Transport Decarbonisation Report

South Oxfordshire and Vale of White Horse District Councils

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Contents

Glossary of terms

Abbreviation	Meaning
BE/BEV	Battery-Electric, Battery Electric Vehicle
CAZ	Clean Air Zone (England and Wales, excluding London)
CCC	UK Climate Change Committee
CNG/LNG	Compressed/Liquid Natural Gas - methane
BEIS (DBEIS)	(Department for) Business, Energy and Industrial Strategy
Defra	Department for Environment Food and Rural Affairs
DVLA	Driver and Vehicle Licencing Agency
DVSA	Driver and Vehicle Standards Agency
EV	Electric Vehicle - usually battery-powered (BEV)
GHG	Greenhouse Gas - in transport usually CO_2, CH_4 and N_2O
GVW	Gross Vehicle Weight – Replaced by MAM
GWP	Global Warming Potential
H2FC	Hydrogen (H_2) Fuel Cell
HCV	Heavy Commercial Vehicle – also known as HGV – over 3.5t MAM
HDV	Heavy Duty Vehicle – All large vehicles: HCVs, Buses, Cranes
HGV	Heavy Goods Vehicle – also known as HCV – over 3.5t MAM
HMT	Her Majesty's Treasury
HVO	Hydrotreated Vegetable Oil – also known as biodiesel HVO
ICE	Internal Combustion Engine – Petrol/Diesel/Gas
ILUC	Indirect Land Use Change – important when considering biofuels.
LCV	Light Commercial Vehicle – Van – up to 3.5t MAM
LEZ	Low Emission Zone (Scotland)
MAM	Maximum Authorised Mass – replaces GVW Gross Vehicle Weight.
NAEI	National Atmospheric Emissions Inventory – Transport Factors
NCAP	New Car Assessment Programme- Safety
NDC	Nationally Determined Contributions (2015 Paris Agreement)
NEDC	New European Driving Cycle (now replaced by WLTP)
NPV	Net Present Value
OCA	Open Charge Alliance
OCPP	Open Charge Point Protocol (currently v2.0.1)
OEM	Original Equipment Manufacturer, e.g. Tesla, Ford, Nissan, Toyota
OZEV	Office for Zero Emission Vehicles
OSCP	Open Smart Charging Protocol (currently v1.0)
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter – associated with wide range of human illness
RCV	Refuse Collection Vehicle (eRCV - electric RCV)
RDE	Real Driving Emissions (RDE1 and RDE2)
REEV	Range Extended Electric Vehicle
RRV	Resource Recycling Vehicle (eRRV - electric RRV) – Waste usage
RRV	Rapid Response Vehicle – Emergency Service usage
SECR	Streamlined Energy and Carbon Reporting
TTW	Tank to Wheel – Scope 1 and 2 GHG emissions
UCO	Used Cooking Oil – the primary feedstock for HVO
ULEV	Ultra-Low Emission Vehicle – under 50gCO_2/km, 70 mile ZE range
ULEZ	Ultra-Low Emission Zone (London only)
V2G	Vehicle to Grid – Technical Guidance (UK Power Networks)
V2O	Vehicle to Office: also V2H – Home, V2S – Site.
VCA	Vehicle Certification Agency
VED	Vehicle Excise Duty – also called Vehicle Tax.
VRM	Vehicle Registration Mark (also VRN – Number)
WLC	Whole Life Cost
WLTP	Worldwide harmonised Light vehicle Test Procedure
WRI	World Resources Institute – GHG Protocol
WTT	Well to Tank – Scope 3 GHG Emissions
WTW	Well to Wheel – Combination of WTT and TTW – Scope 1, 2 & 3
ZEV	Zero Emission Vehicle
ZEZ	Zero Emission Zone (TfL and Mayor of London Guidance)

1. Executive summary

South Oxfordshire (SO) and Vale of White Horse (VWH) Councils (referred to collectively as 'SOVWH') have sought this report to benchmark the greenhouse gas (GHG) emissions and the energy consumption (megawatt hours - MWh) associated with each council's respective road transport fleet. Data for the calendar year 2021 was analysed and used to establish how its fleet could be decarbonised using zero emission electric vehicle (EV) technology. The analysis was undertaken by Energy Saving Trust and funded by the Department for Transport (DfT).

SOVWH's vehicle fleet is entirely shared between the two councils, meaning each asset is employed on both SO and VWH duties over the course of the year. During 2021, the shared fleet consisted of:

0[1]	13	1
Heavy Commercial Vehicles	Light Commercial Vehicles (vans)	Fleet Car

Based on the mileage attribution data supplied, main fleet mileage on SO duties accounted for 43,233 miles in 2021, equivalent to 59,500 kWh of energy and 18 tonnes of GHG emissions.

Similarly, for VWH, main fleet mileage on VWH duties accounted for 135,000 miles in 2021, equivalent to 190,000 kWh of energy and 57 tonnes of GHG emissions.

If the whole of SOVWH's main fleet could be transitioned to battery electric vehicles (BEVs) we would expect the energy use to fall by at least 70%, from 249,000 kWh to 75,000 kWh and for annual energy costs for the two councils to fall from an estimated £28,000 to £12,000, saving £16,000 every year.

This recurring annual fleet energy saving could contribute to funding the higher purchase (or lease) costs of the BEVs, as well as the electric vehicle charging infrastructure (EVCI). Additional savings will be realised from the reduced cost of maintaining an electric vehicle drivetrain and chassis.

SO and VWH have both declared Climate Emergencies and have committed to becoming carbon neutral by 2030. In addition to this both councils have adopted Climate Action Plans laying out the intention to transition to zero emission council vehicles by 2025.

Based on the data provided, we see no reason why SOVWH's main fleet could not be all-electric by 2025, without changes to operational use or charging during shifts. If all main fleet vehicles transition to BEVs powered from the UK Grid in 2030, SOVWH's main fleet transport emissions would still be associated with a predicted 4 tonnes of GHG emissions (representing a 95% reduction on 2021).

SOVWH's main fleet:

Drove 178,000 miles

consumed **249,000 kWh** of fossil fuel energy

produced **74 tonnes** of GHG emissions

BEVs could **reduce energy costs by £16,000 a year**.

[1] It is understood SOVWH owns a sizeable fleet of HCVs, including refuse collection vehicles (RCVs), which are on loan/lease to and under the operational control of Biffa Municipal Limited. Fuel or mileage data for these assets was not provided by Biffa and so these assets could not be included in the scope of this review. It should be noted that waste emissions typically represent 30-40% of a local authority's total transport related emissions. As SOVWH's main fleet is quite small however the share of waste transport related emissions relative to total transport emissions could be higher.

Of similar importance to SO and VWH achieving their carbon neutrality targets is reducing the Scope 3 emissions created by the councils' grey fleet (the term used to describe employees' private vehicles being used for business purposes). These emissions are of comparable size to the Scope 1 emissions created by the council's main fleet, as described above.

In 2021 SO's grey fleet drove 117,500 miles and emitted 41 tonnes GHG, costing the council approximately £52,000. Similarly, VWH's grey fleet drove 115,500 miles and emitted 40 tonnes of GHG, costing approximately £51,000. We believe targeted policies to reduce grey fleet mileage and replace it with more efficient forms of transport, including a suitably sized BEV pool car fleet, could reduce the emissions of both council's grey fleets to a small fraction (20%) of their current level. This could likely be achieved at or below the cost both councils are currently paying out to employees for the use of private vehicles for business purposes and could be introduced in a phased manner. If the new pool cars are specified as BEVs this would be compatible with the broader ambition of having a zero emission council vehicle fleet by 2025.

2. Summary of findings and recommendations

In Table 2-1, we have summarised key recommendations and the resulting impact of whole life cost (WLC) and GHG emissions savings if SOVWH transitions its fleet to BEVs. SOVWH should check our findings, and ideally test BEVs to confirm suitability (e.g. carrying capacity and single charge range) before committing to a particular model or battery size. Most OEMs will provide demonstrator vehicles for this purpose.

Table 2-1: Summary of key recommendations made throughout report

Item	Recommendation	Notes	Page
1	Reach a clear internal decision over the long-term future of SOVWH's vehicle depots this is a pre-requisite for ensuring long term value is delivered on any capital expenditure (CAPEX) on EVCI at SOVWH depots.	(Could save tens of thousands of pounds in avoidable CAPEX on site works if depots are moved more than is necessary, if a long term plan were to have been adopted)	44
2	Provide all main fleet drivers with BEV focused driver training – to educate on how to drive efficiently, as well as make the most out of the new BEV council fleet.	Capex requirement £1-2,000 GHG savings of 4 tonnes / year	13
3	Replace the Grounds Maintenance Team Supervisor's car with a BEV equivalent when the lease expires/prior to 2025, in line with 2025 BEV fleet target.	WLC savings of £1-2,000 / year Capex requirement £20-25,000 GHG savings of 4 tonnes / year	21
4	Replace all LCVs with BEV equivalents, oldest first, over the next 3.5 years in line with 2025 BEV fleet targets.	WLC lifetime saving approximately £160 k Capex requirement approximately £455 k GHG savings 69 tonnes / year	24
5	Create a grey fleet working group to deliver schemes, systems and facilities that enable reductions in emissions of the grey fleet.	These could include: travel hierarchy applied to all journeys, re-imbursement for bicycle business mileage, pool e-bicycles, BEV salary sacrifice scheme. Financial costs/savings, and carbon savings realised, depend on nature of what is implemented. A 25% reduction in grey fleet mileage equates to 20 tonnes GHG saving / year.	38
6	Provide dedicated BEV pool cars to the 10 individuals driving more than 5,000 mpa in personal cars on business purposes.	WLC of pool cars comparable to reimbursements made for employees using private vehicles. GHG savings 23 tonnes / year	42
7	Analyse where grey fleet drivers not covered through item 6 above are starting and finishing journeys most frequently. Begin introducing a BEV pool car fleet of 10 vehicles and install EVCI for these vehicles at the key identified sites.	WLC of pool cars comparable to reimbursements made for employees using private vehicles. GHG savings 23 tonnes / year	42

These recommendations and the transition programme laid out in Table 2-2 is based our understanding of suitable BEVs being available in each sector, the age of existing ICE vehicles and in alignment with SOVWH's target for a zero emissions fleet by 2025. With 14 vehicles to transition, and a recommended 20 BEV pool cars to be procured, on average at least 11 BEVs need to be brought on fleet each year for the next three years. It is unlikely that any of these new vehicles would need replacing prior to 2030.

Table 2-2: Proposed implementation programme for BEV fleet - based on expected availability and fleet age

Fleet Category	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
LCV (3.1-3.5 t)		5	2	2						9
LCV (2.6-3.1 t)		1	1	1						2
LCV (2.6-3.1 t)		1								1
Fleet car			1							1
Fleet pool car[1]		7	6	7						20
BEVs joining fleet		14	10	10						34
GHG Saving		52 t	36 t	31 t						119 t
Capital Cost		£234 k	£149 k	£98 k						£481 k
Change in WLC (lifetime)		-£72 k	-£16 k	-£32 k						-£120 k
Change in WLC (annualised)		-£9 k	-£2 k	-£4 k						-£15 k

[1]For fleet pool cars it is assumed the BEV pool car fleet would wish to be leased initially, until proof of concept is demonstrated

3. Meeting the carbon neutral target by 2030

SO and VWH have both declared Climate Emergencies and have committed to becoming carbon neutral by 2030. In addition to this, both councils have adopted Climate Action Plans laying out the intention to transition to zero emission council vehicles by 2025.This target is in line with the UK Government's updated Nationally Determined Contributions (NDC) made in compliance with the 2015 Paris Agreement (68% GHG reduction from 1990 levels by 2030) and with the legal commitment (Climate Change Act) to a 78% reduction in UK GHG emissions by 2035. It is possible that the whole fleet could be transitioned to electric by 2025 but this will depend on the current replacement schedule and OEM product delivery times.

3.1 Cutting energy costs and GHG emissions

BEVs are much more energy-efficient than Internal Combustion Engine (ICE) vehicles and the energy use (MWh) of a BEV fleet will typically be 65% to 75% less than the equivalent ICE fleet. A BE SOVWH main fleet, charged from the UK Grid, and using 30% of the energy used by the ICE fleet, could reduce energy costs by approximately 57%, saving £16,000 every year. This calculation has been based on an assumed average unit rate for electricity of £0.15/kWh and £1.23/litre for diesel, as observed in the fuel data supplied. It should be remembered that recent volatility and increases to energy prices make both short and long-term energy cost predictions very difficult. It is hard to know how long prices for both electricity and diesel will stay elevated above long-term trends at present.

BEIS data (Appendix A) shows that between 2014 and 2021, the GHG intensity of the UK grid has fallen by 57%. By 2030, it is predicted by BEIS and CCC to fall by a further 76% to about 50 gCO_2e per kWh.

Table 3-1: 2030 GHG emissions, energy use and cost savings from an all-BEV fleet

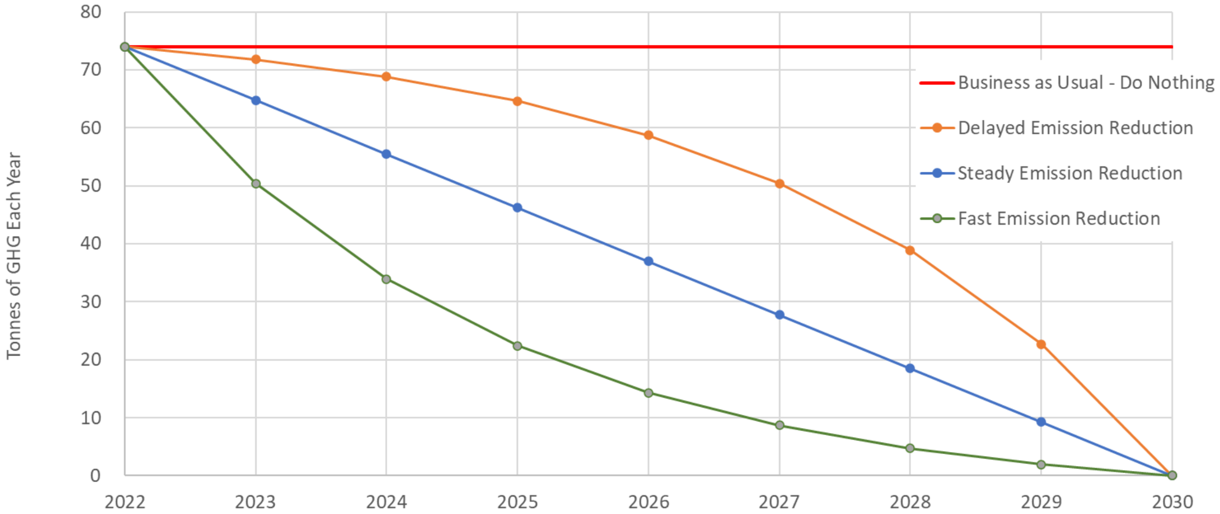
Factor	ICE 2030	BEV 2030	Change	Reduction
Energy consumption (MWh)	250	80	-170	-68%
Annual energy cost (£2021)	£28,000	£12,000	-£16,000	-57%
Annual GHG Emissions (t)	74	4	70	-95%

Table 3-1 shows that in 2030, if powered from the UK Grid, the SOVWH fleet will still be associated with 4 tonnes of GHG emissions, a reduction from current GHG emissions of 95%. Over the next eight years, SOVWH should evaluate implementing its own private wire renewable generation: 80 MWh is equivalent to the expected annual output of a 100 kW wind generator, or a 100 kWp solar photovoltaic array. If the electricity used to power the fleet is 100% renewable, the fleet will be "net zero".

3.2 Speed of change is important

There are several routes to achieving a carbon neutral fleet by 2030. All the change can be left to the end of the decade, steady progress can be made achieving a similar reduction in emissions each year, or a big effort can be made to achieve rapid change as quickly as possible, using the best available technology but avoiding excessive costs. These three routes are illustrated in Figure 3-1 overleaf.

Figure 3-1: Slow, Steady or Fast Emission Reduction



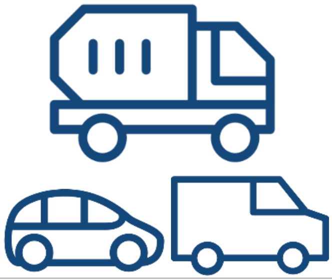
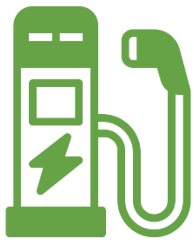
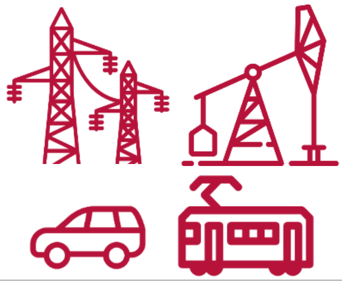
Although each reduction pathway achieves carbon neutrality by 2030 the cumulative emissions released in the interim vary hugely. If the fast emission reduction pathway is adopted, 210 tonnes of CO_2e will be released by SOVWH's main fleet between 2023 and 2030. Conversely if the delayed emissions reduction pathway is adopted, 450 tonnes of CO_2e will be released – over twice as much.

4. Benchmark emissions 2021

4.1 Greenhouse gases

The carbon dioxide (CO_2e) footprint (often shortened to carbon footprint) details the tonnage of carbon dioxide that SOVWH road transport has emitted during the benchmark year. The ‘e’ in CO_2e stands for ‘equivalent’ and indicates that the estimate includes the other reportable GHGs emitted by the fleet (nitrous oxide and methane) expressed in terms of their carbon dioxide equivalence over 100 years. For example, nitrous oxide (N_2O) has a global warming potential (GWP) 265 times that of carbon dioxide and one tonne of N_2O is therefore equivalent to 265 tonnes of CO_2 (GHG Protocol, GWP Values, AR5). The GWP of methane (CH_4) is 28. In the UK, GHG emissions are usually reported under Scopes 1 - 3 (Figure 4-1).

Figure 4-1: Summary of GHG reporting - Scopes relevant to road transport emissions

Scope 1	Scope 2	Scope 3
		
The Fleet You Directly Operate Owned, Leased, Hired (main fleet)	Electric Vehicle Electricity Generation	Transmission, Distribution, Extraction, Refining. Grey Fleet - Staff Travel
Tank to Wheel (TTW) Direct Emissions Operational Emissions	Well to Tank (WTT) Indirect Emissions Upstream Emissions	
Well to Wheel (WTW)		

Summary of SO GHG Emissions

Figure 4-2a: Greenhouse gas emissions (tonnes) by Scope for SO – main fleet

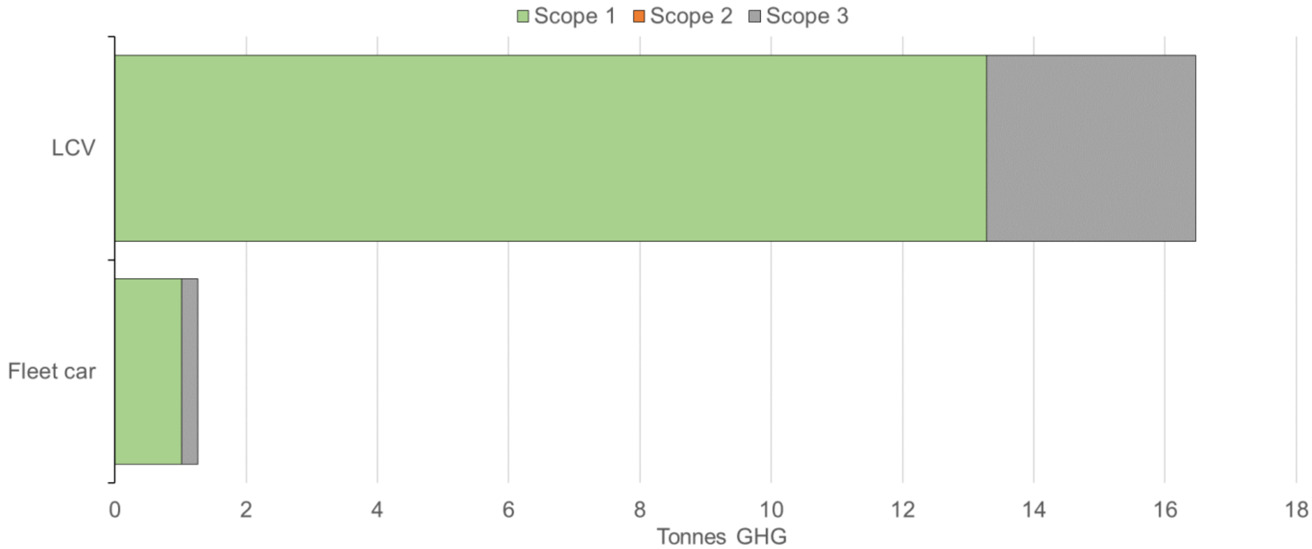


Figure 4-2b: Greenhouse gas emissions (tonnes) by Scope for VWH – main fleet

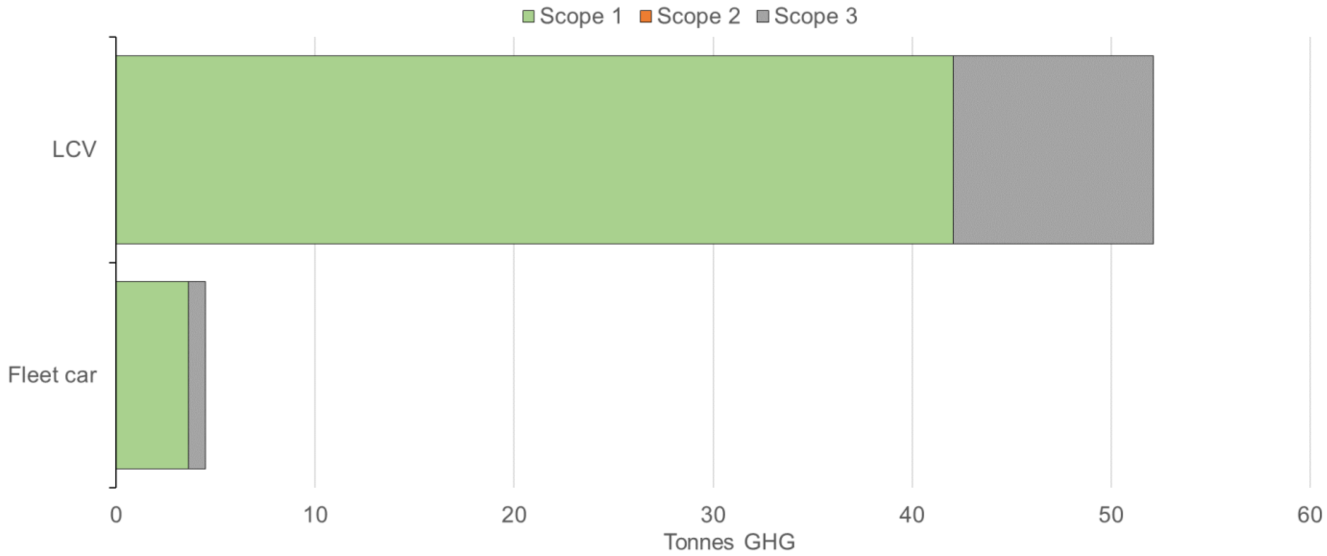
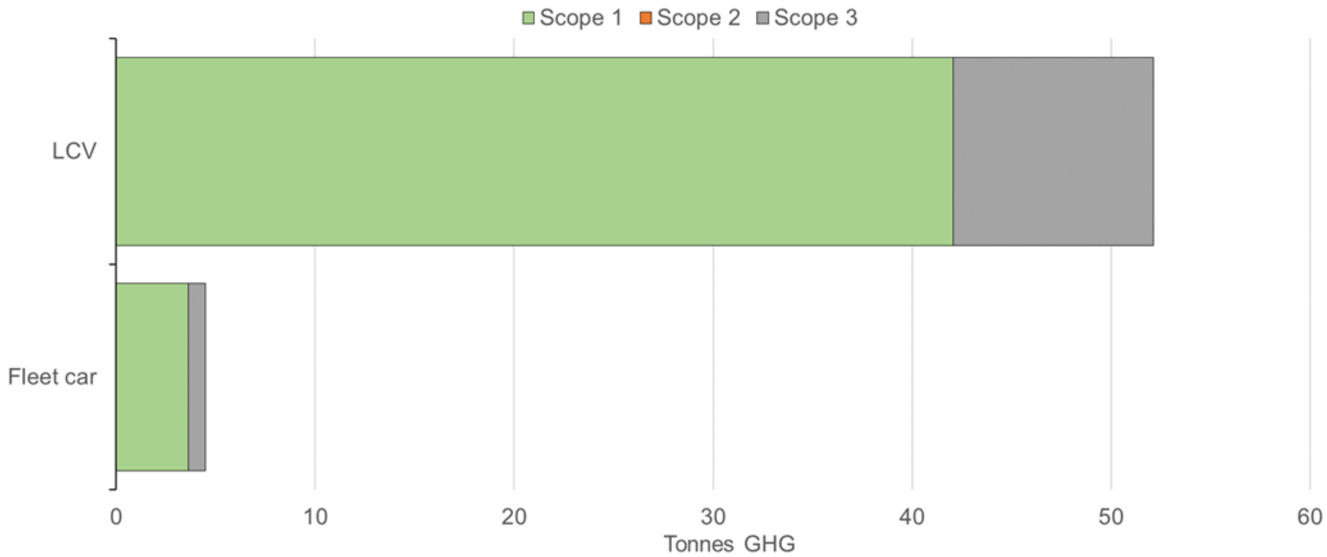


Table 4-1: WTW GHG reporting: Scopes, fleet size, mileage, GHG emissions and energy consumption – inc. grey fleet

	SO				VWH			
Fleet Category	Fleet size	Annual mileage	WTW GHG (tonnes)	Energy (kWh)	Fleet size	Annual mileage	WTW GHG (tonnes)	Energy (kWh)
LCVs (Up to 3.5 tonnes)	13	38,213	16	55,207	13	117,254	52	174,849
Fleet Cars (Leased and owned)	1	5,020	1	4,233	1	17,798	4	15,007
Grey Fleet (Staff owned cars)	*231*	*117,498*	*41*	*138,686*	*228*	*115,503*	*40*	*136,332*
Totals	**246**	**160,730**	**58**	**198,126**	**242**	**250,555**	**96**	**326,188**

Figure 4-3: The WTW GHG footprint of the SOVWH fleets



Figures 4-2a, 4-2b and 4-3 are based on the fuel and mileage data provided by SOVWH. We have calculated this footprint using the year-appropriate GHG Conversion Factors published by BEIS. The methodology used complies with international GHG reporting standards (WRI GHG Protocol) and with UK's SECR Reporting Guidelines which apply to UK public bodies. Not included are the lifecycle GHG emissions associated with the manufacture and disposal of the vehicles, which are out of scope.

