Fleet decarbonisation report

Moray Council

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1. Terms & definitions

- **AC** – alternating current electricity
- **AFR (advisory fuel rate)** - the rates set by government as guidance for reimbursing fuel costs
- **BEV (battery electric vehicle)** – a vehicle driven solely by a battery powered electric motor(s)
- **CAZ (clean air zones)** -areas in towns and cities that restrict access to vehicles with emissions over a certain threshold to improve air quality. Restrictions vary in different cities, with vehicle access usually granted by paying a fee or restricted to certain times of day (like LEZs)
- **Carbon footprint** – is the tonnage of greenhouse gases emitted over the period of a year by an organisation/vehicle
- **Charge point** – a single piece of charging equipment housing one, two or three sockets for charging BEVs. Depending on the specification of the charge point, it will deliver AC electricity at up to 7.4kW, 22kW or 43kW, or DC electricity at up to 50kW. The rate at which electricity can be drawn will also depend on the vehicle
- **Charger** - another term for a charge point
- **CO_2e (carbon dioxide equivalent)** – a standardised method of measuring a carbon footprint where the impact of different greenhouse gases is expressed in terms of the equivalent quantity of CO_2 emitted to create the same amount of warming
- **DC** – direct current electricity
- **DNO (distribution network operator)** – the owner and operator of power lines and infrastructure in an area's electricity transmission network
- **EV** – Electric Vehicle
- **GHG (greenhouse gas)** – gases in the atmosphere responsible for reflecting solar radiation back towards the Earth's surface. Higher levels of greenhouse gases are responsible for atmospheric warming. Common Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3)
- **HDVs (heavy duty vehicles)** – freight vehicles with a gross vehicle weight of more than 3.5 tonnes (trucks) or passenger transport vehicles of more than 8 seats (buses and coaches)
- **HFCV (hydrogen fuel cell vehicle)** – a vehicle powered by a fuel cell generating electricity using compressed hydrogen and oxygen from the air. This is not plugged-in and is refuelled in a similar way to petrol / diesel ie via a pump
- **ICE (internal combustion engine) vehicle** – a vehicle powered by a diesel or petrol engine
- **kWh (kilowatt-hour)** - is a unit of energy equal to one kilowatt (kW) of power sustained for one hour

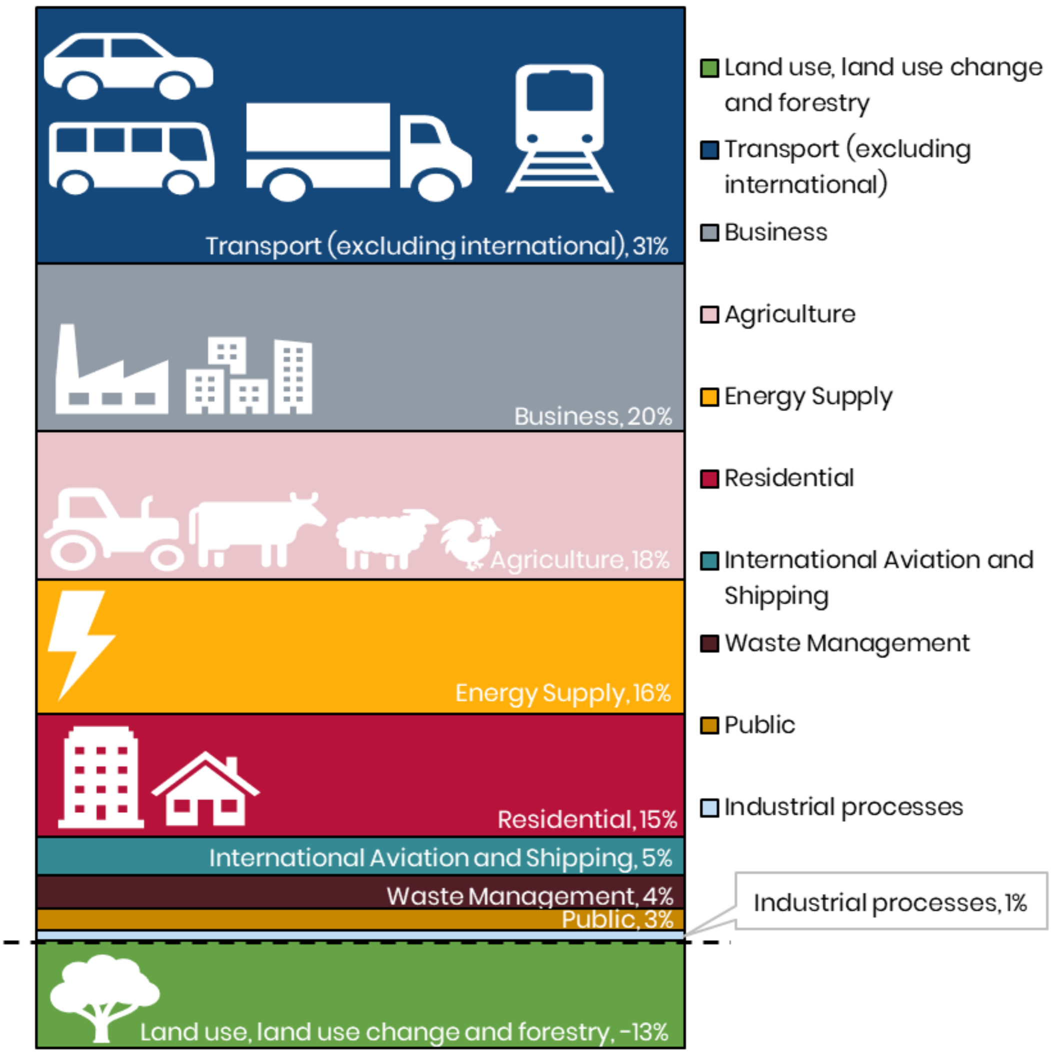
- **LCV (light commercial vehicle) –** vans with a gross vehicle weight of up to 3.5 tonnes
- **LEZ (low emission zone) -** areas in towns and cities that restrict access to vehicles with emissions over a certain threshold to improve air quality. Restrictions vary in different cities, with vehicle access usually granted by paying a fee or restricted to certain times of day. (like CAZs)
- **NIC –** national insurance contribution
- **OZEV -** Office for Zero Emission Vehicles
- **Particulate matter (PM) –** also known as aerosols are fine particles either solids or liquids suspended in the air. These can be natural, like pollen, or manmade such as soot. Inhaling some types of PM can be damaging to health
- **PHEV (plug-in-hybrid electric vehicle) –** a vehicle driven by either an electric motor powered by the battery, a petrol/diesel engine, or a combination of both. This has two separate drive trains
- **Power Factor -** an expression of energy efficiency. It is usually expressed as a percentage - the lower the percentage, the less efficient the power usage
- **PSVs (public service vehicles) –** public transport vehicles (typically over nine seats) including buses and minibuses
- **PV (photovoltaics) –** materials used in solar panels to convert light into electricity
- **SMR –** service maintenance & repair
- **State of charge (SoC) –** the level of charge of a battery ie a battery with a SoC of 100% would be said to be fully charged
- **SUVs (sport utility vehicles) –** larger vehicles with four-wheel drive, traditionally for multipurpose off-road use, but have recently become popular for all uses, including in an urban setting
- **VED (vehicle excise duty) –** a tax paid by vehicles corresponding to their CO_2 emissions
- **WLC** – whole life costs
- **ZEV (zero emissions vehicle) –** a vehicle that emits no tailpipe emissions, can be a BEV or a HFCV

2. Introduction

The Scottish Government declared a climate emergency in April 2019 and has set some of the most ambitious climate change targets in the UK. Moray Council followed suit by declaring a climate emergency in June 2020, one of the earliest local authorities in Scotland to do so. Moray also set ambitious targets in September 2020 to become carbon neutral by 2030. Domestic transport accounts for 31 percent of all greenhouse gas emissions in Scotland (see Figure 2-1). To combat transport emissions and improve air quality the Scottish Government's Programme for Scotland (2019/20) set bold targets to phase out petrol and diesel vehicles, especially within public sector fleets:

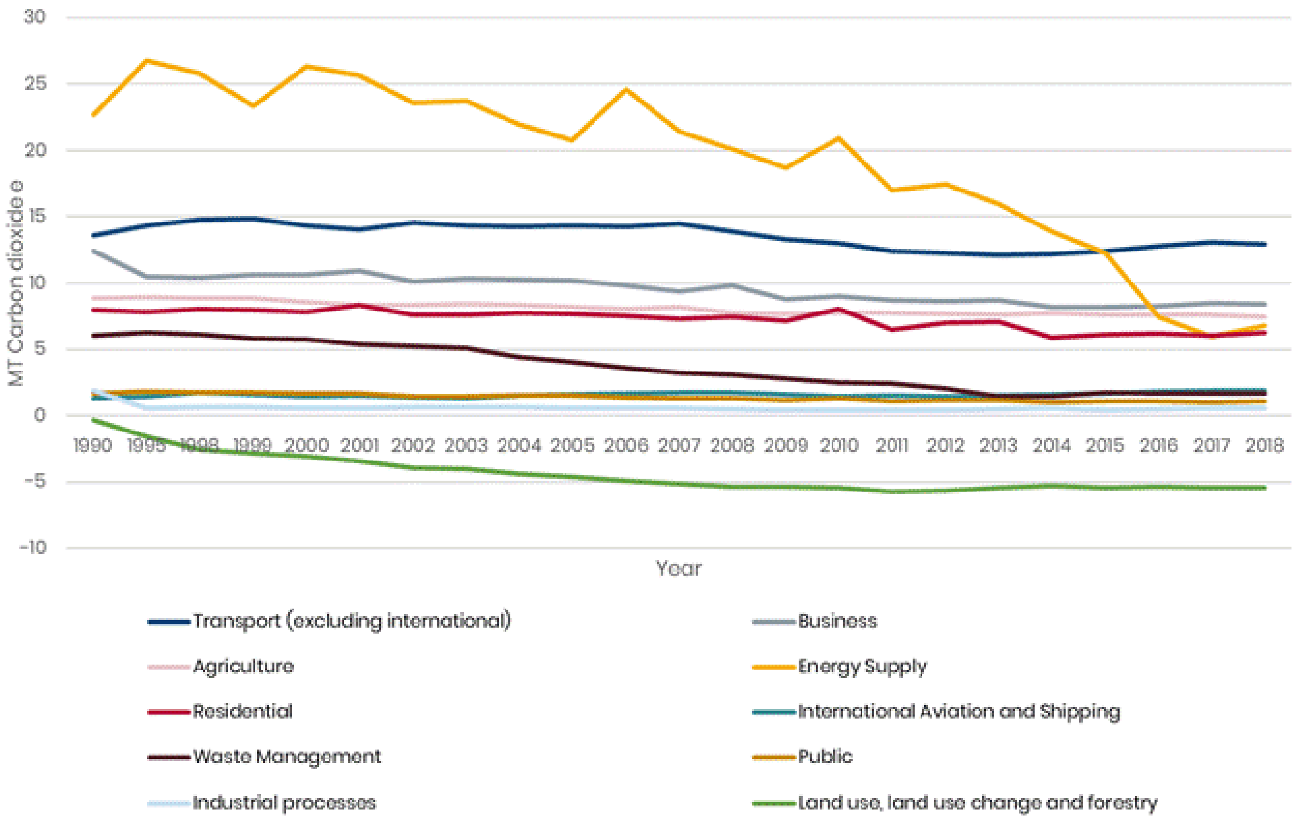
"We will work with public bodies to phase out petrol and diesel cars from our public sector fleet and phase out the need for any new petrol and diesel light commercial vehicles by 2025." (Scottish Government, 2019)

Figure 2-1- Greenhouse gas emissions 2018: estimates, grouped by National Communication category (Scottish Government, 2020)



Transport powered by fossil fuels is killing us. By polluting the air we breathe with Nitrogen Dioxide (NO_2) and particulate matter (particularly PM10 and 2.5), air pollution in the UK is linked to 40,000 deaths a year (Royal College of Physicians, 2016). A high proportion of these pollutants come from burning fuel in our vehicles, wear on our tyres and particulates from our brake pads. Climate change is often viewed as a huge global crisis; however air quality is a crisis on our doorstep and is directly affected by localised emissions. Decarbonising and rationalising our fleets, as well as driving less and using public and active travel more, is key to making our cities, towns, and villages cleaner and healthier places to live. In doing so, we will also be reducing our contribution to climate change and preserving our world for future generations.

Figure 2-2 - GHG emissions by sector change (1990 - 2018) (Scottish Government, 2020)



Vehicles have been getting cleaner, on average emitting less CO_2e per mile driven than they have in the past. But with the current trends of driving larger vehicles such as SUVs and with more vehicles on the road, there has been virtually no change in the transport sector's total CO_2e emissions since the 1990s, shown as the light blue line in Figure 2-2. The public sector must lead the way, to show that we are committed to the climate agenda, and that climate change and air quality are priorities for the government.

Grant funding for the adoption of zero-emission vehicles (ZEVs) will not be around forever. As the cost of ZEVs comes down, and price parity with internal combustion engine (ICE) vehicles is met, there will be no further requirement for additional funding support. As public sector organisations are able to access frameworks and procurement channels that are not available to other organisations, you are able to access large discounts that will substantially reduce ZEV costs. As cost parity is approached between ICE and BEV cars it is likely that Switched on Fleets support will be reduced. It is therefore important that you develop your own financial plans to replace all of your ICE cars with ZEV cars by the target date of 2025.

3. Executive summary

The Scottish Government has declared a climate emergency. In line with this, it has set several targets to reduce emissions from transport, as these make up a large part of the country's total carbon emissions. For the public sector, these targets include phasing out petrol and diesel cars by 2025; phasing out the need for new petrol and diesel vans from 2025; and phasing out the need for petrol and diesel versions of all other vehicles from 2030. You therefore need to take action to ensure your fleet meets these targets.

LCVs make up the largest segment of your vehicle fleet at just over 52%. followed by HDVs and cars with 27% and 20% respectively. PSVs make up the remaining 2%. In terms of total fleet CO_2e emissions, **your fleet emits a total of 3,227t CO_2e annually**. HDVs contribute the greatest amount with 62% of total emissions; LCVs contribute 29%, cars, 5% and PSVs 3%.

Your car fleet comprises 91 vehicles of which 12 are zero-emission vehicles. These are eight Vauxhall Corsa-Es, two Nissan Leafs, one Peugeot Ion and one BMW I3. Reducing your car fleet emissions to zero is a feasible target with currently available vehicles. As part of this work, you should implement a sustainable travel hierarchy to reduce unnecessary journeys. For unavoidable journeys, you should replace your ICE vehicles with ZEVs to create a zero-emission fleet. All of your cars are due to be replaced before 2025, so you are on track to meet the government's target provided these vehicles are replaced on schedule with ZEVs. **Replacing all cars with BEVs will provide an estimated annual saving of approximately £29,402 and 91t CO_2e[1].**

As LCVs make up the largest portion of your fleet, you should also look to replace these with ZEVs where you can. Currently, the number of ZEV LCV replacement options available decreases with increasing vehicle size, however the number of new ZEV models being manufactured is increasing. If a ZEV alternative is not currently available, you should consider delaying the replacement until more zero-emission alternatives are available, or downsizing the vehicle if the larger capacity is not required. **Replacing all LCVs with BEVs will provide an estimated annual saving of approximately £245,627 and 579t CO_2e[1].**

Older vehicles are less efficient, incur greater fuel and repair costs, and emit more CO_2e. The average age of your fleet is just over six years, but you have several vehicles over ten years old. Following your fleet replacement plan you will replace all your vehicles at least once by 2031 and all of your car fleet by FY2023/24. When following the fleet replacement plan, you should consider how ZEV availability will

[1] *The design of the calculators used to make this report's financial estimates and those relating to CO_2e results in very precise savings forecasts. In practice, due to variance in real world situations, these values should all be taken as approximate.*

change over the next decade. Particularly for larger LCVs as these have fewer suitable ZEV replacements in the current market. When you are replacing any such vehicle, if a ZEV alternative is not available you should investigate downsizing the vehicle or taking on a Euro 6 model.

