, electric LCV prices have not reduced sufficiently to bridge the gap with ICEVs owing to ongoing supply constraint and other commercial factors, perhaps driven by the approaching ban on ICEV's in the UK in 2030. Furthermore, with the markedly higher energy and fuel prices, as well as the termination of OZEV grants, which previously provided a financial contribution to businesses installing CPs, it has become harder to reach TCO parity with ICEVs since 2021.

A final consideration to note in the modelling of the 2022 scenario there is also a decreased financial benefit of the congestion charging zone exemption for EVs as there is one less year of benefit until EVs start being charged in 2025. The project analysed the impact of these changes in Section 3.2.4 by building assessments of both the 2021 and 2022 scenario.

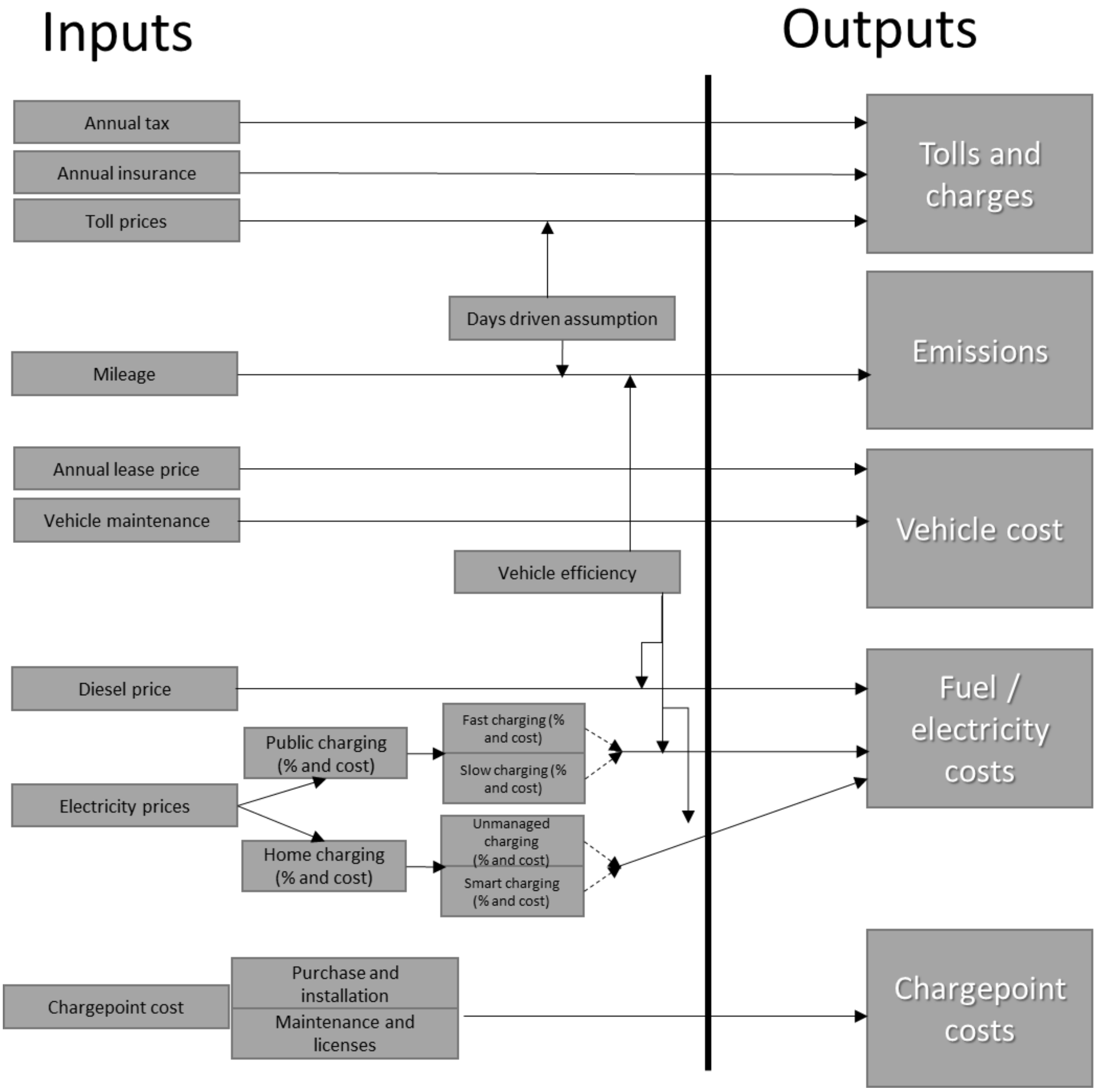
3.1.6 Model Overview

The TCO business model created for the Optimise Prime project is formed of:

- The lease price and annual maintenance costs of the ICEVs and EVs.
- The fuel and electricity costs to power the vans according to vehicle efficiencies and mileages, as well as the diesel price per litre and electricity prices per kWh.
- Associated running costs covering annual insurance, tolls and tax payments.
- Cost of purchase, installation, and maintenance of home charging points for EVs, as well as all necessary licenses.

These inputs and the outputs that are generated are summarised in Figure 19.

Figure 19 – Main inputs and outputs for Centrica TCO assessment



Given there is a mix of drivers who are able to charge at home and those that must charge using public infrastructure, the model was designed to cater for multiple scenarios in which the percentage blend of the fleet using these two forms of charging could be adjusted. Public and home charging both carry very different costs, with the latter composed of lower overall electricity costs. However, additional CP expenses which the former avoids but suffers from the higher price per kWh. Therefore, the percentage of the fleet charging in each way will affect the total cost of operating the fleet.

Each charging method contained subsets within them. Public charging could mean the vehicle was charging at a local, 'Rapid' CP with a certain price per kWh, or it could mean the vehicle is charging at commercial ultra-rapid charging stations, which charge higher rates per kWh. Generally, Centrica expect ~20% of their total fleet once fully electrified to be charging at public CP. With the increase of rapid and ultra-rapid chargers available it is expected that of that 20% of vehicles charging publicly, 50% will be charging at rapid CP with the remainder charging at a ultra-rapid CP (see Table 11). It is noteworthy that use of rapid and ultra-rapid public charging is considerably more expensive than slow or fast charging, so were slower charging to be operationally feasible, there is an opportunity to improve the TCO for EV.

Table 11 – Proportions of charging methods across the Centrica fleet for the Baseline case[10]

Charging type	Percentage	Type of Charging Type	Percentage
Public Charging	20%	Rapid charging	50%
		Ultra-rapid charging	50%
Home Charging	80%	Smart charging	10%
		Unmanaged charging	90%

The home-charging vehicles could either be on time-of-use tariffs capitalising on lower off-peak energy prices by charging their vehicle during the night, or they could be on a regular fixed tariff charging their van at expensive, peak-hours. Currently, approximately 10% of the home-charging British Gas vehicles are on the required time-of-use tariffs to enable charging optimisation (Table 11). However, Centrica hope to increase this as smart charging can significantly reduce their electric TCO.

Table 12 summarises the varied electricity prices that could be paid under the different scenarios outlined above, and Table 13 outlines the assumptions used to model smart and unmanaged charging.

Table 12 – Varying electricity prices for Centrica's TCO assessments[11]

Year	Charging Type	Cost Name	Price (£/ kWh)	Source
2021	Public Charging	Rapid charging	0.42	Benchmark Price (www.zap-map.com) 2021
		Slow charging	0.13	
	Home Charging	Assumed day-tariff	0.17	Benchmark Price (www.britishgas.co.uk) 2021
		Assumed night tariff	0.09	
2022	Public	Rapid charging	0.56	Benchmark Price Cornwall Insight 2022
		Ultra-rapid charging	0.67	
	Home	Standard tariff	0.28	Benchmark Price (www.britishgas.co.uk) 2022
		Assumed day-tariff	0.37	
		Assumed night tariff	0.17	

Table 13 – Smart vs unmanaged charging assumptions

Year	Charging assumptions
Smart charging	80% of charging assumed to be on the night-tariff
	20% of charging assumed to be on the day-tariff
Unmanaged charging	20% of charging assumed to be on the night-tariff
	80% of charging assumed to be on the day-tariff

[10] Table Source - Centrica
[11] Electricity Prices up to 2030 adjusted according to the Cornwall Insight energy prices predictions

3.2 Results

3.2.1 Baseline Case

This section analyses the results of the model to produce outputs that compare the TCO for an EV fleet compared to an ICEV fleet. The vehicle cost assumptions in Table 14 and the division of charging in Table 13 are obtained from discussions with Centrica.

Table 14 – Monthly lease prices for the vehicles[12]

Fuel type	Year	Lease length	Lease costs
Electric	Vauxhall Vivaro-e	Eight Year	~£400 per month
		Five Year	~£535 per month
Diesel	Vauxhall Vivaro	Eight Year	~£219 per month
		Five Year	~£304 per month

3.2.2 Whole Fleet View Comparison

This section analyses the results of the model to compare the costs of an entire ICEV Fleet of 9,500 vehicles to an equivalent EV Fleet.

These whole-fleet TCO comparisons were carried out for both the 2021 and 2022 scenarios. The 2021 whole-fleet model was published in Deliverable D5, however given the time at which it was created, it necessarily used different market inputs. For that reason, it is not included here, as direct comparisons could be misleading. The commentary does make reference to general comparisons between the scenarios where the margin of tolerance is sufficiently broad, and the conclusions remain sound.

3.2.2.1 Whole Fleet View – 2022 scenario

The results of the 2022 scenario demonstrate EVs as even less competitive with ICEVs one year on from 2021 (see Deliverable D5).

There is an increased cumulative net loss of ~£139m for eight years, shown in Figure 20, for EV against ICEV and a net loss of ~£141m over five years (Figure 22). The cumulative cost of an EV fleet, for 2022, totalled £655 million compared to £515 million for ICEVs over eight years (Figure 21). The reason for the large cumulative losses in 2022 of EV against ICEV is because there is a 45% increase in public charging cost and a 56% increase in home charging cost, as a result of changes in wholesale energy prices, whilst only a 30% increase in ICEV fuel cost from 2021 to 2022. Also, the removal of the OZEV government subsidy of £325 for the installation of home CPs has been included (the subsidy ended in April 2022), which meant an increased cost of £2 million for the EV fleet.

Participating in flexibility services can bring some revenue to the EV fleet and help mitigate the gap versus an ICEV fleet. Based on the flexibility trials conducted by Centrica, and current prices, the project predicts that revenues of £817k per year could be possible if 50% of the fleet (4,750 vehicles) participated in flexibility services, offsetting £8m of operational costs over the life of the fleet (Figure 24)

[12] Novuna – Hitachi Capital

Figure 20 – Cumulative fleet level net savings over eight years, EV vs ICEV, 2022

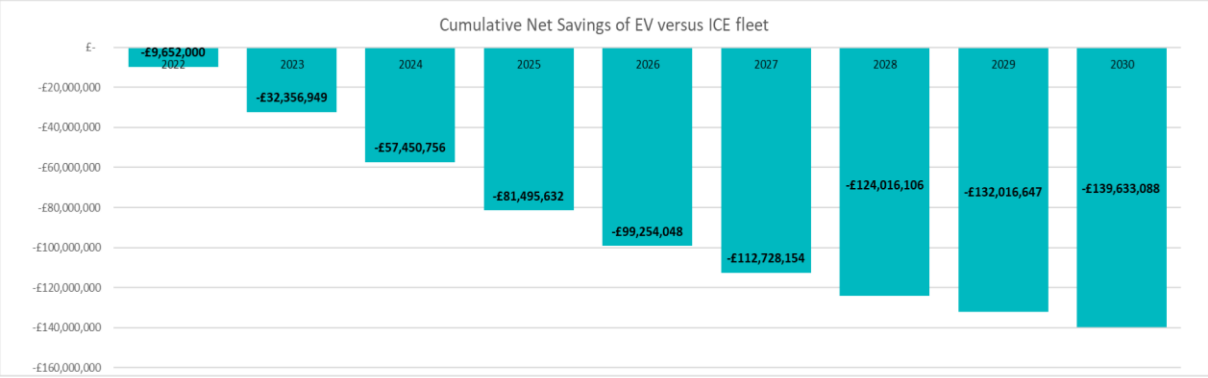


Figure 21 – Cumulative fleet level cost makeup over eight years, EV vs ICEV, 2022