Fleet Category	Fleet size	Annual mileage	Energy (kWh)	Fleet size	Annual mileage	Energy (kWh)
LCVs (Up to 3.5 tonnes)	13	38,213	55,207	13	117,254	174,849
Fleet Cars (Leased and owned)	1	5,020	4,233	1	17,798	15,007
Grey Fleet (Staff owned cars)	*231*	*117,498*	*138,686*	*228*	*115,503*	*136,332*
Totals	**246**	**160,730**	**198,126**	**242**	**250,555**	**326,188**

Table 4-2: GHG Reporting by Scopes – Scope 1 and Scope 2 are mandatory, Scope 3 is discretionary – inc. grey fleet

	SO			VWH		
Fleet Category	Scope 1 GHG Fossil Fuel Burnt (t)	Scope 2 GHG Electricity Consumed (t)	Scope 3 GHG Extraction/ Distribution (also Grey Fleet) (t)	Scope 1 GHG Fossil Fuel Burnt (t)	Scope 2 GHG Electricity Consumed (t)	Scope 3 GHG Extraction/ Distribution (also Grey Fleet) (t)
LCVs (Up to 3.5 tonnes)	55	0	13	42	0	10
Fleet Cars (Leased and owned)	5	0	1	4	0	1
Grey Fleet (Staff owned cars)	0	0	41	0	0	40
Totals	**60**	**0**	**55**	**46**	**0**	**51**

Table 4-2 provides a breakdown of the WTW GHG emissions by reporting Scope. Scope 1 is the most important because it is the fossil-fuel GHG emissions for which SOVWH is directly responsible. The vehicles burning the fuel are fully controlled and operated by SOVWH and all aspects of their use from specification usage, driving standard and monitoring, is its direct responsibility. No other organisation can reduce these emissions.

Table 4-3: Method used for calculating the GHG emissions as a percentage of fleet GHG emissions

Fleet Category	Method 1	Method 2	Method 3	Method 4	Method 5
LCVs (Up to 3.5 tonnes)	100%	0%	0%	0%	0%
Fleet Cars (Leased and owned)	100%	0%	0%	0%	0%
Grey Fleet (Staff owned cars)	0%	0%	0%	0%	100%

Table 4-3 shows the Energy Saving Trust methodology (full description available on request) that we have used to determine the GHG emissions and the energy used. The method used is an indicator of the quality of the data. Method 1 is the most accurate, as it is based on actual fuel burnt or consumed and the analysis of all directly operated fleets should be based on Method 1, as this data should always be available.

Where fuel data is not available, the calculations are based on distance travelled and the vehicles' published carbon dioxide or energy intensity, measured in gCO_2/km or kWh/km (Method 2) but this must be corrected to gCO_2e/km and an age-related uplift must be applied to published NEDC car emissions, to compensate for systematic manipulation of the test procedure by OEMs, before the introduction of WLTP. Even the new WLTP methodology requires an uplift of 13.7% to correct for real world performance (BEIS, Methodology Paper, June 2021, Table 16).

Methods 3 and 4 use basic information about the vehicle such as distance travelled, engine size, fuel type and weight, linked to BEIS national average factors. Method 5 is based on the average UK vehicle of that type (car, LCV, HCV) and the distance travelled – it is the least accurate.

Electric vehicle (EV) emissions (Scope 2 and Scope 3 GHG Reporting)

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

Plug-in hybrid and range-extended electric vehicles (PHEVs and REEVs) have a mix of fossil fuel emissions (Scope 1 and 3) and generation, transmission and distribution emissions (Scope 2 and 3). As no BEVs are currently operated in the SOVWH fleets there are no Scope 2 emissions to report at present.

4.2 Air quality: Substances of concern

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

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

We have determined the data in Table 4-44 using the average emissions of a 2018 UK car, LCV, or HCV adjusted for the area of operation as published by the National Atmospheric Emissions Inventory. This analysis is based on vehicle mileage and cannot be determined from fuel data alone, so where mileage driven is missing, emissions cannot be calculated.

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

	SO		VWH	
Fleet Category	NO_X (kg)	PM (kg)	NO_X (kg)	PM (kg)
LCVs (Up to 3.5 tonnes)	63	0.68	192	2.09
Fleet Cars (Leased and owned)	4	0.06	14	0.20
Grey Fleet (Staff owned cars)	50	0.77	49	0.75
Total	117	1.51	255	3.04

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

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

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

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

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

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

Moving to BEVs will eliminate tailpipe emissions of NO_X and PM but will still leave particulate "emissions" associated with the brakes, tyres and recirculation. If driven well, BEVs can make extensive use of regenerative braking, so particulates from this source should be reduced. However, there is a concern that this may be offset by increased emissions from the tyres, as BEVs are heavier than the equivalent ICE vehicle.

The make of the tyre itself is a critical factor and tyres that meet the EU AA standard for energy efficiency and wet grip, as well as being quiet in use, can have very different wear rates (mg/km). Unfortunately, there is no UK or European tyre-label guidance regarding wear rate to help purchasers select tyres that are energy-efficient, give good grip in the wet, are quiet, and also minimise particulate emissions.

Recent research on car tyre emissions by Emission Analytics has suggested the average wear rate across a range of brands was 64 mg/km but this varied between brands from less the 40 mg/km to nearly 90 mg/km.

Both SO and VWH have AQMAs in force – three each for NO_2, a pollutant with a clear link to road transport. The transition from a diesel fuelled SOVWH fleet to a BEV fleet will of course benefit these AQMAs.

5. Fleet data quality and data management

Central to any well-managed and energy-efficient fleet is good data management. Transport and operational managers should have up-to-date, comprehensive, accurate and accessible data about all the vehicles in use, their energy consumption (litres or kWh) and the distance driven, or hours worked. This applies regardless of the ownership of the vehicles (purchased, leased, hired, or third party contractors delivering statutory services). In addition, fleet operators should hold robust information regarding their drivers and be able to link this to the data about the vehicles they have driven.

Where commercial vehicles and passenger services are involved, it is also important to record information about the work done; for example, the load carried (tonnes or cubic metres), bins emptied, households serviced, repairs or job-sheets completed, passengers transported. With all this data available the performance of an operation can then be linked back to the service it delivered and form part of a suite of Driver, Vehicle and Fleet Performance Indicators.

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

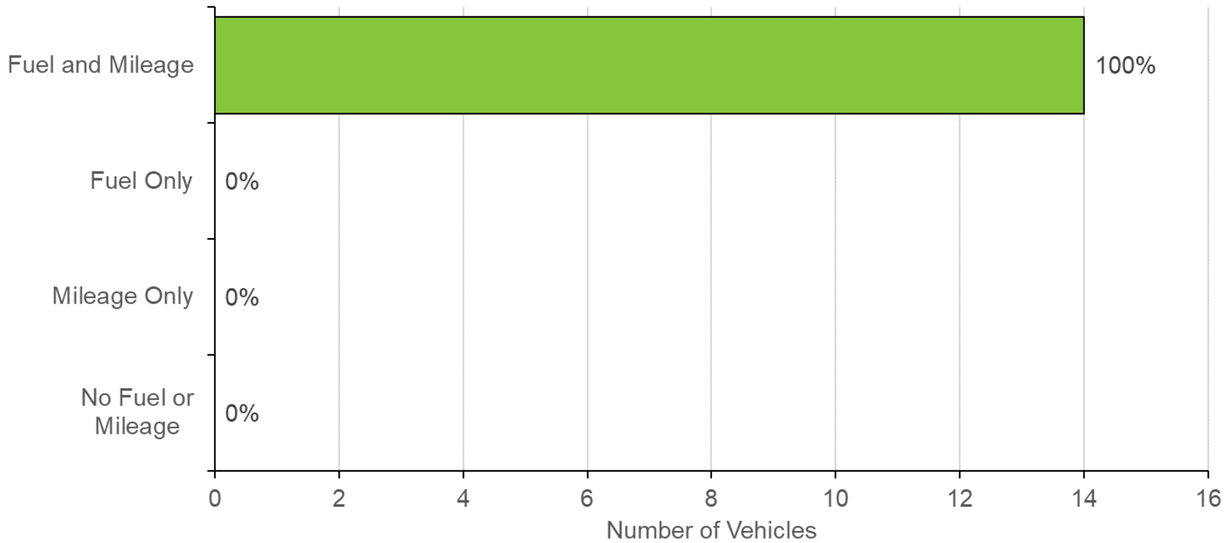
The quality of these commercial systems is variable. Some have not kept pace with developments in technology, and there is often a failure, or inability, to fully integrate the data from all the different sources. For example, combining accurate mileage from CAN bus-linked tracking data with actual fuel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

5.1 Quality of the data set provided

Main fleet

SOVWH provided fuel and mileage data for all of main fleet as well as telemetry data for Grounds Maintenance Team's vehicles. In addition, operational routes for the Grounds Maintenance vehicles were provided also to give further understanding of typical use profiles. Alongside this clear attribution ratios were provided, to permit the reconciling of mileage and fuel for the shared assets to each respective council.

Figure 5-1: Data set quality – fuel and mileage information



For much of the fleet, the fuel drawings and mileage driven gave credible results when energy efficiency (mpg) was determined. Where data is available, it can be described as an excellent data set, with only minor errors observed. One LCV, a Ford Transit (registration: FE18 YAF), was found not have live telemetry data available and additionally, the back-up paper records of the vehicle's daily mileage proved to have a few, albeit easily rectifiable, recording errors within them. The major omission is of course fuel and mileage data for SOVWH's sub-contracted waste operations.

Grey fleet

SOVWH provided mileage and claims data for the grey fleet which was of high quality. The data included the VRN age identifier for the vehicle, its make and model, vehicle type, fuel type as well as the information relating to the claim. This information included the claimant reference number, miles travelled, claim amount and brief journey purpose details (for example 'had to repair and make safe main kitchen back doors'). Similar to the main fleet the data seemed robust and required little cleansing or rectifying. One area was queried around the inclusion or not of the high mileage public services cleaning team's private vehicles within the grey fleet data set. Mileage data for this team's private vehicles was provided by dedicated Word document. On inspection there did not appear to be duplication within the Expenses Travel Data excel document provided. For this reason the two documents were consolidated for analysis, with the data for the public services cleaning team being added to the Expenses Travel Data Excel document.

5.2 Fleet data management

It is important that the departments which operate the fleet vehicles are on a clear pathway to carbon neutral operations, in line with local SOVWH commitments and wider national targets. Departmental GHG targets should be established and monitored. It is therefore a requirement that the fleet systems should provide regular (monthly or weekly) and accurate, energy efficiency, GHG emission and cost data to service managers and their drivers, as well as any other relevant stakeholders for example in the fleet team or climate change or sustainability officers.

The best way to achieve this is to fully integrate the data from all possible sources – fleet management, service records, fuel drawings, and telemetry – and to make every effort to ensure that accurate data is captured whenever fuel is drawn.

Organisations that have addressed this issue directly have, after a period of adaptation, achieved a very high level of compliance. The capture of mileage data can be further enhanced by using multiple sources, including the vehicle's telemetry, workshop service records, and odometer data capture built-in to the recording of the daily walk-around vehicle check - some systems now allow this to be carried out using a smartphone App.

One easy initial win might be around data format supplied by fuel suppliers. When requesting fuel data the fuel provider (Wex) at first provided data in a PDF format, which makes running regular analysis on fuel consumption difficult. On request Wex were happy to provide data in the more useable CSV format – one example of a readily implementable change (a simple request to Wex) that could greatly empower the closer tracking and analysis of fleet fuel consumption.

5.3 Using the data to improve ICE fleet energy efficiency

While the main reason to improve the energy efficiency data is to inform the move to zero emission vehicles, organisations that introduce tight monitoring of fuel use and a focus on fuel efficiency (mpg) have achieved reductions of 5% to 15% in fossil fuel use, the range depending on how weak fuel management has been in the past.

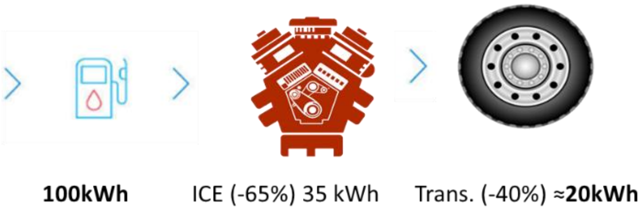
A 5% reduction in diesel fuel use at SO across the main fleet would result in an annual cost saving of £1,400 per year and a reduction in GHG emissions of 3.7 tonnes (WTW). Similarly, for VWH the cost saving would be £1,100 per year and the reduction in GHG emissions around 2.8 tonnes (WTW).

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

5.4 The importance of accurate fuel and mileage data

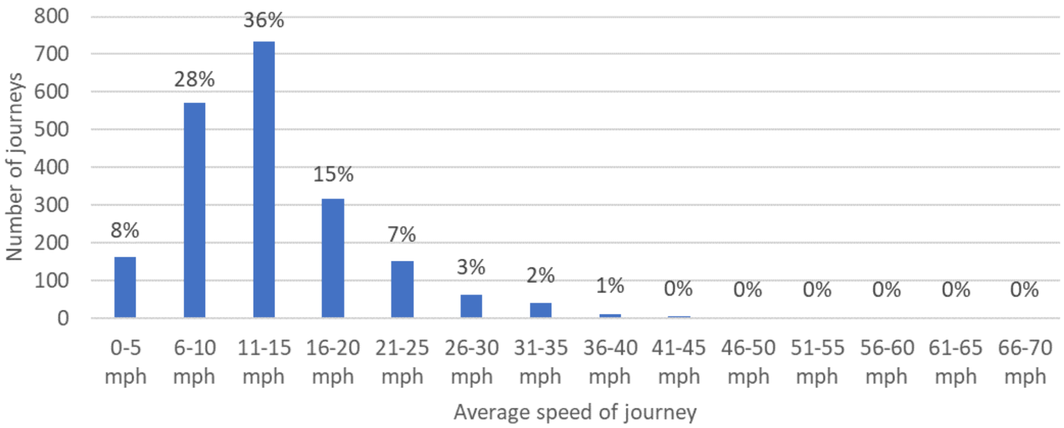
As explained above, accurate energy usage and energy efficiency is critical when trying to determine the future energy requirements of a zero emission BE fleet.

Figure 5-2: Energy efficiency of an internal combustion engine vehicle



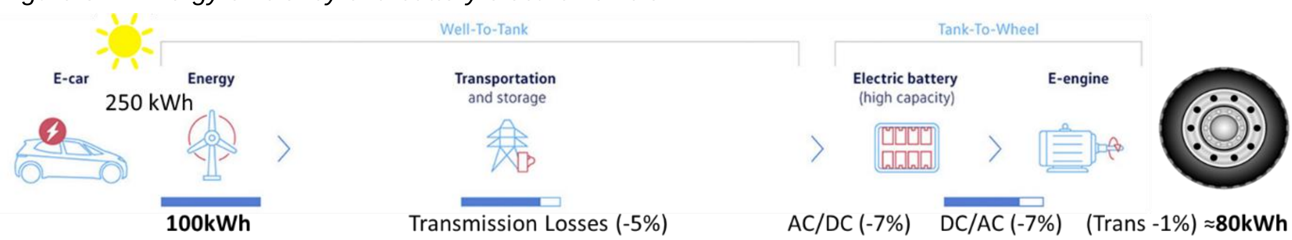
Many ICE vehicles are only 25% to 30% efficient (Figure 5-2) with the losses – mostly heat and friction – occurring in the engine and the transmission. Smaller ICE vehicles like cars and car-derived vans should achieve a higher level of efficiency (up to 30%) especially if they are not used in a start-stop environment. ICE hybrids can achieve efficiencies in the order of 30% to 35% because they make use of energy recovery when braking and energy assist when accelerating to reduce the load on the ICE. Most diesel engine vehicles are at their most efficient when cruising at 50-60 mph. Although the telemetry data available provides only average speed for each journey this is sufficient to build an understanding that for most of the time, on SOVWH journeys, vehicles are moving at speeds well below those at which optimum efficiency is achieved for ICE vehicles.

Figure 5-3: Average moving speed profile of SOVWH journeys



In comparison to the 30% typical efficiency experienced in an ICE vehicle, electric vehicles are about 80% efficient (Figure 5-4). Most of the losses occur in the conversion of AC to DC from the grid to the battery and then back from DC to AC for the electric motor. Other energy losses occur in generating the electricity from the wind or solar energy, but they are upstream of the electricity entering the grid. As a result, BEVs will typically use between one quarter and one third of the ICE vehicle's energy, which gives us an indication of the battery size we will need for the replacement BEV and, therefore, whether a suitable vehicle is available.

Figure 5-4: Energy efficiency of a battery electric vehicle



[*Business vectors created by macrovector - www.freepik.com*](http://www.freepik.com)
Other Images [VW: Battery or fuel cell? That is the question]()

By considering the tracking data of the ICE vehicle combined with accurate energy consumption daily variations in energy use (kWh per day) can be determined. When aggregated across the fleet, this can be modelled to provide an indication of the peak overnight charging demand (kWh) and the site Maximum Import Capacity (kVA) required at the offices and depots where those vehicles are based.

With only fuel data, only mileage data or inaccurate data, only part of the picture is available, and the analysis has to be based on “average” daily performance of similar vehicles, which may not reflect the SOVWH operating environment, particularly if there are local challenges such as particularly hilly topography. Fortunately for SOVWH, good visibility of daily variability in vehicle use is available, as much of the main vehicle fleet has telemetry.

5.5 Implementing future-proof BEV compatible telemetry

It is understood that the present vehicle fleet is largely supplied on lease by Northgate, which may reduce the ability to specify the telemetry system used. Broadly, as the fleet transitions to BEVs, the importance of effective telemetry across the main fleet will remain as high as it is with today’s ICE fleet.

For vehicles where choice of telemetry system is available, the telemetry system adopted should be able to accommodate both legacy ICE vehicles, as well as new and future BEVs. In particular, it is important that the system can report on the electric vehicles’ consumption of electricity, the state of charge (SoC) of the battery, the number of times it has been charged, the type of charge point used and the vehicle’s energy efficiency in terms of miles/kWh or Wh/km. All this information should be accessible from the CAN bus.

Ideally, the system should also have an Application Programming Interface (API) to allow smart charging systems to access this data set to optimise charging and minimise the site's grid capacity. This is not yet commercially available, but several suppliers are working on this integration. Table 5-1 shows the result of a 2020 email and telephone survey of major UK telematics providers. Unfortunately, several have not responded to repeated requests for information about the capabilities of their systems

Table 5-1: Survey of telematic systems’ EV capability

Company	Status	Battery SoC	kWh Received	Wh/mile	Charging Status	Type of Charge point	Charge point API
Masternaut	CAN bus	Yes	Yes	Yes	Yes	No	
Quartix	Due Q2 2021	Planned	Planned	Planned	Planned	Planned	Planned
Teletrac Navman	CAN bus	Yes	Yes	Yes	Yes	No	
Samsara	CAN bus	Yes	Not Yet	Yes	Not Yet	Not Yet	
EV Technology	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
CMS SupaTrak[1]	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
Pure Telematics	In development	Planned	Planned	Planned	Planned	Planned	Planned
UK Telematics	CAN bus	Yes	Not Yet	Yes	Not Yet	Not Yet	Yes
Ctrack	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
Webfleet	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes

[1]The CMS SupaTrak system is used by Dennis Eagle in all their refuse vehicles.
Verizon Connect, Big Change, Microlise, & CrystallBall were contacted but did not supply data.

SOVWH must be able to determine the key parameters identified in Table 5-1, so that a future electric vehicle fleet can be managed, its energy consumption monitored, and its status reported to the charging system, which will allow the optimum charging strategy to be determined. If vehicles are to be sourced on leases from suppliers which are currently used requirements such as these should be shared with leasing companies at first opportunity. This will allow them time to respond in time for the desired dates that BEVs start to join the fleet.

6. Achieving a zero emission fleet 2022-2030

6.1 Establish a transition team

The successful transition of the SOVWH road transport fleet to a zero emission fleet will require SOVWH to establish a small cross-council team to include stakeholders responsible for fleet management, the main vehicle operating departments, estates, energy management, human resources (for grey fleet), procurement and finance. The robust appraisal of need and utilisation, changing vehicle procurement to a model based on whole life cost, funding the new fleet, putting in place the charging infrastructure to support new BEVs and addressing issues like home-based charging, for teams such as the public servicing cleaning team, will require input and resources from all the groups identified above, as well as a governance and reporting structure with full senior management team engagement.

The move to BEVs is a once in a generation transformation and is not just a responsibility for the fleet team. The decarbonisation of the fleet should be occurring in parallel with a move away from the use of fossil fuels such as natural gas or oil for heating buildings and this will usually involve a move to electric heat pumps. The two projects need to be considered in parallel, not independently, as site supplies and infrastructure will need to cope with the demands of heat pumps and vehicle charging. It may well be that on-site PV generation and battery storage should be considered also.

6.2 Identify suitable BEV options

The factors to consider when selecting a suitable BEV include:

- typical daily journey length and load – longest daily trip, maximum load.
- single-charge range – avoiding charging during the working day, if possible, as lower costs overnight.
- opportunities to charge during the day – useful for site-to-site services.
- carrying capacity – seats in cars, MPVs and minibuses; weight and volume in LCVs and HCVs.
- towing capacity – with BEVs under 3.5 tonnes, this is currently limited to one tonne.
- whole life cost (WLC) – cost over the operational lifetime.
- grant funding available – any funding to cover whole life cost difference.

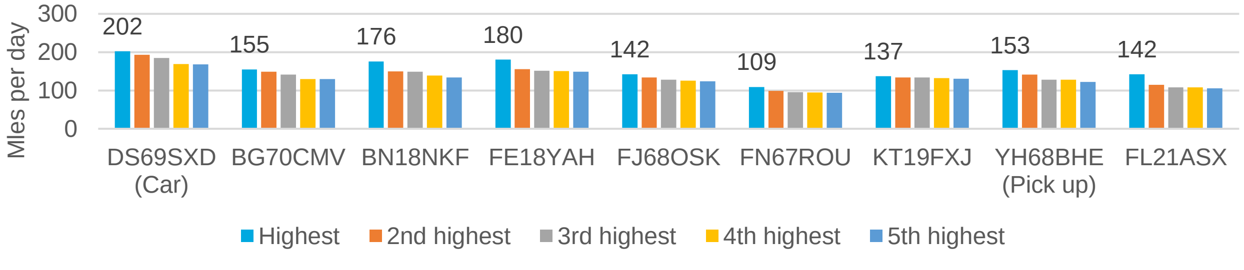
By using the telemetry data and considering the energy efficiency of the ICE fleet over calendar year 2021 we can estimate both the average and peak energy consumption (kWh) requirements of the fleet if transitioned to BE. Table 6-1 suggests that, if funding is not an issue, all vehicles can be replaced by current BEV models in alignment with the council's target for a zero emission fleet by 2025. Figure 6-1 then highlights the very highest daily mileages that the fleet drove in the study period – all of which fall within the single charge range of equivalent BEV vehicles available today.