Alongside adopting BEVs, you need to investigate charging solutions to accommodate your growing electrified fleet. As we did not have data on your depots' electricity use nor their electrical capacities, we were unable to conduct detailed analysis on what charging infrastructure you could install at these sites. However, the key things to consider when designing and implementing charging infrastructure are:

- Site constraints – these can be determined by comparing the available site electrical capacity with current site demand
- The duty cycles of vehicles based at the site – how much time they have available to charge each day
- The daily mileage requirements of the vehicles based at the site
- The energy requirements of the vehicles based at the site – this will vary depending on each vehicle's efficiency
- Engagement with your distribution network operator (DNO) – this should happen as early in the design process as possible to highlight issues that may arise and to speed up the installation phase

Following the recommendations in this report will help you decarbonise your fleet. However, replacing ICE vehicles with ZEVs on a like-for-like basis is not the only solution to combating the climate emergency. It is also important that you reduce the number of journeys you take, use active travel more often, downsize your vehicles, and reduce the number of vehicles you operate.

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4. Summary of recommendations

Description of recommendation	Ease	Estimated % saving	Estimated annual saving (£)	Estimated annual emission reductions (CO_2e tonnes)
Install telematics in all vehicles	Moderate	This will not directly reduce CO_2 emissions or costs. But by analysing the data and using this in tandem with fuel efficient driver training and the travel hierarchy, you will be able to maximise savings.		
Implement a robust travel hierarchy that will reduce unnecessary journeys and encourage active travel	Easy	5%[2]	£25,702	54t CO_2e
Replace all ICE cars with ZEV alternatives at the next replacement cycle.	Easy	[3]55% reduction in CO_2e emissions and 41% reduction in fuel costs	£29,402	91t CO_2e
Replace all ICE LCVs with ZEV alternatives at the next replacement cycle.	Easy	[2]63% reduction in CO_2e emissions and 55% reduction in fuel costs	£245,627	579t CO_2e
Downsize fleet vehicles where possible	Moderate	Up to 25% per vehicle downsized		
Develop the financial plan for replacing all vehicles with ZEVs	Moderate	Carbon, fuel costs, VED and SMR costs will all decrease significantly; the extent varies with vehicle size.		

[4,5]

The design of the calculators used to make this report's financial estimates and those relating to CO_2e results in very precise savings forecasts. In practice, due to variance in real world situations, these values should all be taken as approximate.

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[2] Based on a 5% reduction in fuel cost for company owned fleet. Implemented robustly, this will also tackle grey fleet mileage which will reduce costs further.

[3] Savings are based on all vehicles being replaced with ZEV alternatives. However, not all vehicles will be suitable on a like for like replacement basis. Percentage savings will translate to individual vehicle replacements.

[4] All savings are absolute; therefore, by adopting multiple recommendations actual savings will vary.

[5] Savings do not include reduction in grey fleet CO_2 emissions and mileage claims unless stated.

5. Carbon footprint

5.1. Data quality and assumptions

The method used to calculate CO_2e emissions is dependent on the quality of the data available. There are five methods available. Method one is the most accurate as it uses the fuel type and the litres used. Method five is the least accurate as it uses the vehicle mileage and the emissions of an average vehicle in the UK. Appendix 1 provides further details of the methods used to calculate fleet CO_2e emissions.

For this report, you provided us with annual mileage and fuel type data for most of your vehicles. For 17 of these, DVLA data was unavailable so emissions could not be calculated. These included eight Vauxhall Corsa-Es funded by Switched on Fleets in FY 2019/20, a Vauxhall Movano Tipper and six of your eight PSVs. For these vehicles, an assumed CO_2e/km was estimated based on the vehicles' weight and used to calculate annual CO_2e emissions with the milage provided.

The data also included the total mileage of external hire car used. As there was no record of the individual vehicle details, the CO_2e/km of an average diesel car was used to calculate the carbon footprint.

5.2. LA owned fleet overview

The fleet CO_2e footprint (carbon footprint) quantifies the carbon dioxide that has been emitted by your fleet over a year. The estimate does not include the life cycle CO_2e emissions from vehicle manufacture and disposal, or from fuel refining and distribution.

One tonne of CO_2e is produced when 390 litres of diesel is burnt at a cost of around £510 (based on 2019 UK fuel prices (BEIS, 2020)). Every litre of fuel burned, or mile driven, also results in emissions of nitrogen oxides and particulate matter (emissions with a negative impact on public health). More information on air quality can be found in Appendix 3. These emissions vary depending on driving behaviour, usage cycle, engine condition and the effectiveness of the exhaust gas cleaning system. Average non-greenhouse gas (GHG) emissions from UK car, van or heavy-duty vehicles (HDV) are published by the National Atmospheric Emissions Inventory.

Table 5-1 - Fleet carbon footprint

Fleet group	Fleet size (vehicles)	Annual mileage (miles)	Annual CO_2e emissions (tonnes)
CARS	91	932,380	170
LCVs	235	2,587,158	945
HDVs	121	1,682,421	2,005
PSVs	8	137,972	106[6]
External Hire Cars	nd	218,253	59[7]
Total	**455**	**5,558,184**	**3,285**

Figure 5-1 - Fleet carbon footprint by fleet type

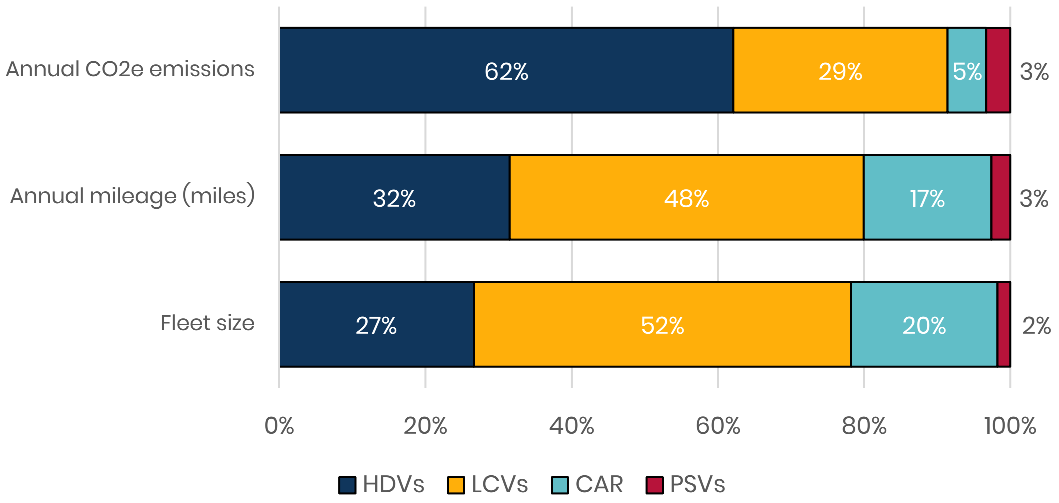

Table 5-1 and Figure 5-1 show the fleet's CO_2e footprint broken down by fleet segment. The CO_2e totals were calculated using (where available) the fuel use in litres, fuel type and the 2019 Greenhouse Gas (GHG) conversion factors published by the UK government (BEIS, 2019). Note that Figure 5-1 does not include the external hire cars.

Figure 5-1 shows that there is not a direct link between carbon emissions and the number of vehicles in a fleet segment. In absolute numbers, cars account for 20% of the entire fleet but contribute 5% of all CO_2e emissions, whereas HDVs account for 27% of the entire fleet but contribute 62% of all CO_2e emissions. LCVs and PSVs account for the remaining 29% and 3% respectively. This demonstrates that some vehicle types, typically larger ones, are less efficient, and more polluting than

[6] No OEM CO_2e g/km data available for PSVs, therefore some assumption had to be made see Section 5.1

[7] No record of the individual vehicle details so average CO2e/km values were used, see Section 5.1 for more details

others. This also highlights the scale of the challenge ahead for Moray Council to transition to ZEVs and to net zero CO_2e emissions.

5.3. Grey fleet overview

You currently operate a grey fleet which covers 1.2 million miles and costs an estimated £571,680 annually (shown in Table 5-2). Without data on the vehicles used, it is not possible to build a detailed profile of this fleet. However, grey fleet vehicles are typically older and more inefficient, which means you are likely to be paying more for miles driven by a polluting fleet. The data provided included only the total annual mileage. As the individual vehicle's gCO_2/km emissions values were not recorded, we used the average emissions value for all cars on the road in 2019 (177.1gCO_{2e}/km) (BEIS, 2019) to calculate an approximate carbon footprint for your grey fleet. We estimate that your grey fleet emits 362t CO_2e annually, over double that of your owned car fleet.

As we were not provided with individual claimants, we cannot perform more detailed analysis, however Figure 5-2 outlines the profile of an average local authority grey fleet. For this grey fleet, a large portion of drivers (58%) claim relatively few miles (under 1,000 miles per year) and are responsible for only 12% of the total miles claimed. A small number of drivers claim most of the miles. In this case, over 50% of the total miles are claimed by only 16% of the drivers, and these drivers are all travelling over 3,000 miles annually.

Table 5-2 - Grey fleet profile

Annual mileage (miles)	Annual CO_2e emissions (tonnes)	Annual grey fleet claims cost (£)
1,270,401	362	571,680

As you do not have any direct control over the vehicles in this fleet it is unlikely that this area of your transport emissions (approximately 362 tonnes of CO_2e) will reduce in line with your owned fleet ambitions. We therefore recommend that you regain control of this element of your fleet by introducing more pool cars, hire cars or car club vehicles as alternatives. While also ensuring that staff follow the sustainable travel hierarchy. Collecting individual grey fleet claim details will allow you to focus on the highest mileage claimants as a priority. This will not only reduce CO_2e emissions, but will also result in a significant cost saving, which can then be ring-fenced for fleet decarbonisation.

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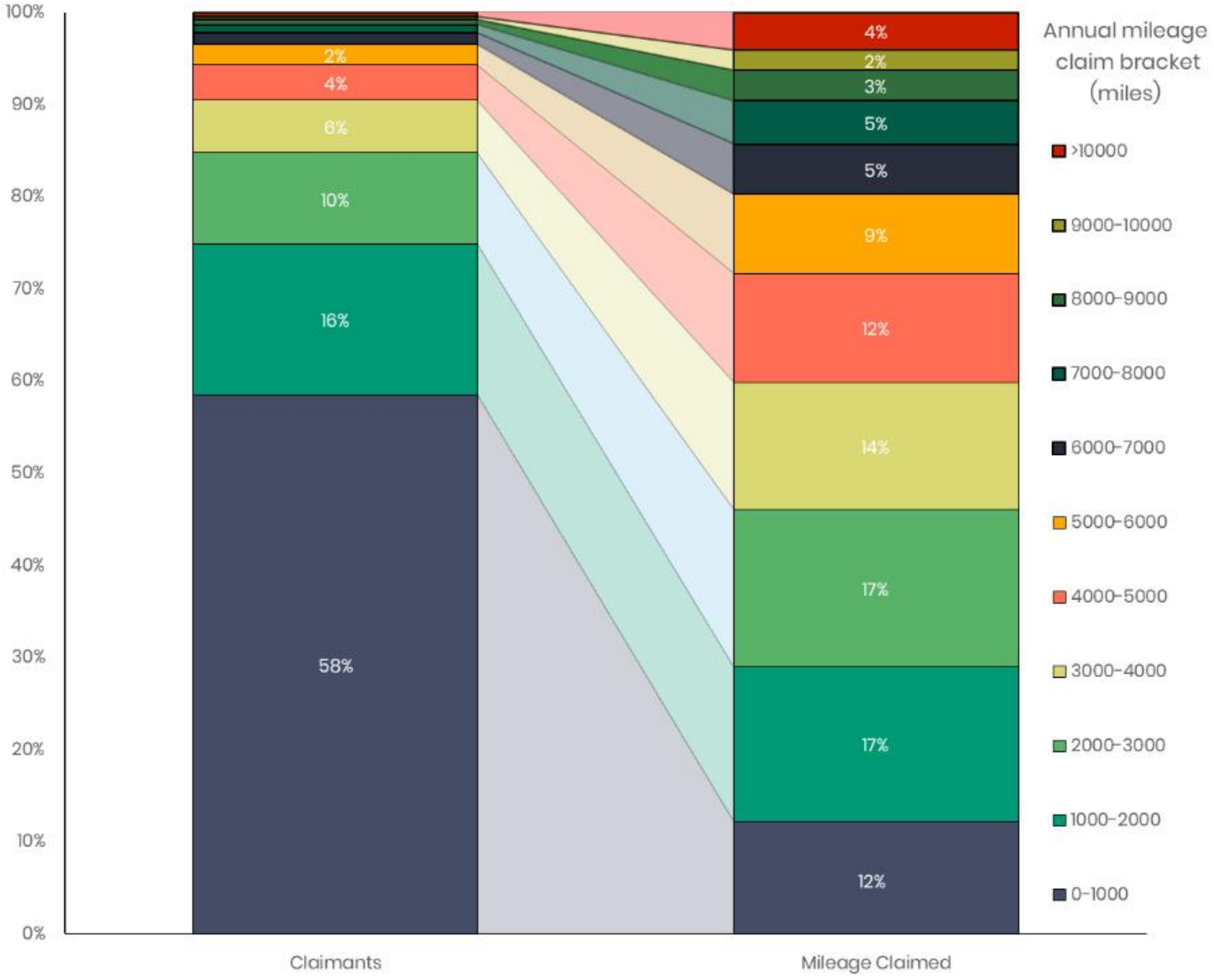
Figure 5-2 - Grey fleet claimant profile



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6. Fleet profile

Your fleet is made up of a variety of cars (20%), LCVs (52%), HDVs (27%) and PSVs (2%). Cars make up 20% of the fleet, with a total of 91 vehicles, the most common model being the Vauxhall Corsa. Your car fleet also currently includes 12 ZEVs; these are eight Vauxhall Corsa-Es, two Nissan Leafs, a Peugeot Ion and a BMW I3.

Your 235 LCVs make up the largest segment of your fleet. These are a mixture of primary panel vans, tippers and car derived vans. The most common models are the Vauxhall Corsa van (50), Vauxhall Movano (47) and Ford Transit 350 (28). The fleet also includes five BEVs, all of which are Nissan E-NV200s.

The HDV fleet is made up of a variety of weights, chassis types and body types and will prove the most difficult to decarbonise. You have a small number of PSVs which may also be challenging to replace with ZEV alternatives. However, it is encouraging to see that you already have an electric PSV on your fleet, the Optare Solo M890 Auto. As these replacements have the highest potential CO_2e savings, it is good that you are already focusing on this fleet segment. Collaboration will play an important part in enabling all of Scotland's local authorities to switch to ZEVs. We would therefore encourage you to share your findings relating to the operation of zero-emission PSVs with colleagues across the country, to assist them in smoothly transitioning their fleets to these vehicles.