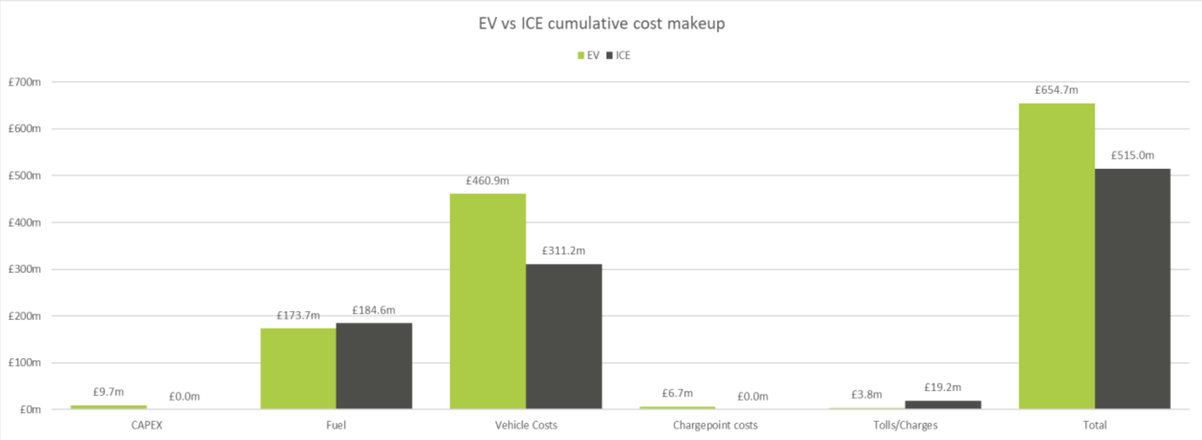


Figure 22 – Cumulative fleet level net savings over five years, EV vs ICEV, 2022

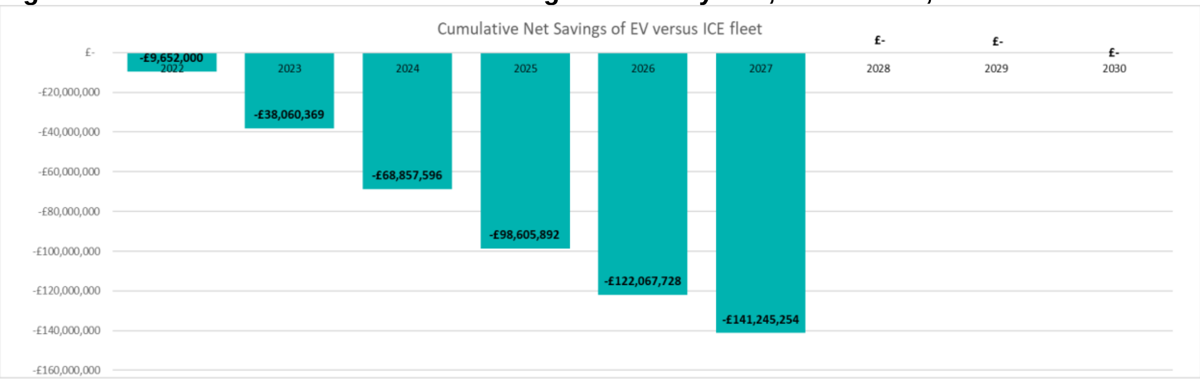


Figure 23 – Cumulative fleet level cost makeup over five years, EV vs ICEV, 2022

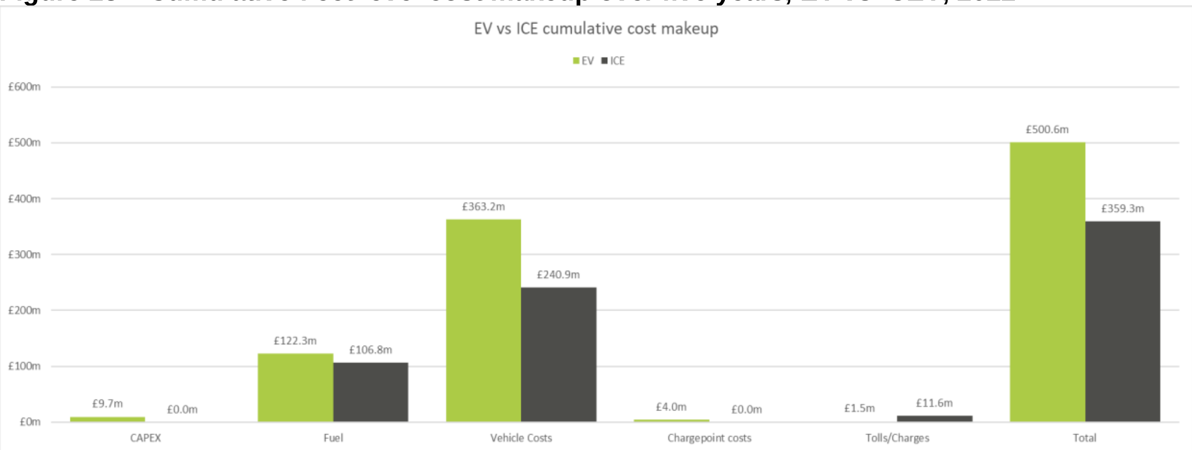
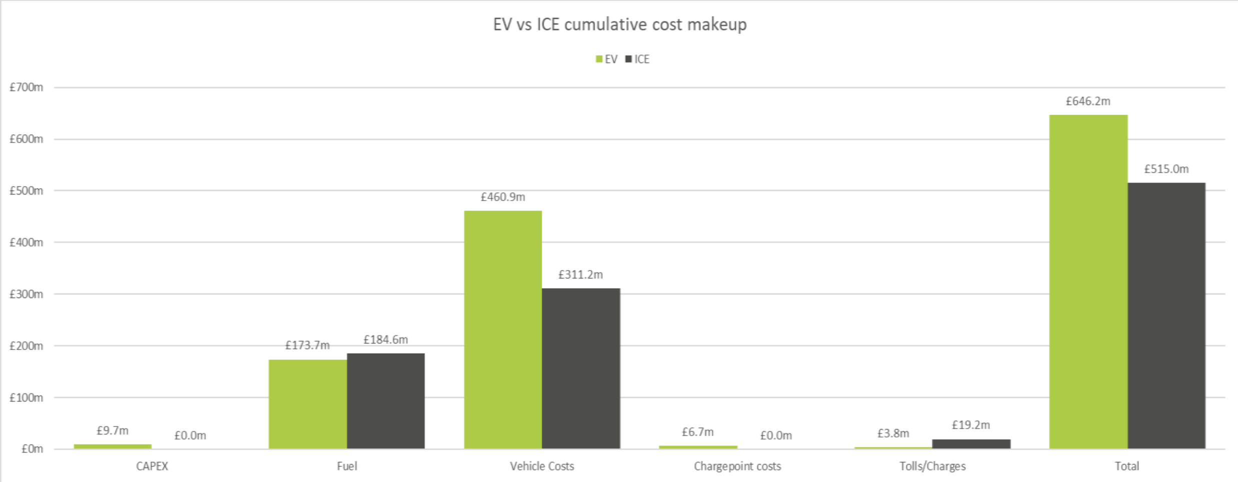


Figure 24 Cumulative fleet level cost makeup over eight years including flexibility revenue, EV vs ICEV, 2022



Whole fleet view conclusions

- In both the 2021 (shown in the Deliverable 5, albeit under some different market inputs) and 2022 scenarios, EVs work out more expensive than ICEVs. This is mostly resulting from large deltas in the monthly lease costs.
- Modelling the 2022 scenario has shown a significant negative change in the commercial environment for EVs compared with analysis using 2021 data. Considering the eight years view, the difference between the whole-fleet ICEV TCO and EV increases by ~£70m.
- Though EVs offer some financial benefits, such as lower running costs and advantages from reduced congestion zone payments, they are overshadowed by the differences in lease costs which currently prevents the EV fleet from reaching parity with an ICEV fleet. Importantly, some benefits from fuel and congestion charge avoidance are offset by the costs to install and maintain the home charging points.

3.2.3 Single vehicle overview

As well as comparing TCO at a whole-fleet level, Optimise Prime assessed the TCO at a single van level. Through analysis on a single van scale, it was possible to get a more detailed understanding of how the three primary options for powering Centrica's fleet differed in terms of their impact on TCO: diesel, public charging and home charging.

The single vehicle comparisons were also completed for both the 2021 (updated from that previously published in Deliverable 5) and 2022 scenarios. The TCO was run including and excluding the London Congestion zone charge.

In order that the average driver's typical electricity costs were fairly represented, blended costs of electricity (per kWh) were created for both public charging and home charging. For public charging, this blended cost takes into account prices for both rapid and ultra-rapid charging; for home charging, both smart and unmanaged charging schedules were blended.

3.2.4 2021 Home Charging vs Public Charging vs ICE

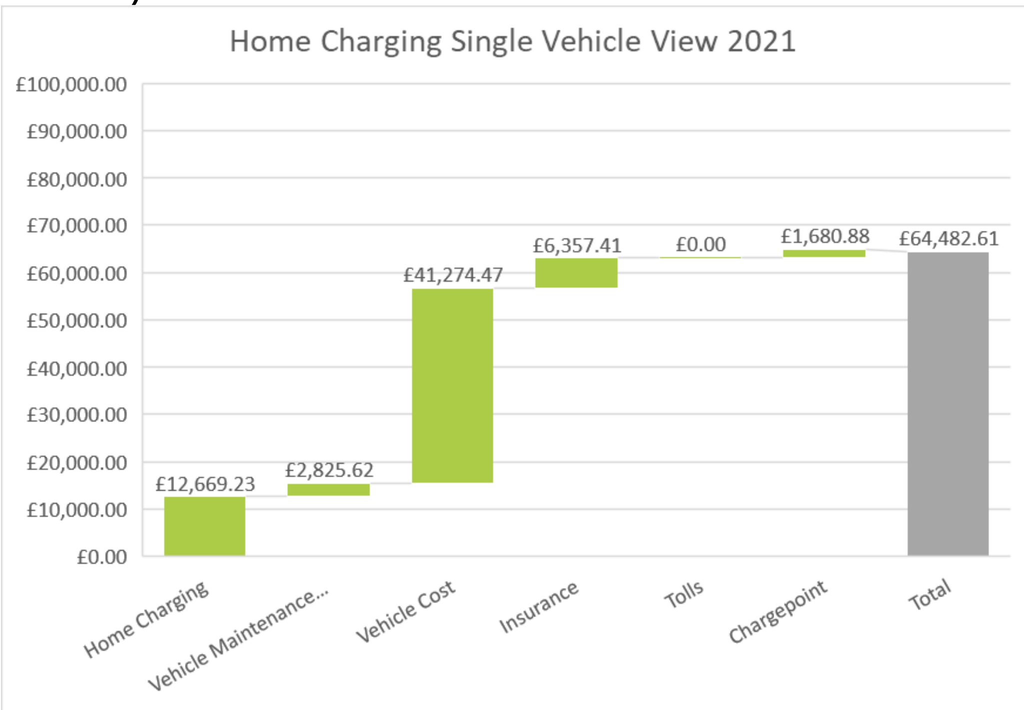
3.2.4.1 Vehicle Comparison 2021 (excluding London Congestion Zone)

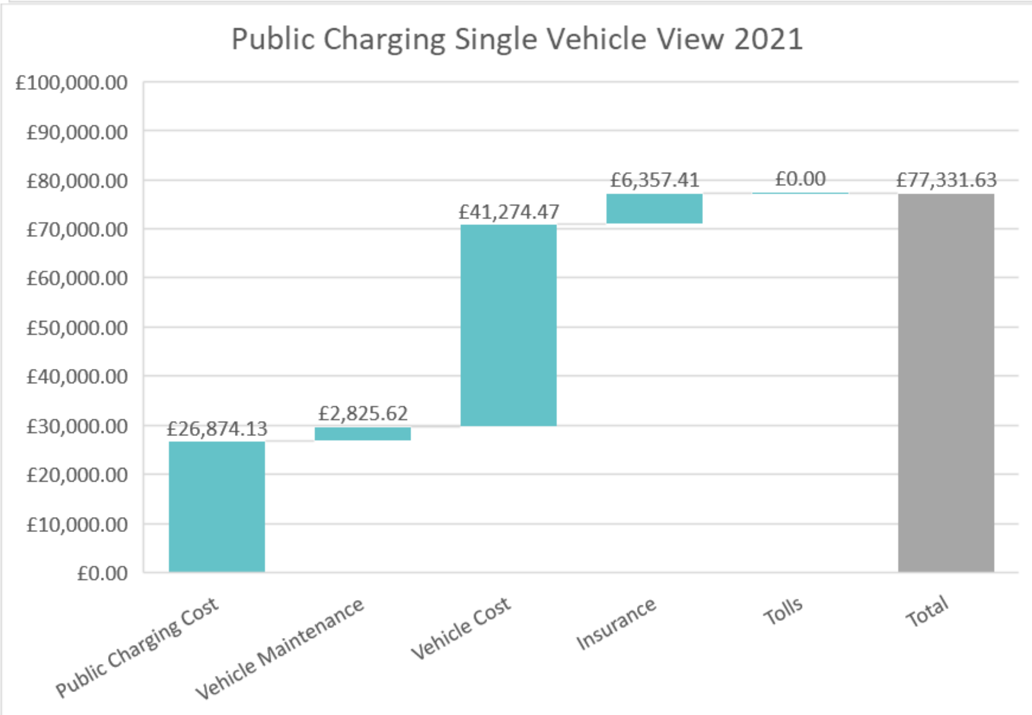
The majority of British Gas drivers (98%) operate outside the London Congestion zone, constituting 9,310 of the total 9,500 van fleet. As a result, the fleet has little cost saving benefit to be gained from toll zones, particularly as the Euro 6 engines used in the Vauxhall Vivaro remain exempt from having to pay the ULEZ zone fee.

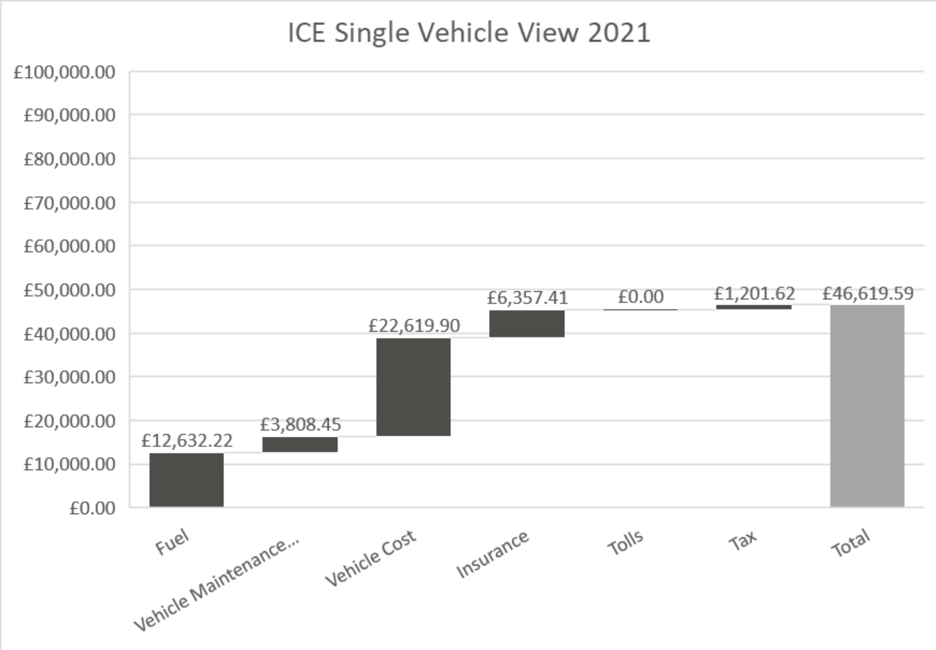
Home charging was the more cost-effective charging strategy for Centrica, working out nearly £13k cheaper per van when compared to public charging. However, neither yielded cost savings when compared to the diesel van while the Congestion Charge was excluded.

Without the London Congestion Charge, diesel vans were ~£17k cheaper across an eight-year lease compared with home charging EVs. This difference widened with public charging where diesel vans would be ~£30k cheaper across an eight-year lease, as shown in Figure 25.

Figure 25 – Single Vehicle TCO Comparisons – 2021 (eight years view, excluding London Congestion Zone)







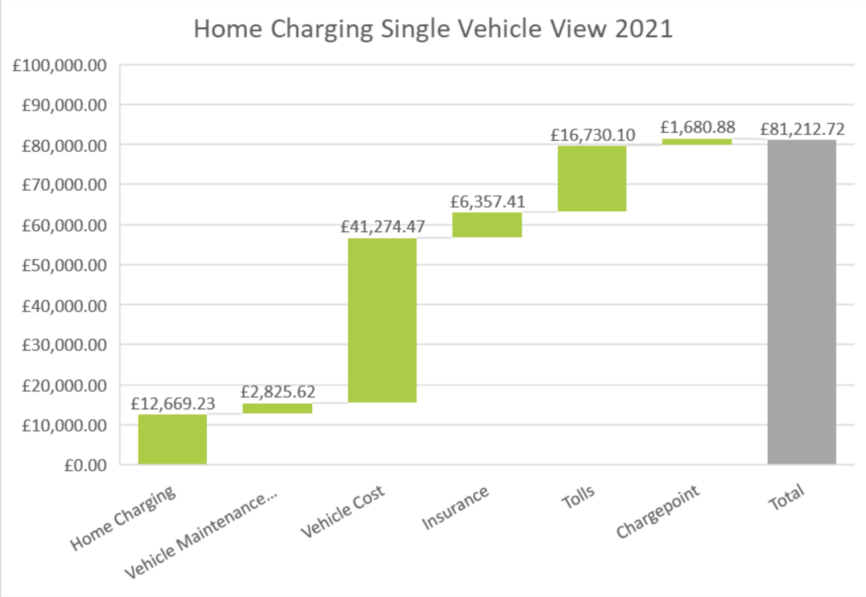
3.2.4.1.1 Single Vehicle Comparison – 2021 (eight-year view, inc. London Congestion Charge)

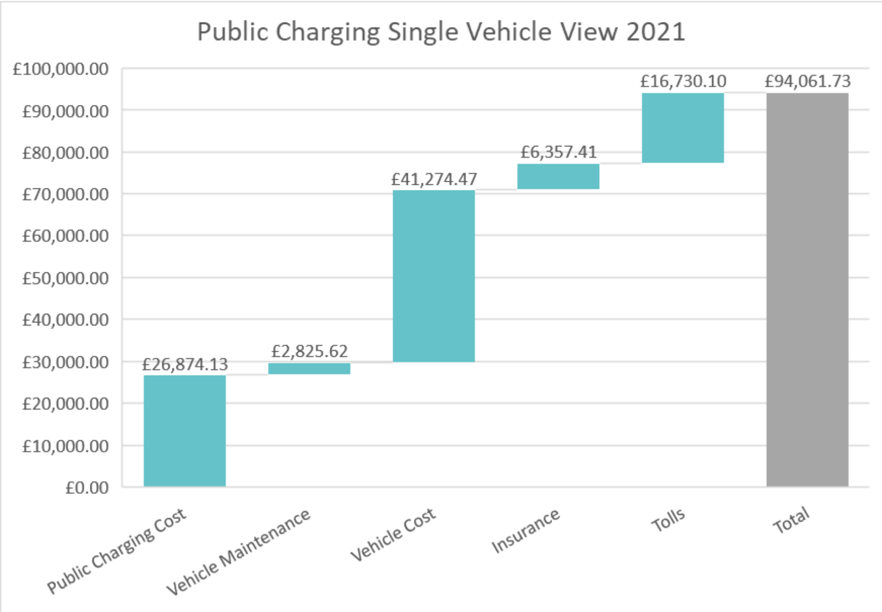
Approximately 190 British Gas drivers (2% of the total fleet) have to pay the Congestion Charge. This has a considerable impact on the TCO comparison.