Table 6-1: Summary of annual mileage and estimated BEV energy requirement across key fleets (30% ICE).

Fleet Category	Average annual mileage	Maximum annual mileage	Average kWh/WD	Maximum daily mileage	Maximum kWh/WD[1]	Battery sizes OEM vehicles currently available
LCVs (Up to 3.5 tonnes)	11,959	20,358	27	180[2]	75[2]	33-89 kWh
Fleet Cars	22,818	22,818	24	nd	nd	17-118 kWh

[1]WD = 240 Working Days, based on diesel energy use adjusted for BEV energy efficiency.
[2]Considered for Grounds Maintenance Team vehicles with telemetry only

Figure 6-1: Consideration of maximum daily mileages driven for each Grounds Maintenance Team vehicle which had telemetry data available



6.3 Review vehicle utilisation

It is important to identify and review the requirement for vehicles with low usage levels, for example, under 6,000 miles a year (average 25 miles a day, 240 working days). There may be a good reason for low utilisation, or it may be a consequence of departmental 'silos' preventing the shared use of a resource that spends a lot of the week parked, next to another similar low-mileage vehicle from another department.

Low mileage has an adverse impact on the WLC of BEVs because the low mileage results in much lower cost savings from the reduction in energy use. As most leasing companies do not provide prices below 6,000 miles per annum (mpa) the very low mileages will not be reflected in lease costs. Even if purchased and retained for the full battery warranty period (typically eight to ten years) they may not recover their higher capital cost. When looking at the data for SOVWH the sharing of assets means that almost all vehicle assets are seeing good annual rates of utilisation with only one (WP70LCW) coming in below the 6,000 miles per annum level noted above. The vast majority were used for above 10,000 miles per annum, representing a good overall rate of utilisation.

Looking at a finer level (permittable through telemetry analysis on the Grounds Maintenance fleet) we see similar rates of utilisation on a day-to-day basis, for vehicles where data is available. Of the vehicles that were on fleet for the whole year, the vehicle used on the least number of days (BG70CMV) was still used on over 200 days – representing approximately 83% of working days for the year.

Weekly and monthly scale analyses of the Grounds Maintenance fleet indicate a balanced and well used fleet also - with all vehicles appearing to be used on all weekdays (M-F). There was however a notable inter-seasonal variation observed in the increased mileage of the Grounds Maintenance fleet in the summer months compared to winter months. Whilst the average monthly mileage across the year for the Grounds Maintenance fleet was just shy of 11,000 miles the average monthly mileage for the summer months (June, July and August) was 13,000 miles, compared to 7,580 for the winter months of December, January and February. This is a notable difference and the implications it might have for correct specification of EVCI should be remembered. In this instance, seasonal energy demand will to some extent be balanced by the reduced efficiency of BEVs in winter months. Similarly, the annual usage profile of the parts of SOVWH's main fleet which do not have telemetry at present should also be considered – might a similar inter-seasonal variability in usage present in these parts of the fleet as well? It seems likely that usage would be more balanced across the course of the year.

6.4 Downsize the LCV fleet wherever possible

Whilst reducing the size of SOVWH's main fleet seems unlikely to be feasible, downsizing the LCV fleet might present more scope for reducing the capital cost and the GHG emissions of a BE LCV fleet. This is because smaller BEVs are cheaper to buy and lease and more energy efficient in operation (miles/kWh) than larger BEVs. Downsizing the current ICE fleet would have similar benefits, in terms of reducing the capital cost and improving fuel efficiency.

Table 6-2: Impact of downsizing on capital costs of a battery electric LCV fleet

Battery electric model	Size Class	GVW/MAM (kg)	Battery	OTR List[1]	ICE Equivalent
Renault Zoe CDV	CDV	Up to 2000	50 kWh	£33,300	£18,800
Vauxhall Combo-e Cargo L2	Small LCV	2001-2600	50 kWh	£36,600	£24,850
Vauxhall Vivaro-e L1 H1	Medium LCV	2601-3100	50 kWh	£44,000	£32,450
Vauxhall Vivaro-e L2 H1	Medium LCV	2601-3100	75 kWh	£50,800	£34,250
Fiat e-Ducato L2 H1	Large LCV	3101-4250	47 kWh	£69,250	£34,980
Vauxhall Movano-e L3 H2	Large LCV	3101-4250	70 kWh	£74,000	£41,300

[1]*The on the road (OTR) price is usually subject to manufacturer discounts.*

Table 6-2 illustrates the increase in capital cost currently associated with the larger LCVs. Depending on the fuel efficiency of the ICE vehicle (mpg) being replaced, the recovery of the difference in capital cost from the lower energy (fuel) cost can require a large BE LCV to achieve high levels of whole life mileages. Even with framework discounts applied, the cost recovery mileage does not fall significantly because of the larger percentage discounts available from the OEMs for their legacy ICE vehicles.

Research carried out by the engineering consultancy Ricardo for DfT showed that the impact on energy efficiency of fully loading a LCV is a 9% to 10% increase in energy consumption; therefore, it is much more cost effective to have a fully loaded small LCV than a half-empty large one. This means there is an operating cost and capital cost saving from using smaller LCVs wherever possible and avoiding the one-size-fits-all procurement model.

When vehicles are due for replacement, it is important to carry out a robust independent review of current usage and challenge the need for large LCVs – especially if the objective is to replace the ICE vehicle with a BE model. A 2 tonne BE LCV will have a much lower WLC than a 3 tonne BE LCV which may have a much lower WLC than a 3.5 tonne ICE LCV. Factors to consider include:

- Meeting the occasional need for a large or long-range LCV with a pool or rental vehicle,
- Holding rarely used specialist equipment in a central store or depot, not in the back of a LCV,
- Using a bespoke fit-out in smaller vehicles to increase carrying or seating capacity,
- Closely tailoring the vehicle and the equipment carried to the service level being delivered.

6.5 Adapt the fleet replacement cycles to BEVs

Although the current fleet is built up of recently manufactured vehicles and conforms to the Euro 6/VI(d) emissions regulations this is to be superseded by cleaner ICE models in 2025/2026 when the new Euro 7/VII regulations, now under consideration, are introduced. Euro 7/VII compliant vehicles will produce less regulated pollutants than today's Euro 6/VI vehicles, but it should be remembered that tailpipe emissions will still be generated by this next generation of ICE vehicles.

Electric vehicles have no tailpipe emissions, so they cannot be superseded by lower emission models. There are emissions associated with the generation of the electricity used to recharge BEVs and, like all vehicles, BEVs do produce particulates from their brakes and tyres as well as recirculating particulates drawn up from the road surface. Brake dust can be mitigated by training the driver to make full use of regenerative braking but tyre wear is more difficult to mitigate because the EU Rating Scheme for tyres relates only to the rolling resistance (energy efficiency), wet grip and noise; no information is available to the purchaser about the wear rate of a tyre (mg/km) which is the process that generates particulates.

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

Energy Saving Trust was advised that SOVWH's main fleet is currently leased but that the intention and capital is broadly available to move to investing in and owning the fleet outright in the future. To maximise the return on any future investment in BEVs, we recommend aligning replacement cycles with the vehicle's battery warranty. This might mean planned replacement cycles of eight or, in some cases, ten years.

6.6 Introduce a BEV procurement policy

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

Other technologies like Hydrogen Fuel Cell (H2FC), Hydrogen ICE (H2ICE), Hydrogen-Diesel Dual-Fuel, Biomethane (BioCNG/LNG) and HVO (BioDiesel) should only be considered where there is no suitable BEV technology available, or expected to be available, by 2030. See Appendix G and Section 12 for a full discussion of these alternative zero (or low) emission technologies. Analysis on the data provided indicates that there are BEV vehicles already available which are suitable to all operational needs.

It is recommended that procurement follows the process in Table 6-3 (overleaf) which starts with a review of the need for a vehicle and a check to see if it can be downsized.

Table 6-3: BEV procurement process

Step	Question	A	Actions
1	Vehicle under 6,000 miles per annum? Has a business need review been completed?	No	Carry out full business need review. Would hire vehicles be lower cost? Could a shared vehicle fulfil the role?
2	Has a smaller vehicle been considered?	No	Investigate the efficient use of the current vehicle. Has racking been installed? Is the requirement for a big vehicle infrequent? Downsize if possible.
3	Does a suitable BEV with WLC similar to ICE exist? Include grants in cost model.	Yes	Procure BEV
4	Would extending the operation life of the BEV make it affordable?	Yes	Procure BEV
5	Could the life of the ICE be extended until a suitable BEV is available?	Yes	Extend existing lease agreement and defer procurement
6	Consider procuring a reconditioned second-hand ICE vehicle or a new vehicle on short term hire linked to anticipated availability of a suitable BEV.		

Where current assets are found to be underutilised, replacements should be robustly challenged because of the high capital cost of BEVs. A well utilised, right-sized BEV can save money. An underutilised, overweight BEV costs money. Initial consideration of the existing fleet would point to the levels of utilisation being high. However, it may be that following close scrutiny of vehicles on a vehicle by vehicle basis, considering closely their carrying requirements (both in terms of weight and volume) downsizing may be an option for some vehicles on the fleet when making future investments.

In Appendix E we have attempted to give a picture of when different categories will be available from the OEMs based on recent announcements. As might be expected, there is a progression over time from limited availability with limited capability, to full availability and ICE-equivalent capability. Based on the data provided, there are already suitable BEVs available to replace all of SOVWH's main fleet.

6.7 Use a Whole Life Cost selection model

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

Why use WLC for vehicle procurement?

For many years, the choice of vehicle power has been limited to petrol or diesel engines and in the commercial sector, often the only option has been diesel. As a result, many fleet managers and procurement teams focus on comparing the vehicle's purchase price or the lease cost. Servicing costs might be considered during procurement, but the analysis would rarely include fuel costs as, for similar diesel vehicles, they are not expected to be significantly different. Instead, they were regarded as a necessary and unavoidable overhead.

Over a BEV's operational life, the large reduction in energy cost may completely offset the higher purchase (or lease) cost and can result in an overall cost saving. It should be noted however that the current disruption to the energy markets caused by high gas and oil prices means it is very difficult to predict the long term (2022-2030) price of electricity, gas, petrol and diesel. As it stands both the price of diesel and electricity are far above their long run price trend.

BEVs are mechanically simpler than ICE vehicles, with significantly fewer components in the drive train and without a complex transmission and exhaust system. As a result, maintenance costs are much lower - up to 40% less. Over an extended operational life of eight to ten years, the saving may be even greater, as ICE vehicles can incur significant costs in later years. The failure of one ICE vehicle component can be very expensive - for example, replacing a gearbox or an exhaust catalyst system. The saving from reduced maintenance costs can further help to offset the higher purchase cost, or add to overall cost savings.

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

6.8 Putting a cost on GHG emissions – carbon accounting

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

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

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

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

That review resulted in a significant increase in the UK shadow carbon price from £72/tonne to £248/tonne in 2022 and from £81/tonne to £280/tonne in 2030. The increase between 2022 and 2030 reflects the greater impact of emitting a tonne of GHG in 2030 on the UK’s ability to reach its new NDCs.

7. Moving to a zero emission car fleet

7.1 Description of the car fleet

The car fleet at SOVWH consists of 1 vehicle, operated by the Grounds Maintenance team. Although it is a modern Euro 6 compliant diesel vehicle, it is likely to be heavier and less efficient than it could be, owing to its compact-SUV geometry.

Table 7-1: Summary of cars on the fleet (2021), their energy efficiency and annual mileage

Fleet Category	Qty	Make	Model	Fuel	OEM gCO2/km	Mpg	Actual gCO_2/km	Annual Mileage
Compact SUV	1	Vauxhall	Grandland	Diesel	113	57	125	22,818

7.2 Electrification of the car fleet

Taking the cars annual mileage and efficiency in operation this would represent the equivalent of 24 kWh of electrical energy, per working day, if the vehicle were to be replaced with an equivalent BEV. This does not hint at variation in daily use, which telemetry or daily mileage logging would offer insight to. As most modern electric cars have battery capacities in the range 40 to 100 kWh, this data would suggest that the Vauxhall Grandland could readily be replaced with a BEV equivalent, when this vehicle is due for replacement.

Electric car availability

With the end of sale of ICE cars by 2030 (2035 including PHEVs) almost all of the OEMs offer a range of BE cars. All categories are available, including hatchbacks, saloons, estate cars, 2x4 SUVs and 4x4 SUVs. Many models now support roof rails and towing. Battery size and single-charge range has increased, while costs have fallen, and it is now not unusual for a BE car to have a range of 200 - 300 miles. Charge times have also fallen, with some new vehicles supporting DC charging rates of over 200 kW. A useful source of information is the Electric Vehicle Database.

Table 7-2: Safety, battery capacity, range, and charge time of a sample of the electric cars now available

Make	Model	NCAP	Battery kWh	RW Range[1]	7.4 kW AC	DC
Peugeot	e208 (Hatch)	4 Star[2]	45	145-200	7.25 hrs	27 min 100kW
Vauxhall	Corsa-e (Hatch)	4 Star[2]	45	145-200	7.25 hrs	27 min 100kW
Fiat	500e	4 Star	42	120-170	6 hours	25 min 85kW
Nissan	Leaf (Hatch)	5 Star	62	170-230	7.25 hrs	35 min 100kW
VW	ID.3 Pro (Hatch)	5 Star	62	180-250	9.25 hrs	33 min 100kW
MG	5EV (Estate)	5 Star	53 or 61	175-270	8.75 hrs	36 min 80kW
Kia	e-Niro (SUV)	5 Star	39 or 64	145-230	10.5 hrs	44 min 77kW
Hyundai	Kona (SUV)	5 Star	64	205-285	10.25 hrs	44 min 77kW
Skoda	Enyaq iV 80X (SUV)	5 Star	82	205-270	12.25 hrs	36 min 125kW
VW	ID.4 (SUV)	5 Star	77	215-290	12.25 hrs	34 min 126kW
Kia	EV6 (2WD)	5 Star	82	260-328	12.5 hrs	17 min 233kW

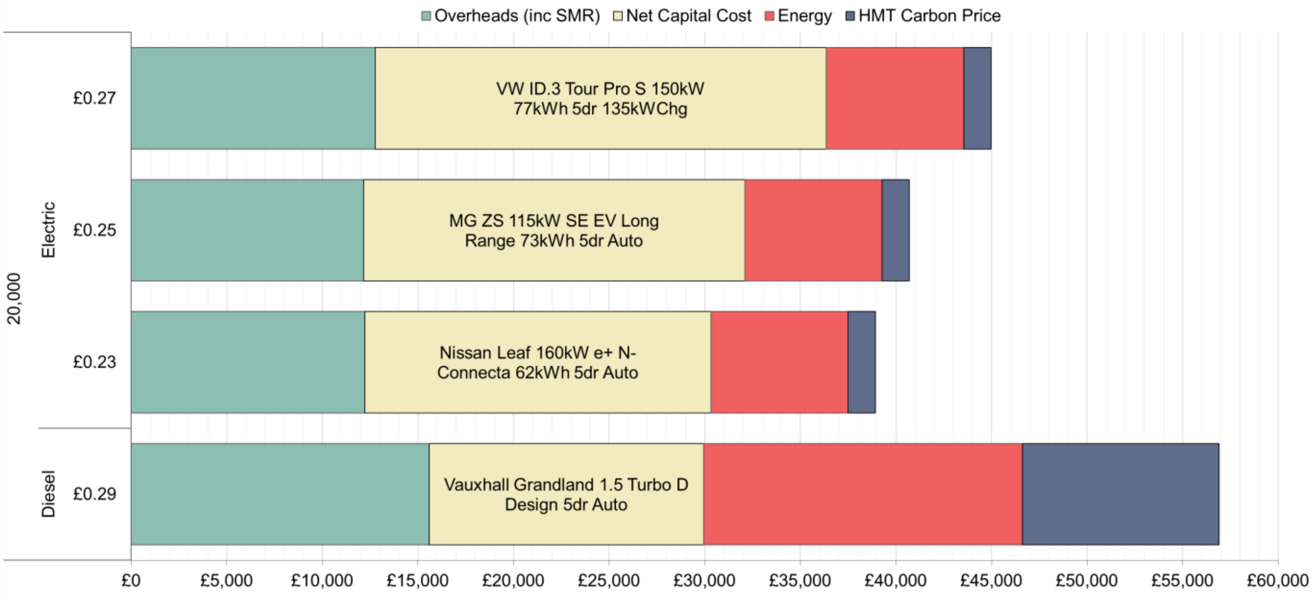
[1]Real World Range – minimum based on "combined" winter use (-10°C) with heating, maximum on mild weather use.
More information about all these vehicles and others is available from https://ev-database.uk/
[2]NCAP assessment for ICE version – EV not yet tested. NCAP applies to "all ICE models" https://www.euroncap.com/en.

The only hydrogen fuel cell (H2FC) cars available in the UK in 2022 are the Toyota Mirai and Hyundai Nexo. Almost all European OEMs including VAG and Mercedes have abandoned development of H2FC cars and have had to write off many years of development costs. Honda has put FCEV car development on hold (production of the Honda Clarity ended in August 2021) and Hyundai is also understood to be pausing development of both H2FC and ICE.

7.3 Whole life cost – compact SUVs

The Vauxhall Grandland on fleet could be replaced with a variety of BEV vehicles, of which a selection of possibilities are presented below. It should be noted that the current vehicle is the highest mileage vehicle on fleet, covering over 22,000 miles in 2021 and driving over 180 miles in one day on three occasions. The maximum daily mileage was 202 miles. The daily operational range of these sample vehicles below is sufficient to ensure even the peak daily mileage could be undertaken by a BEV replacement, on a single charge.

Figure 7-1: WLC comparison of diesel and electric compact SUVs/hatchbacks (Purchase, 8-year retention)



**HMT carbon price not included in ppm calculation figures shown to the left of the chart*

We have modelled WLCs to cover 20,000 mpa and used the 57 mpg achieved by the current vehicle. As can be seen, if the leased Vauxhall Grandland were to be replaced with a purchased equivalent, the equivalent WLC per mile would be around £0.29. In contrast, the selection of BEV vehicles are all able to achieve lower WLC per mile figures of between £0.23 and £0.27/mile, due largely to their lower cost of energy and SMR. It should be noted that although a 160,000 mile operational life for the BEV is likely quite realistic it may be less realistic for the ICE comparison vehicle without significant SMR costs, not covered in this modelling. If SOVWH were to pursue a shorter ownership period prior to replacement, the cost per mile would increase for both ICE and BEV vehicles, however BEV models would still be available at equivalent cost per mile as the ICE comparator. An MG ZS purchased and operated for four years would cost an estimated £0.39 per mile compared to the Vauxhall Grandland at £0.40 per mile. Marginal saving on energy costs for each mile travelled means that the more miles driven, the greater the savings that can be achieved, both financially and in carbon terms.

Table 7-3: Whole life cost and GHG emission comparison at 20,000 mpa, purchase, 8-year retention

Make and Model	Fuel	Discount Purchase Price	£/mile	Whole Life GHG (t)	GHG Shadow Price
VW ID.3 Tour Pro S 150kW 77kWh 5dr 135kWChg	Electric	£31,521	£0.27	5.5	£1,428
MG ZS 115kg SE EV Long Range 73 Kwh 5dr Auto	Electric	£26,328	£0.25	5.5	£1,428
Nissan Leaf 160kW e+ N-Connecta 62kWh 5dr Auto	Electric	£24,668	£0.23	5.5	£1,428
Vauxhall Grandland 1.5 Turbo D Design 5dr Auto	Diesel	£20,212	£0.31	39.8	£10,284

Transitioning the sole fleet car to a BEV will reduce SOVWH’s GHG emissions by an estimated 34.3 tonnes over an 8 year retention and 160,000 miles. The BEV will likely cost less, regardless of whether Shadow Carbon Price is considered, although this will depend on the models considered and how purchase prices may change between now and the time of replacement.

The current fleet car should be replaced with a BEV equivalent at the end of its lease term. It is assumed the lease period is four years, if this is the case this would indicate a late 2023/early 2024 for the current car to be replaced with a BEV. The capital cost is likely to be c. £26 k and the GHG saving will be 4.3 t / year. The saving over the lifetime of the vehicle by adopting a BEV will be approximately £7,500 (or around £950/year).

8. Moving to a zero emission LCV fleet

8.1 Description of the LCV fleet

The LCV fleet at SOVWH consists of 13 vehicles, as shown in Table 8-1.

Table 8-1: Categories of ICE LCVs on the fleet (2020), their energy efficiency and annual mileage

Fleet Category	Qty	Example Make	Example Model	Fuel	Av. OEM gCO_2/km	Adjusted gCO_2e/km[1]	Av. mpg	Av. Annual Mileage
3.1 to 3.5t[2]	9	Ford	Transit 350 leader ecoblue	Diesel	212	230	30	16,781
2.6 to 3.1t[2]	3	Isuzu	D-Max	Diesel	180	224	32	17,764
2.0 to 2.6t	1	Volkswagen	Caddy Max	Diesel	127	103[3]	70[3]	9,505

[1]Uplifted: Real World Scope 1 GHG emissions based on fuel consumption data

[2]the Facilities team LCVs (one 3.1-3.5t and two 2.6-3.1t) had fuel data provided by spreadsheet titled 'Mileage + Fuel costs Jan 2021-December 2021' as well as in the main fuel records supplied. The fuel cited in the 'Mileage + Fuel costs Jan 2021-December 2021' differed from the main fuel data supplied and represented an unrealistically high equivalent mpg (50+) when considered alone. Fuel from both spreadsheets was thus summed to use for forming the CO_2e and average mpg for the relevant vehicles.

[3]The fuel volume for the Public Convenience Cleaning appears quite low for the mileage travelled – it is possible this vehicle achieves an average of 70 mpg but very unlikely, hinting that perhaps not all fuel data for the vehicle is captured/was supplied. In subsequent analysis a more typical fuel economy for a vehicle of this size us used).

The fuel economy delivered by the LCV fleet is generally within the parameters of what would be expected for a mixed operation incorporating rural and urban environments. Typically, real world CO_2e figures are in the region of 30-40% higher than the advertised NEDC figures for the vehicle, however, in this instance they are somewhat more aligned. The outlier appears to be the Public Services Cleaning team's Volkswagen Caddy for which it is assumed there is likely some fuel data missing. A real-world fuel economy of 70mpg would be an exceptionally high fuel economy for a vehicle of this type.

8.2 Electrification of the LCV fleet

Most modern electric LCVs have battery capacities in the range 40 to 90 kWh and on average, all the (SOVWH) LCVs in 2021 used less than 55 kWh per working day, but this does not reflect variations in daily use. To understand variations in daily use telemetry or daily mileage records must be considered and it should be remembered that telemetry is currently only installed on the Grounds Maintenance fleet vehicles, representing 70% of the LCV fleet.

Each size of LCV will be considered in turn and variations in daily energy requirements considered, where telemetry data is available.

8.3 Car Derived Vans (CDV) and Small LCVs – up to 2.6 tonnes

The car derived van category (Table 8-2) includes the Renault Zoe CDV, Maxus eDeliver 3, Renault Kangoo E-Tech, and the Kangoo-based Nissan Townstar which replaces the Nissan e-NV200. New versions of the Stellantis group Peugeot e-Partner, Citroen e-Berlingo and Vauxhall Combo-e Cargo, with larger batteries and improved capabilities, are also available to order. These are all practical BEVs, which achieve real world GHG emission reductions and they can also reduce WLCs. Ford does not currently offer any electric vehicles in this category.