6.1. Age distribution

Figure 6-1 - Fleet age profile (years) proportion of vehicles within fleet group

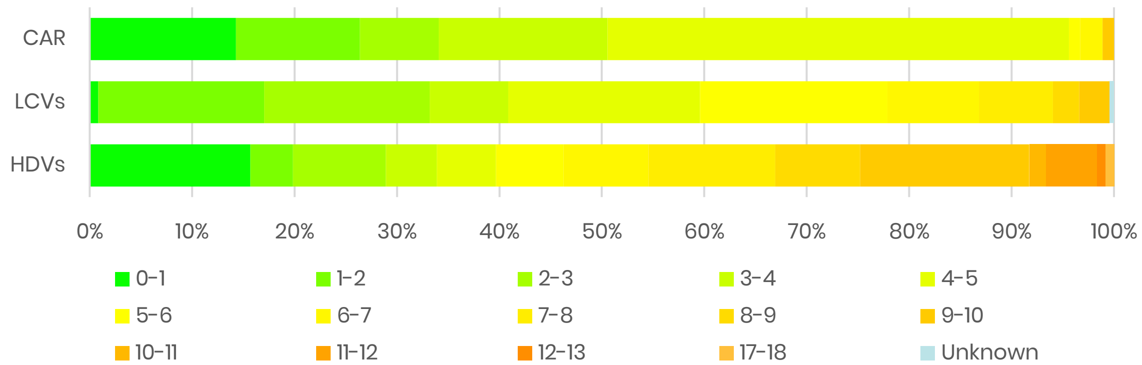

Table 6-1- Fleet age profile (years) number of vehicles by fleet group

	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	17-18	Unknown
CAR	7	17	7	15	41	1	2	0	0	1	0	0	0	0	0
LCV	1	39	38	18	44	41	23	17	6	7	0	0	0	0	1
HDV	19	5	11	6	7	8	10	13	12	20	2	6	1	1	0
Total	**27**	**61**	**56**	**39**	**92**	**50**	**35**	**30**	**18**	**28**	**2**	**6**	**1**	**1**	**1**

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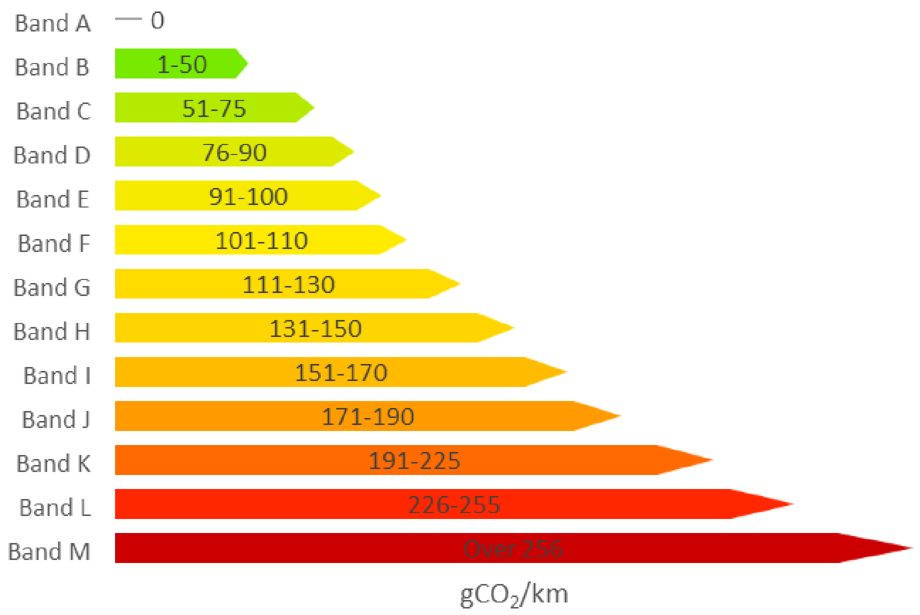
Figure 6-1 shows the age profile of your vehicles as a percentage of the various fleet segments; Table 6-1 shows your fleet age profile in absolute numbers. Over 40% of the whole fleet is at least five years old, with a small number over ten years old. The oldest vehicles are HDVs, which is common as their high costs tend to result in a longer lifecycle. Careful consideration should be given to the timing of replacing vehicles with longer replacement cycles. We suggest that to meet the ZEV adoption targets, you aim to avoid a situation where relatively new ICE vehicles have to be replaced in the late 2020's.

Vehicle age is a key consideration as it impacts adversely on:

- fuel consumption - older engines are less efficient
- air quality - older engines are significantly more polluting
- safety – older vehicles have less safety equipment
- reliability – older vehicles require more regular maintenance
- service delivery – older vehicles are more likely to have breakdowns, which can be disruptive and costly

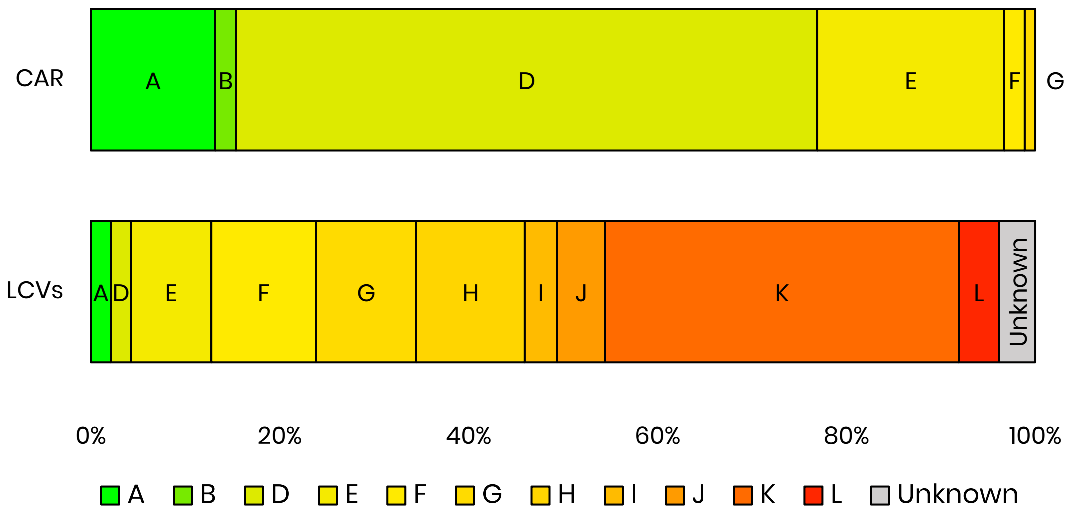
6.2. Carbon emissions

Figure 6-2 - VED bandings (post April 2017 scale)



Vehicle excise duty (VED / road tax) for cars is determined by their CO_2 emissions. Figure 6-2 outlines the VED bands and the corresponding CO_2 emission range for each band. This banding scale is useful as we can use it to profile the emissions of the car and LCV fleet. Unfortunately, it cannot be used for all fleet segments as manufacturer claimed CO_2 emissions are not available for all vehicle types.

Figure 6-3 – Moray Council LCV and car fleet VED profile (post April 2017 banding)



Your fleet emits a total of approximately 3,227t CO_2e annually, with the highest portion emitted by your HGV fleet. Figure 6-3 shows the CO_2 emission profile of the current Moray Council car and LCV fleet. This colour chart can be used as a baseline for measuring future CO_2 emission improvements in these fleet segments. The chart highlights the proportion of ZEVs already in the fleet as band A. At present, there are 18 ZEVs in your fleet, the 12 cars and five LCVs shown in Figure 6-3, and one Optare Solo M890 Auto PSV, all of which are battery electric (BEVs). Cars are the easiest segment to replace with ZEVs. You should therefore replace the remaining ICE cars with ZEVs at their next replacement cycle to meet the 2025 government target.

While you have five ZEVs within the LCV fleet (all Nissan E-NV200s), these only make up 2% of your entire LCV fleet. As many LCVs are small vans with multiple ZEV alternatives already available, you should target this segment for early ZEV adoption. You can transition your larger vans once there are more ZEV options available on the market.

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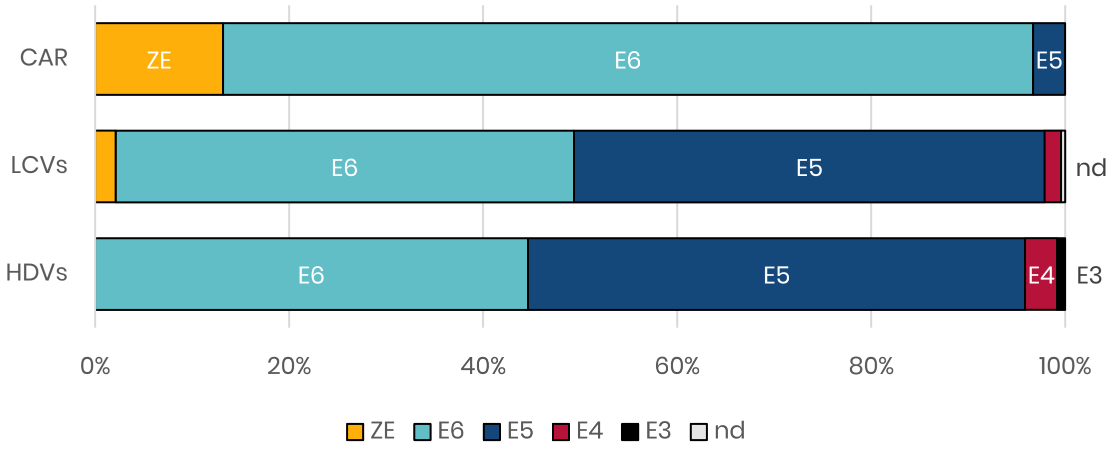
6.3. Euro status

Table 6-2 - Fleet Euro standards

Fleet group	ZE	E6	E5	E4	E3	nd
CARS	12	76	3			
LCVs	5	111	114	4		1
HDVs		54	62	4	1	
Total	**17**	**241**	**179**	**8**	**1**	**1**

Figure 6-4 - Fleet Euro standards



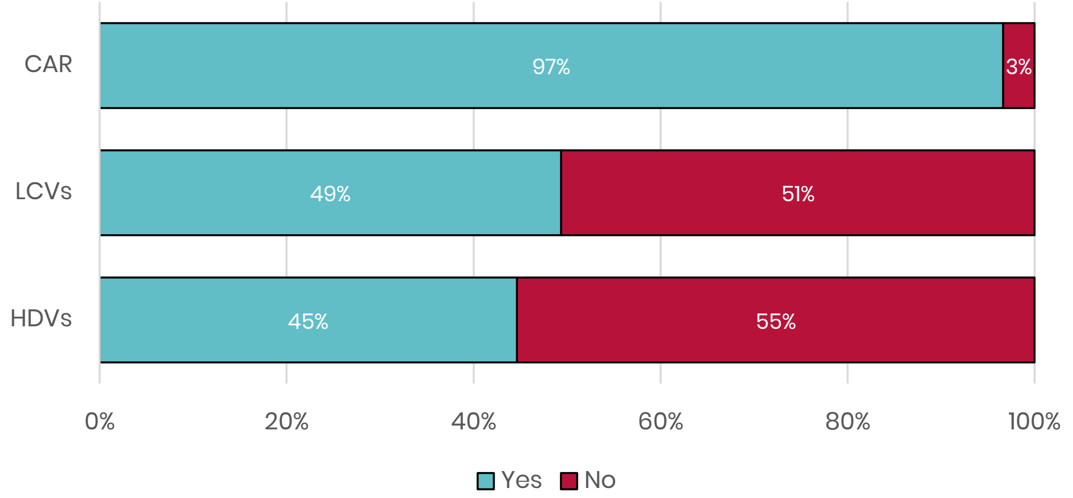
The Euro standard is a measure of the harmful exhaust emissions being produced by a vehicle (see Appendix 2 for more information). From a public health perspective, the two air pollutants of most concern are nitrogen oxides (NO_X) and particulate matter (PM). There are different Euro standards for petrol and diesel vehicles. For example, a 2006 Euro 4 petrol car and a 2016 Euro 6 diesel car produce a similar amount of harmful emissions.

Figure 6-4 shows the Euro standard profile of your whole fleet. As a minimum, vehicles should be Euro 6 compliant. Currently 42% of your fleet is Euro 5 or lower. Just over 3% of cars are not Euro 6 compliant which may be a reflection of the age of these vehicles. Ensuring vehicles are at least Euro 6 compliant should be addressed as a priority during the next replacement cycle.

The LCV and HDV fleets currently have a high proportion of vehicles classed as Euro 5 or lower, with 51% and 55% respectively. We recommend that you aim for a Euro 6 standard as a minimum. The large number of small vans in your LCV fleet can be replaced easily with ZEVs due to the wide range available on the market. This segment of your fleet should be targeted before your HDVs as the replacement of these is more feasible. The range of zero-emission HDVs is expected to expand in the next few years. This should be considered when designing your vehicle replacement plan.

6.4. LEZ compliance

Figure 6-5 - Fleet LEZ compliance



Across the UK, local authorities are implementing Low Emission Zones or Clean Air Zones (LEZ/CAZ) (see Appendix 3). In Scotland, Glasgow is the first city to announce the minimum standards for penalty-free entry. The minimum standards for the Glasgow LEZ are as follows:

- Euro 4 petrol engine
- Euro 6 (Euro VI) diesel engine
- Zero-emission vehicle

The Edinburgh, Dundee and Aberdeen LEZs are currently in consultation but are expected to follow the same standards. More information on LEZs can be found on the Low Emission Zones Scotland website.

Table 6-3 - Fleet LEZ compliance

Row Labels	Yes	No
HDVs	45%	55%
LCVs	49%	51%
CAR	97%	3%
Total	**58%**	**42%**

Table 6-3 shows that at least 42% of your entire fleet is not currently compliant with Scottish LEZs. We recommend that these vehicles are replaced as a priority with vehicles which meet, or exceed, the minimum LEZ standards. Where possible, you should be looking beyond Euro 6 to zero-emission vehicles.

7. Fleet recommendations

There are several actions you can take to decarbonise your fleet.

Rationalise your fleet

You should continually try to rationalise your fleet to make sure that it is as small and efficient as possible. This will help to reduce your costs and CO_2 emissions.

Follow the sustainable travel hierarchy

You should follow the sustainable travel hierarchy (see Figure 7-1 below). The hierarchy encourages people to choose the solution with the lowest CO_2 emissions when deciding how to travel. The first thing to consider is whether you can avoid the journey completely by using remote working technologies, as this provides the largest CO_2 and cost savings. Staff should be encouraged to choose travel options as close to the top of the hierarchy as possible.

Use telematics

You should install a telematics system in all fleet vehicles. With good quality data on your fleet use you will find it easier to develop a plan to transition to zero-emission vehicles.

Downsize vehicles

You should downsize vehicles wherever possible, as smaller vehicles are simply more efficient than larger ones. Smaller vehicles have lower CO_2 emissions and fuel costs. An additional benefit to downsizing LCVs is that there is currently a greater choice of smaller zero-emission LCVs than larger ones.

Adopt ZEVs

You should use zero-emission vehicles wherever possible. It is important you establish your actual vehicle requirements so that you can select the cheapest and lowest emission option for each.