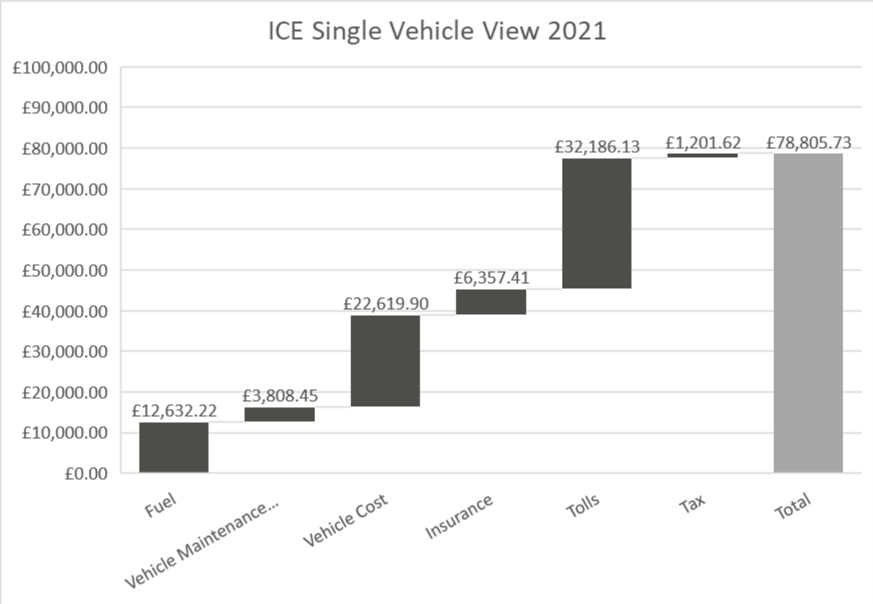
In 2021, with the London Congestion Charge included, there is a net loss of ~£2.5k per EV van compared with ICEV across an eight-year lease period. For a five-year period, EV delivers a net saving of ~£1.5k per van compared with ICEV. The larger savings for a shorter lease period result from the congestion charge exemption for EVs ending after year 2025. Thus, for a five-year view, the four full years of cost benefit out of a total five-year assessment make up a much larger proportion of the TCO than for an eight-year view, where the benefit for EVs only applies in the first four years.

The electricity cost for the public charging van was higher than for the home charging van. Therefore, even with the benefit of congestion charge exemption for EVs, the single vehicle view over eight years comes out as ~£15k more expensive than ICEV, as shown in Figure 26.

Figure 26 – Single Vehicle TCO Comparisons – 2021 (including London Congestion Zone)







3.2.5 2022 Home vs Public charging vs ICE

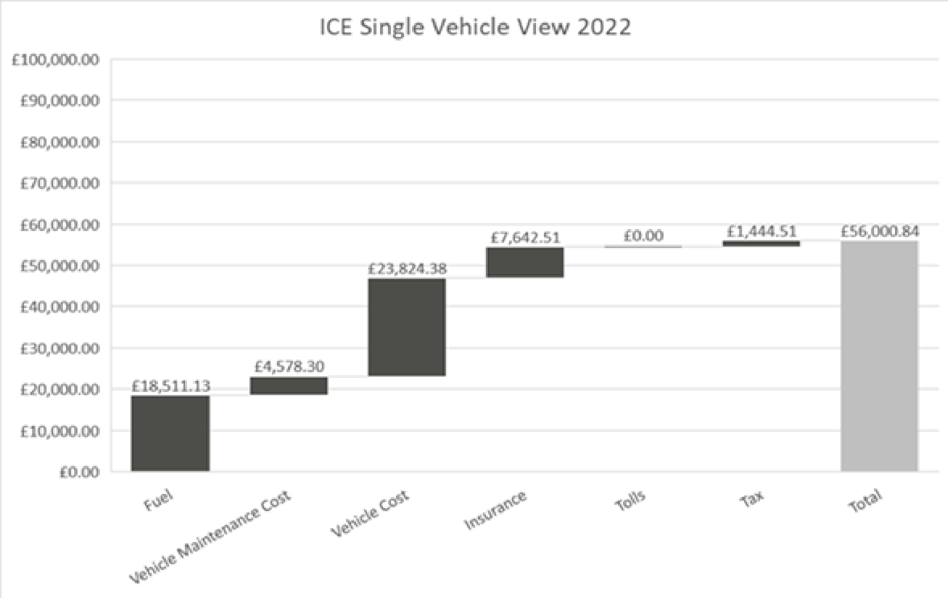
3.2.5.1 Single Vehicle Comparison – 2022 (excluding London Congestion Zone)

In the 2022 scenario, both the diesel van and the electric van are affected by increased costs to power the vehicle. However, the rise in price per kWh for electricity was more significant than the increase in cost for diesel fuel, as noted in the sensitivity analysis in section 3.2.7.

Using 2022 electricity prices, Table 12, for home charging, without the London Congestion Charge, there is a net loss of ~£11k over eight years compared against ICEV. Comparing a public charging EV van against an ICEV van, using 2022 electricity prices, there is a net loss of ~£22k over eight years (Figure 27).

As with the 2021 case, the absence of the congestion charge prevents either the public or home charging EV from reaching parity with ICEV. However, the OZEV subsidy expiry and the sharp rise in the price of electricity are also fundamental factors to this disparity between EV and ICEV.

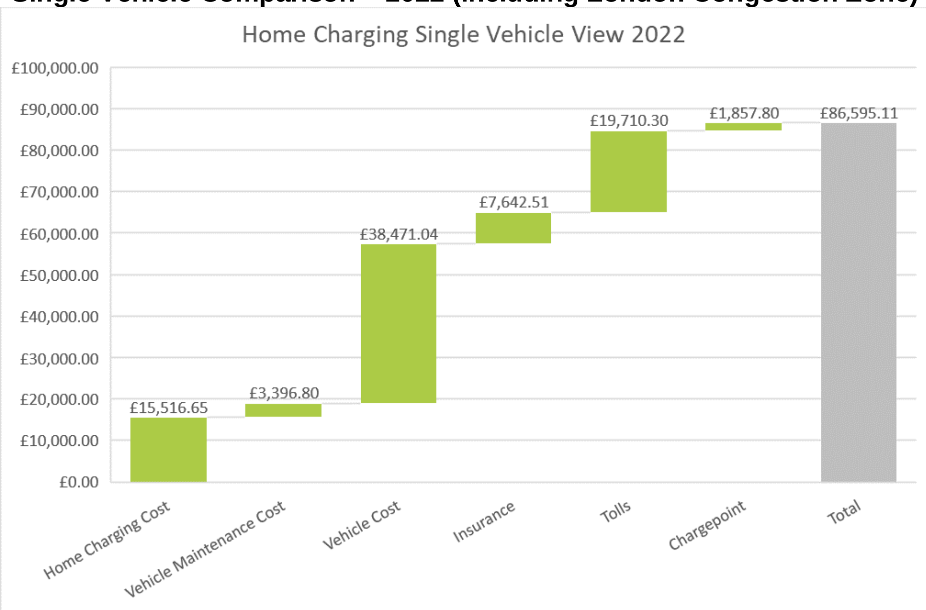
Figure 27 – Single Vehicle Comparison – 2022 (excluding London Congestion Zone)

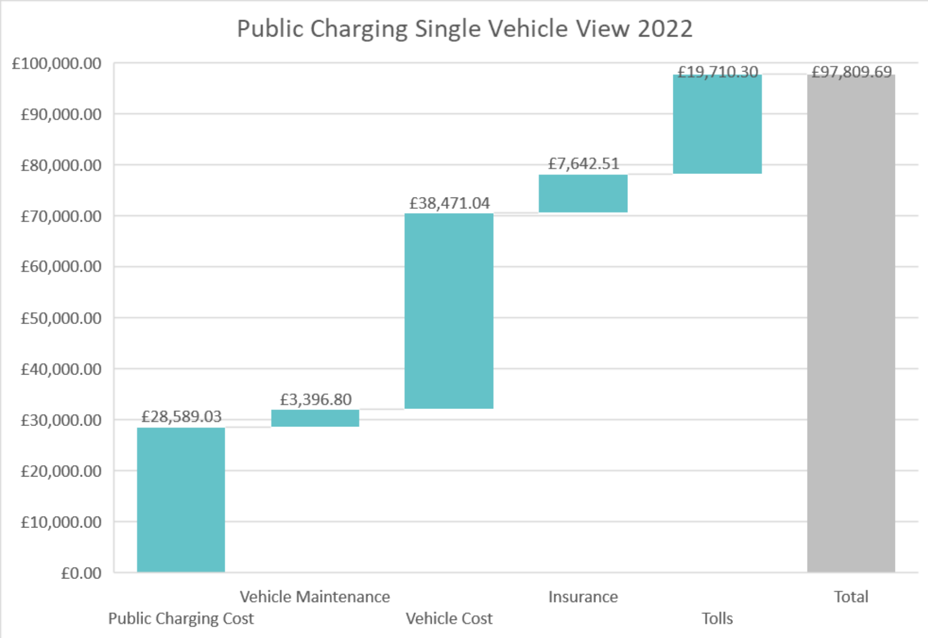


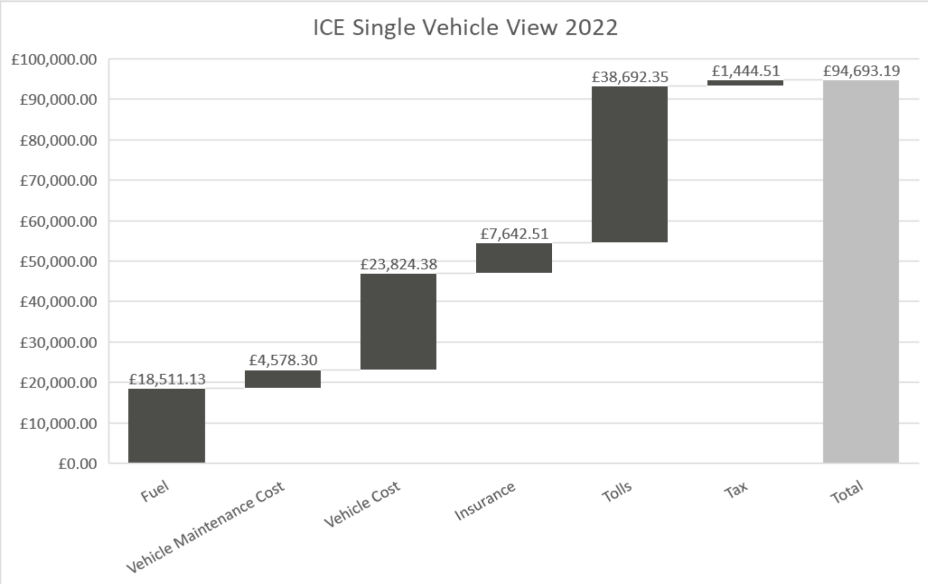
3.2.5.2 *Single Vehicle Comparison – 2022 (including London Congestion Zone)*

When the London Congestion Zone is included, these losses are less pronounced, and ICEV is no longer the most economical option in 2022. There is a net benefit of ~£8k for a home charging van compared to ICEV over eight years (Figure 28). For a single EV that is public charging, compared to an ICEV over eight years there is a net loss of ~£3k. With the benefit of the daily £15 charge for ICE vans until 2025, the EVs can be cheaper than ICEVs but only on a home-charging basis, due to the significantly cheaper home tariff per kWh when compared to public charging prices.

Figure 28 – Single Vehicle Comparison – 2022 (including London Congestion Zone)







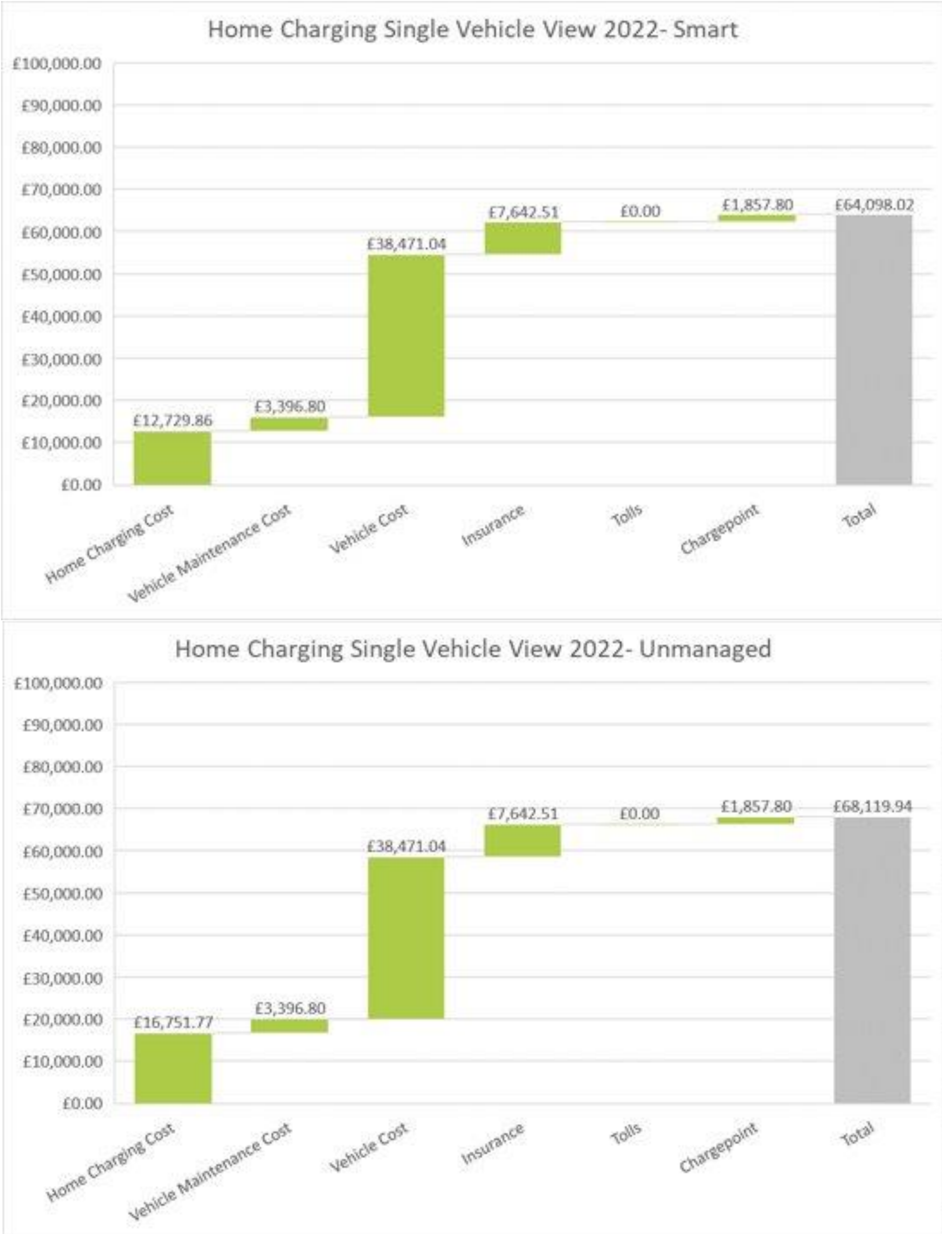
Single Vehicle Conclusions

- A home charging EV was consistently the cheaper option compared with public charging. This was mostly because of the cheaper cost of electricity at home rather than commercial prices at public charging stations.
- EVs only reached net savings against ICEV when the London Congestion Zone was included, showing the impact such policies make on EV adoption. However, this was only possible in the 2022 scenario as diesel prices are predicted to incrementally increase over the years while the electricity price is forecast to stay high for a couple of years only before wholesale prices start decreasing.
- The increased electricity prices and removal of the OZEV subsidy on home charging points have had significant impacts on the EV TCO.