Table 8-2: Payload (kg) and load space (m^3) of electric LCVs up to 2.6 tonnes

Make	Model	Battery (kWh)	RW Range[1] (Miles)	Maximum payload (kg)	Capacity Cubic metres
Renault	Zoe CDV	50	150 - 233	380	1.0
Renault	Kangoo E-Tech (2022 model)	44	164	625	3.6
Nissan	Townstar (2022 model)	44	164	625	3.6
Maxus	eDeliver 3	35 or 53	90 - 150	865 - 1020[2]	4.8
Stellantis	e-Partner/e-Berlingo/Cargo-e	50	170	800 (tow 750)	3.8/4.4

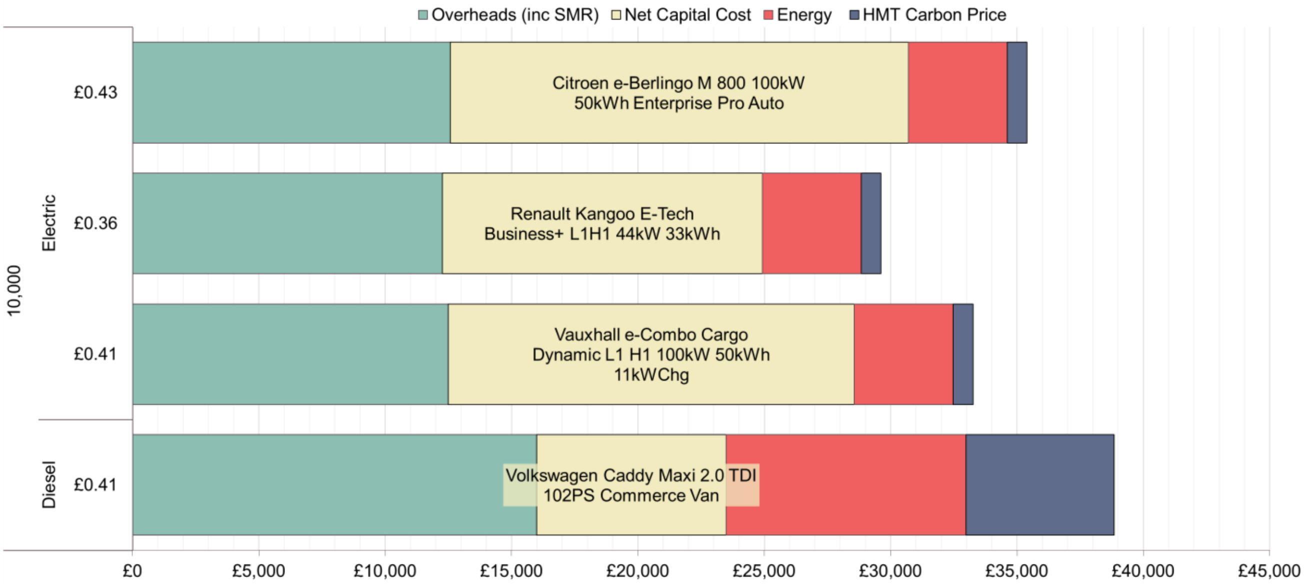
[1]Real World Range – minimum based on winter use (-10°C) with heating.

[2]Depends on the motor/engine power output chosen and vehicle length.

8.4 WLC – Car-derived and Small LCVs – up to 2.6 tonnes

For the following comparison the Volkswagen Caddy's energy consumption is assumed to be 50 mpg and not the 70 mpg calculated. A figure of 50 mpg is more representative for a vehicle of this size. A range of comparative BEVs have been selected to enable informed comparison of the WLCs of BEVs purchases against the purchase of a replacement to the leased Volkswagen Caddy currently on fleet.

Figure 8-1: Comparison of ICE and BE small LCV options – purchase, 8 year retention, 10,000 mpa



We have modelled WLCs to cover 10,000 mpa – in alignment with the current Volkswagen Caddy's annual mileage. As per other comparisons in this report electricity has been modelled at £0.15/kWh (and assuming a 3% inflation rate to this figure) and diesel at £1.25/litre (and assuming a 2% inflation rate for this figure).

Table 8-3: Whole life cost and GHG emission comparison, small LCVs - purchase, 8 year retention, 10,000 mpa

Make and model	Fuel	Purchase	Annualised WLC	£/mile	Whole Life GHG (t)	GHG Shadow Price
Renault Kangoo E-Tech Business+ L1H1 44kW 33kWh	Electric	£21,812	£3,604	£0.36	3.0	£779
Citroen e-Berlingo M 800 100kW 50kWh Enterprise Pro Auto	Electric	£28,060	£4,327	£0.43	3.0	£779
Vauxhall e-Combo Cargo Dynamic L1 H1 100kW 50kWh 11kWChg	Electric	£25,802	£4,059	£0.41	3.0	£779
Volkswagen Caddy Maxi 2.0 TDI 102PS Commerce Van	Diesel	£15,228	£4,122	£0.41	22.7	£5,862

Replacing the existing vehicle with a BEV will reduce GHG emissions by an estimated 2.5 tonnes per year, over the 10,000 miles the vehicle currently travels. Telemetry data is not available for the Volkswagen Caddy currently on fleet. The 9,505 miles it travelled over the course of the year equates to an average of 40 miles per working day.

Assuming the current vehicle's fuel economy is 50 mpg instead of the 70 mpg the data available implies, this equates to an equivalent electrical energy requirement per working day for a BEV vehicle of approximately 11.5 kWh – well within the capacity of all BEV CDVs and small LCVs available today. The analysis indicates that BEV equivalents are available at comparable WLC to the Volkswagen Caddy Maxi. Depending on discount prices available at the time of purchase the analysis indicates it may be possible to achieve a WLC in region of 10% lower for a BEV compared to purchasing an ICE vehicle to replace the current vehicle. For this reason, we would recommend transitioning to BEV when the existing lease expires on the Volkswagen Caddy. If, in the future, the operational requirements of this vehicle were to increase, resulting in more miles travelled each year, the financial advantage to opting for the BEV instead of an ICE vehicle would increase too.

8.5 Medium LCVs – 2.6 to 3.1 tonnes

The medium LCV category (Table 8-4) is dominated by the joint venture 3.1 tonne LCVs from Toyota (e-Proace) and the Stellantis Group (Vauxhall/Opel Vivaro-e, Peugeot e-Expert and Citroën ë-Dispatch). These LCVs have a good range with two battery size options, a good carrying capacity and a useful one tonne towing capacity. The Mercedes e-Vito is also available and has recently been upgraded with a larger 66 kWh battery option. There is currently only one four wheel drive BE pick-up available – the newly released Maxus T90, however more models are expected to market soon.

Table 8-4: Payload (kg) and load space (m^3) of electric LCVs, 2.6 - 3.1 tonnes.

Make	Model	Body	Battery (kWh)	RW Range[1] (miles)	Maximum payload (kg)	Size[3]
Stellantis	e-Expert/Dispatch/Vivaro	Van	50 or 75	140 - 205	1,000 - 1,250[2]	L1, L2, L3
Toyota	e-Proace	Van	50 or 75	140 - 205	1,000 - 1,250[2]	L1, L2, L3
Mercedes	e-Vito	Van	66	162	807	L2, L3
Maxus	T90EV	Pick-up	88.5	220	1,000	-

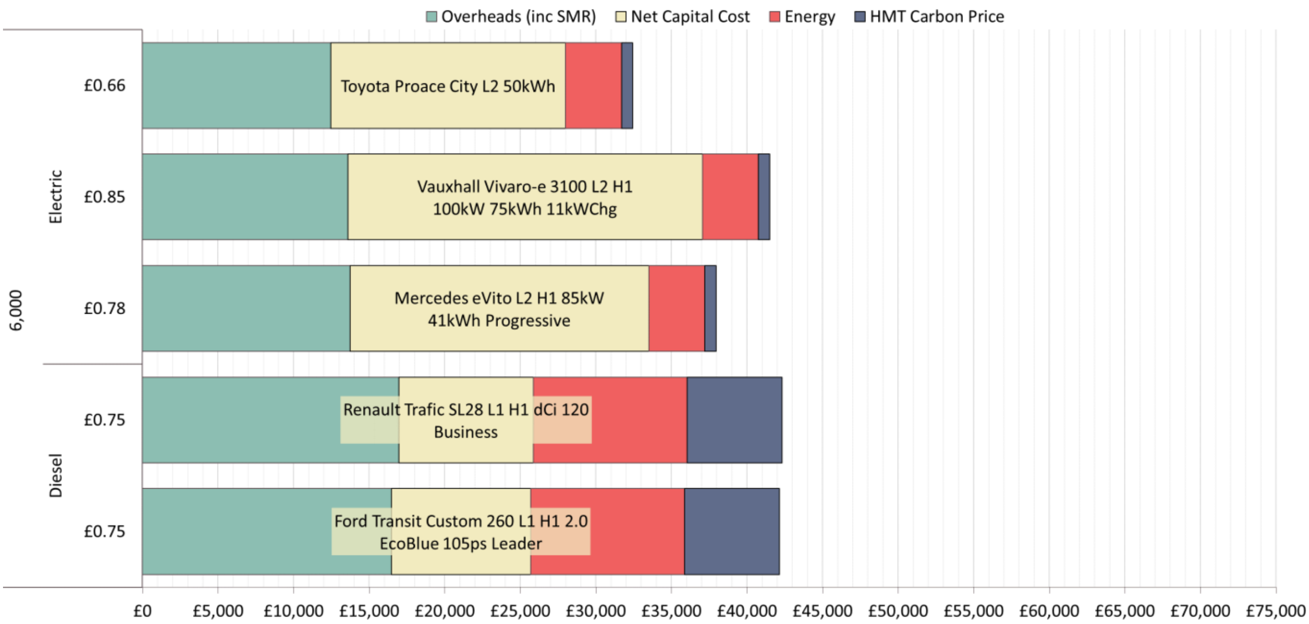
[1]Real World Range – WLTP or NEDC adjusted. [2]Vehicles have a 1,000 kg towing capacity. [3]OEM categories – not the same.

8.6 WLC – Medium LCVs – 2.6 tonnes to 3.1 tonnes

Vans

SOVWH have two vans on fleet in this category, each from a different manufacturer: one Peugeot Expert panel van and one Ford Transit Custom panel van (both Facilities). The two Facilities vehicles both have annual mileages of around 6,000 mpa. Being in the facilities team visibility of these vehicles' daily mileage profile is not available.

Figure 8-2: WLC comparison of ICE and BE medium LCV vans – 8 years, purchase, 6,000 mpa



We have modelled WLCs to cover 6,000 mpa to reflect the current mileage profile, and used an energy consumption of 28 mpg (the average attained for the two vehicles currently on fleet).

Table 8-5: Whole life cost and GHG emission comparison, medium LCVs at 6,000 mpa, purchase and 8 year retention

Make and model	Fuel	Purchase	Annualised WLC	£/mile	Whole Life GHG (t)	GHG Shadow Price
Toyota Proace L2 50 kWh	Electric	£25,204	£3,963	£0.66	2.9	£738
Vauxhall Vivaro e-3100 L2 H1 75 kWh	Electric	£38,429	£5,095	£0.85	2.9	£738
Mercedeze Vito L2 H1 41 kWh	Electric	£35,109	£4,651	£0.78	2.9	£738
Renault Traffic SL28 L1 H1 2.0	Diesel	£15,345	£4,504	£0.75	24.3	£6,281
Ford Transit Custom 260 L1 H1 2.0	Diesel	£15,054	£4,483	£0.75	24.3	£6,281

Table 8-5 highlights how even at the low mileage rate of 6,000 mpa BEVs, model dependent, are at and below price parity with comparably sized ICE 2.6-3.1 t LCVs. If a vehicle such as the Toyota Proace is suitable for SOVWH's operational requirements then notable savings are achievable over the lifetime of the vehicles. With two vehicles of this size category on fleet the combined saving over the life of the vehicles is likely to be around £8,000. Each vehicle will save approximately 2.7 t of carbon per year, compared to the ICE comparator.

Pickup

SOVWH has one Isuzu D-Max pick-up which operates in the Grounds Maintenance team. The vehicle has a high annual mileage of 16,000 mpa. When the daily telemetry data for the Grounds Maintenance vehicle is considered we find the highest single daily mileage over the course of the year was 153 miles.

We have modelled WLCs to cover 6,000 mpa and 16,000 mpa to reflect the current mileage profile, and use an energy consumption of 31.6 mpg (the average attained in the sample period). The ICE vehicle's energy efficiency was set at 39 mpg to reflect the current vehicle's real world performance.

Figure 8-3: WLC comparison of ICE and BE medium LCV pick-ups – 8 years, purchase, 16,000 mpa

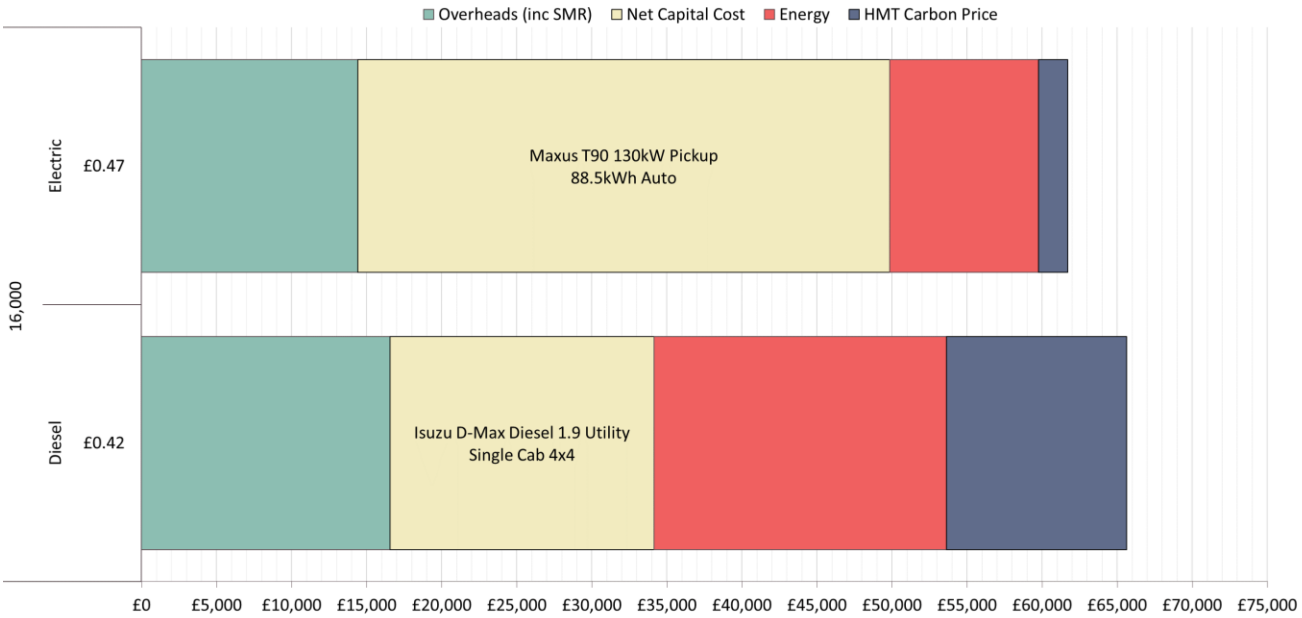


Table 8-6: Whole life cost and GHG emission comparison, medium LCV pick-up, 16,000 mpa, purchase and 8 year retention

Make and model	Fuel	Purchase	Annualised WLC	£/mile	Whole Life GHG (t)	GHG Shadow Price
Isuzu D-Max Diesel 1.9 Utility Single Cab 4x4	Diesel	£23,526	£7,273	£0.42	47	£12,025
Maxus T90 130kW Pickup 88.5kWh Auto	Electric	£49,950	£7,469	£0.47	7.6	£1,967

Table 8-6 shows that the purchase price for a BEV pick-up is more than double that of the currently used ICE model. Even with the high mileage the current vehicle undertakes we see that price parity on a WLC basis can't quite be achieved over the life of the vehicle. That said, it is not in a different league, within 12% and so it is suggested still represents a viable option – particularly when considering other parts of the fleet are able to realise notable savings. It should be noted that the Maxus T90 has a WLTP range of 220 miles and the existing vehicle's maximum daily mileage was approximately 70% of this figure. If the current vehicle were to be replaced with a T90EV and regularly operates with heavy loads, or sees its longest journeys in winter months, it could be possible that this vehicle may require an opportunity charge at some point during the working day on a few occasions each year - perhaps increasingly towards the end of the vehicle's operational life. The T90EV is the first 4x4 BEV to the UK market. It is likely that more will follow in the coming years with greater single charge ranges and possibly lower purchase prices. These might be available by the time the current vehicle is due for replacement. Similarly, as the T90EV has only just been released no discounts are available on its purchase price, this may change in the coming months/years. Transitioning this vehicle to a BEV will realise significant carbon savings of almost 5 t per year.

8.7 Large LCVs – 3.1 to 3.5 tonnes

The first generation of vehicles in this category, such as the Renault Master E-Tech had limited capabilities because of a small battery size. Newer vehicles such as Fiat E-Ducato and Maxus eDeliver 9 are more capable, with a longer range, much greater carrying capacity and they are both in full production. The Ford E-Transit is now available and with a comprehensive range of size options. Stellantis Group have launched the e-Boxer, e-Relay and the Movano-e and these are also available to order now but not all size options are available.

Table 8-7: Payload (kg) and load space (m^3) of electric LCVs, 3.5 tonnes.

Make	Model	Battery (kWh)	RW Range[1] (miles)	Maximum payload (kg)	Size[2]
Fiat	E-Ducato	47 or 79	91 - 148	1,900	L1-L4/H1-H3
Maxus	eDeliver 9	50, 72, 88	136 - 150	1,400	L2-L3/H2-H3
Mercedes	eSprinter	55	96	774	L2-L3/H2-H3
Renault	Master ZE	33	50 - 75	1,000	L2H2
MAN	eTGE	36	65 - 70	1,700	L2H2
Stellantis	e-Boxer/e-Relay/Movano-e	37 or 70	139	1,260 - 1,890	L2-L4/H2
Ford	E-Transit, 350, 390, 425	70	108 - 126	1,470 - 1,970	L2-L4/H2-H3

[1]Real World Range – WLTP or NEDC adjusted. [2]OEM categories – not the same.

8.8 WLC – Large LCVs – 3.1 tonnes to 3.5 tonnes

SOVWH's large LCV fleet is almost entirely made up of Ford Transits, with one Mercedes Sprinter. Most of the fleet (less one vehicle) is operated by the Grounds Maintenance team(s) and undertakes 12,000-20,000 mpa. The one vehicle of this class operated by the Facilities team undertook much lower mileage, in the region of 6,000 mpa. For this reason we have modelled our WLC for this vehicle type for 16,000 mpa and 6,000 with a focus on Ford Transits in particular, to reflect the build-up of the current fleet. The current fleet averaged a respectable 31.4mpg in 2021.

Figure 8-4: WLC comparison of ICE and BE large LCV options - 8 years, purchase, 16,000 mpa

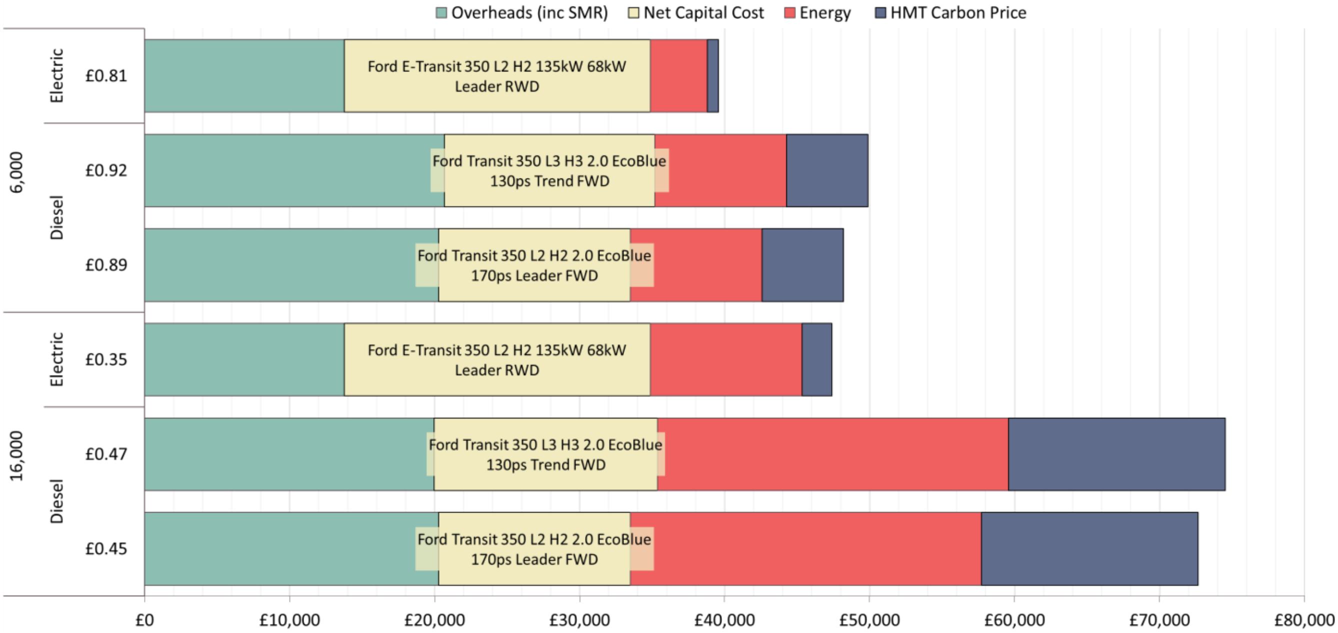


Table 8-8: Whole life cost and GHG emission comparison, at 16,000 mpa, purchase, 8 year retention

Make and model	Purchase	Annualised WLC	£/mile	Whole Life GHG (t)	GHG Shadow Price
Ford Transit 135kW 68kWh 350 L3 Chassis Cab Auto	£36,504	£5,666	£0.35	8.0	£2,078
Ford Transit 350 L3 H3 2.0 EcoBlue 130ps Trend FWD	£23,518	£7,447	£0.47	57.9	£14,935
Ford Transit 350 L2 H2 2.0 EcoBlue 170ps Leader FWD	£21,733	£7,214	£0.45	57.9	£14,935

The BE Ford E-Transit is very competitively priced compared to rivals and at 16,000 mpa the business case for transitioning the large LCV fleet to BEVs is clear to see. Over an 8-year retention period each BEV vehicle is likely to save SOVWH around £12,000 compared to an ICE equivalent. Similarly, as the largest vehicles on the fleet, undertaking high annual mileage, the carbon reduction potential is also greatest for these vehicles at 50 tonnes per vehicle (6.2 tonnes GHG per vehicle per year) - again, assuming an average of 16,000 mpa.

When considering the Facilities vehicle, with lower mileage per year, the economics are still compelling when assuming the vehicle is retained for an 8-year period (Table 8-9). Transitioning the lower mileage Large LCV to a BEV equivalent will reduce GHG emissions by an estimated 2.3 tonnes per year, assuming a similar annual mileage profile of 6,000 mpa in future years.

Table 8-9: Whole life cost and GHG emission comparison, at 6,000 mpa, purchase, 8 year retention

Make and model	Purchase	Annualised WLC	£/mile	Whole Life GHG (t)	GHG Shadow Price
Ford E-Transit 350 L2 H2 135kW 68kW Leader RWD	£36,504	£4,850	£0.81	3.0	£779
Ford Transit 350 L3 H3 2.0 EcoBlue 130ps Trend FWD	£23,518	£5,532	£0.92	21.7	£5,601
Ford Transit 350 L2 H2 2.0 EcoBlue 170ps Leader FWD	£21,733	£5,322	£0.89	21.7	£5,601

8.9 LCVs that could transition to BEV

Consideration of the telemetry data available as well as fuel, mileage and vehicle information supplied indicates that all of SOVWH's vehicles are suitable for transition to BEV equivalents with models currently available. For some vehicles the WLC has been found to be slightly higher for BEV models, for others, notably lower than ICE equivalents.

Table 8-10 draws out a schedule for replacement, based on the age of the current fleet (whereby the oldest vehicles are replaced first) and the objective shared that SOVWH wishes to transition to zero emission council vehicles by 2025.