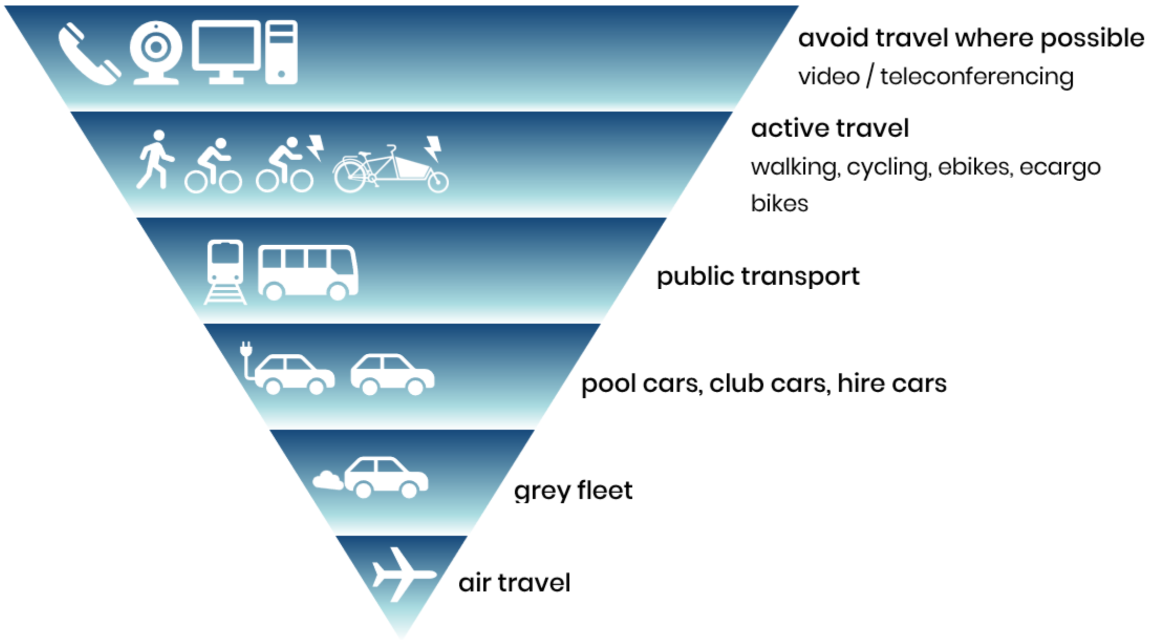
7.1. Rationalise your fleet

Fleet rationalisation is the process of reducing the size of your fleet to ensure that each vehicle is used as efficiently as possible. This involves examining the usage of each vehicle and removing any vehicles that are excess to requirements. This can provide significant cost savings as less vehicles need to be leased, purchased and insured. This also provides CO_2 savings as each vehicle has CO_2 emissions imbodied in its production.

It will be important to rationalise your fleet as you recover from the Covid pandemic. The pandemic has encouraged widespread use of remote working technology and this is likely to have a permanent impact on the number of miles that you need to physically travel. This means that you may no longer need some of your fleet vehicles. Aside from the impact of the Covid pandemic, encouraging staff to follow the sustainable travel hierarchy (ie encouraging remote working, active travel, public transport use, car sharing and car clubs) naturally leads to a reduction in the need for fleet vehicles. Fleet rationalisation should therefore be a continual part of your fleet management activity.

7.2. Follow the sustainable travel hierarchy

Figure 7-1 - Sustainable travel hierarchy



First and foremost, if you don't need to travel, you shouldn't. This is the simplest, most cost effective and immediate way to reduce CO_2e emissions, improve air quality and save money. COVID-19 has shown how useful, powerful, and appropriate video conferencing can be in delivering everything from team meetings to interviews and stakeholder engagement. Using video technology can bring substantial efficiencies to business by cutting out the time lost to travelling. It can also help improve communication and team working. This should be your first step in implementing a sustainable travel hierarchy or building a sustainable travel or decarbonisation strategy.

Active travel should replace short trips that may otherwise be completed using a vehicle. You can encourage staff to choose the most sustainable travel option by introducing a travel hierarchy for all staff and providing incentives such as pool ebikes / bikes. The aim of this is to guide staff through a decision-making process that will help them choose the most sustainable mode of transport possible. A simplified sustainable travel hierarchy can be seen in Figure 7-1.

The benefits of active business travel are:

- reduced or free travel costs
- healthier and more productive staff – staff that use active travel take on average 50% less sick days per year than those who don't (Sustrans, 2013)
- reduced parking space provision and associated costs
- reduced congestion
- contribution to improved air quality
- potential to combine with public transport.

Short local business journeys of up to three miles from the office could potentially be completed by active travel ie walking and cycling.

Way to Work is a new time-saving tool which helps workplaces in Scotland to promote active and sustainable travel. It showcases funding, training, advice and activities available, alongside inspiring case studies and the latest sustainable travel news.

Utilising software designed to advise users on the most efficient mode of transport to take for a specified journey can encourage the use of the sustainable hierarchy model. For example, if a journey is under three miles and does not require moving luggage, the employee will be encouraged to walk or use a bike or e-bike. Likewise, if the journey is within ZEV range (which most journeys now are) the software will encourage the user to take a ZEV. Although it might feel like employees are 'forced' into using ZEVs, users tend to have a much more positive perception of ZEVs once they have driven one.

The data available does not allow us to determine the proportion of short journeys that could be replaced with active travel. However, as many of your journeys are within towns and cities it is expected that many will be short. Replacing 5% of all journeys with active travel would provide annual savings of **54 tonnes of CO_2e** and **£25,702[8].**

Shorter journeys tend to be in urban areas and, because city driving is the least efficient form of travel for ICE vehicles, fuel and CO_2e emissions may be higher than stated. Driving in towns and cities also contributes significantly to local air pollution. Although the journey distances are short, urban congestion can increase journey time resulting in vehicles producing high quantities of harmful emissions.

[8] *Based on a 5% reduction in fuel cost for company owned cars and LCVs. Implemented robustly this will also tackle the grey fleet mileage as well which will reduce costs further.*

Poor air quality from harmful emissions contributes to 40,000 deaths a year in the UK (based on figures from (Royal College of Physicians, 2016)).

7.2.1. Adopt eBikes

An ebike is an electric-assisted pedal bicycle. That is a regular bicycle with the addition of an electric motor and battery. The battery supplies power to the motor and can be charged from a regular 3-pin socket. The motor provides power assistance when the cyclist is pedalling to ease the amount of effort required. The power assistance removes some of the physical effort required to cycle, meaning staff can arrive at their destination without being exhausted or in need of a shower.

The efficiency of ebikes, and the low cost of electricity, means that any miles cycled instead of driven will result in a reduction in CO_2e emissions and a significant reduction in fuel costs. A five-mile journey in a grey fleet vehicle costs £2.25 at £0.45 per mile, while an ebike costs <£0.01 in electricity and saves around 1.34kg of CO_2e. Cycling 100-miles on an ebike costs as little as 8p in electricity costs. eBike journeys offer all the same health benefits to staff of active travel.

Ebikes are a suitable alternative to driving short distances such as those journeys under ten miles.

7.2.2. Adopt eCargo bikes

eCargo bikes are specially designed to carry a load and come in many shapes and sizes. With a weight capacity of up to 350kg and a load volume capacity of up to $1m^3$, ecargo bikes can be ideal for short distance deliveries and logistics in and around urban areas and between operational sites.

eCargo bikes offer similar cost and CO_2e savings to standard ebikes although the increased weight of the bike means they have slightly higher running cost. From a business perspective however the increase in running costs is negligible. Travelling 100-miles on an ecargo bike, for example, will cost around 28p in electricity costs.

If introducing ecargo bikes into the fleet, we recommend that you implement a training programme to familiarise staff with ecargo bikes. Familiarisation training will build staff confidence with the bikes, reduce risk, and ultimately ensure the organisation reaps the maximum financial and environmental benefits from the bikes.

Cycling Scotland currently offers a suite of cycle training programmes to support workplaces with pool bike adoption. Cycling Scotland also offers funding towards installing cycling infrastructure in the workplace. Funding is also available to local authorities for the purchase of ebikes through Energy Saving Trust's eBike Grant Fund.

7.3. Install telematics in all fleet vehicles

As with many aspects of modern life, having good quality data allows good decisions to be made. If you implement zero-emission vehicles into your fleet based on good quality fleet use data, the process should be smooth and easy. Telematics systems can provide the good quality fleet data required to successfully implement zero-emission vehicles. The most important factors to consider when selecting a ZEV replacement are the daily mileage and maximum range required, and the opportunities for recharging (usually overnight but also during the day). You can also use telematics data to identify potential locations for charging hubs. The data highlights the locations where vehicles are stationary during the day, and the length of time that they are stationary for, thereby pinpointing potential locations for charging infrastructure.

You can also use telematics data to forecast the energy required at each charging hub. You can calculate the energy used by each vehicle to get to each charging location, and therefore how much energy it will need to recharge. This energy requirement can then be compared with the available energy supply at the site, to work out whether a connection upgrade is needed.

You can also use telematics data to identify vehicles that are underused. This will help inform your fleet rationalisation decisions. You can then make decisions over whether some vehicles can be removed from fleet, or whether additional work can be put on them to make them more effective.

Overall, telematics systems provide you with a clearer picture of how your fleet is being used. This data makes the process of transitioning your fleet to ZEVs easier, as you can match zero emission technology with vehicles, and accurately plan your charging infrastructure.

7.4. Downsize vehicles where possible

Table 7-1 - Emissions reduction from downsizing fleet cars

Volkswagen car model	Fuel	Class	Combined mpg	mpg change	CO_2 g/km	[9]£/mile fuel	OTR price
VW up! 3Dr	Petrol	City car	55.4	-	117	£0.11	£12,705
VW Golf	Petrol	5-door hatchback	53.3	+4%	121	£0.12	£23,300
VW T-Cross	Petrol	Small SUV	47.1	+15%	136	£0.13	£24,970
VW Touareg	Diesel	SUV	34.4	+38%	214	£0.19	£50,705

Table 7-2 - Emissions reductions from downsizing fleet vans

Ford van model	Fuel	Class	Combined mpg	mpg change	CO_2 g/km	[7]£/mile fuel	OTR price
Fiesta van 1.0	Petrol	I	54.3	-	118	£0.12	£18,490
Transit Connect L2	Petrol	II	44.1	+19%	136	£0.13	£22,186
Transit Custom L1	Diesel	II	39.8	+27%	186	£0.16	£28,689
Transit Custom L2 H2	Diesel	III	35.8	+34%	206	£0.18	£32,049

Downsizing fleet vehicles will reduce emissions and costs. Table 7-1 and Table 7-2 illustrates the change in carbon emissions and fuel use across the VW car and Ford van range. A similar table could be produced for any of the major manufacturers.

Both fuel and capital costs increase with size, with fuel costs increasing by up to 72% in the car comparison and 50% in the van comparison. Research carried out by Ricardo for Department for Transport (DfT) has shown the impact on fuel efficiency of fully loading a van is a 9-10% increase in fuel consumption (AEA Technology, 2010). Therefore, it is significantly more efficient to have a full small van than a half empty large van.

There are carbon, operating cost, and capital cost savings from using smaller vehicles whenever possible. We recommend avoiding a one-size-fits-all procurement model and instead assess vehicle suitability during the replacement process. As the market for ZEVs is still considerably smaller than that of ICE vehicles, there may not be a direct replacement for every vehicle. However, as there is a larger variety of smaller ZEVs for both cars and vans, if you can downsize, you will have more options to choose from.

[9] *Fuel costs are based off the average UK fuel prices in 2019 excluding VAT, petrol: 100.609ppl diesel: 105.012ppl*

7.5. Adopt ZEVs

When ICE vehicles are due for replacement, you should replace them with ZEVs wherever possible. The choice of ZEVs on the market is continually growing and is expected to grow significantly over the next few years. *The UK Government website* lists most of the ZEVs currently available. There are less ZEV replacement options as vehicle size increases. There is, for example, a high number of ZEV car models available however there are fewer zero-emission HDVs, RCVs and SPVs (See Appendix 4 for more information).

Creating a zero-emission fleet will likely require you to replace current vehicles with a mixture of different technologies. Currently most ZEVs are battery electric vehicles (BEVs) but there are also hydrogen options available.

It is important to develop a good knowledge of the ZEVs currently available and to keep abreast of new models as they arrive on the market. Supply constraints can be an issue, so placing orders early, can be advantageous.

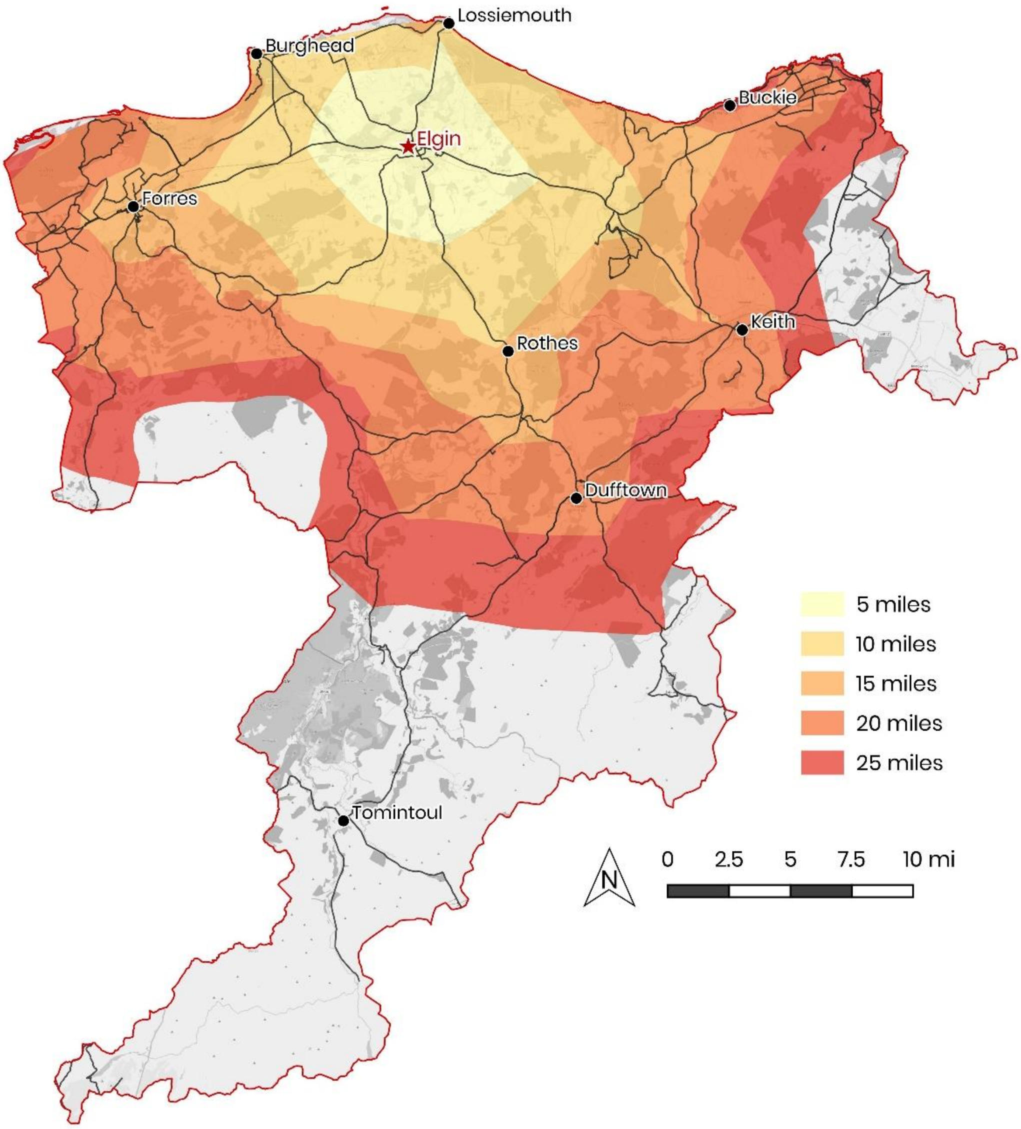
Once you find a ZEV that is a potential replacement for a current ICE vehicle (ie correct size, load carrying capacity, seats, equipment etc.), you must then assess its operational viability. The key considerations are as follows:

1. Maximum required driving range of the vehicle on a single charge
2. Rate of charge (charging time)
3. Whole life cost (see section 7.6)
4. Vehicle efficiency (Wh/km or kWh/100km).