3.2.6 2022 Single Vehicle View Unmanaged charging vs Smart Charging

The economic benefit that smart charging can yield for a home charging fleet was analysed (Figure 29). The cost of running an unmanaged charging schedule on a home charging van was compared against a van smart charging on an optimised schedule. For an unmanaged charging schedule, the van was modelled to charge 80% of the time on the more expensive daytime (£0.37 / kWh) tariff and the remaining 20% on the cheaper night-time tariff (£0.17 / kWh). A smart charging schedule was assumed to be the opposite of the unmanaged charging schedule, charging on the cheaper tariff 80% of the time and only 20% when prices were higher, as Table 13 outlines.

Figure 29 – Smart vs Unmanaged Charging Comparison – 2022



The conclusion is that a single EV charging at home can save up to ~£4k over the course of an eight-year lease using smart charging compared to an EV charging with an unmanaged schedule. This amounts to a 6% cost decrease for a single EV over eight years. For an entire EV fleet, smart home charging could amount to a £38 million saving, demonstrating that smart charging should be prioritised when electrifying as it can be effective at reducing OPEX costs.

There is a disparity between how many drivers Centrica would like to have on smart charging tariffs and how many it has currently. Currently, only 10% of Centrica's fleet are on time-of-use electricity tariffs, which are required to access smart charging benefits. Considering

Centrica's current charging case across the fleet, outlined in Table 13, if Centrica were to increase the percentage of those who smart charge from around 10% to 50%, there would be a ~£2m net saving over an eight-year window from £655 million to £653 million. If Centrica were to increase the proportion of the home charging vehicles that are smart charging to 100% there would be a saving of ~£8m over eight years.

Although smart charging can add immediate and significant economic benefit, this saving is small relative to the comparative cost of leasing the vehicles. **Figure 30**The vehicle costs shown in Figure 30 and Figure 31 demonstrate that the gap in lease prices between the ICEV and EV dictates that smart charging alone cannot lift EVs to TCO parity; even with up to 100% of the home-charging fleet smart charging, there is still a 20% cost deficit for ICEV.

Figure 30 – Impact of 50% Smart Charging on TCO – 2022

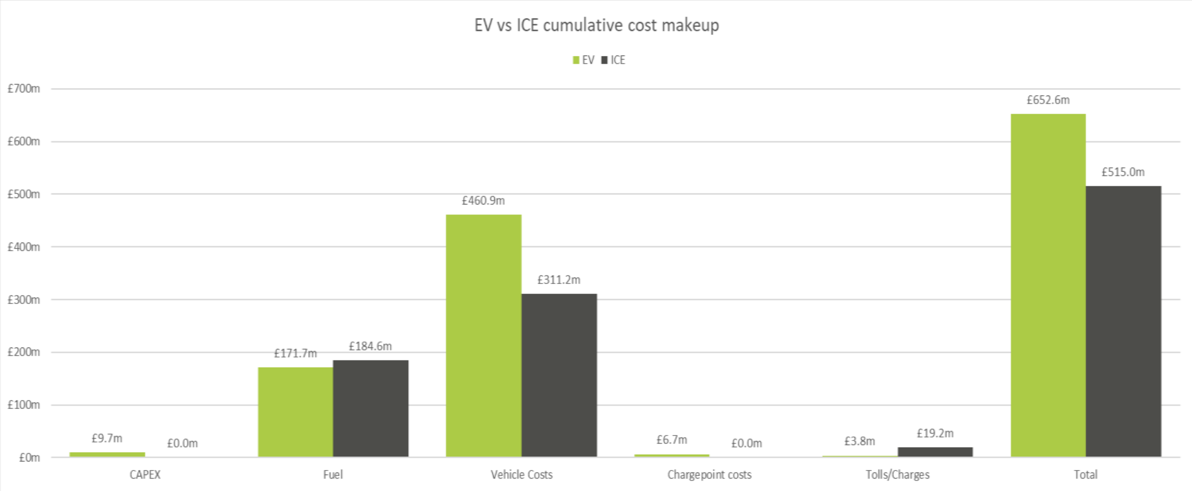
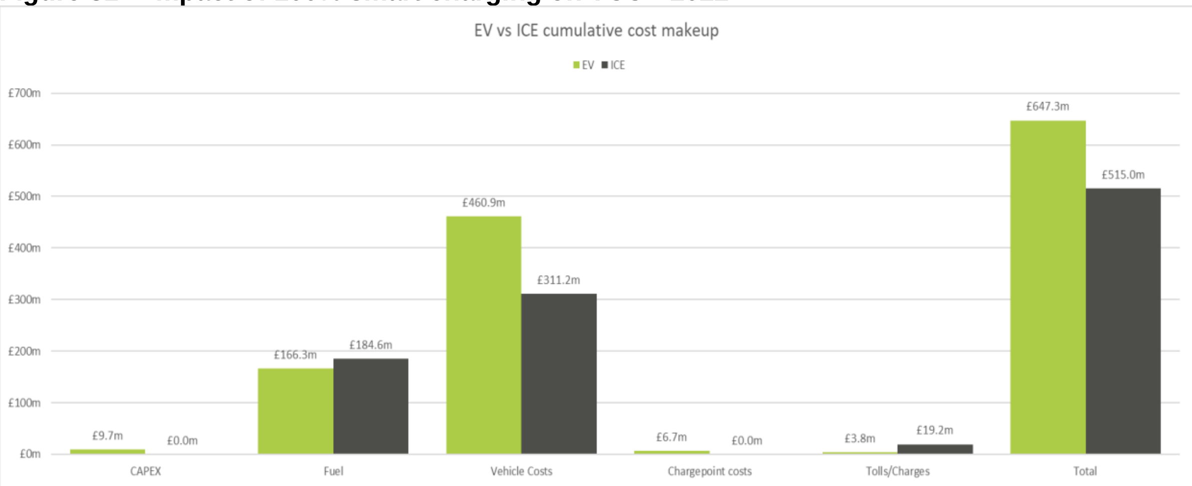


Figure 31 – Impact of 100% smart charging on TCO - 2022



Smart charging conclusions

- Smart charging can have a positive effect on EV TCO, however, with only 10% of the fleet being on an Economy 7 or similar time-of-use tariff, the saving from smart charging accounts for only 1% of the total cost. Expanding the percentage of the fleet that smart charge can result in large TCO savings when aggregated across the fleet.
- Smart charging alone is not sufficient to bridge the TCO gap between EV and ICEV because of the difference in lease costs.

3.2.7 Sensitivity Analysis

Sensitivity Analysis was conducted on the following variables in order to gauge which had the most influence on the overall TCO of Centrica's fleet. All charging options were included, and then the cost difference adjustments were made to key factors to explore the model's sensitivity.

3.2.7.1.1 Analysis Overview

The following variables were prioritised for the analysis, either to view their direct cost impact, or to allow comparison with other factors. They are summarised in Table 15.

Table 15 – Selected Factors for Sensitivity Analysis

Factor	Explanation
Baseline	Standard assumptions used, consistent with input from Optimise Prime partners
High electricity costs	Cost of electricity increased by 20%
Low electricity costs	Cost of electricity reduced by 20%
High fuel costs	Cost of diesel increased by 20%
Low fuel costs	Cost of fuel reduced by 20%
Low mileage	Mileage reduced to 50 miles per day (at the lower end of British Gas drivers' self-reported daily distances)
High mileage	Mileage increased to 120 miles per day (at the top end of British Gas drivers' self-reported daily distances)
Inc. London Congestion Zone	Daily London Congestion Zone charge included, including EV payments from 2025
High EV price	Monthly EV lease price increased by 20%
Low EV price	Monthly EV lease price reduced by 20%

A range of scenarios were tested. An ICEV scenario was used as a benchmark, and then three scenarios per charging type were designed to cover most of the types of charging strategy that the British Gas engineers would be operating for their EVs. The selected scenarios are summarised in Table 16.

Table 16 – Selected Scenarios for Sensitivity Analysis

ICE_ TCO (£)	EV Public Charging – Blended_ TCO (£)	EV Public Charging – Rapid_ TCO (£)	EV Public Charging- Slow_ TCO (£)	EV Home Charging – Blended_ TCO (£)	EV Home Charging- Smart_ TCO (£)	EV Home Charging– Unmanaged _ TCO (£)
Regular ICEV	Public charging EV using a blend (50:50) of electricity from rapid and slow CPs	Public charging EV using mostly rapid charging (80:20 rapid to Slow split)	Public charging EV using mostly slow charging (80:20 Slow to rapid split)	Home charging EV optimising their charging half of the time (50:50 smart and unmanaged charging)	Home charging EV following a smart charging schedule	Home charging EV following an unmanaged charging schedule

As can be seen in Figure 32 and Figure 33, The London Congestion Charge was shown to have a significant impact in influencing the TCO of an EV vs ICEV. When the Congestion Charge is included, all of the EV scenarios were cheaper than the ICEV apart from the Rapid charging EV. Although the Congestion Charge is due to expire in 2025, this analysis proved the Congestion Charge to be a strong economic measure that can incentivise EV adoption, which is an important consideration if other cities aiming to encourage low emission transport.

Similarly, a reduction in the lease price of EVs can improve its TCO, Figure 33. In the 2022 scenario, a 20% reduction in price resulted in a home charging EV on a smart, optimised charging schedule, to achieve parity with an ICEV, Figure 32. Moreover, in the high mileage scenario, home charging EVs (blended) also reach parity with ICEV, while smart charging at home can reduce the operational costs so EV becomes cheaper than ICEV. With EV OEMs building economies of scale, and with prices of batteries expected to fall over in the future, this should also improve the EV TCO.

Figure 32 – Sensitivity Analysis on a Single Vehicle Case – 2022

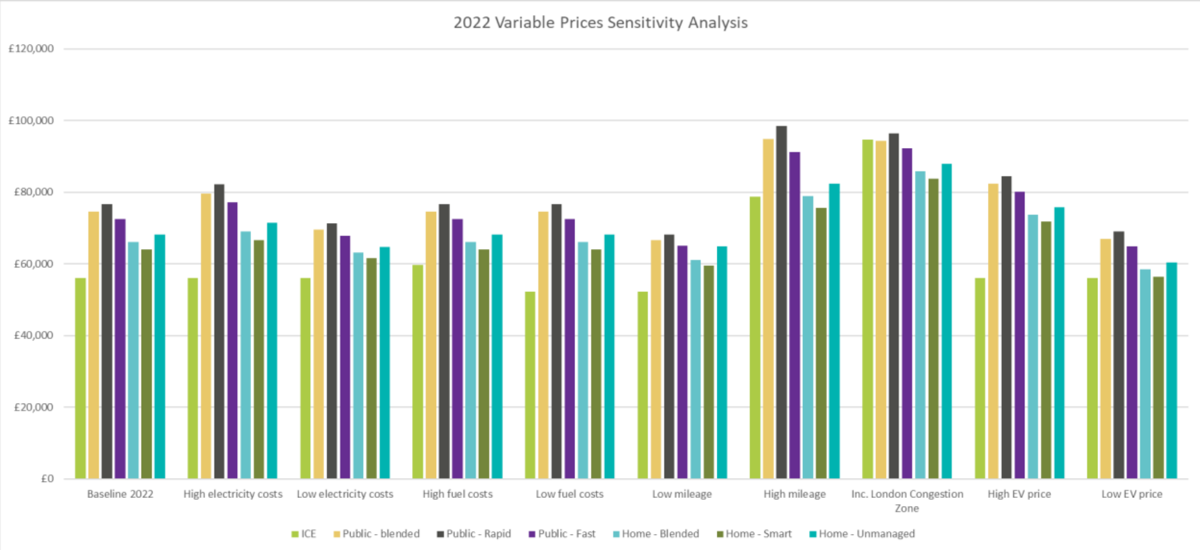


Figure 33 – Cost Impact from Analysis – 2022

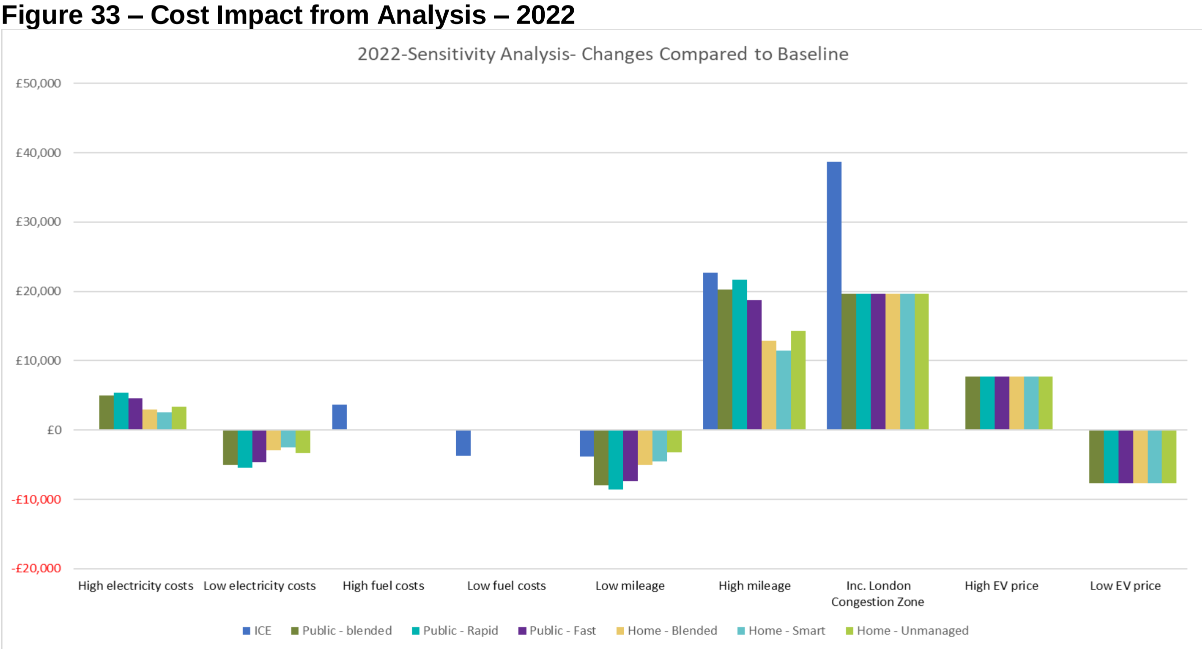


Table 17 – Data Supporting 2022 Sensitivity Analysis

	ICE - TCO	EV Public Charging-Blended TCO	EV Public Charging - Rapid TCO	EV Public Charging - Fast TCO	EV Home Charging - Blended TCO	EV Home Charging - Smart TCO	EV Home Charging - Unmanaged TCO
Baseline 2022	£56,000	£74,604	£76,701	£72,507	£66,109	£64,098	£68,120
High electricity costs	£56,000	£79,623	£82,139	£77,106	£69,057	£66,644	£71,470
Low electricity costs	£56,000	£69,585	£71,263	£67,908	£63,161	£61,552	£64,770
High fuel costs	£59,703	£74,604	£76,701	£72,507	£66,109	£64,098	£68,120
Low fuel costs	£52,299	£74,604	£76,701	£72,507	£66,109	£64,098	£68,120
Low mileage	£52,201	£66,627	£68,137	£65,117	£61,030	£59,583	£64,891
High mileage	£78,725	£94,832	£98,418	£91,246	£78,987	£75,548	£82,425
Inc. London Congestion Zone	£94,693	£94,314	£96,412	£92,217	£85,819	£83,808	£87,830
High EV price	£56,000	£82,298	£84,395	£80,201	£73,803	£71,792	£75,814
Low EV price	£56,000	£66,910	£69,007	£64,813	£58,415	£56,404	£60,426

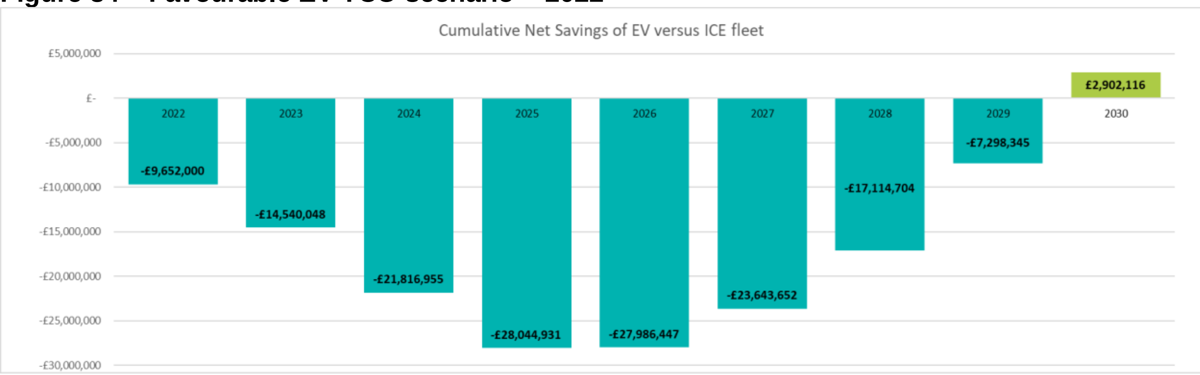
3.2.7.2 *2022 Lease cost sensitivity analysis – What's needed today for significant savings?*

For 2022, a 39% reduction in lease price is required to deliver parity between the vehicle technologies. This would require the cost of leasing an EV van to reach £244 per month and would result in savings of ~£3m across the fleet over an eight-year period, Figure 34. Across the whole fleet over eight years, at 2022 electricity prices, there would need to be a £12 million reduction in EV lease costs to yield significant savings compared with ICEV.