Table 8-10: Proposed Implementation programme for ZEV LCV fleet

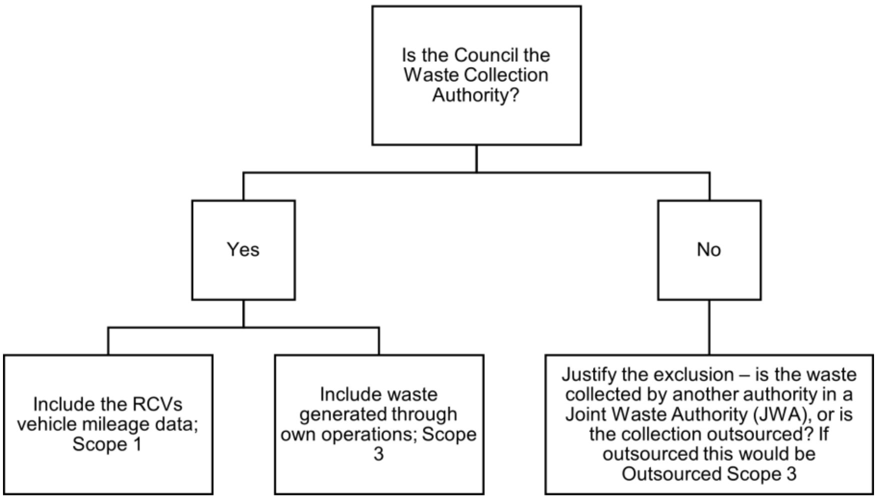
Fleet Category	2022	2023	2024	2025	2026	**Total**
3.1 - 3.5t		5	2	2		**9**
2.6 - 3.1t		1	1	1		**3**
Up to 2.6t		1				**1**
GHG Saving		36 t	17 t	15 t		**69 t**
Capital Cost		£234 k	£123 k	£98 k		**£455 k**
Change in WLC (lifetime)		-£69 k	-£23 k	-£29 k		**-£122 k**
Change in WLC (annualised)		-£9k	-£3k	-£4k		**-£-15k**

9. Moving to a zero emission waste fleet at SOVWH

9.1 Requirements of sub-contractors

SO and VWH are both Waste Collection Authorities, charged by central government with the collection of municipal waste. This responsibility brings with it the requirement to report on emissions associated with waste collection. As this core service has been outsourced the Local Government Association advises that waste related emissions should be included in Scope 3.

Figure 9-1: Local Government Association decision tree explaining how local authorities should report on waste related emissions



At present, the contract for collecting and transporting municipal waste for treatment in SO and VWH is held by Biffa Municipal Limited (BML). SOVWH have advised that in 2021 BML made use of 96 vehicles in conducting SOVWH's waste collection duties. The vehicle data provided by BML indicated that these vehicles were a mixture of owned, hired and leased vehicles, although it is unclear how many are owned by SOVWH. The average age of vehicle was 5 years old. Within the 96 vehicles there were: 38 RCVs, c. 17 RRVs, 5 sweepers, and a variety of other HCVs and LCVs (29 in total). From the fleet list supplied by BML the eight listed as 'owned' (which it is assumed may be owned by SOVWH) were all registered in 2013 or 2014. All 96 vehicles were ICE models, fuelled by diesel.

Unfortunately, on request by SOVWH, no data other than a fleet list could be provided to SOVWH. This means we have not been able to include emissions related to waste collection and any other activities sub-contracted to BML in the scope of this report. It also means SOVWH is unable to fulfil its requirement to include waste related emissions in Scope 3 GHG reporting. Energy Saving Trust would advise this is a point that requires addressing and resolving through the appropriate channels with SOVWH's waste contract manager.

As it is unclear whether the vehicles on the fleet list are employed solely on SOVWH business, or shared with other clients, the total mileage undertaken on behalf of SOVWH each year is not known, nor the fuel consumption of any of the vehicles operated by BML. This makes any analysis to establish the carbon footprint of BML's service undertaken on behalf of SOVWH impossible.

In the absence of data, an indication is provided below of a typical mileage and carbon footprint of a fleet of 10 RCVs. It is likely that more than these (with a greater annual mileage) serve the combined SOVWH geography, however this provides an indication of the importance of waste related transport emissions to SOVWH's overall transport emissions. It should be noted that BML also operate a fleet of sweepers and RRVs alongside RCVs, on behalf of SOVWH.

Table 9-1: Indication of the carbon intensity of waste collection operations in relation to other elements of SOVWH's transport emissions

Fleet Category	Fleet size	Example Make	Example Model/Size	Avg mpg	Fleet Average Annual Mileage	Total annual mileage	Fleet GHG (t)
RCVs	10[1]	Dennis	Eagle 6 (26 t)	2.8	10,000[1]	100,000	508
Main fleet	14	-	-	36	12,735	178,285	74
Grey fleet	238	-	-	39	979	233,000	81

[1]N.B. indicative only – for the purposes of comparing potential scale

It is very important that the contract holder for SOVWH's refuse operations initiates the transition to zero emission vehicles. Just two diesel RCVs conducting rounds of approximately 190 miles each per week emit more GHG emissions (102 t) than SOVWH's in-house main fleet put together (74 t). Put another way, one RCV running 10,000 miles produces around 51 tonnes of GHG in a year, which is around ten times the average GHG produced for each vehicle on SOVWH's main fleet.

Typically, where operating data is available, we are able to cost the replacement of waste vehicles and use energy efficiency data of an existing ICE fleet to inform the likely energy costs of the fleet when transitioned to BEVs. With this in hand we can indicate the relative financial competitiveness of transitioning waste vehicles to electric, as well as the carbon implications of doing so. In this instance, operating data is not available so indicative data has been used. This has been done with the aim of giving an indication (only) to SOVWH of how BEV waste vehicles, particularly vehicles with high annual usage may be economically viable for sub-contractors to introduce when current vehicles come to the end of their lease.

9.2 Battery electric refuse and recycling vehicles

The first all-electric eRCV was launched by Electra in 2018 with a 200 kWh battery on a 26 tonne, three-axle Mercedes Econic chassis. In Manchester, the first vehicle was operated by Biffa on the City Council domestic contract for a six month trial and has continued in use as part of the current Biffa fleet. During the trial, the Electra eRCV was successfully used for the collection of all domestic waste streams including garden & food waste, recyclables (plastic, glass, paper, cardboard) and residuals (anything that cannot be recycled).

The 200 kWh battery of the prototype completed all the Manchester rounds, but had less than 10% charge left when used on the garden waste collection because of a 20 mile run to the composting centre. The vehicle is now available with a range of battery packs up to 300 kWh and can be supplied on 18 tonne and 26 tonne chassis. The range of the 300 kWh vehicle is up to 100 miles (160 km).

The City of London (Veolia) and Manchester City Council (Biffa) now have substantial fleets of the 18 tonne (2-axle) and 26 tonne (3-axle) Electra (Figure 9-) in operation. The Electra vehicle has also entered service with several other councils and it is currently the only vehicle in this size class to receive the full £25,000 grant funding from OZEV.

Also available to order is the Dennis Eagle eCollect, which is a 300 kWh battery electric version of the company's popular 26 tonne "Narrow" model. It has been extensively tested with local authorities around the UK, is in full production and already in service with many councils including Nottingham, Newport, Cardiff, Oxford, Powys, Dundee, York, Cambridge, Sunderland, and Islington.

Volvo/Renault has sold its first UK 26 tonne eRCV (D Wide ZE) to SUEZ Recycling who are using it for commercial waste collections in Bristol city centre. Volvo/Renault have also announced the availability of a low entry cab for the electric HCV range. The first DAF 6x2 eRCV has been supplied to the Dutch waste company ROVA (it has a 170 kWh battery and a 30 minute rapid recharge time).

Figure 9-2: One of the City of Manchester's 27 Electra/Mercedes 26 tonne 300 kWh electric refuse vehicles

An alternative to buying a new electric RCV is offered by the UK company Refuse Vehicle Solutions (RVS) who have entered into an agreement with EMOSS to use its technology to convert donor RCVs from diesel to electric. The old vehicle chassis, cab and waste collection rig are refurbished, new electric bin lifts are fitted, and the diesel drive train is replaced by an EMOSS electric drive with the option of a 200 kWh or 280 kWh battery. The Geesinknorba group have also developed an electric RCV in collaboration with GINAF, using a DAF LF chassis. The vehicle has a 200 kWh battery and a 44kW on-board charge point.

It is understood that a BE resource recovery vehicle (eRRV) the RQ-E will shortly be available from Romaquip based on a DAF glider chassis and that Terberg (owners of Dennis Eagle) are working with Electra to produce a RRV based on an IVECO glider chassis for their kerbside/loader range.

9.3 Battery electric sweepers, gritters, tankers, tippers and pickups

Scarab has confirmed that it is developing a BE sweeper and plans to launch it by June 2023. In advance of this, (end of 2022) Scarab plans to launch a truck-based BE sweeper called the Emerlin62, which will be based on the diesel Merlin62. The expectation is that the Emerlin62 will retail at about £400,000.

Recently launched from the Fayat group, which owns Scarab, is the ERavo, which is an 11.5t sweeper with a payload of approximately 5t and retail cost of approximately £390,000. Whilst we don't have access to sufficient BE sweeper specifications, cost or operating data required for a comparison between BEV and ICE sweepers, it is prudent to plan for the electric sweepers to have a capital cost that is approximately 2.5 times the cost of the diesel sweeper.

Nottingham City Council is operating a fleet of eight small electric sweepers (Boschung). Companies like Whale (tankers and gully cleaners – Figure 9-3) and Johnston/Bucher sweepers have used electric drive kits from the Dutch company EMOSS to convert donor vehicles.

Figure 9-3: Whale battery electric MVC tanker and Bucher V65e electric street sweeper

Edinburgh recently took delivery of an electric street sweeper manufactured by Bucher Municipal which is estimated to reduce diesel fuel costs by £18,000 per annum.

9.4 WLC model for electrification of RCVs

We have costed the replacement of one RCV and have used indicative energy efficiency data (mpg) to determine the energy cost savings and GHG emissions based on an annual mileage of 10,000 miles.

Because the BEV drive train is more reliable with many fewer wearing parts, we have modelled the life of the BEV over 10 years and the ICE vehicle over seven years (Table 9-2) with a new ICE vehicle to be procured for the last three years (incurred costs are proportionately considered in the model). What is not included in this model is the cost of rig or battery refurbishment during the ten-year operational life of the eRCVs, or the additional cost of future diesel RCVs associated with meeting the new Euro VII emission standard in 2026/27.

Table 9-2: Electric 26 tonne RCV fleet – factors used in the whole life cost energy model

RCV Factor	Electric	Diesel	Notes/Units
Project Life	10		Years
Vehicle Lifespan	10	7	OEM Advice & Fleet policy
Fleet Size	1	1	Fleet data
Annual Mileage/Vehicle	10,000	10,000	Fleet data
Energy Efficiency	5.17 kWh/m	3.5 mpg	EV derived from diesel
Cost of energy/fuel	£0.15 / kWh	£1.23 / l	Diesel price as in fuel data provided
Annual Inflation to 2030	3.24%	1.79%	Based on BEIS 2009-19

The cost savings from eRCV chassis maintenance are significant but the cost of maintaining the rig will be similar for both vehicle types. The energy costs of £0.15/kwh and £1.23/litre have been used as the base year but an annual inflationary increase has been applied. Future carbon taxes have not been considered but may be significant.

Table 9-3: Ten-year net (ex VAT) capital cost of an electric and diesel RCV fleet (Dennis Eagle e-Collect)

Cost Summary	Electric	Diesel	EV Cost (-Saving)	Notes
Vehicle Capital Cost	£430,000	£220,000	£210,000	OEM data
Residual Value (Chassis)	-£19,600	-£15,400	-£4,200	BEV 5%, ICE 5%
OZEV Grant Funding	£0	£0	£0	Only available for Electra
Residual Value (Battery)	-£22,500	£0	-£22,500	Estimated as 20%
Total Vehicle Cost	£387,900	£204,900	£95,614	
Over 10-year Project	£387,900	£292,286	£95,614	ICE figure scaled to apportion capital investment in 2nd vehicle for final three years
Fleet Net Capital Cost	**£387,900**	**£292,286**	**£95,614**	

The high capital cost of the eRCV is apparent in Table 9-3. Even if the ICE RCV is renewed at seven years and the costs associated with the additional three years included, the eRCV still has a significant additional capital cost of £95,614 over the 10 years modelled. The residual value of the batteries may be higher than our estimate (they have a second life in energy storage and can be refurbished) and it is possible that in 2030, an electric chassis will be worth much more than a diesel chassis, as has been reflected in the BEV having a marginally higher chassis residual value than the ICE comparator.

Table 9-4: Ten-year Whole Life Cost – includes fuel, AdBlue, VED and road user levy

Cost Summary	Electric	Diesel	EV Cost (-Saving)	Notes
Fleet Net Capital Cost	**£387,900**	**£292,286**	**£95,614**	**From previous table**
Total Energy Cost	£92,723	£220,400	-£127,676	Includes inflation
AdBlue Cost	£0	£6,819	-£6,819	No inflation
SMR (ex-Tyres) Costs	£84,000	£120,000	-£36,000	OEM Estimate
VED + Road User Levy	£0	£5,835	-£5,835	DVLA V149/1 - 2020 Policy
Euro VI CAZ Levy from 2027	£0	£0	£0	Relevant if a local CAZ is to be enforced in SOVWH?
Whole Life Cost	**£564,623**	**£645,339**	**-£80,716**	

We would expect the eRCV to have an energy cost of approximately £92,723 for the 10 years modelled, compared to over twice that amount for the ICE vehicle (£220,400). This, along with other savings realised by the eRCV over the project period in Table 9-4 means that the whole life cost comes out at less than that for the ICE by around 13% (£80,716 saving over the 10 years). OZEV grants are available but have not been included for the purposes of this model.

*Table 9-5: Ten-year energy use (kWh) and GHG Emissions (*kg CO_2e*) of an electric and diesel RCV fleet*

Energy Use and GHG	Electric	Diesel	EV Cost (-Benefit)	Notes
Energy consumption (kWh)	516,638	1,772,125	-1,205,125	Assumes 70% reduction
Scope 1 kg CO_2e	0	407,903	-407,903	BEIS Factors
Scope 1 AdBlue kg CO_2e	0	1,237	-1,237	Used by SCR - BEIS
Scope 2 kg CO_2e	59,475	0	59,475	UK Grid - Predicted
Scope 3 T&D kg CO_2e	5,236	0	5,263	UK Grid - Predicted
Scope 3 WTT kg CO_2e	16,857	99,017	-82,160	BEIS Factors, 2021
WL WTW GHG (kg CO_2e)	**81,595**	**508,157**	**-426,563**	**-427 tonnes over project life**

Over the ten-year lifetime of the eRCVs, total GHG emissions will reduce by 427 tonnes (Table 9-5) and by at least 90% in 2030. The eRCVs have no Scope 1 emissions and all the GHG emissions are Scope 2, from the generation of electricity and Scope 3 from transmission and distribution (T&D) losses as well as "WTT" emissions at the generator – all of these will fall over the lifetime of the project, as the UK Grid decarbonises. Local generation of electricity using a wind turbine, or PV array, would reduce the electrical energy costs and remove uncertainty regarding the future cost of energy.

Air quality improvements

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

Table 9-6 below has been determined using the COPERT5 model for a Euro VI diesel operating at an average speed of 10 km per hour (6.2 mph) reflecting semi-urban operation. This is a vehicle specific model and very different from the "Average UK HCV" values presented earlier in this report.

Table 9-6: Air Quality: Emissions over the 10-year life of the ICE and BEV RCV fleets (kg)

Air Quality (Project Life)	Electric	Diesel	BEV Emission reduction	Notes
Nitrogen Oxides (NO_X) kg	0	307	-307	NAEI COPERT5 (10 km/hr)
Particulate matter (PM) kg	0	2.4	-2.4	NAEI COPERT5 (10 km/hr)

Benefit to Society – HM Treasury Net Present Value methodology

The HM Treasury Green Book (2021) provides a methodology to assess the net present value (NPV) of the transition to eRCVs in terms of the reduced UK shadow carbon cost of the vehicles' GHG emissions, and societal benefits of improved air quality. The NPV model also includes a measure of the cost saving to HM Treasury from the change in fuel use. The results from the HMT Green Book NPV methodology are shown in Table 9-7.

Table 9-7: HMT Green Book (2021) valuation of energy use, GHG emissions and air quality impact

eRCV Project – NPV	Electric	Diesel	Value (£2022)
Energy use change (HMT impact)	£41,492	£63,659	-£22,166
UK GHG (CO_2e) emission reduction	£14,848	£91,268	-£76,420
Local air quality - reduced health impacts	£952	£11,000	-£10,049
Net Present Value (NPV)	**£57,292**	**£165,928**	**-£108,636**

The tax paid on road fuel is not included in the HMT cost saving model as both the road fuel duty and VAT is recovered by the Treasury. As a result, the cost saving in the NPV model is significantly less than the actual energy cost saving we estimate could be achieved by SOVWH (Table 9-4) which is based on market prices and the inability of operators to recover road fuel duty.

The large shadow carbon price for UK GHG emissions is associated, in part, with the significantly higher cost associated with meeting the UK's more ambitious Nationally Determined Contributions (NDCs) announced in April 2021 prior to COP26 in compliance with the Paris Agreement (2015).

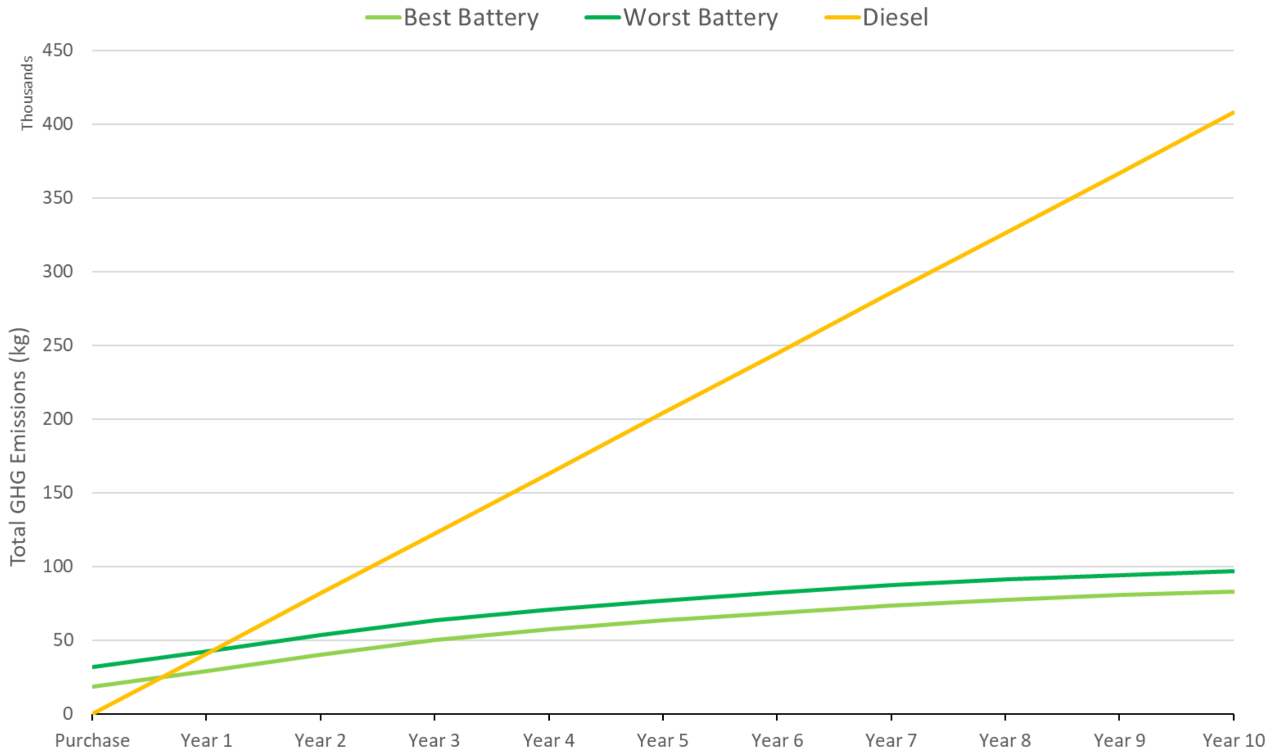
The reduction in GHG emissions and improved air quality, are valued at £86,469 which further extends the case for moving to eRCVs (and potentially other energy intensive waste vehicles) as good value for money for SOVWH.

Offsetting the GHG embedded in the battery

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

In 2019, the range was from 61 $kgCO_2e/kWh$ to 106 $kgCO_2e/kWh$. Figure 9-4 demonstrates that even with the most GHG intense battery (worst battery) the electric RCV breaks even on the GHG embedded in its manufacture within 14 months - when the yellow line of cumulative diesel emissions crosses the green lines of cumulative EV emissions. In the case of the "best battery" this occurs after about nine months use.

Figure 9-4: Cumulative GHG Emissions, 300 kWh battery, 10-year life, UK Grid, RCV operation.



Over the last three years many battery manufacturers around the world have moved to using renewable energy for the production process, which places their batteries in the "best" category. Even if the battery manufacturing plant is 100% net zero, there are still GHG emissions associated with the extraction, processing and transport of the raw materials required for manufacture of the battery – hence the best category representing 18.3 t of embodied GHG emissions in the batteries' manufacture.

Treating the principal components as separate assets

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

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

10. Grey fleet

There are 238 staff that use their own privately-owned and operated vehicles to drive work-related (business) miles across the two councils. This population's vehicles is called the "grey fleet" and the Scope 3 emissions that come from this grey fleet count towards both council's respective (GHG – CO_2e) footprint. In line with SO and VWH's 2030 carbon neutrality targets the emissions of the grey fleet should be considered alongside the Scope 1 emissions of SO and VWH's main fleet.

In 2021 the SOVWH grey fleet drove 233,000 miles cumulatively, emitting 76 tonnes of CO_2e in the process.

Table 10-1: Grey fleet summary for the respective councils

Council	Grey fleet drivers	Total mileage	Total CO2e (kg)	PM (kg)	NO_X (kg)	£[1]
South Oxfordshire	231	117,498	38,444	1.55	50.31	£51,792
Vale of White Horse	228	115,503	37,689	1.53	49.72	£50,895
Combined	238	233,000	76,133	3.07	100.3	£102,687

[1]assuming SO & VWH employ HMRC's mileage and fuel rates and allowances

The average GHG intensity of the combined grey fleet was found to be 203 gCO2e/km from the data provided. If SO and VWH are to meet their targets of being carbon neutral by 2030, each council would need to reduce its grey fleet mileage by approximately 15,000 miles every year, from 2022 to 2030, or take steps to transfer the mileage to a zero emission fleet.

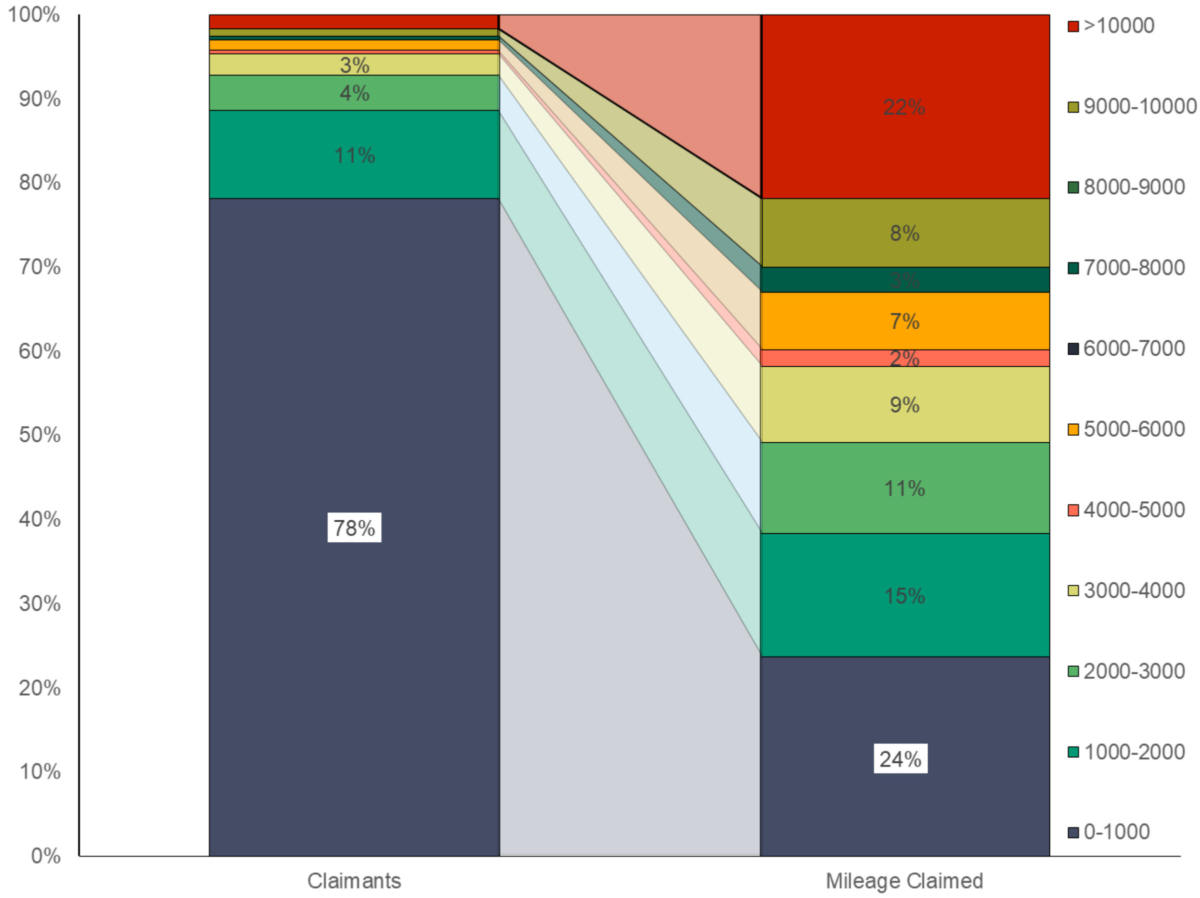
221 of the 238 grey fleet drivers drove their personal vehicles for business purposes for both councils so any policies implemented to reduce grey fleet emissions should be closely aligned, and most likely mirrored, across the two councils to reflect the shared nature of employee's business.