BEVs have a lower range on a single charge than most ICE vehicles do on a full tank of fuel, however, it is important to understand exactly how far you need to drive. Some fleet vehicles may drive long distances, but if they have regular stops, and can access a charge point, a vehicle with a relatively small battery may be suitable. This will reduce your capital costs as the battery is often the most expensive component in the vehicle. It will also reduce your CO_2e emissions as there are embedded CO_2e emissions in battery production. Driving with an unnecessarily large battery is also less efficient as batteries are heavy. Installing and using telematics will highlight how often vehicles are driving high mileages. You could then have dedicated vehicles for high mileage journeys and others for shorter trips.

Figure 7-2 shows journey distances in 5 miles increments up to 25 miles from Elgin. The largest distance showing on the figure therefore represents a 50-mile round trip from Elgin. This shows the journeys that you could easily complete using a battery electric vehicle. Most battery electric cars now have ranges of over 150 miles, and some of up to 250 miles, on a single charge. Therefore multiple 50-mile round trips (ie Elgin, to Dufftown) would be possible on a single charge. For larger electric LCVs, the range is more limited. The Renault Master ZE, for example, has a driving range of around 50 miles in poor conditions when fully laden. In good conditions, and unladen, however, it can exceed 124 miles. Even in the worst conditions therefore, a large electric LCV could complete a 50-mile round trip from Elhin, to Dufftown or Keith. Whether large battery electric LCVs can replace any of your large LCVs now, will depend on the daily mileage required of each vehicle, and the availability of charging opportunities.

Figure 7-2 - Map of Moray Council area showing 25-mile distances from Elgin, demonstrating approximate travel distances for a 25-mile and 50-mile round trips.



Most BEVs on the market can rapid charge (at around 50kW). This can add between 50 and 80 miles of range in 30-40 minutes (depending on the size and efficiency of the vehicle). Models that are not capable of rapid charging take longer to charge, but are cheaper to purchase, so may be a better option if rapid charging isn't a requirement. If vehicles are used during the day, but are parked all night, they may never need to rapid charge. Therefore, understanding your vehicle duty cycles will help you select the best ZEV replacement option. It is important to avoid over-specifying vehicles, or automatically replacing them on a like-for-like basis, as this will only add unnecessary costs and CO_2e emissions to your fleet.

A vehicle with high mileage, but which stops regularly throughout the day, may have time for additional charges. This type of work pattern can increase the maximum daily range of an electric vehicle, making lower specification models a viable option (reducing costs and CO_2e emissions). Careful consideration has to be taken to ensure that there is suitable charging infrastructure in place to support this. Further information relating to charging infrastructure can be found section 9.

The efficiency of ICE vehicles is measured in miles per gallon (mpg). For electric vehicles this is measured in Wh/km or kWh/100km. Vehicle efficiency can be affected by vehicle weight, drag, battery size and motor type. Therefore, it is important to determine exactly what your requirements are in terms of range (battery size), charging type and vehicle size, before you buy. You should aim to purchase the most efficient models possible as this will translate into the lowest running costs and largest CO_2e savings.

7.5.1. ZEV car replacement

We have analysed your fleet data using the data provided and have calculated the carbon and cost savings that would result from you switching to BEVs. Within your car fleet there are currently 79 non-ZEV vehicles which you need to replace with ZEVs before 2025 to meet the Scottish Government's public sector fleet decarbonisation target

Replacing all your non-ZEV cars with ZEVs could lead to 41% savings in fuel and Vehicle Excise Duty (VED) costs and a 55% reduction in CO_2e emissions. In addition to this you would see savings in service, maintenance, and repair (SMR). **This would provide annual savings of £29,402 and 91 tonnes of CO_2e**. Table 7-3 outlines a breakdown of the savings you could achieve based on two of the most common car models in your fleet – assuming a mileage of 10,000 miles per year.

Also, if any of your ICE cars are used by staff for personal use, and you replace these with ZEVs, they would benefit from the reduced benefit in kind (BIK) rate of 0% that came into effect in April 2020. This could provide substantial savings in national insurance contributions (NIC) for the council and BIK savings for your employees.

Table 7-3- Replacement savings from ICE cars to BEV equivalents

Based on 10,000 miles per year	*Existing vehicle*	*ZEV Alternative*	*Existing vehicle*	*ZEV Alternative*
	Vauxhall Corsa 	Vauxhall Corsa-e 	Vauxhall Astra 	Peugeot e-208 
Official CO_2 emissions (g/km)	94[1]	0	118[1]	0
Annual CO_2e (tonnes)[2]	2.01	0.80[3]	2.52	0.84[3]
Annual fuel cost	£829[4]	£456[5]	£1,041[4]	£478[5]
Fuel over 6 years	£4,976	£2,733	£6,246	£2,867
First year VED[6]	£125	£0	£165	£0
VED over 6 years	£825	£0	£865	£0
First year costs (Fuel + VED)	£954	£456	£1,206	£478
6-year costs (Fuel + VED)	£5,801	£2,733	£7,111	£2,867
First year cost saving	**£499**		**£728**	
6-year cost saving	**£3,068**		**£4,244**	
Annual CO_2e saving	**1.21t CO_2e**		**1.69t CO_2e**	

[1] CO_2 figure obtained from https://vehicleenquiry.service.gov.uk.
[2] Includes an uplift to reflect real-world driving style, based on BEIS methodology.
[3] Electric vehicle CO_2 emissions are calculated using the BEIS/Defra figure for average emissions from UK electricity generation.
[4] Fuel prices based on 105p/litre for diesel, 100.6p/litre for petrol.
[5] Electric vehicle fuel cost is based on a 13.34p/kWh tariff. Further savings can be made if off-peak charging is utilised or vehicle is charged using a free ChargePlace Scotland charger.
[6] Vehicle Excise Duty (road tax). VED figures are based on the date the current vehicle was first registered and the post April 2017 rates for the replacement vehicle. Annual VED of £320 is payable in years 2-6 if the vehicle costs more than £40,000.

7.5.2. ZEV LCV replacement

You have a large LCV fleet of 235 vehicles including five BEVs (all Nissan E-NV200 Acentas). In addition to your cars, you should replace as many of your LCV fleet as possible with zero-emission alternatives. The vehicles to replace are your smaller panel vans and car-derived vans like the Vauxhall Combo, Vauxhall Corsa Van, and Vauxhall Vivaro. It will be easy to replace vehicles with daily mileages within the range of electric alternatives like the Nissan e-NV200, Renault Kangoo Z.E. and Renault Zoe van. Table 7-4 provides a breakdown of the savings you could achieve based on two of the most common van models in your fleet – assuming a mileage of 10,000 miles per year.

Our analysis of the data provided suggests that replacing all ICE LCVs with the ZEVs outlined could save in the region of 55% in fuel and VED costs and 63% in CO_2e emissions, in addition to cost savings in SMR. **This would provide annual savings of £245,627[10] and 579 tonnes of CO_2e.** If any of your fleet LCVs are used for personal use, and you switch these to zero-emission vehicles, you would benefit from reduced national insurance contributions (NIC). Staff members with zero-emission company vans will also pay lower company van tax due to the reduced BIK rate for zero-emission vans.

Table 7-4- Replacement savings from ICE small/medium LCVs to BEV equivalents

Based on 10,000 miles per year	*Existing vehicle* Vauxhall Combo 	*ZEV Alternative* Renault Kangoo Z.E. 	*Existing vehicle* Ford Transit 350 	*ZEV Alternative* Mercedes eSprinter 
Official CO_2 emissions (g/km)	133[1]	0	222[1]	0
Annual CO_2e (tonnes)[2]	2.98	0.80[3]	4.81	2.01[3]
Annual fuel cost	£1,231[4]	£457[5]	£1,985[4]	£1,150[5]
Fuel over 6 years	£7,384	£2,741	£11,913	£6,900
First year VED[6]	£265	£0	£265	£0
VED over 6 years	£1,590	£0	£1,590	£0
First year costs (Fuel + VED)	£1,496	£457	£2,250	£1,150
6-year costs (Fuel + VED)	£8,974	£2,741	£13,503	£6,900
First year cost saving	**£1,039**		**£1,101**	
6-year cost saving	**£6,233**		**£6,603**	
Annual CO_2e saving	**2.19t CO_2e**		**2.80t CO_2e**	

[1] CO_2 figure obtained from https://vehicleenquiry.service.gov.uk.
[2] Includes an uplift to reflect real-world driving style, based on BEIS methodology.
[3] Electric vehicle CO_2 emissions are calculated using the BEIS/Defra figure for average emissions from UK electricity generation.
[4] Fuel prices based on 105p/litre for diesel, 100.6p/litre for petrol.
[5] Electric vehicle fuel cost is based on a 13.34p/kWh tariff. Further savings can be made if off-peak charging is utilised or vehicle is charged using a free ChargePlace Scotland charger.
[6] Vehicle Excise Duty (road tax). VED figures are based on the date the current vehicle was first registered and the post April 2017 rates for the replacement vehicle. Annual VED of £320 is payable in years 2-6 if the vehicle costs more than £40,000.

[10] This does not consider whole life cost savings and in many cases the increased capital costs will reduce any running cost savings, this is discussed further in section7.6.

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7.6. Use a whole life cost procurement method

ZEVs currently have higher capital costs than their ICE counterparts, but they do have lower running costs. Because of this, it is important to consider all aspects of vehicle ownership when working out cost comparisons between ICE and ZEV models. As a minimum the areas to consider are as follows:

- Depreciation (if purchased) / lease costs (if leased)
- Service, maintenance, and repair costs (SMR)
- Value added tax (VAT)
- Vehicle excise duty (VED)
- Fuel and electricity costs
- Class 1a national insurance contributions (NIC) (if applicable)
- Vehicle insurance
- Grants that may be available for specific vehicles and charging infrastructure.

Adopting a WLC based policy often satisfies both financial and environmental objectives. This is because vehicles with a lower WLC tend to use less fuel and emit less pollutants. Where the WLC analysis includes ZEVs, a pragmatic approach must be taken when considering range and opportunity to recharge.

Organisations that do not use a WLC approach are often found to be buying vehicles that are cheaper to acquire but which are more expensive to run over their operational life.

Table 7-5 shows WLC comparisons between a variety of ICE vehicles and BEV alternatives. Table 7-5 assumes that these vehicles are leased for four years and are driving 10,000 miles per year. ZEVs are not always the lowest cost option, but they are the lowest carbon option. The use of the WLC model allows you to put a cost on your carbon reduction programme.

The following comparisons do not consider NIC as it is assumed that vehicles are pool vehicles and therefore not for staff personal use. If vehicles are for staff personal use, such as company cars, NIC must be included, this will work in favour of the electric models as they carry a lower BIK rate. For certain models, the NIC saving from switching from ICE to BEV amounts to thousands of pounds per year. Insurance is not included in the below comparison as we assumed that you self-insure your vehicles.

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Table 7-5 - WLC analysis of ICE vehicles and ZEVs; based on vehicles being leased for four years and 10,000 miles, costs are accurate as of 01/10/2020

Based on 4 years and 10,000 miles	Seat Ibiza	Nissan Leaf	Kia Sportage	Kia e-Niro 39kWh	Ford Fiesta van	Renault Zoe van	Renault Kangoo ML19	Renault Kangoo Z.E.	Peugeot Expert Standard 1000kg	Peugeot e-Expert
Annual lease cost excluding VAT	£1,755	£2,603	£2,394	£2,998	£1,755	£2,476	£1,755	£2,679	£1,755	£2,777
Annual fuel / electricity cost	£1,204	£543	£1,746	£450	£1,164	£522	£1,314	£459	£1,553	£656
SMR annual	£246	£205	£334	£262	£295	£192	£435	£214	£397	£241
VED Total (+1st year registration fee)	£665	£55	£1,360	£55	£1,115	£55	£1,115	£55	£1,115	£55
Total CO_2e emissions (tonnes)	2.59	0.80	3.76	0.78	2.51	0.80	3.19	0.80	3.76	1.14
Total cost (4 year)	£13,483	£13,458	£19,257	£14,894	£13,969	£12,815	£15,132	£13,460	£15,932	£14,748
£ per mile	£0.34	£0.34	£0.48	£0.37	£0.35	£0.32	£0.38	£0.34	£0.40	£0.37
Cost difference per mile	**£0.00**		**-£0.11**		**-£0.03**		**-£0.04**		**-£0.03**	
Cost difference per year	**-£6**		**-£1,091**		**-£288**		**-£418**		**-£296**	
Cost difference over 4 years	**-£24**		**-£4,363**		**-£1,154**		**-£1,671**		**-£1,184**	

The ZEVs come out cheaper over the term of the lease. This is down to their lower running costs and associated taxes. Savings will continue to increase for those vehicles that travel more than 10,000 miles per year, however those with a lower mileage can work out more expensive than their ICE counterparts. You should also factor-in the cost of charging infrastructure. Charging infrastructure will however have a much longer lifecycle than the vehicle lease, so you will have to take a pragmatic approach to this.

There will be many internal factors that will influence the procurement approach used, however, whether you lease or purchase, using a WLC analysis will ensure that you select the most suitable and cost-effective vehicle models.

8. Fleet decarbonisation strategy

As you have started to invest in BEVs, you have already begun to decarbonise your fleet. The majority of your fleet (just under 60%) is under five years old, with very few vehicles over ten years old. You do not have any vehicles that are overdue for replacement, and provided you follow your fleet replacement plans, you are on course to meet both the Scottish Government's 2025 and 2030 decarbonisation targets.

Your car fleet already contains 12 BEVs, leaving 79 vehicles you need to transition to ZEVs. With the wide range of BEV cars on the market, making this a zero-emission fleet by 2025 should be easily achievable. Your cars are also the youngest part of your fleet, with an average age of under four years. The oldest vehicle is a ten-year-old, BEV Peugeot Ion due for replacement this year (2021) so is not a concern.

Your LCV fleet will be more difficult to transition to ZEVs. These vehicles have replacement cycles of over six years on average, compared to an average of under four years for car fleet vehicles. It is important to therefore consider ZEVs now, to avoid at least six years of unnecessarily running highly polluting vehicles. This is particularly important for the smallest vehicles in this group as there are many ZEV models already available that fall into this category, so these will be the easiest to decarbonise.

8.1. Vehicle replacement profiles and plans

You have a varied fleet, with some expensive specialist and purpose-built vehicles that have long replacement cycles to maximise the return on their investment. Moray Council vehicle replacement cycles currently range from 3.7 years on average for cars, to 6.1 years for the light fleet, and 9.1 years for the heavy fleet. Because of the length of these cycles, it is crucial to consider ZEVs now, rather than at the end of the next replacement cycle. This will help you make emissions reductions sooner.

It may be preferable to have an equally distributed replacement cycle from a procurement perspective. As supply is often an issue when adopting large numbers of ZEVs. However, spreading the replacement of vehicles will be dependent on how your vehicles are financed, and may not always be possible. Your replacement plans are currently weighted towards FY2020/21 with 152 due for replacement in this year, roughly a third of your entire fleet. Evenly distributing replacements across many years may avoid a disproportionately large financial pressure on any year, especially if supporting charging infrastructure also has to be installed.