Sensitivity Analysis conclusions

- The most impactful factor on EVs reaching TCO parity with ICEVs is the lease price, as this is the largest part of the total cost.
- Congestion charges were also shown to be influential EV incentives leading to price parity with ICEV in all except the rapid public charging case.
- Significant lease cost reductions would be required to yield net savings for EV (a reduction in monthly lease costs of 39%) if the relative costs of electricity and fuel do not change.
- EV TCOs have on average experienced price rises double that of ICEVs, and in some cases the prices have increased by three times more than ICEV, due to recent volatility in electricity prices.

Figure 34 – Favourable EV TCO scenario – 2022



3.3 *Summary of Key Learnings*

Reducing the lease price between 20%-30% using 2021 prices is necessary for EV to be at a competitive level compared to ICEV TCO. Due primarily to increased electricity costs in 2022, lease costs would now need to fall by 30-50% to reach TCO parity.

The sensitivity analysis presented in D5 showed that a 19% decrease in EV price is sufficient for approximate parity under 2021 conditions. The 2022 case presented here demonstrated that a 39% decrease in EV lease price would be required to reach parity with ICEV and could yield close to £3m in savings across the fleet. This would require large shifts in pricing from OEMs and/or leasing providers, however, is likely that reductions in lease prices would need to be accompanied by other cost saving measures – such as capitalising on smart charging for the home charging vehicles – in order to reach a realistic case where EV could be on a par with ICEV.

The electricity price increases in 2022 have made the commercial case for transitioning to an EV fleet more uncertain

Cost of electricity for the EVs increased by ~£3k for a home charging van, and ~£2k for a public charging van across eight years. Although electricity prices are expected to come down in future, the sensitivity of the model to electricity price highlights the importance of smart charging and flexibility to offset potential volatility.

Government subsidies and charges can make a significant difference to EV business cases

Based on the assumption from available forecasts that electricity prices will reduce over the next few years, if more cities start to introduce congestion charge zones, as seen in London, there may be additional savings in the future for EV fleets. An example of this is in Oxford, which will have an expanded zero emission zone and a £2 to £10 per day fee for all vehicles that are not 100% emission free, this could help swing the balance back towards electric in this region. The sensitivity analysis concluded that the EV benefit from congestion charging was the most influential factor on operating costs. Maximising the scope of this policy is likely to encourage adoption.

Smart charging and flexibility can improve EV TCO competitiveness, although this is not always possible for home-based fleets

A smart charging EV was consistently the most cost-effective option in the TCO assessment. If Centrica could ensure that even half of its home charging fleet were smart charging, then they could achieve savings of around £7m. Further, participation in flexibility events could add around £8m in revenue (assuming 50% of the fleet participate). Optimising charge schedules for predominantly home-based charging fleets around time-of-use tariffs, and identifying opportunities for flexibility delivery, should be priority.

4 Total Cost of Ownership from a Mixed Fleet – an example of a driver on the Uber platform

4.1 Introduction

The Uber TCO aims to model the total costs of owning and operating PHV on the Uber platform, comparing a petrol baseline vehicle to an electric model. Unlike with Royal Mail and Centrica, this model is based on a single vehicle view rather than a fleet view, due to the nature of Uber's business model where the vehicle and operational costs are covered by the drivers. This TCO helps to understand the decision-making of Uber drivers when selecting a vehicle, however, the behavioural surveys highlighted that EV price is one of the main barriers to switching to EVs (see Appendix 5 for more detail).

4.1.1 Persona approach

Five main Uber driver personas were created, based on data obtained from the questionnaire results. The personas are then split into different scenarios, which represent the options available to each persona in terms of vehicle purchase or leasing options.

1. **New ICE**: is a full-time Uber driver who buys or leases a Toyota Prius as it is the vehicle the driver has been driving and they enjoy the convenience of refuelling. The driver understands there will be a switch to EVs at some point in the future but is not prepared to be one of the first to do it. The driver thinks finding a place to charge an EV and longer stops will mean a longer working day with fewer paid trips.

The New ICE persona represents a reliable TCO comparison baseline because of the availability of data on new vehicle pricing, leasing and financing deals in the market. However, this persona represents a minority of Uber drivers, who typically tend to buy second-hand vehicles.

2. **New EV – Home CP**: buys or leases an EV and has a CP installed at home. It is convenient for the driver to charge at home, meaning a full "tank" every morning. The driver selects a Kia eNiro as a reliable, long-range EV – avoiding the current congestion charges and reducing fuel costs. Despite mostly charging at home, on occasion the driver will need to charge at a rapid CP in the city (from questionnaire results and data science results, this is roughly 25% of the total electricity used each year).

3. **New EV – Public CP**: buys or leases an EV despite not having off-street parking at home. The driver believes the public charging infrastructure in London will be convenient enough to cover energy needs during the day and does not mind making a few extra trips and occasionally waiting while the vehicle charges up. While the fuel cost differential compared to an ICEV is not as high as charging at home, there are advantages in avoiding the congestion charge and receiving incentives from Uber for the completed EV trips.

The above EV personas (New EV – Home CP/Public CP) represent a group of early adopters, who thus far account for the minority of Uber drivers.

4. **Second-hand ICE**: buys a second-hand ICEV to keep a low initial investment, and to avoid a longer-term commitment on a financing or leasing deal. The driver does not have off-street parking and is reluctant to consider a new EV for this reason. The driver would definitely consider buying a used EV, as this would mitigate the high up-front purchase cost or high fixed cost of a financing or a leasing deal for a new EV, but the second-hand EV market is limited so they have not done so yet. If the driver switched to an EV, the

driver would need to rely on public charging, but is concerned about the availability and reliability of public CPs.

5. **Second-hand EV – Public CP**: is a part-time Uber driver who wants to switch to an EV because they are conscious about urban air pollution and believes more customers will be choosing green transport options. As driving hours and income are unpredictable, the driver wants to avoid the commitment of a long-term financing deal or a high fixed cost of a leasing deal. The driver monitors the growing second-hand EV market for a reliable, recent model, with the expectations that some older EV models may not have the required battery size, range and reliability. Charging is at public charging stations.

Second-hand ICEV drivers represent the largest group of current Uber drivers. The Second-hand EV persona represents an ideal and realistic scenario from a TCO point of view, with lower initial investment and lower running cost compared to ICEV, however, only a small portion of drivers fall into this category due to limited supply of suitable used EVs and inconsistent access to suitable public charging infrastructure.

4.1.2 Main inputs, outputs and assumptions

The main model inputs and outputs are detailed Table 18 and Table 19 and summarised in Figure 35. These were discussed and validated with Uber, who provided guidance based on internal research and data. Changing key inputs, such as fuel and electricity costs, home vs public charging, vehicle power efficiency, and mileage driven, it is possible to run different scenarios based on the personas described above. Some key assumptions remain unvaried for each scenario, such as the London Congestion Charge of £15 per day and inflation rates. This is further discussed in the sensitivity analysis section.

- **Vehicle choices:** based on input from the Uber Clean Air team, the vehicle choices include two ICEVs and three EVs. These reflect the most used ICEV, which is the Toyota Prius, and the EVs showing the strongest uptake by Uber drivers: the Kia eNiro 2, and the MG5. The second-hand vehicle choices are a Toyota Prius 2015 and a Nissan Leaf 2018. See Table 19 for more detail on costs and power efficiencies for these vehicles.
- **Power efficiency:** the fuel and power efficiencies were obtained from real-life mileage databases for city-driving (Table 19), to obtain a more realistic range to accurately calculate operational costs. While WLTP ranges are industry-standard, they often do not reflect the achieved mileage ranges due to traffic conditions, temperature, driver behaviour, and other factors.
- **Tolls/charges:** based on input from the Uber Clean Air team, as well as trip data analysed by the Optimise Prime data science team, Uber drivers often drive within London's Congestion Zone. As a baseline, it has been assumed that a driver will enter the Congestion Zone on 75% of the days driven per year. Currently, the Congestion Zone charge exemption for EVs is due to end at the end of 2025, meaning that EV drivers in this model will start paying the charge from January 2026.
- **Distance driven:** assumed 50,000km per year driven by Uber drivers, which was validated by the Uber Clean Air team. Sensitivity analysis will also show how an increase or decrease of driving mileages would affect the TCO.
- **Percentage of times charged at public CP:** a small percentage of drivers will be able to install a CP at home. Additionally, drivers who charge at home may need top-up charges during their shift. For this reason, EV Home CP persona uses public CPs 25% of the time, while EV Public CP always uses public CPs. This in turn affects their total electricity costs.
- **TCO period:** a period of five years was selected based on the high vehicle utilisation by Uber drivers.

Figure 35 – Inputs and outputs of the Uber TCO model

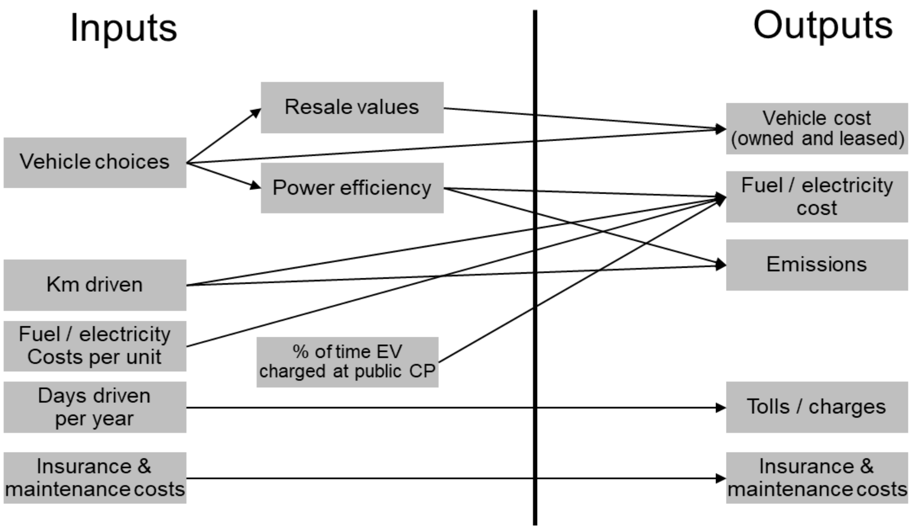


Table 18 – Baseline operational assumptions for Uber TCO. All assumptions updated as of 22 September 2022

Key assumptions	Inputs	Sources
Home CP cost	£859.00	Uber partner website (EO charging) – OZEV grant excluded.
Km driven per year	50,000	Uber input
Days driven per year	250	Uber input
Fuel efficiency (L/100km) – ICEV	3.7	Hitachi research based on WLTP ranges and expected real range (average of user inputs based on city driving). 3.7 for new ICE, 5.6 for older ICE.
Power efficiency (Wh/km) – EV	236	Hitachi research based on WLTP ranges and expected real range. EV database. Varies based with model of EV (see table 20)
ICEV maintenance cost per month	£61.42	Online PHV-driver forums, Hitachi research Increased by 30% for second-hand vehicles
EV maintenance cost per month	£42.99	Online PHV-driver forums, Hitachi research Increased by 30% for second-hand vehicles
Petrol fuel cost (£/L)	£1.66	Gov stats 26/09/2020 https://www.gov.uk/government/statistics/weekly-road-fuel-prices
Electricity home charge cost (£/kWh)	£0.28	April's 2022 Price Cap
Electricity public charge cost (£/kWh) – Blend of charger rates	£0.61	September 2022 Electric Vehicle Market Metrics – Cornwall Insight
% of energy utilised at public CP	EV home CP = 25% EV public CP = 100%	Hitachi estimate based on data science and questionnaire results
Vehicle resale value after five years (% of vehicle purchase price)	20% for new, 33% for second hand	Hitachi research on used vehicle prices, averaged across multiple sources and vehicle types
Yearly insurance cost	£2,500.00	Uber input, Hitachi research Reduced by 40% for second-hand vehicles
Vehicle financing terms	Five-year contract at 7.9% APR, £5,000 down-payment	Hitachi research. Assumed same rates for ICEV and EV for comparability.

Table 19 – Vehicle cost assumptions for the Uber TCO model[13]

Vehicle choice	Cost (owned)	Lease cost (monthly)	Power efficiency (Wh/km)	Fuel efficiency (L/100km)
Nissan Leaf EV N-Connecta 40kWh	£29,995.00	£992.00	138	NA
MG5 EV Long Range Exclusive 60kWh	£27,250.00	£1,079.00	140	NA
Kia e-Niro 2 EV 64kWh	£34,995.00	£1,122.00	136	NA
Second-hand Nissan Leaf EV Acenta (2018) 40kWh	£19,290.00	NA	140	NA
Toyota Prius	£25,000.00	£949.00	NA	3.7
Second-hand Toyota Prius	£13,500.00	NA	NA	5.6

4.1.3 Opportunity cost of rapid vs ultra-rapid charging

Currently, charging EVs takes longer than refuelling an ICEV. For Uber drivers, a significant stop represents an opportunity cost when not accepting paid trips. When in need of charging, Uber drivers in London have two main options: a rapid CP with a maximum output of 50kW, or an ultra-rapid CP which can output up to 150kW. Table 20 shows the opportunity cost of charging, given a £25/hour revenue estimate for Uber drivers in London. While the ultra-rapid CP costs more per unit, the total cost of charging when considering foregone revenue is higher for a rapid CP. This effect is more pronounced in slower CPs, which would keep a driver stopped for significantly longer time. However, it needs to be noted that not all vehicles can charge on ultra-rapid CP, therefore, consideration of opportunity costs should be taken into account when selecting appropriate EV mode.

When analysing results for the EV Public CP persona, opportunity cost will be discussed as an additional cost component to the EV TCO.