10.1 Staff business mileage – analysis

It is often found that a small minority of drivers are responsible for a large proportion of overall mileage. Considering SOVWH's grey fleet the principle applies quite closely – 20% of drivers (48) were responsible for 75% of the overall mileage in 2021 (173,715 miles).

Looking at first at the high mileage drivers (those driving over 10,000 miles per year), numbering only four, their cumulative mileage makes up a significant portion of the fleet's overall mileage (nearing on one quarter), as Figure 10-1 depicts.

Figure 10-1: Staff business mileage profile



Expanding focus to consider drivers undertaking in excess of 5,000 miles per year (approximately 100 miles per week) - it can be seen that just 10 drivers (4% of claimants) are driving 40% of the cumulative grey fleet miles across the two councils. This 4% of claimants are too responsible for approximately 40% of the grey fleet's cumulative carbon emissions as well.

When considering the makeup of this cohort of high mileage drivers it might be expected that the number is comprised largely of the Public Convenience Cleaning team's vehicles who, with the exception of the Team Supervisor, use their own private vehicles to attend their various sites. This is partly the case, with five of the ten being from the Public Convenience Team, however the remaining five work in other teams.

Drawing focus to the Public Convenience Cleaning Team as a whole - its eight individuals drove 52,178 miles in 2021 – equating to 16.4 t of CO_2e and an average of 6,522 miles per employee. Although the highest business mileage in a personal car was from a member of the Public Services Cleaning Team (16,353) the other very high usage drivers of above 10,000 miles per year were not from the Public Services Cleaning Team.

Considering the cumulative mileage driven of the SOVWH's combined grey fleet and the mixed geography of both council territories (including rural and urban areas) it is likely that employees are spending in excess of 8,500h driving each year driving their personal vehicles for business use (equivalent to 4.6 working years, each year). This is based on an average speed of 26.6 mph (DfT data, mixed roads, England, December 2020).

Assuming both councils follow the HMRC's standard mileage rates and allowances, the combined average cost per mile of the grey fleet was £0.441/mile – the figure is lower than £0.45/mile owing to the small number of individuals driving personal cars in excess of 10,000 miles per year (4). The average claimant would have driven 978 miles in their vehicle in 2021.

The breakdown of mileage by fuel type was almost 50:50 between petrol and diesel, with less than 1% of mileage completed in battery or hybrid vehicles.

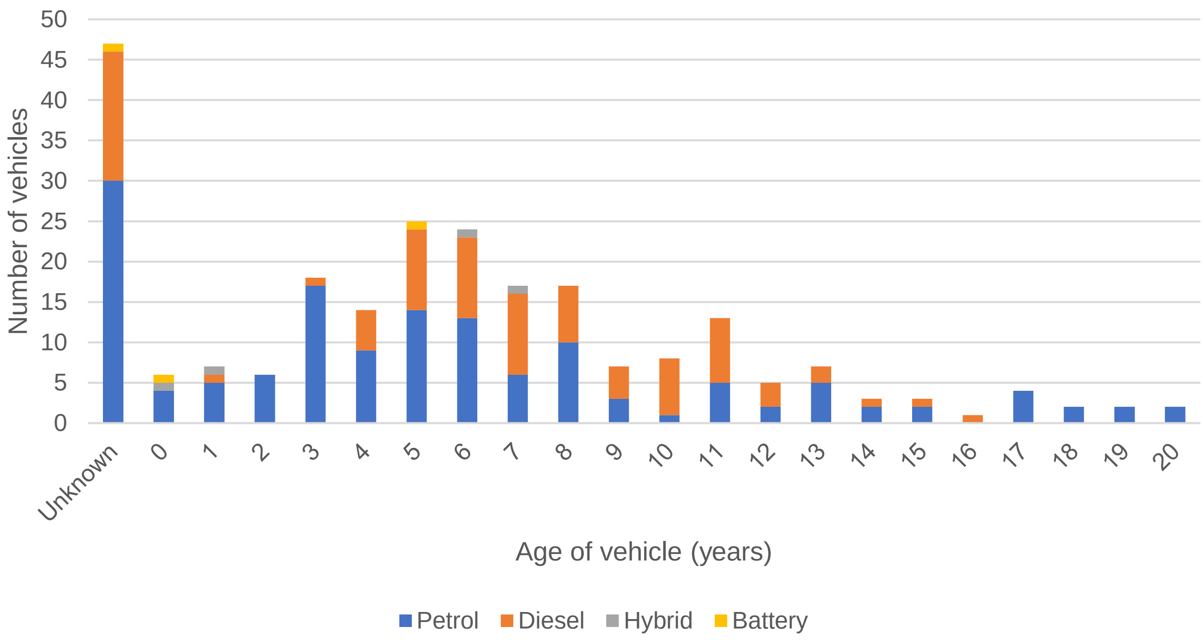
10.2 Grey fleet age profile

This chart below reflects the age of staff grey fleet cars which were in use in 2021. Vehicle age matters because it impacts adversely on:

- fuel consumption – old engines are less efficient,
- air quality – old engines are significantly more polluting,
- safety – not equipped with modern accident-avoidance technology,
- reliability – much more likely to break down,
- service delivery – when they break down it can be very disruptive.

The average age of SOVWH's grey fleet in 2021 was 7.2 years, which is less than the average UK car at 8.4 years old. The mileage per vehicle was considered in regards to its age and there was no trend evident that older vehicles are undertaking higher mileages per year than younger vehicles.

Figure 10-2: Average daily energy use (kWh) of an all-electric HCV fleet (30% ICE energy use – 2020 data)



10.3 Travel hierarchy – reducing grey fleet mileage

Reducing grey fleet usage is not easy. The £0.45 mile payment may be regarded by some staff as part of their monthly income. For an employee with a car costing £0.15 a mile for fuel (about 50 mpg), the contribution to running costs is £0.30 a mile, which at 6,000 miles a year is £1,800, free of income tax, national insurance and pension contribution.

Those large organisations that have successfully reduced grey fleet mileage have done so by dedicating a staff resource to achieving change in this area – typically for a period of 18 to 24 months. Several have successfully lowered overall staff business mileage (both grey and pool fleet) by as much as 40% and reduced their overall travel costs proportionately. One public sector body achieved an 80% reduction in grey fleet mileage and a 50% reduction in overall road mileage (including pool fleet) with some mileage disappearing, some transferring to video conferencing and some to public transport – mostly trains.

A travel hierarchy (Appendix F) requires employees to question the need for travel and then guides them to the most cost-effective and environmentally friendly solution. It also requires a manager to sign-off the journey before it is made, thereby confirming that it is necessary, and the most appropriate form of transport has been selected.

A good Travel Policy and a robustly-implemented Travel Hierarchy can help, as can identifying the relatively small number of high mileage drivers and spending time with them, working out how they can reduce their mileage, or use other modes, whilst also supporting SOVWH's duty-of-care obligations by moving business travel into a mode over which it can exert more control.

The promotion and use of non-travel options such as online meetings are very important as is walking or cycling to local meetings. "Active travel" can have considerable health benefits which outweigh the risks associated with the mode of travel. Staff should also be encouraged to use public transport for longer journeys wherever possible, and especially the train, as that mode can allow travel time to be used productively.

When road transport is the only option staff should be encouraged to use pool, car club, hire cars or salary sacrifice vehicles. In the case of very high mileage employees, an assigned pool car with no private use permitted may be appropriate (private use can be monitored to HMRC satisfaction, using telemetry). This could be of particular relevance in SOVWH's case to the five individuals in the Public Convenience Cleaning team and the five remaining individuals across the two councils driving more than 100 miles per week in personal vehicles.

Figure 10-3: One of South Lanarkshire Council's 141 Renault Zoes

South Lanarkshire Council has 141 Renault Zoe electric cars (Figure 10-3) and has transitioned its entire diesel pool fleet of 104 vehicles to EVs. The remaining 37 vehicles are allocated to the Community Services team. The vehicles have been leased.

The fleet is charged on site and the council has installed chargers at 20 council sites in its administrative area to ensure they can be topped up when they arrive at a council office.

A similar scheme at SO and VWH has the potential to reduce carbon emissions significantly when considering the grey fleet average GHG intensity in 2021 was 203 gCO_2e/km, whilst the equivalent emissions from a mid-sized EV at the same time were approximately one quarter of this amount, at 53 $gCO2_e$ / km . Providing even just the ten individuals with the highest annual mileage across the two councils with a dedicated EV pool car to use each (representing almost 100,000 miles between them in 2021), instead of their private vehicle, would reduce the cumulative grey fleet GHG emissions by approximately 23t per year (40% of 2021 grey fleet total). As almost £40,000 was paid out to these individuals in mileage reimbursements the potential for lease costs to be offset by marginal cost savings for each mile travelled is clear too and this is explored further below.

A further ten BEV pool car vehicles, in the right places, with the right charging facilities, fair usage policy, booking system and travel hierarchy adopted, could be sufficient for offsetting a similar amount of carbon again, when made available to all council staff. As with all transitions to BEVs, as the UK grid continues to decarbonise the marginal $CO2_e$ / km saving for each mile driven in a BEV compared to an ICE alternative will continue to increase with time. If the ten further vehicles could reduce grey fleet mileage by the same amount as achieved by the 10 vehicles to be allocated to the council's highest mileage drivers, then the remaining grey fleet mileage would be around 46,500 miles/year – or approximately 20% of that in 2021.

If the EV pool fleet was rolled out alongside other initiatives to further mitigate the need for grey fleet travel in private cars (such as pool bicycles, investment in computers and video call software and so on) this remaining grey fleet mileage can be reduced further. It also represents a far more manageable amount to offset in alignment with SOVWH's target of being carbon neutral by 2030.

10.4 Pool car fleet creation – consideration of economics

It is assumed that SOVWH would likely wish to lease a pool car fleet initially, as opposed to purchase outright, to ensure that the concept can be demonstrated as viable for the respective councils before significant capital outlay is considered.

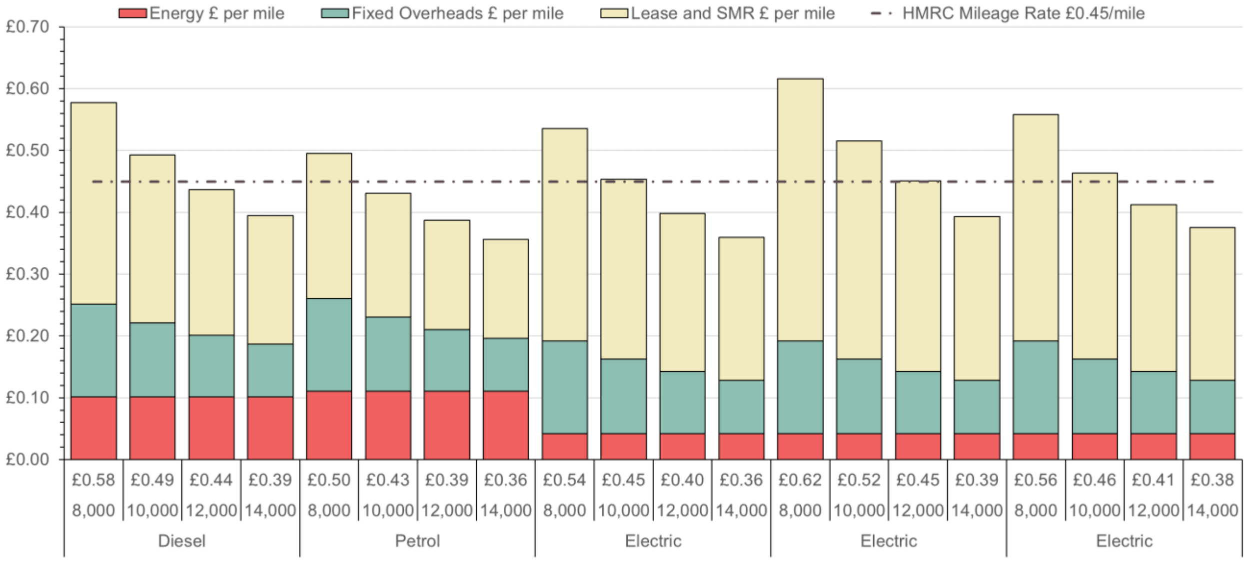
With this in mind it should be remembered that lease costs only rise slightly as the annual mileage specified in the terms of the lease is increased. Logically then, ensuring high rates of annual utilisation of the pool car fleet is key to ensuring price competitiveness to SOVWH against the status quo – employees driving their own private vehicles for business purposes.

In Figure 10-4 we see the WLC of a range of BEV hatchbacks (including two petrol and diesel comparators) modelled for different annual mileages. The horizontal black dotted line represents the HMRC mileage rate of £0.45/mile that if the WLC/mile figure for the lease vehicle falls below a saving is realised to the council compared to employees using private vehicles to complete the business journeys.

The figure makes clear that it is possible, at present, for BEV pool cars to achieve savings when utilised well. The Nissan Leaf N-Connecta 110 for example, with a 40 kWh battery, is able to achieve price parity compared to grey fleet mileage costs at 10,000 miles per year (equating to approximately 200 miles per week / 40 miles per day). In 2021 the 10 highest mileage individuals travelled an average of 9,268 miles over the course of the year. If a lease quote could be obtained any lower than the indicative figures we have sourced below, which may well be possible if a number of vehicles are being procured at once, then it can be seen that WLC price parity is quite possible for this section of a BEV pool car fleet. For some individuals it should be noted that a vehicle with a greater single-charge range than is permitted by the 40 kWh Nissan Leaf may be required. Newer competitively priced alternatives with larger batteries, such as the MG4, may be attainable at a comparable WLC.

A further 10 BEV pool cars, for general business use and not allocated to any individual/team could see similar carbon savings achieved if managed in the right way and if a similar level of overall utilisation could be realised as the 10 cars reserved for the highest mileage individuals. There is no reason why in time a much larger BEV pool car fleet could be procured that is capable of offsetting a much greater portion of grey fleet mileage and emissions. To ensure a new BEV pool fleet is established in an optimised way we propose a phased approach to its growth. This will enable lessons to be learned from the initial 10/20 vehicles procured that will inform what vehicles, where and with what infrastructure and policies will be required for further pool vehicles in due course, to ensure that any additional vehicles procured are part of a system that is set up to facilitate similarly high utilisation rates of further cars.

Figure 10-4: establishing price parity of a BEV pool car fleet



11. BEV charging requirements

It is usually impossible to roll out an electric vehicle fleet if the fleet cannot be charged at their normal overnight location, whether in the depot, or at the employee's home. We recommend that at sites where fleet vehicles are based, there is initially one charge point installed for each vehicle, as the first BEVs join the fleet. This ensures that all the vehicles can be fully recharged overnight for the next working day and allows pre-conditioning in summer and winter. With time and experience, as further vehicles are added to the fleet and team members become more familiar with how to use the vehicles and get the most out of them, it may well be that fewer than one charger per BEV is required.

In most cases, low cost 7.4 kW AC charge points will be able to recharge all the SOVWH LCVs overnight and these can also be used for home-based charging where the employee regularly takes a SOVWH vehicle home at night and has off-road parking.

Appendix C has a brief introduction to electric vehicle charging infrastructure (EVCI). The Energy Saving Trust Guide to Chargepoint Infrastructure (2017) has more information on EV charging as does the Beama Guide To Electric Vehicle Infrastructure (2015). Also useful are the Beama Best Practice for Future Proofing Electric Vehicle Infrastructure (2020), Making the right connections, UK EVSE, (2019), BVRLA Fleet Charging Guide (2022) and SPEN Connecting your EV Fleet.

11.1 Charging demand

Assuming a BEV fleet will use around 30% of the energy used by the current ICE fleet, it is possible to estimate the average daily energy demand of a future zero emission electric fleet (Table 11-1). The table below provides a holistic overview of the different portions of the fleet together – in reality, as depot locations evolve in the coming months/years all vehicles will not likely be based at the same single location and so rows, or portions of rows, should be considered as appropriate for the different sites charging is to take place at.

Table 11-1: Estimated overnight energy requirement of a future BEV fleet – 12 hour charging window, 240 working days/year, power factor 0.95

	Fleet Size	Annual EV kWh	WD EV kWh	kW/hr	+Headroom (kW)	kVA Required
Facilities LCVs	3	10,372	43	4	1	6
Grounds Maintenance LCVs	9	56,686	253	21	5	28
Grounds Maintenance fleet car	1	5,772	24	2	1	3
Public Convenience Cleaning team LCV	1	1,959	8	1	1	2
Pool car fleet[1]	*20*	65,632	274	23	6	31
	34	**140,421**	**602**	**51**	**14**	**70**

[1]*proposed in this report*

The data presented in Table 11-1 suggests that, with an additional 25% headroom to cover daily variation, a maximum import capacity of at least 70 kVA will be needed to meet the peak charging demand for an electrified main fleet, including the proposed BEV pool car fleet of 20 vehicles.

This is a simplistic view, based on the average annual EV kWh required, compared to the total working days. It assumes that vehicles charge over the entire charging window each night, which would require a balanced load system to achieve.

Further headroom may be required depending on a variety of factors. One factor is which vehicles are based at which site. For example, if vehicles with a notable and similar seasonal variability to mileage profile are based at the same site, then a greater headroom will likely be required. The seasonal variability in mileage of the Grounds Maintenance fleet is a good example of this (Figure 11-1). Similarly, if vehicles with similar or particularly varied day-to-day variability in mileage are based at the same site then again, a greater headroom will likely be required. When considering the day-to-day mileage profile of the Grounds Maintenance fleet over the course of the year (Figure 11-2) the daily variability of particular weeks is smoothed – further analysis of inter-day variability of vehicles at particular sites would inform further on headroom requirements.

Figure 11-1: Monthly mileage profile of Grounds Maintenance Fleet

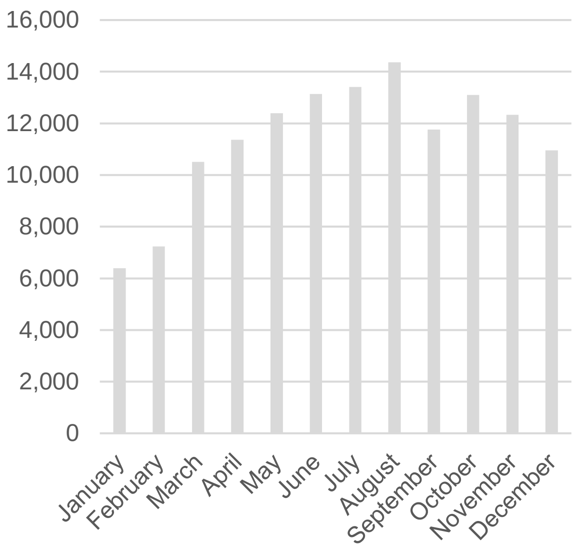
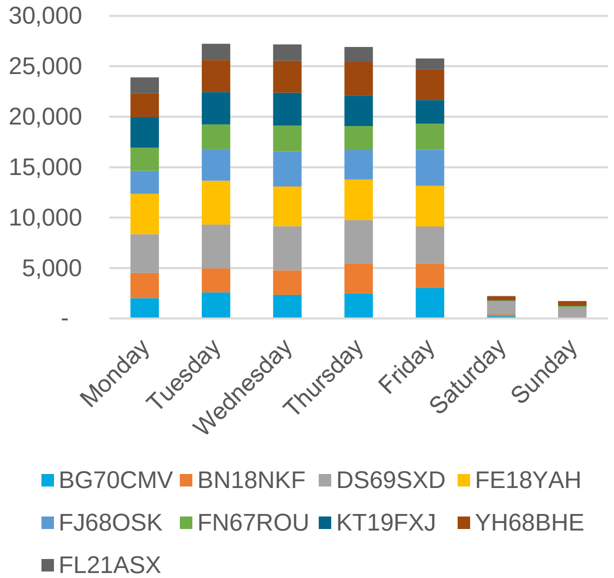


Figure 11-2: Weekly mileage profile of Grounds Maintenance fleet



Similarly, if it is likely that mileage of the fleet based at a particular location is likely to increase in the future, then again further headroom should be factored in accordingly.

If a site(s) has a constrained supply, rather than increase site supply capacity to cope with high intermittent demand it may, in the long run, cost less to install on-site battery storage capacity to cope with the peak demand.

11.2 Full EVCI review

A more detailed analysis of the depot EVCI requirement can be provided by Energy Saving Trust as a separate report. The “EVCI Review” will require data on the maximum import capacity (MIC) at each depot, the power factor (PF) and the half hour (HH) energy consumption data (kWh) for a whole year as well as the VRNs associated to each site.

All this information should be available from your energy management team, or from your energy supply company. Information about installed or planned private wire renewable generation can also inform an EVCI review, as it may impact on the maximum import capacity required.

It has previously been shared that the current depots are temporary sites and may be moved to more permanent locations in the near future. To avoid significant capex incurred on installing EVCI at the current depots only being utilised for a short period, a clear internal decision as to the future location(s) of each of SOVWH’s depots should be prioritised. Clarity over the future longevity of fleet depots will enable more grounded investment decisions to be made, such as the optimum time to transition different parts of the fleet to BEVs.

12. Spotlight on hydrotreated vegetable oil (HVO)

As requested, this section has been included to provide context on the suitability of HVO for use in the SOVWH fleet and key sustainability and ethical considerations that should be fully understood if considering use.

HVO is a 'drop-in' diesel replacement fuel. It requires little in the way of retrofit for existing fleets and has typically sold for a price premium of around 20-30% above fossil diesel. It can be made from different vegetable oils however almost all the HVO sold in the UK is made from used cooking oil (UCO). Last year (2021) 95.5% of HVO sold in the UK used UCO[2] as a feedstock

Some of the UCO used for producing HVO sold in the UK is from the UK (7% in 2021) and some from the EU (19%) however, the majority tends to be sourced from outside the EU. Three Asian countries supplied over half of overall UCO used for HVO last year - China (39%), Indonesia (8%) and Malaysia (7%)[3]. Whereas supply chains for domestically produced UCO are readily auditable, supply chains for UCO from countries such as these are far more complex and opaque and typically feature six or seven organisations in the chain of custody.

Fleet operators are drawn to using HVO by the fuel's very low TTW CO_2e conversion factor of 0.04 $kgCO_2e$ per litre. When Scope 3 emissions for the fuel are considered the WTW emissions for the fuel come to 0.39 $kgCO_2e$ per litre – 12% of the equivalent emissions for average biofuel blend diesel (3.17 kg CO_2e / litre)[3].

Figure 12-1: Consideration of the GHG emissions intensity of different diesel fuels by GHG reporting scope (Source: UK Government GHG Conversion Factors for Company Reporting, 2022)

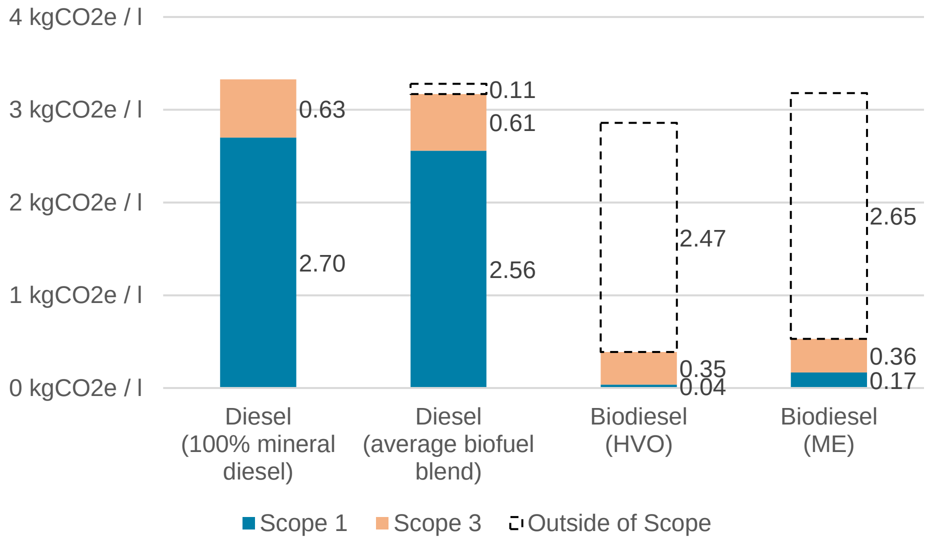


Figure 12-1 shows that outside of scope emissions for HVO equate to 2.47 kg CO_2/litre. This figure represents the carbon dioxide emissions released at the tailpipe when HVO is burnt. They are permitted to be excluded from scope because, as for other biofuels made from short cycle biogenic materials, the same amount of carbon is deemed to have been absorbed by the plant when growing as when ultimately combusted as HVO. The resultant Scope 1 emissions relate only to non-carbon GHG emissions generated when the fuel is burnt (for example, NO_X emissions).