You may want to consider altering your replacement plan based on the availability of ZEV alternatives. For example, small LCVs with suitable ZEV replacements currently available could be changed sooner than planned. While you could delay changing larger vehicles without a suitable ZEV replacement until such alternatives become available. This would most likely speed up the rate of fleet decarbonisation and reduce your overall emissions sooner.

8.1.1. Cars

Figure 8-1 - Cars replacement profile curve (based on existing replacement dates)

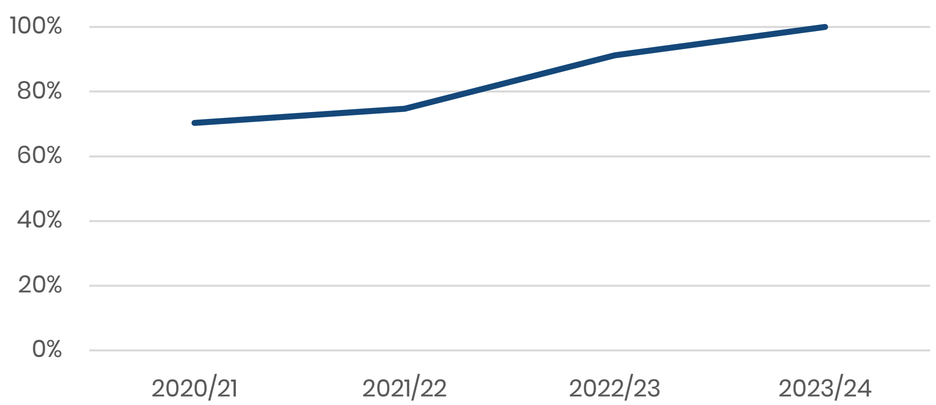

Table 8-1 - Cars replacement profile (number of vehicles replaced per year)

Fleet group	2020/21	2021/22	2022/23	2023/24
Car	64	4	15	8

Figure 8-1 and Table 8-1 outline the current replacement profile for your car fleet. From this you can see that all cars are scheduled to be replaced at least once by FY2023/24. Provided these cars are replaced with ZEVs, you are on course to meet the Scottish Government's target to phase out petrol and diesel cars from public sector fleets by 2025. Since there are alternative ZEV models available for every car in your fleet, this is the earliest date at which you could have a zero-emission car fleet if you follow your replacement cycles.

Your replacement plan is weighted towards FY2020/21, as a positive result of which you will decarbonise your fleet faster. However, it will require a large number of chargers to accommodate all these new BEVs. We did not receive data on your existing charging facilities and depot site electrical capacities so have not provided forecasts of the level of new infrastructure you will require. Given the number of new vehicles you will take on, it is likely you will need to install a large number of chargers to meet these vehicles' energy demands. Depending on your existing infrastructure, replacing a large number of cars in FY2020/21 may result in an initial lack of chargers. You will therefore need to determine how much infrastructure you need and set installation plans in motion as early as possible.

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8.1.2. LCVs

Figure 8-2 - LCVs replacement profile curve

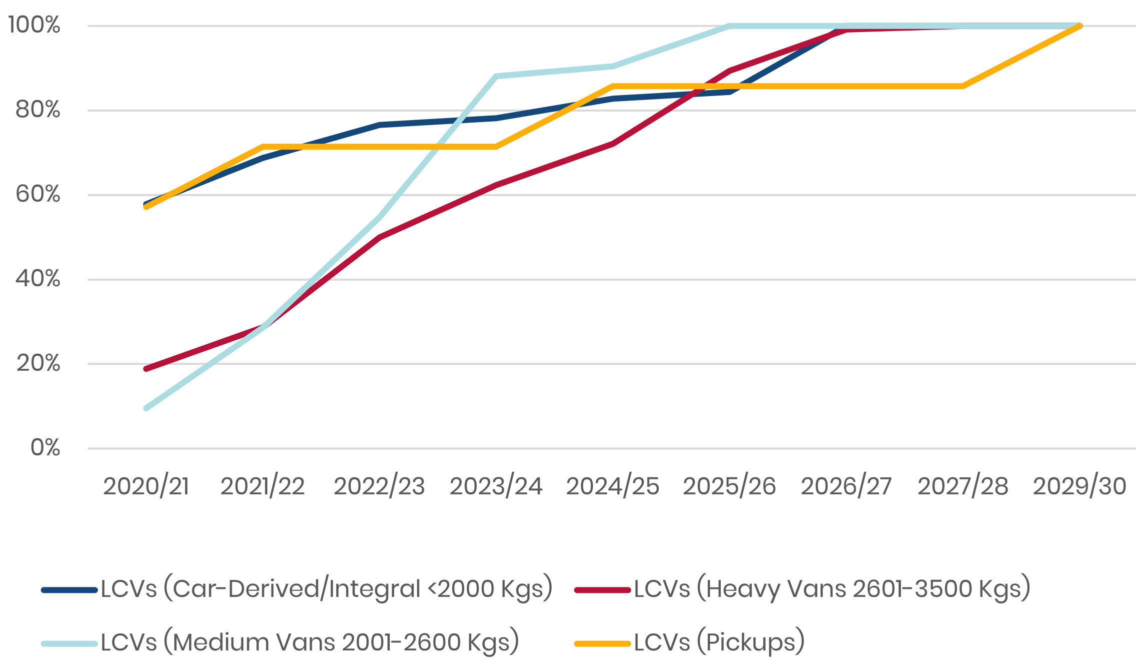

Table 8-2 - LCVs replacement profile (number of vehicles replaced per year)

Fleet group	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2029/30
LCVs (car-derived/integral <2000 Kgs)	37	7	5	1	3	1	10		
LCVs (medium vans 2001-2600 Kgs)	4	8	11	14	1	4			
LCVs (heavy vans 2601-3500 Kgs)	23	12	26	15	12	21	12	1	
LCVs (pickups)	4	1			1				1
Total	**68**	**28**	**42**	**30**	**17**	**26**	**22**	**1**	**1**

With your current replacement plan, you are on course to meet the government's 2030 target to phase out all new petrol and diesel vehicles by 2030. Like your car fleet, the number of vehicles due to be replaced are weighted towards 2020/21. To accelerate the reduction of your fleet's carbon impact, we recommend that you aim to replace diesel LCVs with zero-emission alternatives whenever possible. If a diesel LCV has to be replaced between now and the end of 2025 and a ZEV model is not a viable replacement, we recommend that a Euro 6 diesel option is selected. The process of replacing the Euro 4 and Euro 5 diesel LCVS should be accelerated to ensure that these vehicles are compliant with the low emission zones that are due to be implemented across Scotland.

While you shouldn't have a problem adopting replacements for your smaller LCVs, or your car-derived and medium vans, replacing some of your larger vans may be more difficult, as there are fewer alternatives available. Particularly if they are required to do high journey mileage. Your LCV fleet averages 43 miles daily[11] which is within the range limits of larger LCVs like the Renault Master Z.E. For smaller vans, there are a range of vehicles available on the market that can travel up to 250 miles on a single charge. These vehicles will be sufficient for the bulk of your driving needs, as journey longer than this will be very rare. There are also several new BEV or range extended electric vehicle (REEV/REX/eREV) vans due to come onto the market this year (2020) which may be more suitable for higher mileage driving. The arrival of these vehicles, alongside the continued growth of Scotland's network of public charging infrastructure, will help to overcome any barriers posed by the Moray area's size.

[11] *Calculated assuming LCVs are used for 255 working days per year.*

8.1.3. HDVs

Figure 8-3- HDVs replacement profile curve

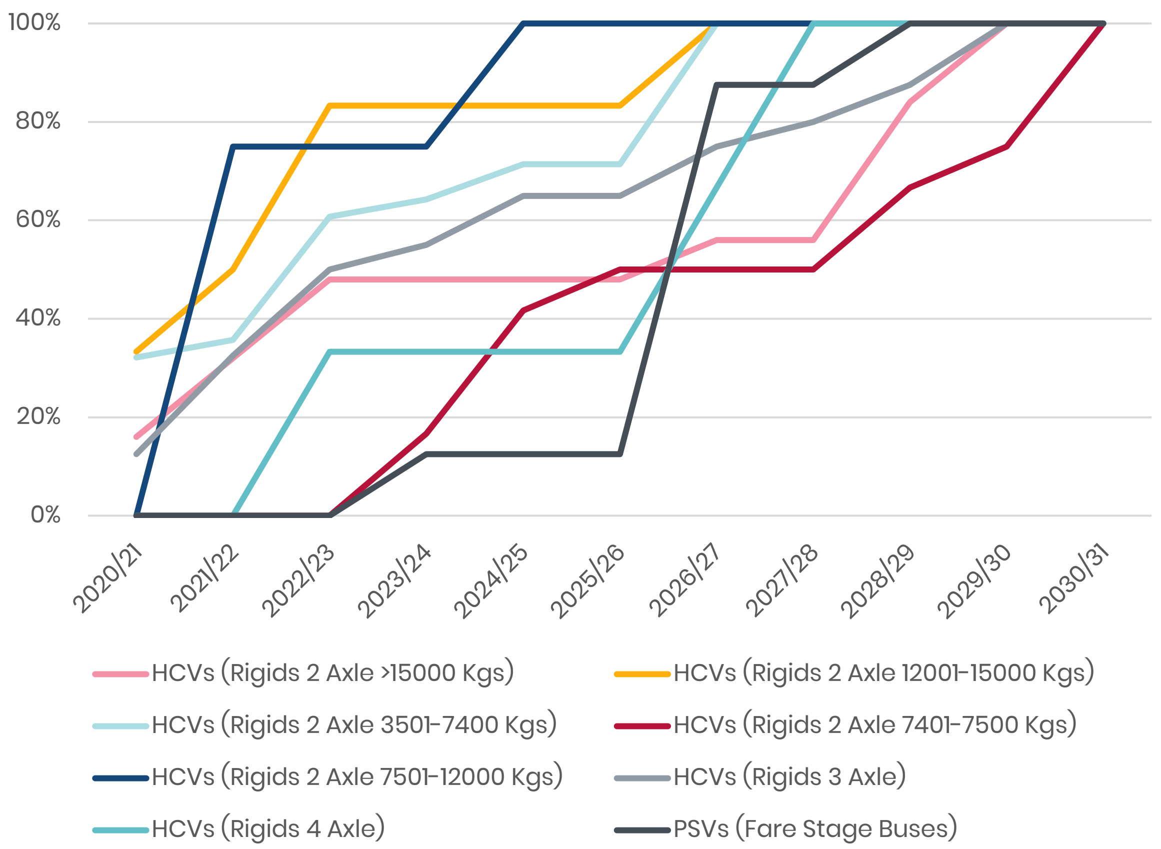

Table 7-4- HDVs replacement profile curve

Fleet groups	2020/21	2021/22	2022/23	2023/24	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
HDVs (rigids 2 axle >15000 Kgs)	4	4	4				2		7	4	
HDVs (rigids 2 axle 12001-15000 Kgs)	2	1	2				1				
HDVs (rigids 2 axle 3501-7400 Kgs)	9	1	7	1	2		8				
HDVs (rigids 2 axle 7401-7500 Kgs)				2	3	1			2	1	3
HDVs (rigids 2 axle 7501-12000 Kgs)		3			1						
HDVs (rigids 3 axle)	5	8	7	2	4		4	2	3	5	
HDVs (rigids 4 axle)			1				1	1			
PSVs				1			6		1		
Total	**20**	**17**	**21**	**6**	**10**	**1**	**22**	**3**	**13**	**10**	**3**

Your replacement plan for HDVs is quite evenly spread out over the next 10 years. This will be beneficial if you find it easier to replace the same number of vehicles each year. Unlike cars and LCVs, there are few suitable ZEV HDVs currently on the market. However, this is expected to change over the next decade as technology develops. Manufacturers such as Tesla, Hyundai and Mercedes-Benz are currently producing electric HDVs for short and long-haul journeys. As a result, you may want to consider delaying the replacement of HDVs where an electric equivalent is due to be released. Especially those in a lower weight class or those that do short journeys.

You should investigate the possibility of downsizing vehicles that need replaced in the next two years. Where this is not feasible due to the requirements of the vehicle, you should take on Euro 6 models, as these are more efficient and so release less carbon. Under the current Scottish Government targets for the public sector fleet there is no requirement to buy ZEV HDVs until 2030. Between now and then the market is expected to mature significantly with greater choice and reduced costs.

9. Charging infrastructure requirement

9.1. Charging site Considerations

As we were not provided data on the half hourly energy consumption of the sites and the available capacity that you have agreed with your provider, we cannot provide specific charging infrastructure advice based on your depots. This data would allow us to state whether you would be able to install any additional charge points without requiring a larger capacity or grid connection upgrade. You should try to minimise the need for grid connection upgrades as these can add substantial cost and delays to any project, although sometimes these works are unavoidable.

Figure 9-1 - Example half hourly site energy demand (yearly average)

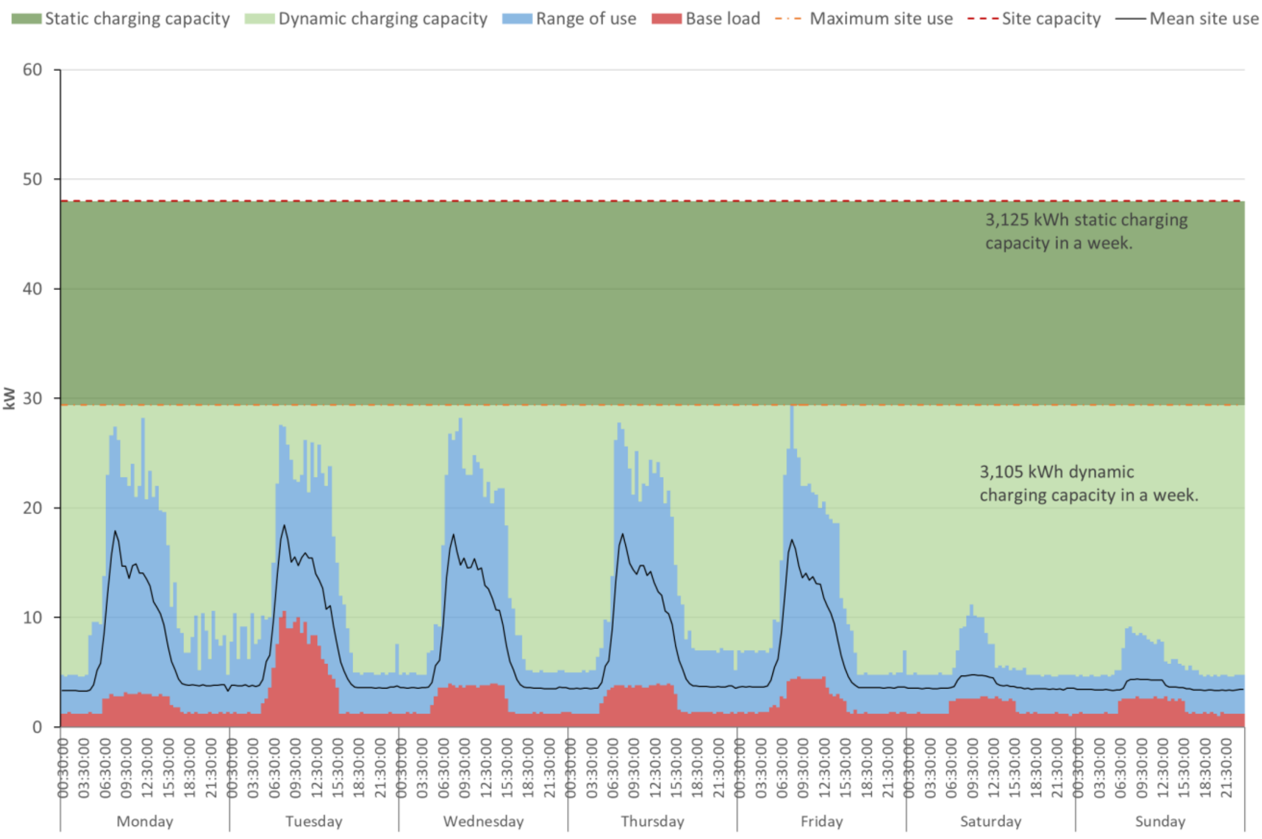

Figure 9-1 shows an example energy consumption profile at a typical local authority depot, averaged over a whole year. In this figure the capacity at the site is 50kVA. Applying a 95% power factor to this means the maximum consumption at the site could be 47.5kW. The consumption peaks at 29kW and under these conditions it would be possible to install 18.5kW of static basic charging without any issues (the types of chargers are discussed further in section 9.2). This could be one 3.7kW and two 7.4kW single-outlet chargers, five 3.7kW single-outlet chargers or any combination which when added total under 18.5kW. The blue area of the graph shows where there may be spare capacity, as this represents one-off high usage events. Investigating whether this could be controlled would determine what additional energy might be made available here.