Table 20 – Opportunity cost of rapid and ultra-rapid charging

Cost Type	Rapid CP (50kW)	Ultra-rapid CP (150kW)
Cost per kWh (Average Market Prices - CI)	56p	67p
Time taken to charge a 64kWh EV from 20% to 80%	45 mins	15 mins[14]
Charging cost	£21.28	£25.46
Opportunity cost	£18.75	£6.25
Total cost (including opportunity cost)	£40.03	£31.71

The opportunity cost of charging is reduced when EV drivers are able to combine charging with a regular break – this is discussed further in the behavioural section of this report, Appendix 5, section 3.3. Additionally, it is beneficial for EV drivers to charge the vehicle fully between shifts (e.g. overnight) at a cheaper public on-street slow/fast charger, and only utilise rapid chargers to top-up during the day when required.

It should be noted that the majority of Uber drivers charge between shifts either at their own CP, or more commonly, at public charging infrastructure close to their home location. The

[13] Efficiencies sourced from https://ev-database.uk/
[14] EV must be capable of accepting 150kW charge rate to charge in this time

proportion of drivers charging off-shift is expected to continue to grow as battery capacity and vehicle range increases with new EV models.

4.2 Overview of results

Table 21 summarises the headline results from the Uber TCO model, split by the different personas and scenarios. The five-year TCO can be used to compare between ICEV and EV costs, with further scenarios such as leasing, financing, and second-hand vehicles.

4.2.1 Summary of key findings

Five main persona comparisons are analysed in the results section, with the following key learnings:

- **New ICE vs New EV – Home CP (outright purchase):** Given the initial higher CAPEX of the EV and the CP installation, the EV remains the more expensive option in the first two to three years of its lifetime. Savings in congestion charges and running costs mean a lower TCO for EV compared to ICEV over the five-year TCO period.
- **New EV – Home CP vs New EV – Public CP (outright purchase):** public charging increases operational costs of driving an EV, yet the TCO remains beneficial towards EV owners compared to ICEV over the five-year term. However, the opportunity cost of public charging can be up to £15,625 over the five-year period when top-up charging every shift, thus reducing the net benefit to opposite. Nonetheless, with the increase in battery size in new EVs, the expectation is that charging on-shift will reduce considerably, therefore, opportunity costs will be less of a consideration.
- **New EV – Public CP (outright purchase vs. leasing and financing):** Leasing or financing may be the most likely choice for PHV drivers when switching from a second hand ICEV to a new EV. Despite the initial CAPEX being lower, the high leasing costs mean a higher five-year TCO compared to EV ownership.
- **Second-hand ICE vs Second-hand EV – Public CP (outright purchase):** pre-owned vehicles had the lowest TCOs: The lower vehicle costs meant the operational savings from the EV made up for the initial CAPEX gap of £5,800 between the second-hand Toyota Prius and the pre-owned Nissan Leaf. The opportunity cost of public charging can be reduced if top-up charging is conducted during rest breaks.

Table 21 – Overview of Uber TCO results for different scenarios

Persona	Scenario	Scenario description	5-year TCO (£1,000s)	Initial CAPEX investment (£1,000s)
New ICE	New ICE – Outright purchase	Toyota Prius bought with no financing	75.3	25
	New ICE – Leasing	Toyota Prius, leased	91.4	0.5
	New ICE – Financing	Toyota Prius, financed	82.0	5
New EV – Home CP	New EV – Home CP – Outright purchase	Kia eNiro 2 bought with no financing. Home charging (75% of total energy usage)	61.6	35
	New EV – Home CP – Leasing	Kia eNiro 2, leased	82.2	0.5
	New EV – Home CP – Financing	Kia eNiro 2, financed	71.1	5

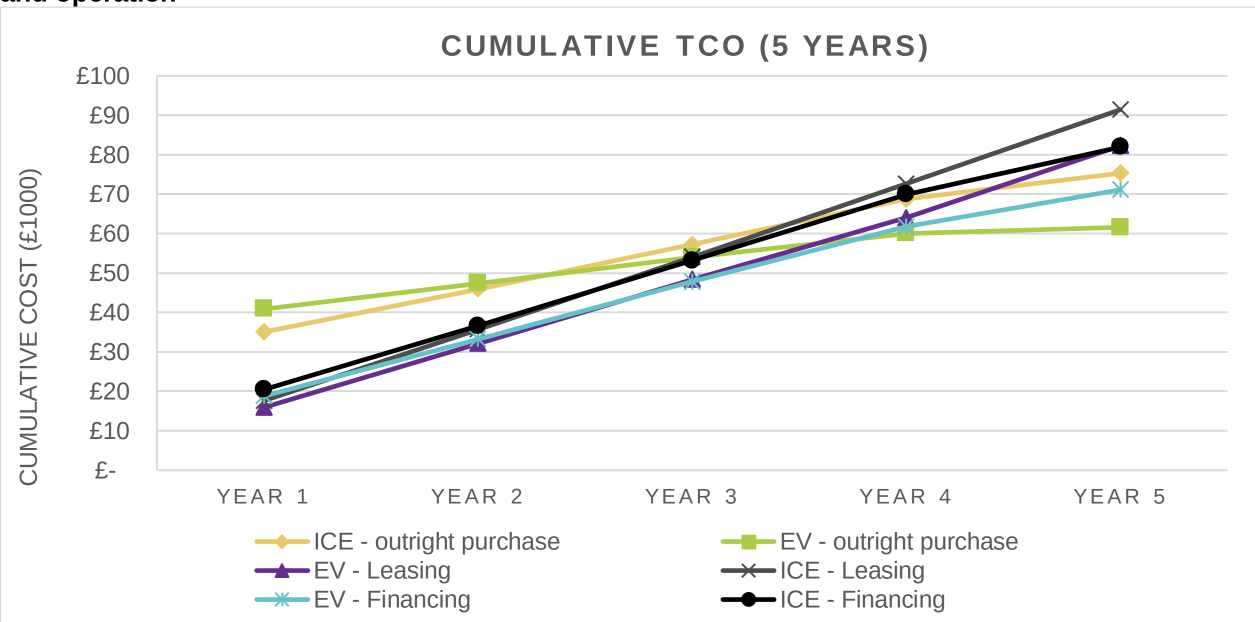
Persona	Scenario	Scenario description	5-year TCO (£1,000s)	Initial CAPEX investment (£1,000s)
New EV – Public CP	New EV – Public CP – Outright purchase	Kia eNiro 2 bought with no financing. Public charging	68.0	35
	New EV – Public CP – Leasing	Kia eNiro 2, leased. Public charging	88.6	0.5
	New EV – Public CP – Financing	Kia eNiro 2, financed. Public charging	77.5	5
Second-hand ICE	Second-hand ICE – Outright purchase	Pre-owned Toyota Prius, bought with no financing	61.3	13.5
Second-hand EV – Public CP	Second-hand EV – Public CP – Outright purchase	Pre-owned Nissan Leaf	51.2	19.3

4.3 Scenario comparisons

4.3.1 Persona comparison: New ICE vs New EV – Home CP

This analysis explores the comparison of a five-year TCO for a new ICEV and a new EV with a home CP, under different financing scenarios (outright purchase, leasing and financing). While the outright purchase is an unlikely option for drivers, it provides an initial like-for-like comparison between EV and ICEV.

Figure 36 – Cumulative TCO over five years for different scenarios of Uber vehicle ownership and operation



As shown in Figure 36, given the initial higher CAPEX of the EV and the CP installation, the EV remains the more expensive option in the first two to three years of its lifetime when purchased outright.

Figure 37 – Breakdown of five years TCO for New ICE – outright purchase and New EV – Home CP – outright purchase scenarios

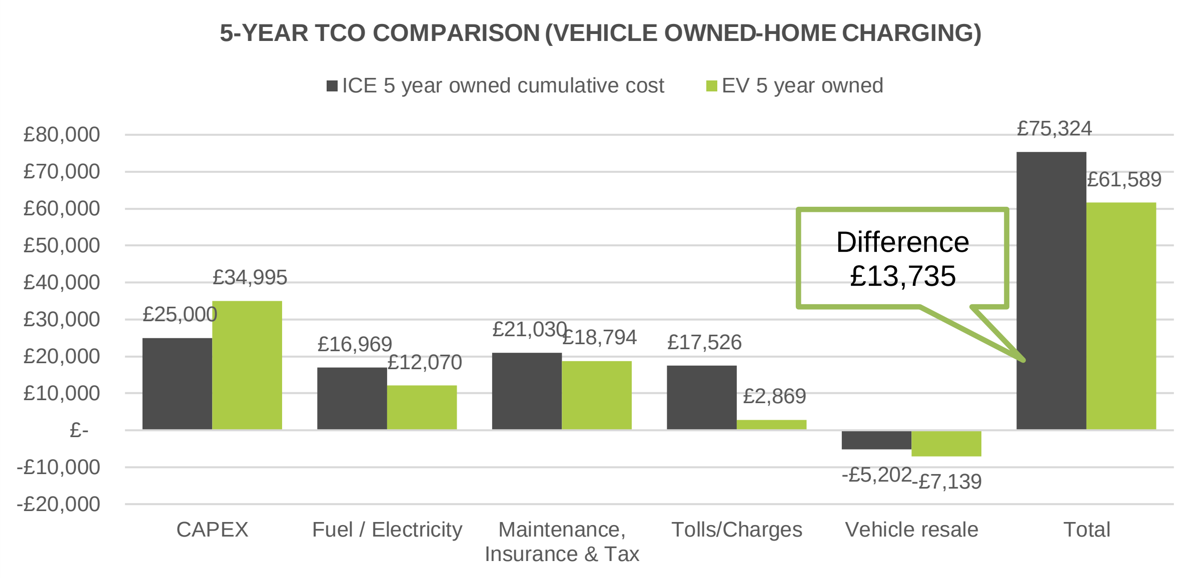


Figure 37 shows the breakdown of costs over five years comparing the outright purchase scenario of a new ICEV vs. a new EV with a home CP. Tolls and charges create the largest difference between the scenarios due to the exemption of EVs from the London Congestion Charge Zone until the end of 2025: there is a net difference of £14,657 between those applying to ICEV vs. EV. Assuming calculations start at the beginning of 2022, the benefit accrues over the first four years of EV ownership. Despite a higher initial investment, the net saving for EV through tolls recoups the extra investment required for EV in OPEX savings.

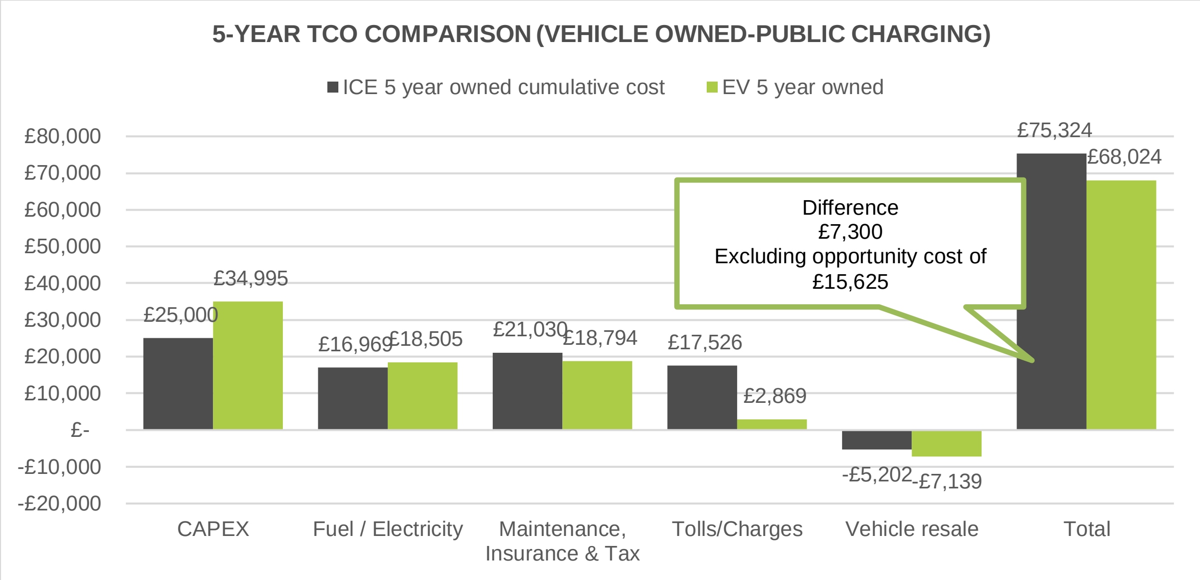
Despite a rise in electricity costs in 2022, the EV remains cheaper to charge than an ICEV is to refuel under the home CP scenario. Under the public charging scenario charging becomes more expensive than refuelling, nonetheless, the TCO for EV still remains cheaper than ICEV. This is based on a public charging cost of 61p/kWh and a home charging cost of 28p/kWh (as of 2022), but also based on Cornwall Insight predictions where wholesale electricity prices will start to decrease from 2023 while petrol and diesel will continue to gradually increase (based on the historic UK fuel prices). The difference in fuel costs is thus the second highest, after Tolls/Charges, in the five-year TCO, creating savings of £4,899 across five years in home charging case.

Key learning: When comparing the outright purchase of a new EV and a home CP to a new ICEV over five years, the TCO for the EV is 18% lower despite the initial CAPEX being 40% higher. The higher CAPEX is offset by savings in congestion charges and running costs, resulting in a payback of two to three years for the EV compared to an ICEV. A leasing deal on the EV would offer more flexibility and reduce the initial CAPEX, but results in a five years TCO being 34% higher than outright purchase for the New EV – Home CP persona and 9% more expensive than an outright purchase of a new ICE.

4.3.2 Persona comparison: New EV – Public CP vs New EV – Home CP – outright purchase

The New EV – Public CP persona, shown in Figure 38, does not have off-street parking and so must charge on public CPs 100% of the time. A major difference in this scenario is therefore a higher overall electricity cost, up by 53% compared to the New EV – Home CP persona. The CAPEX is also affected by the CP installation costs. This signifies a reduction in the TCO gap between ICEV and EV outright purchase, now down to £7,300 over the five-year period compared to £13,735 for New EV – Home CP persona.

Figure 38 – Five year TCO for New EV – Public CP persona – outright purchase



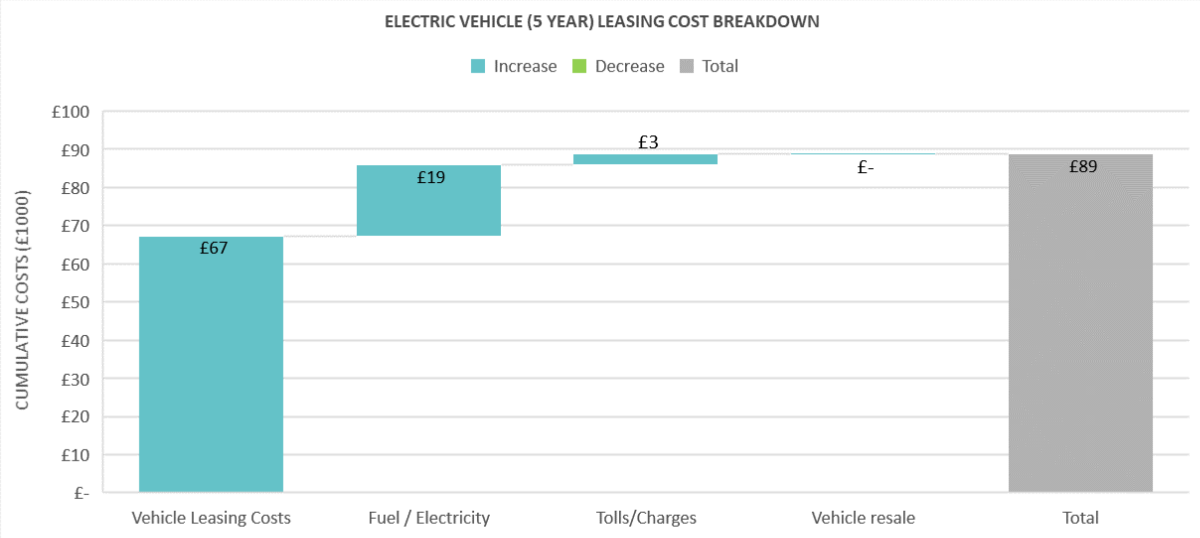
The time spent public charging while on shift also results in an opportunity cost of not accepting Uber trips, which has not been factored into the TCO model. The size of the opportunity cost changes depending on whether the driver is able to charge the EV overnight, on-street, near their home, or whether they rely entirely on the rapid charging network. In the latter scenario, the New EV – Public CP persona would top-up charge once per day, thus spending 45 minutes charging (c.30 minutes longer than a petrol stop), for a total opportunity cost of £15,625 over the five-year TCO period assuming an average hourly income of £25. This net cost reduced to £3,906 over five years if only some top-up charges are required (25% of the time).