The process for ensuring the sustainability of biofuels supplied in the UK is governed by the Renewable Transport Fuel Obligation (RTFO). The RTFO lays out the guidelines and requirements for which renewable fuels must meet if they are to be deemed sustainable. Whether a supplier is demonstrating these requirements is checked by an RTFO approved independent third-party assurance organisation.

For most biofuels, the RTFO mandates two sustainability themes that must be demonstrated for sustainability to be certified. The first theme covers land use compliance – this considers, for example, whether the growing of energy crops to create biofuels created biodiversity losses, or losses to carbon stocks through the

[2] Renewable fuel statistics 2021: Fifth provisional report, DFT (August 2022)

[3] Greenhouse gas reporting: conversion factors 2022, DBEIS (June 2022)

deforestation of rainforest or degradation of soils. The second theme then considers the GHG savings of the biofuel, to ensure it delivers a good carbon saving compared to fossil fuel equivalents. Sustainability in both these themes must be achieved if the fuel supplier is to count the fuel towards their mandatory supply requirement for renewable transport fuels.

For UCO-derived HVO however, the RTFO advises only the second sustainability theme has to be demonstrated[4]. This exemption results from RTFO's universal classification of UCO as a waste product. The implications of this is that so long as the origin of UCO used as feedstock for HVO is established to be 'used cooking oil', then no sustainability criteria are applied to the oil upstream of its used cooking oil classification.

Audit rigor in ensuring UCO entering the HVO supply chain is genuinely a waste product is fundamental to describing the end product as 'sustainable'. At present however, under the guidelines of the RTFO, third party assurance bodies such as ISCC typically use only a basic assessment: they establish whether a one page 'self-certification' statement has been provided from the supplier of the UCO to the collector (stating that the product supplied to the collector was UCO). They then complete an online search, to see if there is evidence that a sample of the stated collection points exist[5]. The lack of robustness to these checks, which form a core foundation of the current sustainability assurance process for UCO entering the HVO supply chain, should be considered very closely by any parties considering adopting HVO. Many organisations believe the risk of fraudulent labelling of virgin vegetable oils as UCO is high[6].

Building on this, however, a perhaps equally concerning practice to the risk of fraudulent labelling of virgin oil as UCO could be taking place as a result of policy-created market forces.

In the UK and EU transport fuels policy is mandating: overall supply levels of renewable fuels within the fuel mix are achieved, the amount of non-waste origin biofuels within this renewable supply are to be restricted and the fuels from waste origin (development fuels) may be double counted towards required renewable fuel supply levels. Combined, this policy environment is driving global demand for UCO to new highs, as well as the price paid for UCO on global markets, to levels in excess of virgin vegetable oils[7].

When market prices for UCO exceed that of virgin vegetable oils, it is sensible to assume that as an actor in the food processing/restaurant industry, you would likely choose to process as much vegetable oil into used cooking oil as possible.

Although such activity is not fundamentally fraudulent by the virgin oil user, when considered holistically, it is clear how such UCO production-boosting practices, such as these, represent a clear failure of the intentions to use a genuine waste product as a more sustainable substitute for fossil diesel.

On this note, it should be remembered that although UCO is classified as a waste product in the UK, this is not also the case in all UCO supplier countries. Permitted uses of UCO may exist, such as in China, where oils used for vegetable cooking have previously been fed to livestock[7,8] and high prices of UCO are now causing displacement effects. Where UCO was once used as a feed supplement, virgin vegetable oils are now likely being sought to meet calorific energy needs of livestock that were previously delivered by UCO. The RTFO (and RED II's) over-simplification in classification of UCO as a waste product worldwide, regardless of UCO's waste status in supplier countries, is a seldom mentioned flaw to the current supply chain and sustainability assurance process.

Related to this, in countries where UCO has a waste classification such as in the UK, the UK's indirect purchasing of another country's limited supply of UCO removes the ability of the supply country to use it as a renewable transport fuel feedstock themselves. If the UK (and EU's) policy environment were not so strongly incentivising the use of waste-derived fuels, driving up prices for UCO significantly on the world market, it should be considered whether supply countries such as China would likely now be using their domestically generated UCO as a transport fuel feedstock for domestic use. As there is a carbon implication to shipping UCO from countries such as China to the UK for processing into HVO, from a carbon perspective, it would be more efficient for UCO to be processed and used in its country of generation. Countries such as the UK indirectly purchasing another country's UCO can thus be seen as impeding on supply countries' abilities to decarbonise, which raises its own questions around ethics of use and whether the purchase of non-

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[4] Renewable Transport Fuel Obligation: Third-Party Assurance Guidance, DFT (January 2022) – 3.3.2

[5] ISCC EU 203 Traceability and chain of custody, ISCC (2021) – 3.4.6

[6] Used Cooking Oil (UCO) as biofuel feedstock in the EU, Transport and Environment (2020) – 5.2

[8] Implications of Imported Used Cooking Oil (UCO) as a Biodiesel Feedstock, NNFC (2019) – 4.2.2

domestically produced UCO is in fact offshoring domestic transport carbon emissions to UCO supplying countries.

As well as a climate change emergency, we also face a global biodiversity emergency, fuelled in part by agricultural sprawl continuing to take place into virgin ecosystems. 25.3 MHa of tree cover was lost globally last year – approximately 12 times the size of Wales. Against this backdrop, the ethics of biofuel use more fundamentally in relation to collapsing global biodiversity and the food-fuel debate should also be considered very closely.

Combined, considerations such as those laid out here point to the need for very close scrutiny of whether the current HVO supply chain and sustainability assurance limitations merits the use of HVO within your organisation. Caution is required both from sustainability and ethical standpoints. In addition, evidence of systematic fraud in the industry, if ever forthcoming, could lead to significant reputational risks to user organisations. Further information on HVO is available in the Energy Saving Trust HVO Position Paper. It should also be remembered that although HVO has a low TTW $CO2_e$ conversion factor, its combustion still releases regulated pollutants such as NO_x and PM.

Appendix

Appendix A: UK Grid 2014 to 2030

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

Table A-1 shows:

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

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

Year	BEIS GHG Scope 2 Factor	Year on Year Change	Actual in year from Elexon Portal	CCC Balanced Pathway 6th Budget	BEIS 2021 (Table 1)"	CCC - BEIS Average	Central Carbon Value (BEIS 2021)
2014	494.26		415.7				
2015	462.19	-6%	364.2				
2016	412.04	-11%	277.1	269.0	287.6	278	
2017	351.56	-15%	247.1	240.0	257.0	248	
2018	283.07	-19%	227.8	219.0	238.8	229	
2019	255.60	-10%	204.3	193.0	212.9	203	
2020	233.14	-9%	184.4	153.0	159.4	156	£241
2021	212.33	-9%	184.9	151.0	148.7	150	£245
2022	**193.52**			**148.4**	**138.9**	**144**	**£248**
2023	176.32			134.5	133.3	134	£252
2024	160.67			135.4	145.4	140	£256
2025	146.40			125.2	123.0	124	£260
2026	133.40			93.3	90.7	92	£264
2027	121.56			74.8	75.0	75	£268
2028	110.76			64.6	69.4	67	£272
2029	100.93			58.1	65.0	62	£276
2030	91.96			46.1	51.6	49	£280
2031	83.80			37.1	40.8	39	£285
2032	76.36			26.5	35.3	31	£289
This data is available from CCC and BEIS until 2050							

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

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

Appendix B: Whole Life Cost (WLC) in practice

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

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

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

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

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

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

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

Vehicle Excise Duty (VED) (L): This is the annual road use charge; for new cars it is linked to OEM published carbon emissions in the first year but is then a flat rate. VED for zero emission vehicles is currently fixed at zero.

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

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

National Insurance Contributions (NICs): If the vehicle is made available for private use, the employee will incur a benefit-in-kind (BIK) scale charge and the employer will pay Class 1A NIC on the scale charge.

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

Table B-1 Whole life cost model – the factors you need to consider.

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

The GHG emissions of the ICE fleet are straight forward to determine, as they are based on the carbon emitted by burning a litre of fuel and that will stay fairly constant over the lifetime of the vehicle. BEVs are more complicated, as the electricity supply will decarbonise over the next 10 years and that means the GHG emissions of the vehicles will decrease year-on-year (see *Table A-1*).

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

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

Item Description	Value	Value	Units
Diesel cost (ex VAT) in first year and annual inflation rate	£1.23	+2%	£/litre
Electricity cost (ex VAT) in first year (off peak) and annual inflation rate	£0.15	+3%	£/kWh
Average GHG emissions of diesel (BEIS 2021)	2.546		$kgCO_2$/litre
Average emissions of electricity (CCC/BEIS predictions)	See Appendix A		gCO_2/kWh
Average GHG Shadow Price: HM Treasury Central Carbon Value	See Appendix A		£/tonne
Fleet Insurance and Fleet Management costs	£650	£550	£/annum

At the end of 2021/22, there was considerable disruption in energy prices and it is difficult to predict for how long the higher prices for diesel, petrol, natural gas and electricity will be sustained. As the BEV fleet grows, it is expected that diesel and petrol prices will increase, as garages try to recover their fixed costs from reduced fuel sales. Many garages rely on income from their associated shops but with fewer visits, that source of income will also reduce putting even greater pressure on fuel prices.

Appendix C: Introduction to EVCI

Charging an electric vehicle fleet

With the exception of some emergency service vehicles and 24/7 delivery vehicles, or passenger services, most BEV fleets can be fully recharged overnight, or during other periods of inactivity. If the BEV has been matched to the service being delivered, it should, if fully charged, be able to complete its normal working day without top-up charging. There are high mileage services that do offer frequent top-up charging opportunities – for example, an inter-site delivery or minibus service – but these are a special case. It is also possible to consider a split shift service where a rapid charge point top-up to 80% battery capacity during the day would enable a second shift to operate. These are special cases and the business case for each needs to be considered separately.

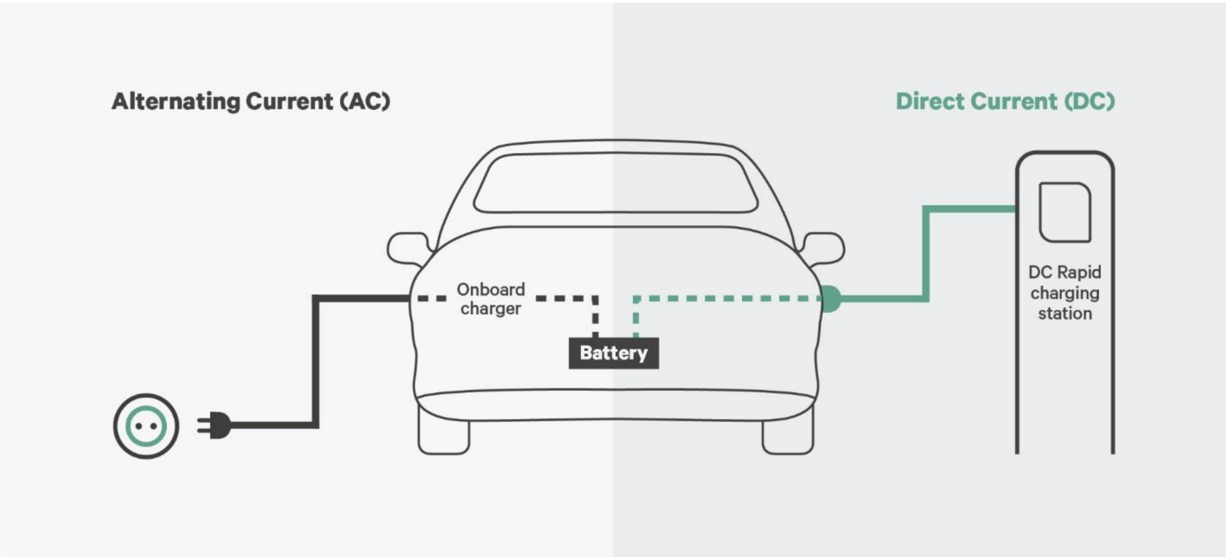
AC or DC charging and Smart Management

There are two basic types of charging infrastructure. Alternating Current (AC) and Direct Current (DC). Electricity that comes from the grid, or a private wire electrical supply, is always AC. However, batteries within BEVs only store power as DC. AC charge points are usually referred to as fast and DC charge points as rapid.

AC (fast) charging

If a vehicle is using an AC charge point, it must convert the electricity to DC. On board the vehicle is a conversion system known as the 'onboard charger', which converts the power and feeds it into the vehicle's battery. The output of AC charging systems ranges from 3.4kW up to 43kW but are usually 7.4kW or 22kW. Charging speed is dictated by the vehicle. Different vehicles have different maximum charging rates. Most new BE cars available today can charge at 7.4kW, or up to 11kW, and a few can charge at 22kW. These types of charge points are usually found in domestic properties, commercial sites for overnight charging and destination charging locations (tourist attractions, sites where people stay for several hours). In BE LCVs and HCVs, higher AC and DC charge rates are more common.

Figure C-1: AC and DC charging



(Source: https://wallbox.com/en_uk/faqs-difference-ac-dc)

DC (rapid) charging

If a vehicle is using a DC charge point, the conversion system is within the charge point itself. This means the power bypasses the vehicle's on-board conversion system and flows directly into the vehicle's battery. The output of DC charge points ranges from 20kW up to 600kW. Usually, DC charge points are classified as rapid (20kW – 100kW), or ultra-rapid (100kW and above). Like AC charging, the speed of charge is dictated by the battery technology vehicle. The speed of charge is concurrent with the battery size and voltage. As vehicles with larger batteries are introduced to the market, the charging speed of these vehicles is increasing. These types of charge points are usually found at motorway service stations, on-street in cities, and at depots housing larger vehicles such as electric refuse vehicles (eRCVs).

Table C-1: Indicative BEV charging times (assumed from 20% state of charge[7])

Battery size (right) Power output (below)	25kWh	50kWh	75kWh	100kWh	200kWh
7.4 kW	3h 45m	7h 45m	10h	13h 30m	59h 15m
11 kW	2h	5h 15m	6h 45m	9h	16h 9m
22 kW	1h	3h	4h 30m	6h	8h 4m
50 kW	36m	53m	1h 20m	1h 48m	3h 33m
120 kW	11m	22m	33m	44m	1h 28m
150 kW	10m	18m	27m	36m	1h 11m
240 kW	6m	12m	17m	22m	44m
350 kW	3m	7m	11m	15m	30m

Hardware

EVCI is designed in a number of ways. Fast charge points can have a single or dual socket (Type 2[8]) and can come with charging cables tethered (cables affixed, largely for domestic charging) or untethered (just the sockets). Rapid charge points can have either one charging port (CCS or CHAdeMO), two charging ports (both the same connector or one of each) or three charging ports (CCS, CHAdeMO and AC Type 2). Charge points can be post mounted, wall mounted, mobile, part of an overhead gantry system, stand alone, satellite posts and more. It is important to consider specific site requirements when procuring hardware.

Smart charging and load management

The Energy Saving Trust Smart Charging For Electric Vehicles guide provides comprehenisve information on smart charging systems, and should be read in conjuction with this report. (is there a link to our guide here?)

Smart charging

Smart charging is a system whereby a BEV and a charge point share a data connection, and the charge point shares a data connection with an operating system. Older charge points would simply allow for a BEV to plug into a charge point and receive a charge. Smart charge points are connected to a cloud network, either through Wi-Fi, ethernet or 3G/4G/5G. This allows the charge point to monitor, manage, and restrict the use of the device remotely to optimise energy consumption. Connected vehicles, in a smart charging system, will react with the changes in the grid system in order not to overload or unbalance the grid. Smart charging allows you to set your charging preferences, which may include:

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

Smart charging is essential as BEV uptake continues to exponentially increase. There are many benefits to fleet operators looking to implement smart charging systems within their workplace.

[7] Battery charging times are universally calculated from 20%. With rapid charging, the charging speed can slow down above an 80% state of charge.

[8] AC and DC charge points have different connectors. Information on these can be found here. (is there a link missing?)

Table C-2: Benefits of smart charging

Feature	Benefit
Cost saving	By using an energy tariff that has been designed specifically for BEV drivers, you can make the most out of smart charging, as lower tariff rates are applied during off-peak times (e.g., overnight). Smart charging can reduce organisational costs overall, when compared to traditional charging using a standard BEV tariff.
Convenience	Smart charging requires little effort – when the vehicle is returned to a site, or an employee's home, you just plug your BEV into its smart charge point. The smart functionality ensures the vehicle is charged by the time set by the user.
Environmental benefits	BEVs produce no emissions when being driven, and the electricity used to charge them is increasingly being generated from renewable sources. In the future, smart charging will also increasingly be used to charge BEVs when renewable energy is more abundant on the grid, such as after windy or sunny periods. This would help reduce carbon emissions further.
Balancing grid demand	Most BEV users charge their vehicles after a shift, or at the end of the working day, corresponding with peak demand on the grid. Using smart charging, you can still plug in your vehicle when it is returned to the depot, or the employee's home, but the charge point then manages and adjusts the vehicle's charging to a time when electricity demand is lower.

Load Management

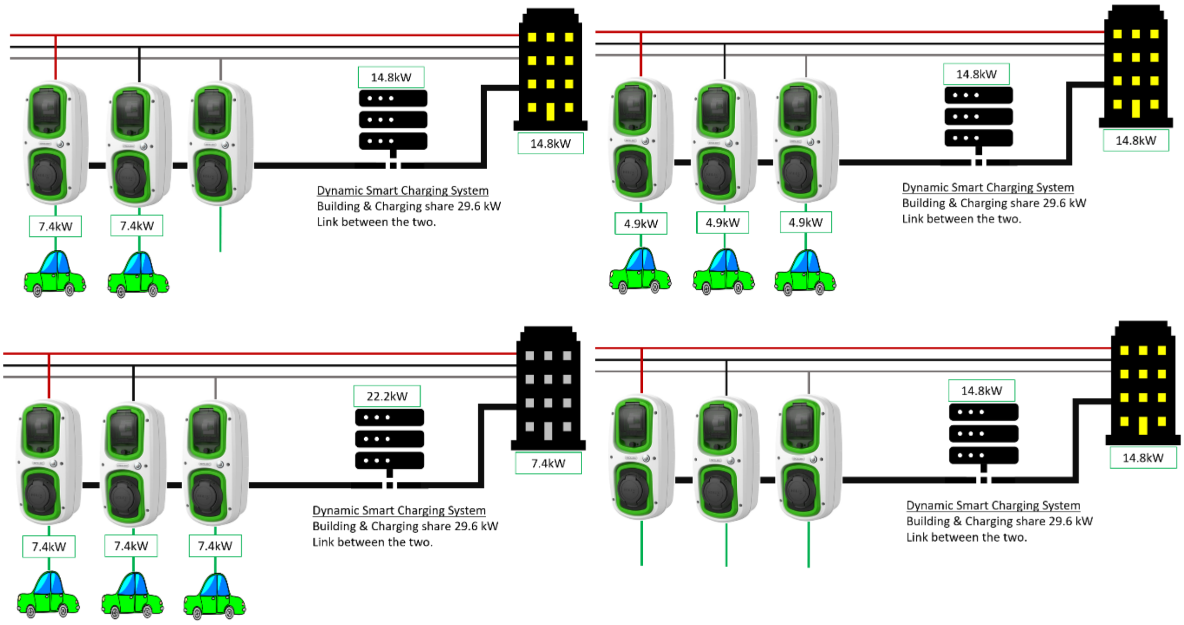
Through smart charging, charge point operators have the ability to distribute power to different charge points on a network (reactively) with demand from the vehicles, to ensure that the total incoming supply capacity can not be exceeded. Charge points will analyse the available capacity of the supply and distribute the power based on the maximum capacity of the connection. This is known as static load management, or static load balancing.

Dynamic load balancing is more complex but can benefit sites which have other electrical requirements on the same circuit as the charge points. The load balancing system will take into accunt other electrical circuits when vehicles are charging. For example, if vehicles are plugged in during the day time and the building supply is powering the lighting at the same time, the vehicles will receive a reduced rate of charge. Once the lighting system is turned off, more power will be available for the electric vehicles to use, and the charge rate will increase. This is the same for heating generators in the winter months turning off, once employees have left site.

For private and public sector organisations, load balancing means they can avoid cost increases in connection capacity and prevent peak loads that result in extra charges. The operation of a fleet would not be restricted as a result of load balancing through slower charging, as the vehicles can retire to charging points when shifts have ended and charge overnight during downtime hours.

Figure C-2 shows a basic example of dynamic load balancing with three BEVs using the same electrical supply as a building, at different stages of charge, where the distribution of power changes according to demand. The images follow on from one another from top left, to top right, then bottom left and finally bottom right. Image three shows an increased charge rate to each vehicle once the building's lighting system has switched off.

Figure C-2: Dynamic load balancing example (29.6kW supply – building plus 3 x 7.4kW EVCPs)



(Source: [Gfleet Services](#))

V2X Technology (Vehicle to grid, building, and home)

V2X is a collective term made up of Vehicle to Grid (V2G), Vehicle to Home (V2H) and Vehicle to Building (V2B) technologies. These technologies enable energy to be pushed back into either the power grid, home or building, from the battery of a BEV through the charge point it is connected to. Vehicle batteries can be charged and discharged depending on energy production, nearby consumption, or through periods of high energy demand. This technology goes one step further than smart charging and the ability to increase and decrease charging power when required, by balancing variation in energy production and consumption. A good example of how this technology works, is [Octopus Energy's Powerloop project](#), in which Energy Saving Trust is a partner.

V2X technology can benefit organisations, through commercial buildings and the local grid. The electrical connection can be the largest cost of any EVCI installation project, as upgrades are expensive. Combined with smart energy management and dynamic load management, V2X can assist with providing this additional power. Grid consumption can be overloaded when demand increases in the local area. As the grid decarbonises over the years, V2X technology could play a crucial role in stabilising the grid electricity, as renewable energy sources such as wind and solar are volatile within the grid. In situations such as this, grid congestion can occur, preventing electricity from reaching its destination.

V2X is currently available through CHAdeMO compatible vehicles, however there is currently a roadmap in place for [CCS to reach full V2X capacity](#) by around 2025, therefore making V2X technology in Europe a technology of the future. BEVs produced by Nissan are the only vehicles that can utilise this technology at present. For organisations which carry out seasonal work, for example gritters on highways, batteries are problematic, as these vehicles are only required for a certain number of months annually, V2X technology would allow these vehicles to act as a power bank for depots when not in use. This could resolve the issue of battery degradation due to long periods of inactivity.

Charge Point Management and Back Office

Smart charge points are managed through a 'back office' system. Data is transferred by connecting the charge points to a cloud-based platform through SIM cards within the units, through a Wi-Fi connection or through ethernet cables. This system enables the operator to manage their charge points remotely. Through the back office, the organisation can schedule charging, set tariffs (if open to visitors to the site or the public), see (and fix) live faults within charge points, observe live charging sessions, obtain management information data including billing, energy consumed, charging session times and a variety of other features.

A comprehensive back office system, including a fleet platform, should be considered when installing EVCI. Similar to the hardware, there are a variety of platforms and fleet portals to choose from. A number of hardware OEMs have their own system. Alternatively, most charge points are manufactured in line with the latest [Open Charge Point Protocol](#) (OCPP – currently OCPP 2.0.1). With this protocol, charge points can be managed by a different back office system to the hardware manufacturer. This enables an organisation to tailor their fleet management platform to their requirements, while fulfilling the hardware needs of the BEVs they operate. Some innovative solutions to BEV fleet management are listed below.