There is a large amount of spare overnight capacity at this example site which could be utilised to charge electric vehicles. Between approximately 6pm and 6am the power requirement drops to below 5kW. This is quite typical for the usage in most depots, so you are likely to also experience this. In this scenario, with a 50kVA capacity, the site could accommodate around 42.5kW of charging through the night. This could provide up to 510kWh of electricity to electric vehicles, enough to travel around 1,500 miles[12] . This charge could be split between up to 11x3.7kW single-outlet charge points. Therefore supporting 11 individual vehicles if they need to charge every night. Depending on the duty cycle of vehicles and daily mileage, they may only need to charge every other day, then these charge points could support double that number of vehicles. To allow this sort of charging your infrastructure must be able to understand the energy demand of your building and be able to vary the power output of the chargers. This is a more expensive option than static basic chargers but could allow you to avoid costly connection upgrades (more on this in section 9.2).

Depending on the vehicle types, daily mileage and downtime, the type of charging infrastructure you need will vary. Ideally you should charge your vehicles as slowly as possible to maximise your available capacity. You should avoid charging patterns in which vehicles draw a high power for a short amount of time, then sit plugged in and fully charged until they are picked up for their next shift. This will save you money as you won't need as high a power capacity at your site.

With the average daily mileages in your LCVs and cars fleets being around 43 miles and 40 miles respectively, most vehicles are not going to be completing long journeys regularly. You tend to use each of your vehicles over an eight-hour period per day, leaving at least 16 hours of possible charging time. Because the mileages are not excessively high, if you have electric vehicle that can drive 100 to 200 miles on a charge, they will usually only require a top up charge. Given this, you should not need many, if any, high powered chargers. Over 13 hours a 3.7kW charger will charge a battery with up to 48kWh of electricity, enough energy to drive around 144 miles[12]

[12] *Based on a rough average of three miles per kWh in an average electric car.*

9.2. Types of chargers

9.2.1. AC or DC charging and smart management

There are two basic types of charging infrastructure: AC (Alternating Current) and DC (Direct Current). Batteries need DC and electric motors need AC. An AC charger relies on the vehicle's "on-board" charge management system to convert the AC to DC and ensure that the battery is not damaged during charging. This is the simplest type of charger. The output of AC charging systems range from 3.7kW (240 Volt, 16 Amp, single phase) up to 43 kW (400 Volt, 60 Amp, three phase) but are usually 7.4 kW (240 Volt, 32 Amp, single phase) or 22 kW (400 Volt, 32 Amp, three phase).

DC charging systems deliver the power directly to the batteries and do not use the vehicle's on-board charge management system. To do this safely and without damaging the expensive batteries, the DC charge point must communicate with the vehicle and understand the size of the battery as well as its state of charge (SoC). DC chargers are, therefore, a lot "smarter" and management of DC charging can be more sophisticated as the charge management software knows the SoC and battery size of all the vehicles it is connected to.

A charging strategy must also consider the non-linear nature of the process. If a vehicle returns to a 7.4kW charger needing 74 kWh of energy to replenish its battery, it will take longer than 10 hours to fully recharge it. When a battery is fully depleted there is little internal resistance to the flow of current (Amps) and so energy can be quickly transferred to the battery, but as it reaches 80%-90% SoC, the internal resistance increases, and the charging system has to increase the voltage to maintain the current. However, there is a maximum voltage above which damage to the battery will occur. When that voltage is reached, the flow of energy to the battery (Amps) falls and the battery charge rate diminishes. Because of this, the vehicle that returns to a 7.4kW charger requiring 74 kWh of energy may take 12 hours to fully recharge.

9.2.2. Basic chargers

Basic chargers, or as they are commonly known, dumb chargers, are given this name due to the charge point's level of intelligence, connectivity, and communication. A basic charger can often be no more than a socket on a wall. They tend however, to be rated between 3.7kW and 7.4kW (AC) and can be either tethered (permanently connected to a charging cable) or untethered (allowing the charging cable to be removed from the unit and swapped). When you plug a vehicle into it, it will charge at the rated power output until the vehicle is fully charged. These units can normally be de-rated (the power output reduced from say 7.4kW to 5kW) if there is insufficient supply. This is a manual process and would need to be completed by an engineer.

The benefit of this style of charge point is its simplicity and cost. However, because it cannot communicate there is no way to optimise charging times (at the unit, this may be possible by programming the vehicle itself), monitor electricity consumption or connect to a back office.

9.2.3. Smart chargers

A smart charger does all the things a basic charger can do, but also allows for communication between the charge point and an app, back-office system or another piece of software. This allows you to set charging times, monitor charge point availability (which will be crucial in depot charging) and even automate over-the-air (OTA) updates for the charge point's software. This additional capability does however come at a cost and therefore smart chargers are more expensive than basic chargers.

9.2.4. Rapid chargers

Rapid chargers tend to be rated at around 50kW and depending on the unit can be either DC only, or DC and AC. These will always be smart capable and offer you the ability to add between 50 and 80 miles of range in 30-40 minutes, depending on the size and efficiency of the vehicle. These are the most expensive units and, due to the power that they draw, they will often require a supply upgrade. If you are installing multiple rapid chargers, sometimes you will even need a new substation. In depot charging situations these units will only be used when vehicles have very little down time and need to be charged quickly before going back out on the road. Installing rapid chargers should always be a last resort for a depot as they will add substantial cost to any charge point installation project and are often unnecessary.

9.3. Load management

Load management type	Description
Static load management	Evenly distributes a set power to all charge points. No matter how many of the vehicles are charging, every charging station is allocated the same power.
Dynamic load management	The power available for charging is variable based on the current power consumption of the site or building. More power will be available for charging vehicles if the building or site decreases its power consumption.

Load management systems offer a potential solution for multiple charge points to be operated without exceeding the maximum power capacity of a site. Load management works by distributing the available power to the charge points that are in use. This is demonstrated in Figure 9-2.

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Load management systems can also limit the proportion of a site's total energy supply that BEV charge points can use, again preventing exceedance of that site's total capacity. The use of load management technology can avoid costly upgrades to electrical supply.

The principle of load management is that when a charge point is being used, the vehicle is charged at the fastest speed permitted by the charge point and vehicle in question. When several charge points are being used, the rate of charge being delivered to each can be reduced.

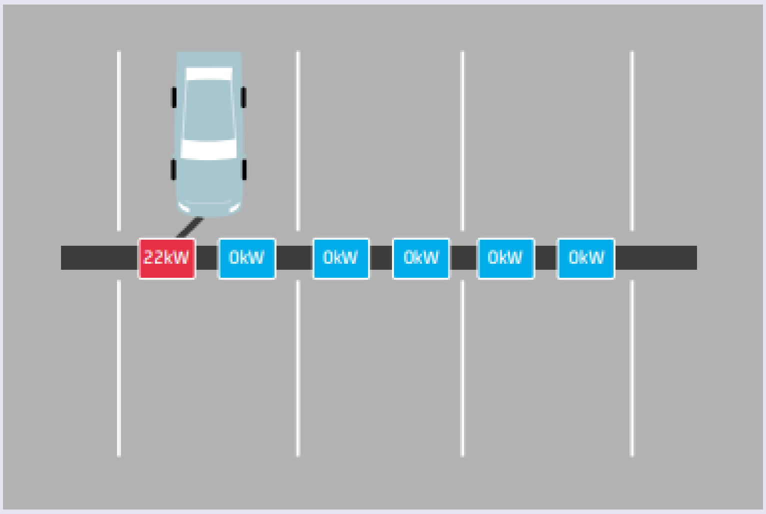
Organisations running fleets with vehicles requiring quick top-up charges during shifts and vehicles requiring a slow charge overnight at the end of a shift, would benefit from load management systems. Particularly if the system allows the business to avoid costly upgrades to its electrical supply. Fleet managers should consider the likely future growth of their BEV fleet, as installing flexible load management technology at the outset can save on infrastructure replacement and upgrades later. Charge points with features such as remote access functionality, back office integration and load management are also useful from a payment perspective. They can also include the ability to remotely control charge points (to end or prioritise a vehicle charging session, for example) and to monitor the usage of charging infrastructure on site over time. The end-user can often be identified through an RFID card or user app which is advantageous for determining the amount of electricity any vehicle is using and allows individual vehicle and driver efficiencies to be determined and costs charged to cost centres. Where employees can charge their private vehicles at work, this system can allow the cost of the electricity they use to be charged to them. In the same way visitors using the infrastructure on site can be identified and managed as deemed appropriate.

Figure 9-2 - The principle of load management

The principle of load management

Total spare electrical capacity: 32kW

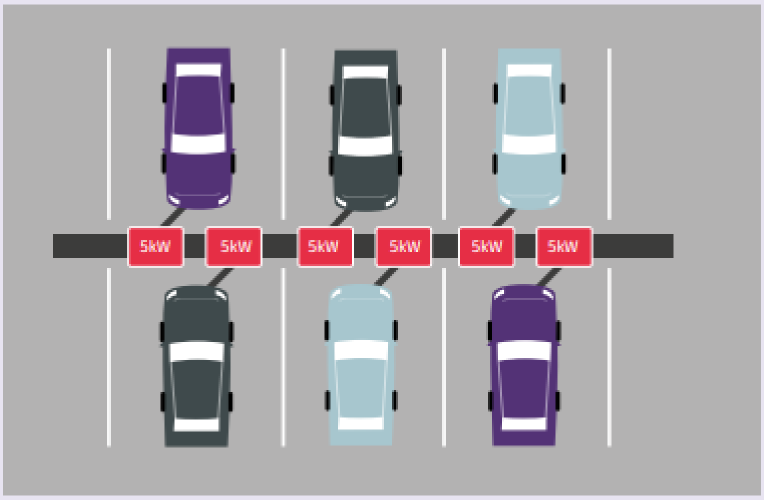
A bank of six chargepoints, with a maximum power rating of 22kW, on a site with 32kW of spare electrical capacity.



Chargepoint in use

Chargepoint not in use

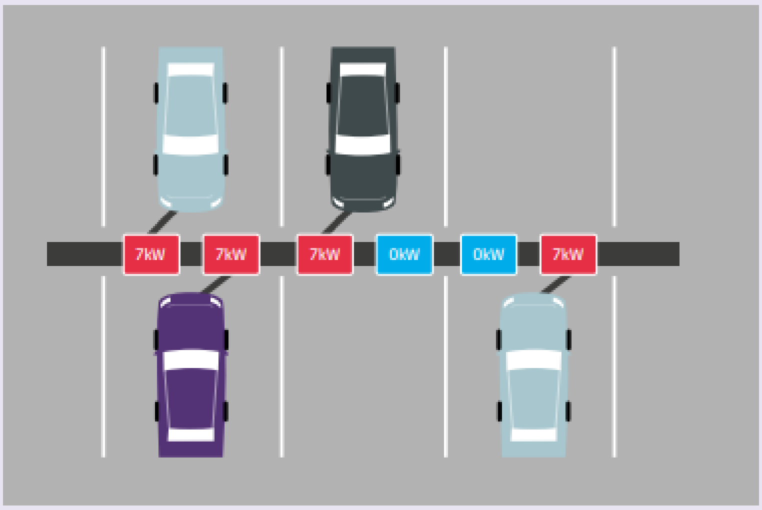
When all six chargepoints are being used, the load management equipment limits the amount of power at each chargepoint, to avoid exceeding the spare capacity.



Chargepoint in use

Chargepoint not in use

With any number between one and six vehicles, the load management equipment will ensure the maximum charge possible is delivered, whilst not exceeding spare capacity.

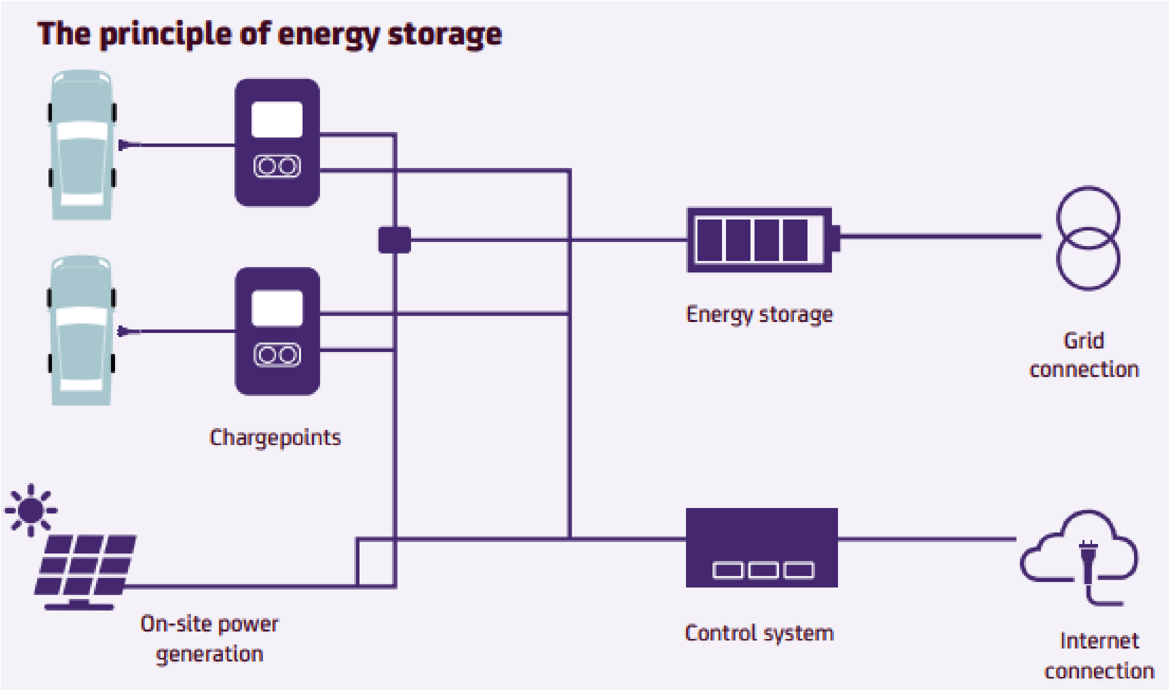


Chargepoint in use

Chargepoint not in use

9.4. Energy storage and solar PV

Figure 9-3 - The principles of energy storage



If your charging requirements exceed the capacity of the local network infrastructure, an alternative to a costly distribution network upgrade is to install a charge point solution which incorporates energy storage (batteries). This would offer a means of storing electricity off grid to charge electric vehicles, but would also incorporate load management, and integrate with smart charging. This can be further improved by installing solar PV to generate renewable energy during daylight hours. Solar energy can be stored on site, ready to be used to charge vehicles at any time of day at a lower cost than electricity from the grid. Figure 9-3 illustrates how this sort of charging system would work. These systems have been used widely, for example Dundee City Council has implemented multiple systems, like the one outlined, for its charging hubs. The incorporated load management allows more charge points to be available but at slightly reduced rates of charge.