Key learning: public charging reduces the TCO benefit of EV compared with ICEV regardless of finance option, but EV remains advantageous over the long-term. However, factoring in the opportunity cost of time spent public charging rather than driving can add as much as £15,625 over the five-year period, tipping the TCO balance against EV. To reduce the opportunity cost, it is necessary for the public charging infrastructure to be easily accessible and reliable.

4.3.3 Persona comparison: New EV – Public CP – Outright purchase vs. Leasing vs. Financing

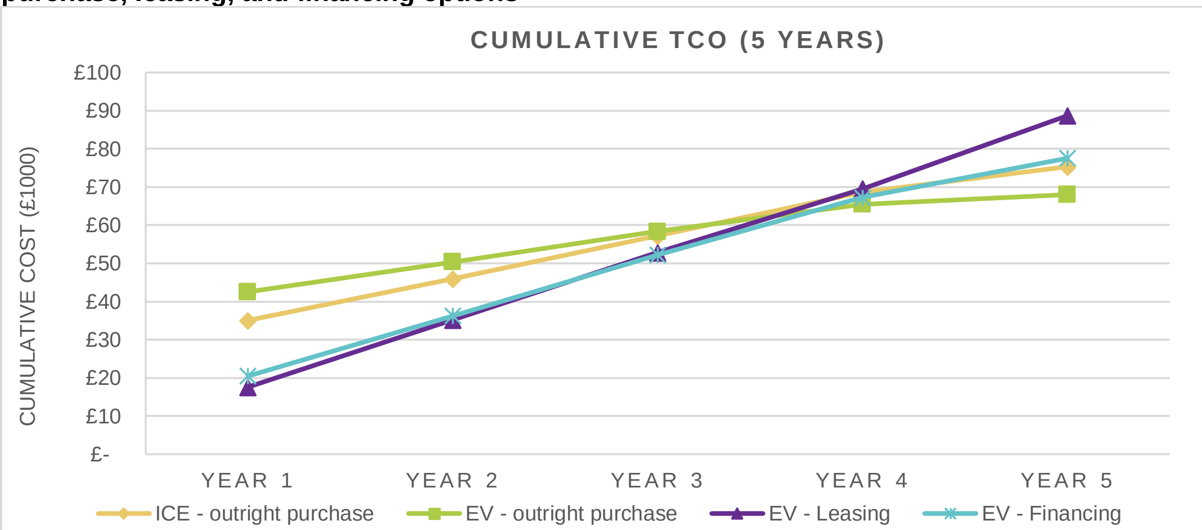
Many Uber drivers opt for leasing a vehicle rather than a cash purchase or financing option, to avoid a high initial investment and allow for flexibility on their contract. Most leasing companies also offer insurance, tax and maintenance included in the monthly lease price. This means a higher overall TCO, with a different split between fixed and variable costs: as seen in Figure 39, the vehicle leasing costs alone reach £67k over five years for the New EV – Public CP persona. This constitutes over 75% of the total TCO and represents a fixed monthly cost for Uber drivers regardless of their utilisation – this may be a barrier for drivers whose income is variable and difficult to forecast. An advantage of a leasing deal is that it can usually be terminated early, offering some level of flexibility should the circumstances change.

Figure 39 – Five years TCO breakdown for New EV – Public CP persona – leasing



The financing option falls in between cash purchase and leasing: monthly repayments plus interest mean a higher TCO than the outright purchase, but lower than a leasing option, with a total TCO of £77,546 for the New EV – Public CP persona (see Figure 40 for comparison to other ownership models). This is a popular option for Uber drivers who have access to finance, as it allows a low CAPEX investment while gaining ownership of the vehicle after the repayments are made. At the same time, termination of financing arrangements usually attracts penalties, making it a less flexible option than leasing. The questionnaire analysis section discusses some of the difficulties for Uber drivers to access financing options for their vehicles.

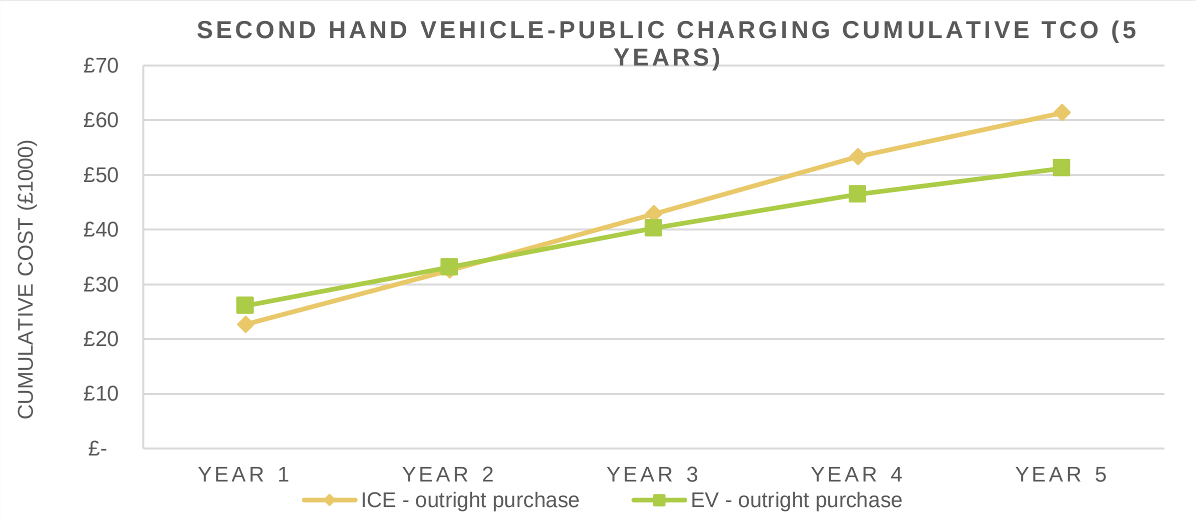
Figure 40 – Cumulative five-year TCO comparison for New EV – Public CP persona outright purchase, leasing, and financing options

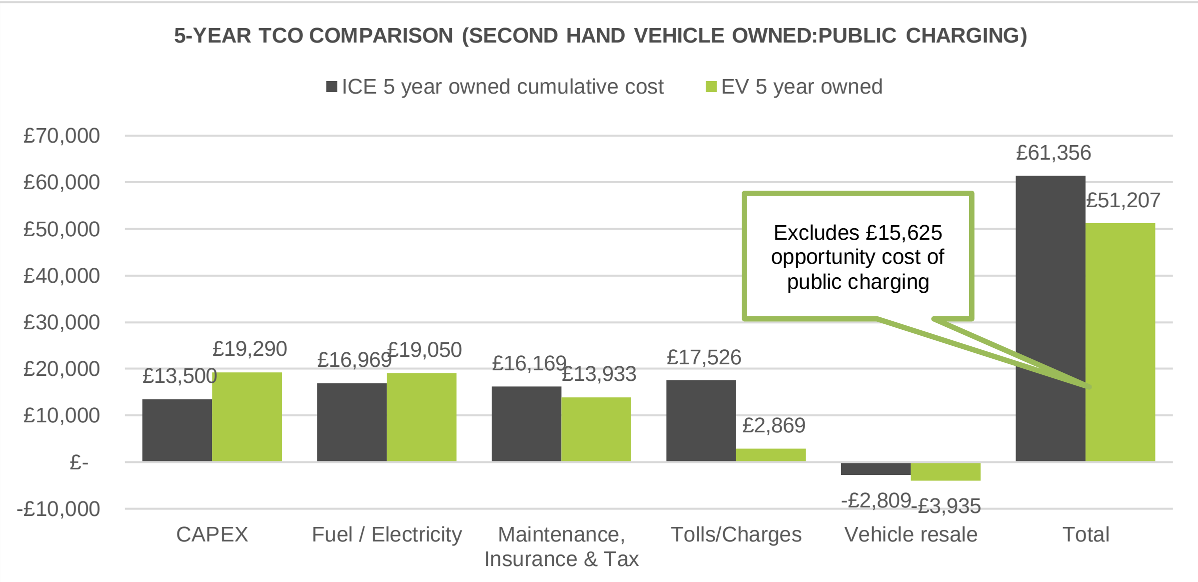


Key learning: Leasing and Financing are the most likely choice for PHV drivers switching to EVs due to the lower upfront CAPEX cost. However, the high leasing and financing costs mean a higher five year TCO compared to an outright EV or ICEV purchase.

The scenario analysed in Figure 41 is a comparison between second-hand ICE purchase and second-hand EV – public CP. This like-for-like comparison would be ideal for Uber drivers, given the popularity of second-hand vehicles as a lower CAPEX option. However, the unavailability of used EVs suitable for PHVs is preventing rapid uptake from the drivers. The second-hand ICE is modelled as a Toyota Prius 2015 model, bought for £13,500, with related lower fuel efficiency of 5.6L/100km and lower vehicle resale value, as well as higher maintenance costs, but lower insurance. The second-hand EV is a Nissan Leaf 2018 bought for £19,290. When factoring in the opportunity cost of public charging, the EV TCO reaches £66,832, thus cancelling out the difference between the two TCOs and making the EV more expensive than the ICEV.

Figure 41 – Cumulative TCO comparison between Second-hand ICE and Second-hand EV – Public CP outright purchase personas





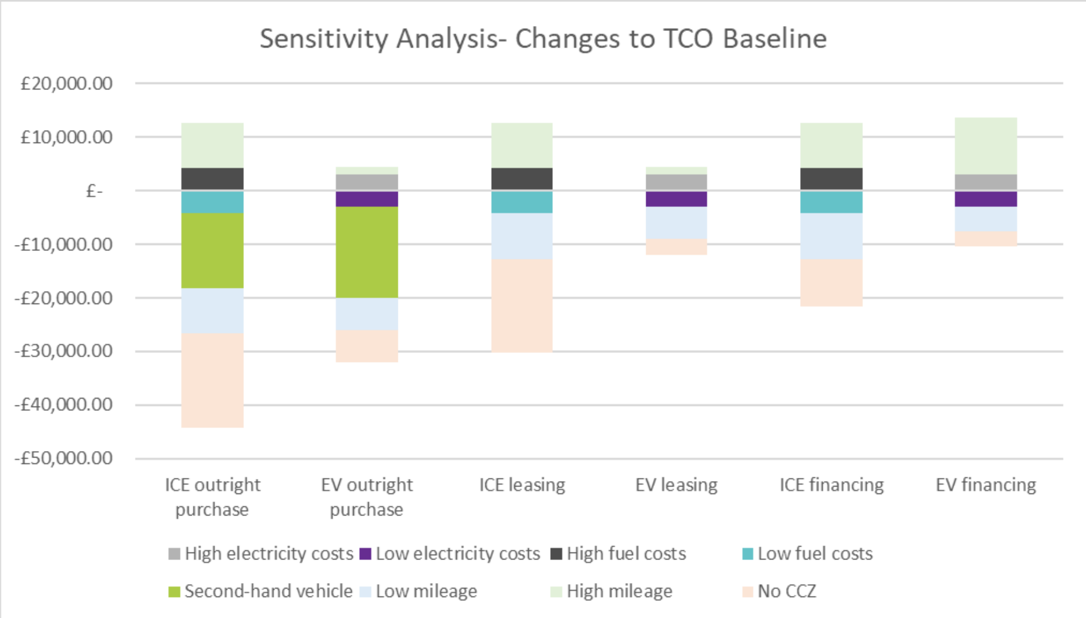
Key learning: this like-for-like comparison shows the potential of second-hand EVs in the PHV market: lower CAPEX reduces barriers to entry, and parity with ICEV TCO is achieved in year one, which encourages more risk-averse drivers to make the switch. However, currently a lack of affordable second-hand EV options remains a barrier for the majority of PHV drivers. The opportunity cost of public charging shows the importance of reliable rapid CPs within the city.

The most likely scenario given the lack of available second hand EVs, comparing a second-hand outright-purchase ICEV and a leased new EV, shows a TCO of 45% higher for the New EV – Public CP driver.

4.4 Sensitivity analysis

The sensitivity analysis below (Figure 42) compares the five-year TCO results for the different personas and scenarios covered in this report. Each scenario (second-hand, mileage, electricity costs, and congestion charge) has a positive or negative impact on the TCO for each persona. It should be noted that the graph illustrates the impact of each factor on the baseline independent of other factors. Some factors will be interdependent, for example the impact of changes in fuel cost increases with higher mileage.

Figure 42 – Sensitivity analysis – TCO changes for different personas and scenarios, compared to their respective baselines

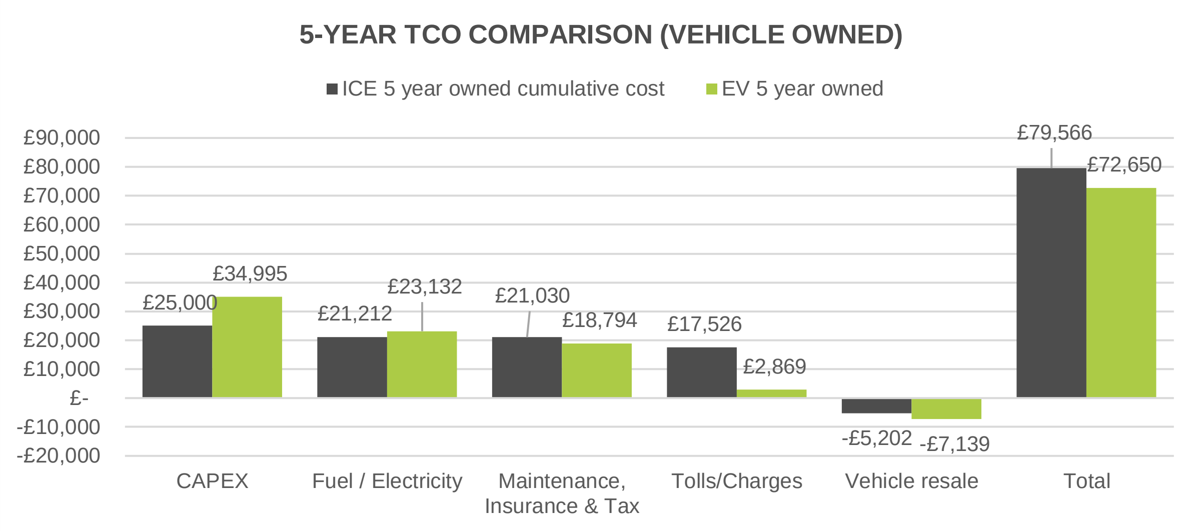


As expected, selecting a second-hand vehicle, no congestion charges zones and driving fewer miles have the highest impact on the five-year TCO. Second-hand vehicle purchase reduces the TCO by 19% on ICEV and 28% on EV outright purchases. The low mileage scenario reduces the TCO by 11% and 10% for ICEV and EVs respectively. The next highest TCO reduction is from lower fuel and electricity costs which reduce the TCO by 5% on EV and by 6% for ICEV outright purchase, compared to the baseline scenarios. These findings reflect the fact that the highest cost components are the vehicle purchase price and the main operational costs of fuel and electricity.