Table C-3 Charge point fleet platform back-office features

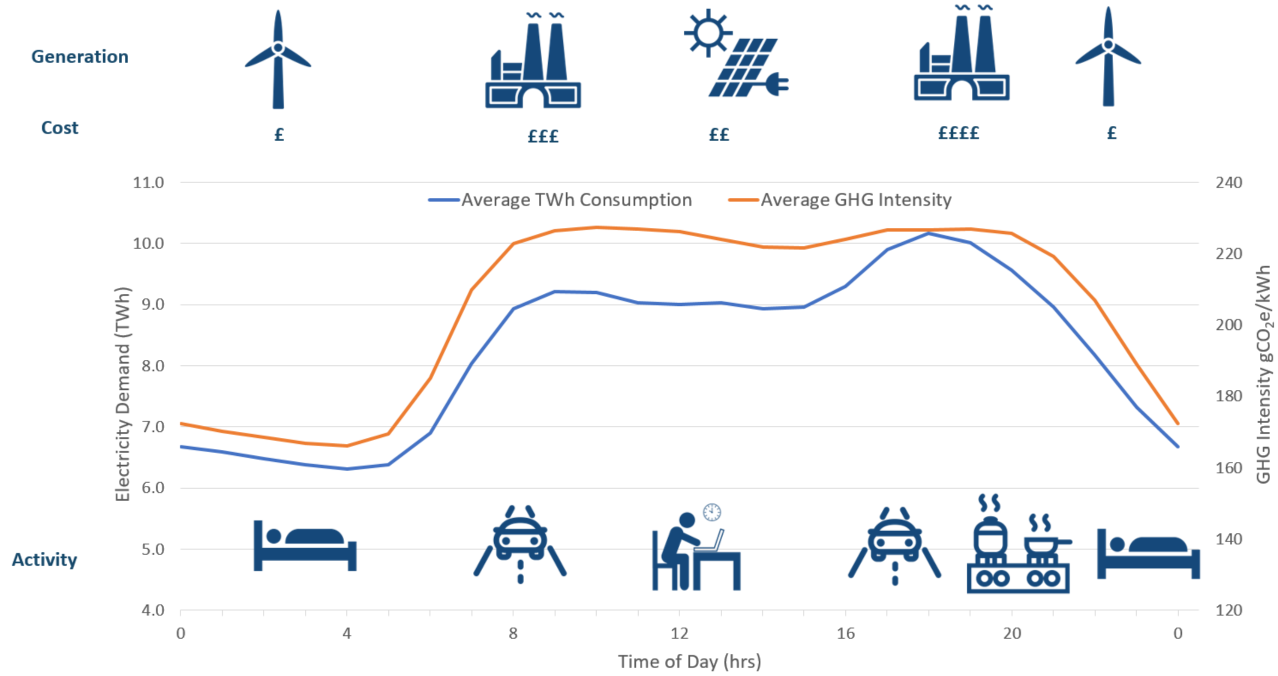
Feature	Breakdown
Integration	Integration with telematics systems already in use by an organisation. Integration with employee's energy provider and home charge points to calculate true charging cost. Business platform integration. Energy trading to buy electricity at flexible tariffs. Operable with multiple hardware OEMs.
Reimbursement	Automatic reimbursement from home charging through charge point tracking. Reimburse employees directly through back office platform. Home and public charge costs directly reimbursed through energy provider invoicing. Employee pays nothing.
Reporting	View CO2e savings to help monitor net zero targets. View all costs of charging in one place, including split bills from home, work, and public charging. View charging sessions (kWh, session times). Download management information reports (useful for OZEV workplace charging scheme reporting). Track business and personal mileage.
Scheduling and Accessibility	Set charging times for vehicles to make use of off-peak electricity tariffs and manage site electrical supply. Multi-user access. Ability to make EVCI available to different fleets (grey fleet, company cars, main fleet).

Getting the right time to charge

Ideally, vehicles should be charged overnight, to avoid the demand from large scale EV charging having a negative impact on the UK grid. During the working week demand on the UK Grid is at its maximum in the early morning and late afternoon, during these periods the GHG intensity (kgCO_2e/kWh) of the grid may be high due to the use of fossil-fuel based generation – typically gas – to meet the high demand (Figure C-3).

However, avoiding these peaks entirely leaves a narrow window of six or seven hours in which to charge vehicles and that may require the use of 11kW or 22kW AC charge points rather than the slightly lower-cost 7.2kW AC points. The reduction in GHG emissions from avoiding the high intensity periods is typically 10%-15% over the entire charging period and in terms of tonnes of GHG this will diminish in importance as the grid decarbonises and significantly less use is made of fossil fuel generation. What may have a bigger impact on the decision to delay charging is the higher cost of electricity during peak periods and this may prove to be a greater incentive to time-shift charging vehicles to off-peak, low cost and low GHG periods.

Figure C-3: UK Grid: Relationship between Consumption, Cost, Generation and GHG (Data: Mon-Fri, 2021)



(Based on graphic by Char.gy)

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

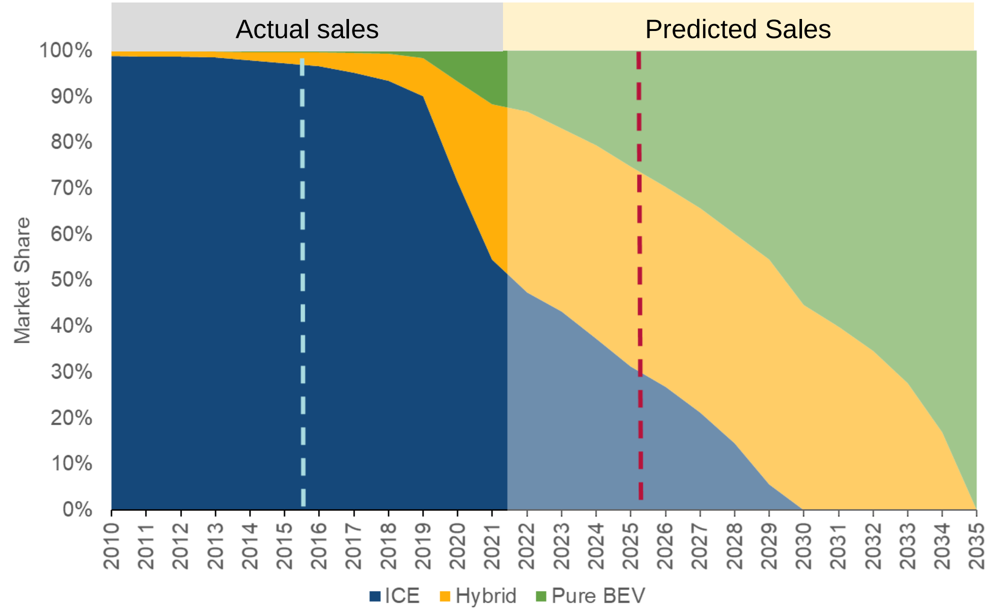
Please contact Energy Saving Trust for more detail on a separate, standalone EVCI report for your organisation.

Appendix D: ICE car availability 2025 to 2030

Consumer demand and the EU's introduction of Euro 7 emission standards, currently expected in 2025/26, may have a much earlier impact on the availability of ICE cars than the UK Government's ban on their sale in 2030.

The significant cost associated with developing engines to meet the Euro 7 standard may not be recoverable, as the sale of ICE vehicles is restricted and market share in all sectors is lost to BEVs. Where manufacturers do make a Euro 7 engine, it is expected to significantly increase the vehicles' capital cost, in turn pushing more consumers towards ever cheaper and more capable BEVs, so further reducing potential sales.

Figure D-1: Past and future car sales in the UK, split by propulsion type. Chart based on SMMT data.[9]



The Euro 6 emissions standard for cars was introduced in September 2015 (Figure D- - pale blue dashed line), and engines that comply to these standards can be sold until the introduction of Euro 7, expected in 2025/26 (Figure D-1 - red dashed line). By the time Euro 7 is mandatory, engine manufacturers will have had a decade of car sales, and several years with ICE vehicles holding near 100% market share, to recover development costs.

Between the introduction of Euro 7 and the ban on ICE car sales in 2030, manufactures have half as long, and a minority market share, to recover the development costs. By 2025, we predict there will have been approximately 15 million Euro 6 compliant cars sold in the UK. Total UK Euro 7 sales are predicted to be under 1.7 million units, less than the number of Euro 6 engines sold in the first year. Given the reduction in predicted sales, manufacturers can be expected to limit the number of ICE models available and focus on BEV and hybrid drive train development but even the hybrid engines will have a limited lifespan and diminishing market share.

Audi have announced they have halted pure-ICE development; BMW have announced they will not develop a diesel Euro 7 engine for cars, Nissan has suspended development of new combustion engines in all markets except the USA, and Mercedes intend to halve the number of engines variants available. Stellantis have announced phase out dates for all its European brands between 2024 and 2028. In all cases the reason given is to free up resources and capital for the development of BEV drives. Depending on the final standard agreed, and uptake of BEVs over the next five years, we could see the 2030 phase out date for large numbers of ICE car models effectively brought forward to 2026 by market factors.

For this reason, all organisations with large car fleets – and this includes the emergency services who tend to have the largest car fleets – need to be prepared to transition all new car procurement to ZEVs or ULEVs by 2026. From a planning perspective, this will require a charging infrastructure to be in place for the car fleet by 2026 at the latest.

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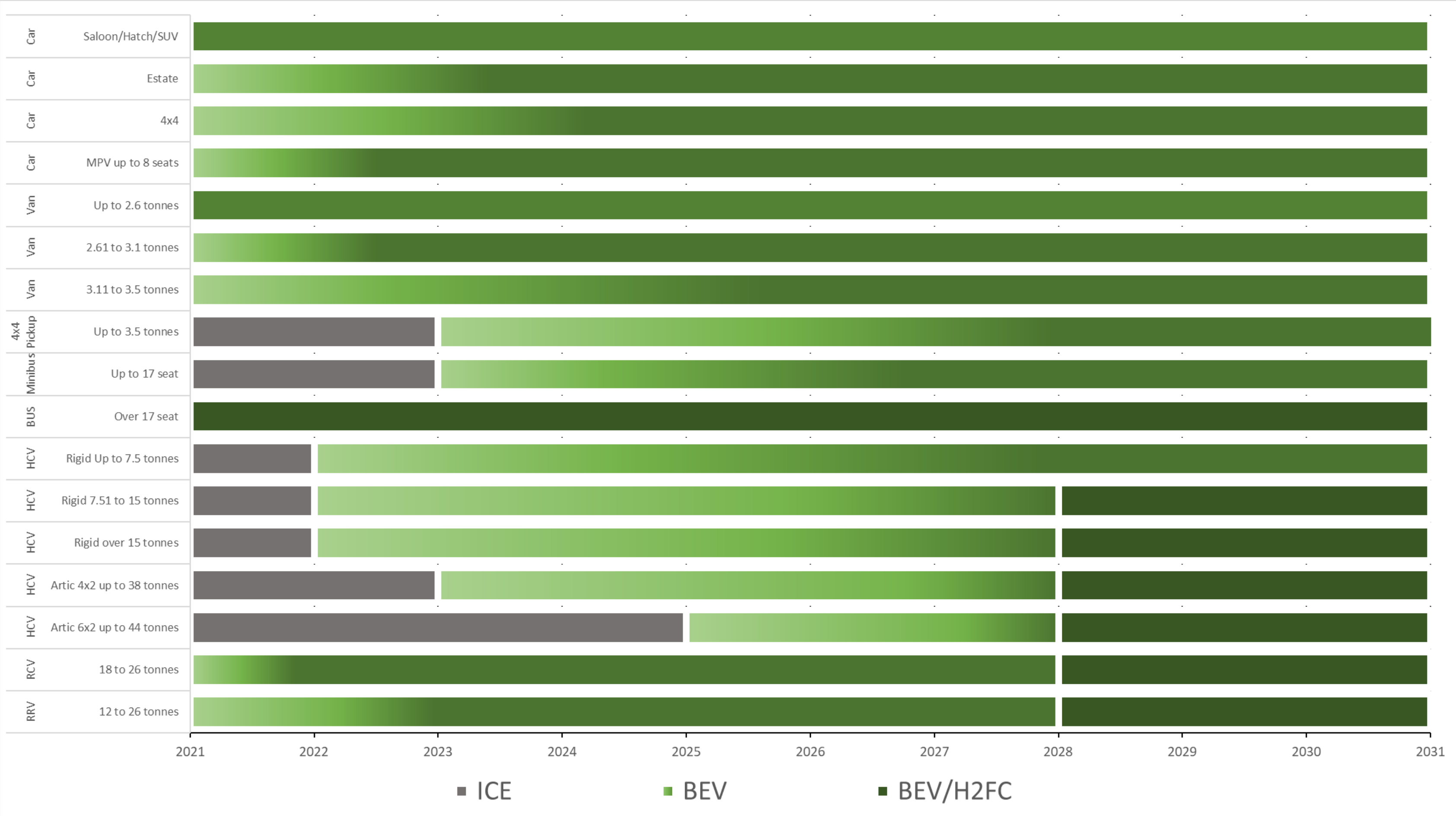
[9] Data from SMMT's new car market outlook to 2035, adjusted to match Q4 2021 car sales data.

Appendix E: Availability of OEM Zero Emission vehicles

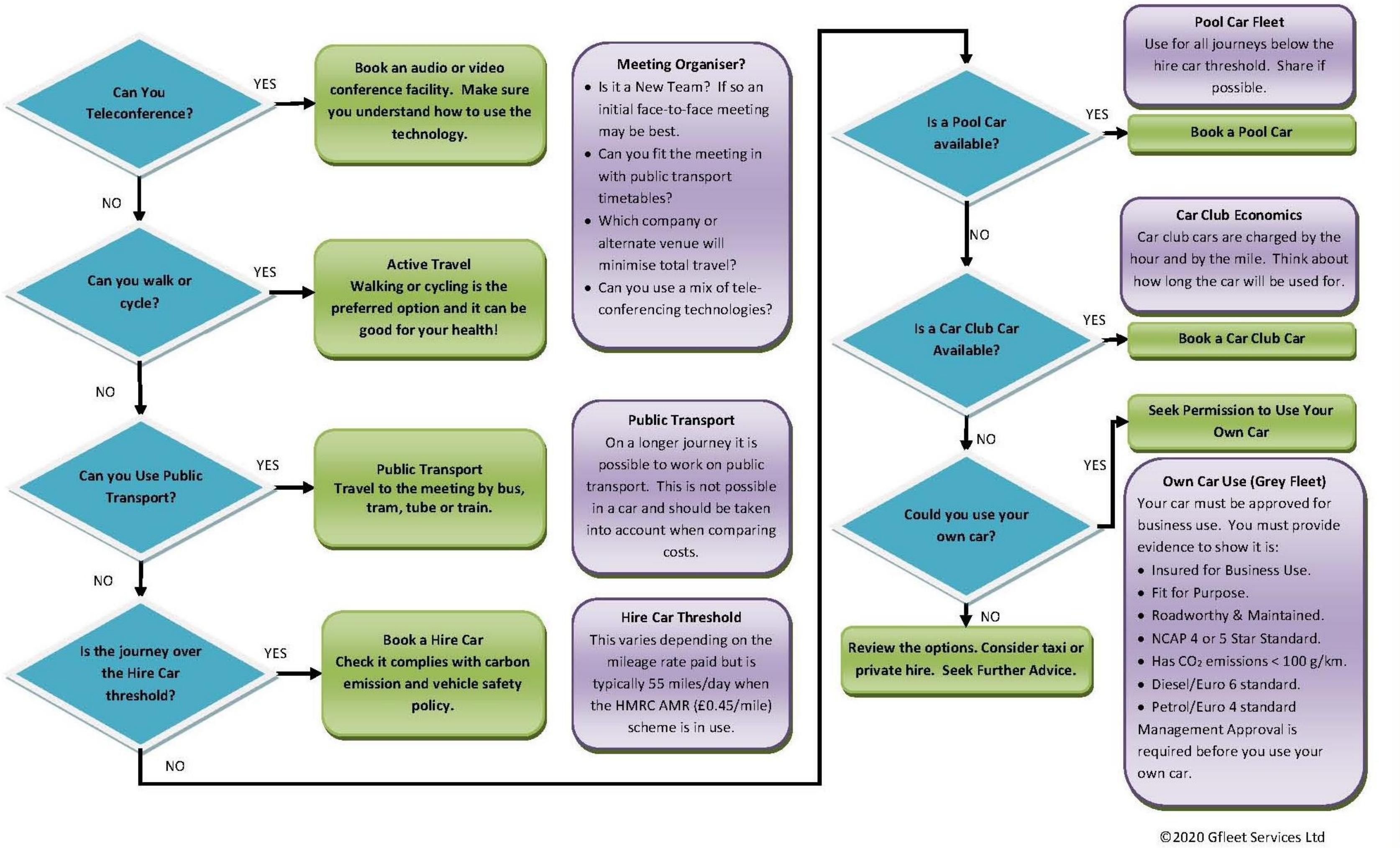


The graduated bars indicate a period of introduction – they have not been precisely scaled! Solid colours represent availability of a full range of vehicles.

Most vehicle categories are already available as BEVs but the full range of specialist body types is not yet available. Not all vehicles can carry the same load or tow as well as their ICE equivalent – but that position should improve. By 2027/28, it is expected that most vehicle categories will be available as a BEV, with equivalent load carrying capability and that in the last few years of the decade, fuel cell models may come to market, although that may not happen if new energy-dense battery technology like solid state or semi-solid state lithium is available by then. This chart is indicative and may be pessimistic in some categories but optimistic in others.

Appendix F: Example travel hierarchy for reducing grey fleet mileage

Example Urban/Semi-Urban Travel



Appendix G: Current ZEV and ULEV technology

There are several ZEV and ULEV technologies that could help SOVWH reduce GHG emissions in its fleet. Some, such as Electric Road System (also known as Catenary), are under development and evaluation but not yet commercially viable. Current ZEV and ULEV technologies are given below:

Battery Electric Vehicles BEVs

- **Large number of OEM cars, LCVs and Buses available now** including many third generation BEVs
- **Full range of BE HCVs from all European OEMs by end 2024** including 44 tonne tractor units
- **Widespread national charging infrastructure,** although some gaps still persist
- **Can charge at staff homes** but usually limited to 7.4kW AC charging, off-street parking required
- **Immediate GHG reduction** currently about 70% less than ICE equivalent, will be 95% by 2030
- **GHG intensity falls with grid intensity** and faster if using on-site renewable generation
- **Secure supply** almost all electricity generated in the UK (some imported by interconnects at peak)
- **Daily range limited by current battery technology** unless opportunistic rapid charging is an option
- **Higher capital cost but lower running cost,** typically a 75% reduction in energy costs v ICE.

H2FC (including range-extended fuel cell – REFCs)

- **Very limited OEM vehicles currently available,** Vauxhall Vivaro-e Hydrogen available in UK 2022.
- **Production H2FC from European OEMs not expected until end of the decade (2027/28).**
- **Very limited national infrastructure,** currently refuelling infrastructure is sparse and London centric
- **Cannot be refuelled at home,** vehicles will always require refuelling stations
- **No guarantee of GHG reduction, may increase,** depends on how the hydrogen has been produced
- **GHG intensity falls with grid intensity** if hydrogen generated from UK national grid
- **Variable security of supply,** depends on how the hydrogen is made – grey/blue = imported methane
- **Daily range will be higher** than the current generation of BEVs but limited by tank capacity/space
- **Higher capital cost and higher running cost** than both ICE and BEV.

Biomethane – bioCNG and bioLNG (Natural Gas)

- **Limited OEM vehicles available**, the IVECO Daily is the only CNG LCV available
- **Mercedes, Scania and Volvo produce a range of CNG and LNG HCVs**
- **Limited national infrastructure**, currently aimed at HCV market so mostly on or near trunk roads
- **Cannot be refuelled at home,** vehicles will always require refuelling stations
- **Robust GHG reduction, feedstock not imported, most fuel manufactured in UK, good audit trail**
- **Secure supply manufactured in the UK from UK waste feedstock**; limited bioLNG imported from EU
- **CNG has reduced range (tank capacity)**, LNG has comparable range to ICE
- **Higher capital cost offset by gas fuel duty discount**, so small savings are possible.

Biodiesel – HVO and (FAME – limited use)

- **HVO is a ‘drop-in’ fuel**, FAME limited in use due to waxing – not ISO diesel.
- **Depot based bulk tank fuel**, not aware of any publicly accessible 24/7 refuelling sites
- **Cannot be refuelled at home vehicles**, will always require refuelling stations
- **Good GHG reduction presuming all feedstocks are genuine waste and no GHG displacement**
- **Poor security of supply** - 74% of the feedstock for UK HVO comes from outside Europe
- **No change in capital cost**, higher energy cost but any ICE diesel vehicle or plant can be used
- **Still produce particulates and nitrogen oxides** - no known safe level of particulates.

When a BEV can do the job, it will be the most energy efficient, have the lowest emissions and as shown in this report can cost less to operate than any of the other technologies (whole life cost, also known as total cost of ownership). For HCVs, the catenary or electric road system (ERS) could be a very cost effective and energy efficient option but will only be relevant to long-distance heavy haulage. A BEV with a hydrogen fuel cell range extender is the next best technology, and after that fuel cell but Hydrogen made from renewable energy is not widely available and is currently expensive. Biomethane is a good alternative but still has tailpipe emissions. Biodiesel and in particular HVO, is only viable if the feedstock is genuine waste with no displaced emissions; the HVO-powered diesel engine will still have tailpipe emissions of particulates and nitrogen oxides (NO_X) and will need both a particulate trap and a SCR (AdBlue) system. Claimed reductions in PM and NO_X emissions from using HVO are not based on robust, published, peer-reviewed, research.

Sources of Information

Further information on a range of topics relating the UK's current GHG emissions, decarbonisation of the UK road fleet and the use of a range of alternative fuels are available from:

IPCC comprehensive Assessment Reports – AR6 (2021 and 2022)
World Resources Institute: GHG Reporting Protocol
Defra/BEIS UK Environmental Reporting Guidelines including SECR
BEIS UK GHG Emissions – Updated Annually
BEIS UK GHG Emission Reporting Factors – Updated Annually
DfT Renewable Fuel Statistics – Updated Quarterly
DfT UK Vehicle Statistics – Updated Quarterly and Annually
BEIS Predicted UK Grid GHG Intensity – Updated Annually
HM Treasury Green Book: Valuation of energy use and GHG emissions
Global EV Outlook 2021 – International Energy Agency (2021)
Determining the Environmental Impact of conventional and alternatively fuelled vehicles through LCA, Ricardo, For ECDG Climate Action (2020)
A comparative life-cycle analysis of low GHG HGV powertrain technologies and fuels. Ricardo (2020)
Zero Emission HGV Infrastructure Requirements, Ricardo. For UK CCC (2020)
Making zero emission trucking a reality, PWC, (2020)
Decarbonising the UK's Long-Haul Road Freight – UK Centre for Sustainable Road Freight (2020)
Hydrogen in a low-carbon economy – UK Committee on Climate Change (CCC -2020)
Zemo: Hydrogen Vehicle Well-to-Wheel GHG and Energy Study
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JIVE (Joint Initiative for Hydrogen Vehicles across Europe) (2017)
Hydrogen technology is unlikely to play a major role in sustainable road transport, Nature, (2022)
Separating Hype from Hydrogen – Part One: The Supply Side (BNEF - 2020)
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Hydrogen Is Big Oil's Last Grand Scam, CleanTechnica, (2021)
COP26: Widespread use of green hydrogen in heating and cars is practically impossible, Recharge, (2021)
End of the road for pioneering TfL hydrogen buses, Bus and Train User, (2020)
French city cancels purchase of 51 hydrogen buses, Recharge, (2022)
Hydrogen Mobility Europe (H2ME) – Emerging Conclusions (2021)
Battery or fuel cell? That is the question, VW Group, (2020).
Volvo Group Capital Markets Day, Volvo, (2020)
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Environmental sustainability of biofuels: a review, Proceedings Royal Society, 2020
ICCT: estimating displacement emissions from waste, residue, and by-product biofuel feedstocks (2020-22)
Used Cooking Oil (UCO) as biofuel feedstock in the EU
Used Cooking Oil (UCO) demand likely to double, and EU can't fully ensure sustainability (2021)
Implications of imported Used Cooking Oil (UCO) as a biodiesel feedstock (2019)
Targeting net zero – Next steps for the Renewable Transport Fuels Obligation, T&E, (2021)
Europe's imports of dubious 'used' cooking oil set to rise, fuelling deforestation, (2021)
The Uninhabitable Earth: A Story of the Future. David Wallace-Wells, Penguin, 2019

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