4.4.1 25% higher fuel and electricity prices

The model is sensitive to fuel and electricity prices only if the prices do not change to the same degree. If electricity prices were to rise by a further 25%, this would increase the EV Public CP persona TCO by 7%. A 25% increase in fuel prices would have a similar impact on TCO, 6%. The EV TCO remains lower than ICEV if both fuel and electricity priced increased by 25%, for all models of ownership (Figure 43) and in the outright purchase scenario the EV TCO would remain lower than ICEV TCO if electricity prices increased by 25% while fuel prices did not change.

Figure 43 – Breakdown of costs for 25% higher fuel and electricity price scenario (New ICE and New EV – Public CP personas (outright purchase))

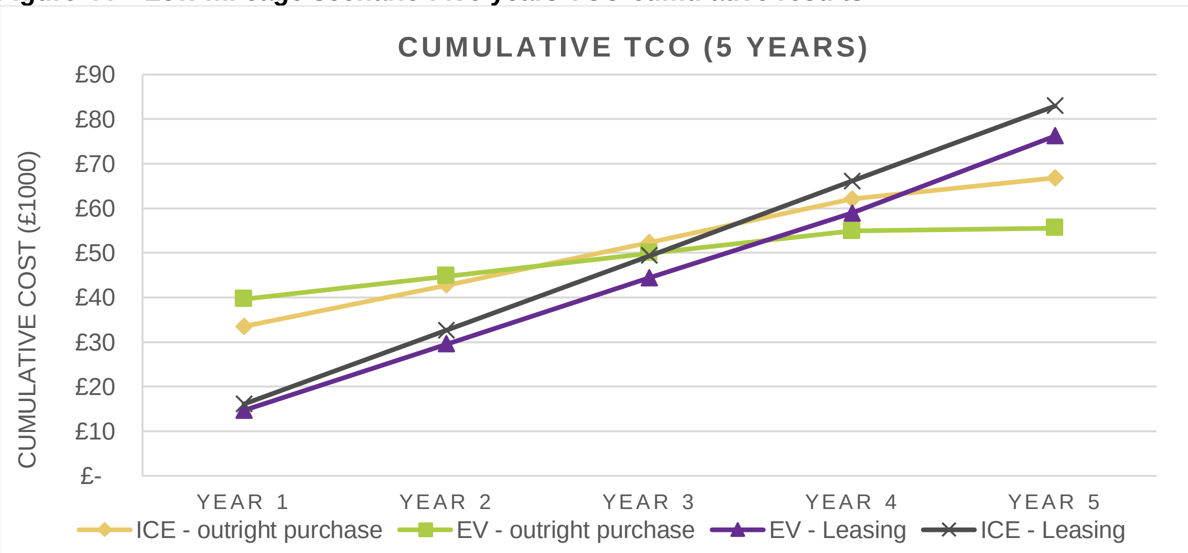


4.4.2 Distance and days driven per year

A change in kilometres driven per year is combined with a higher or lower number of days driven in central London within the Congestion Zone. This affects the toll costs section for petrol vehicles, with a high sensitivity towards the TCO.

The model is highly sensitive to kilometres driven per year. As the model excludes any revenue generated through Uber trips, a higher mileage will directly correlate to a higher TCO due to increased usage. However, the proportion of fixed and variable costs changes significantly, as fixed costs such as lease payments or insurance remain constant while fuel and electricity vary. Higher mileage also favours the EV TCO compared to the ICEV, as long as the difference between electricity and fuel prices remains constant or increases. At 25,000 km and 200 days of driving per year, the EV Home CP persona breaks even with the New ICE persona after year two (Figure 44). This can be an important consideration for PHV drivers when assessing their vehicle options.

Figure 44 – Low mileage scenario Five years TCO cumulative results



4.4.3 Congestion Charge Zone

At £15 per day, the congestion charge represents a significant cost for ICEV Uber drivers in London. Across the five-year period, a non-EV driver could expect to pay nearly £15,000 in tolls if entering the Zone 75% of the operational days. EV drivers are exempt from the congestion charge, generating a significant saving compared to ICEV counterparts. However, this exemption is due to end in December 2025. For this reason, the EV TCO includes an element of congestion charge payments from January 2026 onwards.

In the sensitivity analysis results above (Figure 42), the No CCZ scenario symbolises a driver who rarely enters the congestion charge zone – only 25 days per year. In this case, the New ICE TCO is lower than the New EV – Public CP TCO regardless of the ownership model thanks to savings of £17,526 over the five years – a 23% reduction in TCO on the ICEV outright purchase, or 19% on vehicle leasing.

4.4.4 Vehicle Tax

Vehicle tax has less effect on the TCO model: ICEVs pay £140 in the first year of ownership, and £160 every year thereafter. EVs are currently exempt from Vehicle Excise Duty – meaning a saving of £793 (including inflation) over the five years TCO period.

Key learning: the congestion charge exemption is a key factor in reducing operational costs for EV drivers. Availability of suitable second-hand vehicle will also play a crucial role in the TCO for EV PHV drivers.

4.5 Emissions analysis

The graphs in Figure 45 and Figure 46 display the cumulative and yearly carbon equivalent emissions comparing ICEV and EV, under baseline scenario conditions, for a single driver and vehicle. A timeline to 2030 was chosen in order to capture the reduction in EV charging emissions based on the National Grid's electricity generation mix.

Figure 45 – Cumulative CO2e operational emissions from vehicle use

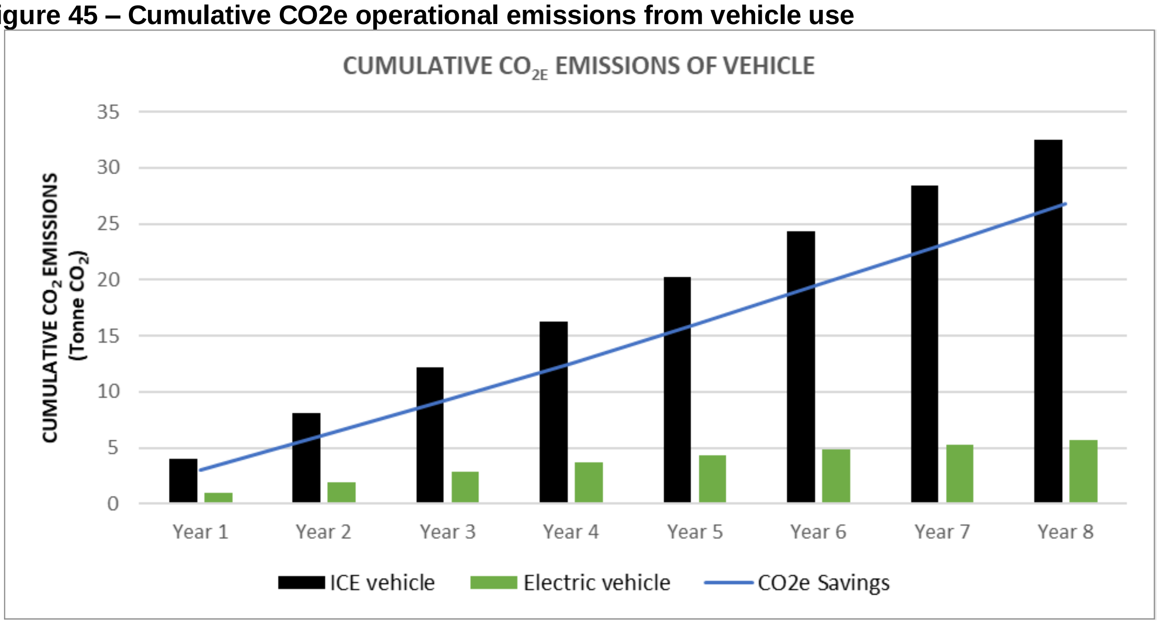
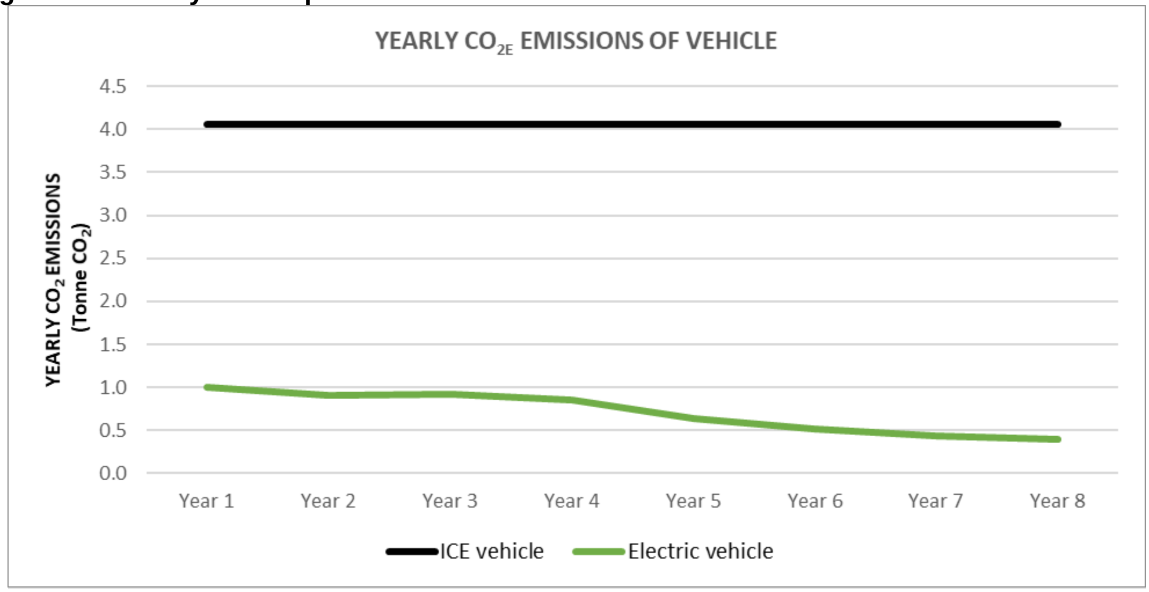


Figure 46 – Yearly CO2e operational emissions from vehicle use



ICEV yearly emissions remain stable until 2030, at around four tonnes of CO2e, reflecting the direct link between petrol usage and vehicle emissions. EV usage emissions are more complicated and variable, as they reflect emissions from electricity generation. As seen in the chart above, EV yearly emissions from electricity use are predicted to decrease from a baseline of one tonne of CO2e to 0.45 tonnes in 2030, based on National Grid ESO's Future Energy Scenarios. Over the five-year TCO period, the difference in emissions between the ICEV and EV will be of 16 tonnes of CO2e given 250,000km driven.

4.6 Key learnings from the Mixed-fleet TCO

The outlook on the Uber TCO is encouraging, with most like-for-like scenarios leading to a lower five-year cost for EVs compared to ICEVs despite a higher vehicle cost. However, a lack of affordable and available second-hand EV options remains a barrier to achieving breakeven with non-EV models for the majority of PHV drivers.

The congestion charging exemption for EVs plays a crucial role in the breakeven point between the ICEV and EV TCO

The cost savings seen in the EV TCO are mostly from the exemption from the London congestion charging zone and the resulting lower operational costs: the hard stop for the exemption in December 2025 lowers the operational benefits for EV significantly, cutting a key incentive for PHV drivers. The introduction of a new clean air toll on non-EV vehicles in 2025, or provision of incentives on short-term leasing contracts for EVs could further lower the gap between the TCOs during the transition period to 2025, after which vehicle financing and second-hand options may become more affordable.

The limited availability of affordable second-hand EVs at present could be a barrier to some drivers

Some key comparison scenarios remain in favour of ICEV, the most important being with second-hand vehicles: this is a typical purchase for an Uber driver, and the lack of affordable second-hand EVs remains a barrier to achieving break-even with the ICEV models. This is likely to change over time as the market matures.

Opportunity cost of public charging tips the TCO against EV

Factoring in the opportunity cost of £15,625 for time spent public charging rather than completing trips leans the TCO balance against EV, for drivers who charge during their shift. To reduce the opportunity cost, it is necessary for public charging infrastructure to be easily accessible and reliable, both in Central London and in outer regions close to the drivers' home locations.

Nuances in the decision-making process means not all drivers will place the same importance on TCO results

While this model is useful in comparing ownership costs between ICEVs and EVs in general terms, Uber drivers act as individual decision-makers: the rational TCO calculations displayed in this analysis may interest drivers of certain characteristics who are particularly sensitive to cost. However, as analysed in the behavioural questionnaire results, reluctance to switch to an EV is often not only a financial decision with nuances such as vehicle choice, range anxiety, and convenience involved.

Operational emissions analysis shows the clear environmental benefit for PHV drivers to switch to an EV

The operational emissions analysis showed the obvious benefit in switching to an EV for a high-mileage driver demographic (16 tonnes over five years). By 2030, emission reduction becomes increasingly marked as the grid energy mix transforms, headed towards Net Zero. Emissions considerations will also be relevant for Uber and other PHV organisations while transitioning to fully electric fleets.

5 Summary of Key Learnings from TCO analysis

Across the three project partners, the economic findings of the TCO approach yielded different results but also some common learnings:

At present, whether TCO favours EV or ICEV fleets varies considerably across and within the different use cases

EV prices are the key determinant of whether EVs make purely economic sense for a fleet, but there are many other factors influencing the cost, including connection costs for depots

The impact of electricity price rises relative to diesel costs is especially noticeable in fleets using public charging. Ongoing volatility in these costs is likely to continue to impact the accuracy of cost forecasts

Smart charging appears to be one of the best routes to improve TCO competitiveness, wherever possible, for depot or home-based fleets

The Congestion Charging exemption for EVs plays a crucial role in the breakeven point between the ICEV and EV TCO for a driver on the Uber platform, and significantly impacts EV favourability for other fleets operating in London

Operational emissions analysis shows the clear environmental benefit for PHV and fleet drivers to switch to an EV

6 Annexes

6.1 CP Types and charging speeds

Table 22 – CP types and charging speeds

CP Type	Charge Speed	Time needed to charge from 20% to 90% SoC		
		40kWh battery capacity EV	60kWh battery capacity EV	80kWh battery capacity EV
AC 16A single phase	3.6kW	8 hours	12 hours	16 hours
AC 32A single phase	7.4kW	4 hours	6 hours	8 hours
AC 32A three-phase	22kW	1 hour 20 minutes	2 hours	2 hours 40 minutes
Rapid DC CCS	50-100kW (example calculated at 50kw)	35 minutes	50 minutes	1 hour 10 minutes
Ultra-rapid DC CCS	100+kW (example calculated at 150kW)	12 minutes	18 minutes	24 minutes

Times given are approximate and may vary due to the vehicle's on-board charging system. Not all vehicles are capable of charging at all rates, especially 22kW AC and Ultra-rapid DC.

6.2 Example calculation of EV and CP numbers

The calculations steps below are based on the Premier Park Depot. This is due to Premier Park Depot already having three different types of vehicles in their EV fleet. In order to make results comparable in the TCO, Mercedes eVito was removed from the assumed fleet and converted into eExpert. Based on the input from the project partner, the price point for eVito model was considerably higher than eExpert, therefore, having it in the TCO would not make a comparable result and assumed EV fleet would look more like an upgrade rather than conversion into EVs. Therefore, from the table below, current eVito vehicles were added to the current eExpert model. Then in order to obtain 100% EV, remaining 62 ICEVs were added to EV fleet based on the ratio of current vehicles without eVito. Regarding Assumed CP, this was calculated based on OP Partner Input where there will be one double CP purchased per four vehicles which gives ratio of 2:1, vehicle: socket.

Table 23 – Vehicles and CPs at Premier Park Depot

Premier Park (111 Vehicles)	
Current Vehicles	
ICEV	EV
62 Unknown Vehicle Model	37 ePartner
	2 eExpert
	10 eVito
Current Vehicles without eVito	
ICEV	EV
62 Unknown Vehicle Model	37 ePartner
	12 eExpert
Assumed Vehicles	
100% ICEV	100% EV
84 Partner	84 ePartner
27 Expert	27 eExpert
Assumed CPs	
28	