This energy storage does have a capacity limit. Once the stored energy is consumed, you will rely fully on the existing site connection capacity. When considering installing large numbers of charge points it is key that you engage with your distribution network operator (DNO) and installer early to uncover any issues that your site may have.

9.5. Emerging technology

9.5.1. Inductive (wireless) charging

Inductive, or wireless charging uses an electromagnetic field to transfer energy between an electric vehicle and a charging pad through electromagnetic induction. There are many companies around the world that are working in this space and many charge points are already being installed in such a way that when wireless charging becomes available, the existing charge points can be switched to this technology relatively easily. There is even a wireless charging road in Sweden that charges vehicles as they drive on it (Smartroad Gotland, 2020). This technology, although new, may be worth considering. It is also worth ensuring that when you are looking to install charge points that it is easy to update the technology type.

9.5.2. Vehicle to grid (V2G)

Another technological advancement is Vehicle-to-Grid (V2G). This looks and acts very similar to a standard charging installation but includes bi-directional inverters so that energy flows both to and from the vehicle. In effect, this turns a vehicle into a portable battery which can provide services to the home, business, and grid such as energy storage. This will maximise the benefits of charging on time of use tariffs. V2G technology is currently in the testing for commercialisation stage and trials are underway, most recently with EON and Nissan. FleetNews wrote an article on this (07/08/2020) and highlighted that further participants are being sought to take part in the trials, the full article can be found *here*.

9.6. Charging profiles

9.6.1. Socket per vehicle

To support a smooth transition from ICE vehicles to BEVs, recharging should be made as simple as possible. Ensuring that every vehicle has its own socket means that whenever a vehicle comes off shift, staff will not have to go searching for a charge. Staff buy-in is crucial to BEV adoption and the success of a decarbonisation strategy, so you want to make charging as simple and convenient as possible.

The simplest solution could involve installing basic chargers, that will charge the vehicle at the highest rate possible from the charge point, and allowable by the vehicle. So long as the sum of the power ratings of a number of charge points is below the static charging availability (shown in dark green in Figure 9-1) there will be no issues. However, this system can result in spikes in power demand, as if everyone plugs in at the same time, all vehicles will try and draw the maximum allowable power. If you need more sockets than you have capacity for, you will need to apply for a larger capacity from your grid connection. This may result in expensive grid connection upgrades, capacity charges or even the requirement for a new substation. Individual charge points can be manually downrated to avoid exceeding the site capacity, but this might prove impractical if vehicles sometimes need to charge more quickly, for instance, if shift patterns change.

To install more sockets on the same grid connection, you could adopt this solution in tandem with load management. This will allow you to charge more vehicles at the same time at lower charging speeds (for instance, overnight), but if there are fewer vehicles charging, those plugged in can charge more quickly. This will give you more flexibility than downrating charge points.

If you need even more charge points but are still trying to avoid grid upgrades, you could opt for using dynamic load management. This will allow you to dip into the power that is available elsewhere on the site (e.g. buildings or offices) (shown in light green in Figure 9-1), when it is not being consumed, for instance if offices on site are shut and there are no lights or heaters on. This system requires you to be able to actively monitor the building consumption in real time and will be the most expensive form of load management but offers the most flexibility. It is also likely to be cheaper than upgrading grid connections.

9.6.2. Charge vehicles on a rota

The average daily mileage of your fleet is only 46 miles. Although daily milage will vary, most electric vehicles on the road today can drive well over 100 miles on a single charge. Considerably more than the daily distances driven by most of your vehicles. It will therefore not be necessary for you to charge your vehicles every day. By using a rota system where (depending on the daily mileage of the vehicle and the BEVs range on a full charge) staff charge their vehicle on one or more specific days of the week, the number of required charge points could potentially be reduced.

It is important to keep the rota system simple to ensure staff plug in when they are supposed to (e.g. by letting them charge on the same day/s each week) and avoid a situation where charge points are blocked by vehicles that do not require a charge. A system also needs to be devised to allow for essential charging, where a vehicle is greatly in need of a charge, but a charge point is not available. This could be installing a small number of buffer chargers that are only used for essential charging or using public charge points if available.

This system would require smart chargers so that the charge point usage could be monitored and effectively managed. This would also allow you to stagger the time of charge to further reduce the maximum required demand from the grid, as well as allowing you to take advantage of time-of-use tariffs.

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9.6.3. Charging vehicles at home

In situations where staff take fleet vehicles home with them, a home charging solution will be required. This brings unique challenges around how to charge these vehicles and reimburse staff for the energy used.

In the first instance, you should determine if fleet vehicles really must go home with staff. For those vehicles that do, you should ensure that staff are able to get a charge point installed at their home (ie they have off street parking). If staff do not have off street parking, they could instead be provided with a ChargePlace Scotland card to access the public charging network. This could be linked to a company account meaning the employee could recharge on the public network without having to pay for it themselves. These cards can be specific to a vehicle, or staff member, so energy consumption can be monitored.

The typical cost for a home charge point and its installation is approximately £1000. As part of its Electric Vehicle Homecharge scheme, OZEV currently offers applicants £350 towards this cost. Energy Saving Trust (EST) will also provide up to a further £300 funding on top of this, with an additional £100 available for those in the most remote parts of Scotland. For the cost covered by OZEV, you will not need to make any payment to your supplier, as they will receive this money from OZEV directly. For the costs above what OZEV cover, you will have to pay your supplier, and EST will then provide you with your reimbursement. Any remaining costs above the £350 provided by OZEV, and the funding provided by EST, you would need to pay for yourself. Full terms and conditions can be found on our website here.

Then comes the task of reimbursing staff for the personal electricity used. Currently, the advisory fuel rate (AFR) for BEVs is 4 pence per mile, hybrid cars are treated as either petrol or diesel cars when working out mileage rates. Fuel rates can be found on the government website here. Combining the use of a telematics system with these fuel rates will allow you to accurately reimburse staff for their business fuel use. There are however alternative solutions coming to market. One solution involves a third-party provider connecting directly to the employee's energy supplier; this means the employee can charge at home or on the public network without having to directly pay themselves. Instead, the provider sends the employer an invoice for all the energy consumed (both at the employee's home and on the public network). This is currently being trialled by Mitie, as highlighted in this FleetWorld article. As this is an emerging challenge for fleet managers. new products are continually being developed to take it on. We therefore recommend that you keep abreast of these developments to find the best solution for you and your staff.

9.6.4. Getting the timing right

Ideally, vehicles should be charged overnight, to avoid the demand from large scale BEV charging having a negative impact on the grid. During the working week, from 06:00 to 23:00 hrs, demand on the UK Grid is at its maximum, and grid GHG emission intensity (kgCO_2e/kWh) may be high due to the use of fossil-fuel based generation having to be used to meet demand.

However, avoiding the peak entirely leaves a narrow window of seven hours in which to charge vehicles. The reduction in GHG emissions from avoiding the higher "daytime" intensity is around 10%-15% over the entire charging period. As the grid decarbonises the amount of CO_2e saved by charging off peak will reduce.

During the summer months, on-site solar PV generation can be used during the late afternoon and early evening to charge vehicles at a time when the "domestic" site load is falling. Using the solar PV to displace grid import will have a significant cost saving and GHG emission reduction.

9.7. Estimated infrastructure costs

Our experience administering grants for the installation of charge points gives us a good insight into the average cost of installing charging infrastructure. Table 9-1 below outlines the average cost of installing charging infrastructure of different power ratings. The costs include the purchase of the hardware (the charge point unit). As these are average costs per unit, installing large numbers of units, as would be done in a depot installation, would naturally bring costs down.

Table 9-1 - Average cost of installing charge points combining FY2019/20 and FY2020/21 (not publicly accessible) (excluding DNO costs)

Charge point rating (kW) and type	Average charge point cost[13]
50kW triple outlet, smart, AC/DC	£37,304
22kW double outlet, smart	£10,877
7kW double outlet, smart	£7,101
7kW single outlet, basic	£2,635

Although you do not currently need any bespoke advice on installing charge points, you can use this table to give you an idea of costs as your electric fleet expands over the next few years. Additionally, although we mostly recommend low power chargers, it is worth considering installing a rapid charger within the depot charging mix. Some local authorities have opted for this approach as a fail-safe, for instance in case of human error issues with pool car charging. This can be a good option for boosting resilience, note however that a rapid charger would

[13] The cost is inclusive of the purchase of the hardware and the installation of the charge point but does not include any costs that may be associated with grid connection upgrades. These costs are derived from those charge points that were funded by the EST administered Workplace Charge Point Grant Fund through FY2019/20.

impose a significant additional electricity demand on the site. This would curtail the number of lower power units that could be installed if smart charging and load management solutions were not also included.

9.8. Engagement with the DNO

Once the decision has been taken to progress a project at a location, initial engagement with the DNO should take place as soon as reasonably practicable. This will enable the full logistics of the project to be scoped out, determining amongst other things, if there is enough existing capacity to accommodate the installation(s) and therefore whether a substation upgrade, or new substation, will be required. As well as introducing substantial additional cost – likely to be in the region of £50k – lead times for the delivery of new substations can be in excess of nine months, making it vital that planning arrangements are initiated as early as possible. Providing the DNO with clear long-term plans for each location will allow them to determine what additional undertakings should be included, such as ducting, to facilitate later works should the decision be taken to expand infrastructure provision.

10. Conclusion

At the end of FY2019/20 you had a fleet of 455 vehicles. 20% of this fleet is cars, 52% LCVs and 27% HDVs. 40% of the fleet is over five years old, with HDVs the oldest segment. **In total, your fleet emits more than 3,227 tonnes of CO_2e annually**, 62% of which comes from your HDVs, 29% from your LCVs, 5% from your cars and 3% from PSVs.

You currently have 18 ZEVs in your fleet, 12 of which are cars. To meet the Scottish Government's fleet decarbonisation target, all your cars must be ZEVs by 2025. **Replacing all the remaining non-ZEV 79 vehicles with ZEVs will save you approximately £29,402 per year and 91t CO_2e.**

You have a large LCV fleet of 235 vehicles which already contains five BEVs. We recommend that you replace all small and medium ICE vehicles with BEV equivalents as soon as possible. There is a range of ZEV alternatives to these ICE vehicles already available. While there are fewer large ZEV LCVs, you should aim to replace as many of your LCVs as you can, based whether you can viably switch them for BEV equivalents. **Replacing all your ICE LCVs with BEVs would provide annual savings of approximately £245,627 and 579t CO_2e.** Currently your replacement strategy puts you on target to meet the Scottish Government's fleet decarbonisation targets for 2025 and 2030.

There are sufficient BEV model options available on the market to replace all your cars and potentially all of your LCVs with zero-emission equivalents. While the BEV heavy LCVs recommended should meet your requirements, you should identify the maximum daily mileage of each of your vehicles before replacing them. This will avoid you procuring BEV vehicles required to regularly complete journeys exceeding their range. We recommend that you base your funding strategy for these vehicle replacements on the fleet decarbonisation plan outlined in this report.

In addition to ZEV fleet replacement, you should continue encouraging staff to use pool cars and car clubs, instead of grey fleet. Most importantly, you should advise staff to follow the sustainable travel hierarchy when selecting business travel options.

We were not provided with any data on your depots, so have not provided any specific, bespoke advice. However, in terms of general infrastructure advice, the key things to be aware of when designing and implementing charging infrastructure are as follows:

- Site constraints – these can be determined by comparing the available site electrical capacity with current site demand

- The duty cycles of vehicles based at the site – how much time they have available to charge each day
- The daily mileage requirements of the vehicles based at the site
- The energy requirements of the vehicles based at the site – this will vary depending on each vehicle's efficiency
- Engagement with your distribution network operator (DNO) – this should happen as early in the design process as possible to highlight issues that may arise and to speed up the installation phase

You are moving towards having a fully decarbonised fleet, having already replaced a number of your vehicles with ZEVs. Your priority should be to ensure that your fleet replacement plans are followed, and ZEVs are adopted wherever possible. This is particularly the case for your car fleet, which you need to make sure is entirely zero-emission by 2025.

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Appendix 1 GHG Methodology – Road Transport

Reporting of GHG emissions

The carbon dioxide (CO_2e) footprint (often shortened to carbon footprint) of an organisation, details the tonnage of greenhouse gases (GHG) emitted in a period of one year. The 'e' in CO_2e stands for 'equivalent' and indicates that the estimate includes all the reportable greenhouse gases emitted.

For road transport the reportable GHGs are carbon dioxide (CO_2), methane (NH_4) and nitrous oxide (N_2O). The methane and nitrous oxide are reported in terms of their carbon dioxide equivalence using their global warming potential (GHG Protocol, GWP Values). For example, one tonne of nitrous oxide has a GWP 265 times that of carbon dioxide and is therefore equivalent to 265 tonnes of CO_2. The GWP of methane is 28 so one tonne is reported as 28 tonnes CO_2. All organisations should report CO_2e emissions and not just CO_2 if the reporting is to comply with national and international GHG reporting standards.

For reporting of road transport GHG emissions, we use tank to wheel (TTW) factors. This means that the factors do not include any CO_2e emissions relating to the extraction, refining and distribution of the fuels, known as well to tank (WTT) factors, nor do they include the manufacture and disposal of the vehicles. WTT factors are published and can be combined with TTW factors to give well to wheel (WTW) values, but the upstream emissions of WTT should be reported by the supplier of the fuel.

Emission reporting categories – use of scopes

GHG emissions are reported in one of four categories known as Scope 1, Scope 2, Scope 3, and "Out of Scope". All the GHG emissions from the direct burning of fossil fuels are in Scope 1. For road transport these are the fuels that the organisation buys and burns in its vehicles and are usually diesel, petrol, LPG or natural gas. Scope 2 covers purchased energy, so this includes the GHG emissions associated with generating the electricity used to charge all plug-in electric vehicles.

Scope 3 is used for "indirect" emissions. This is where the GHG emissions associated with cash allowance cars and grey fleet vehicles fall; the organisation has paid for the use of the vehicle as a service and some of that payment has gone to buying fossil fuels or electricity. "Out of Scope" GHG emissions covers all the biogenic emissions associated with biofuels like biomethane, biodiesel and bioethanol. These are carbon emissions produced from short-cycle carbon sources like crops.

All large organisations must report Scope 1, Scope 2, and some of the Scope 3 emissions over which it has direct control such as those associated with the grey fleet, cash allowances cars, rail travel and air travel. Some organisations go further and report the Scope 3 emissions associated with their supply chain, both upstream & downstream, this is not mandatory but could be regarded as best practice as long as it does not trivialise the Scope 1 and Scope 2 emissions of the organisation by making them seem insignificant in comparison.

Scope 1 and 2 GHG emissions as well as Scope 3 transport emissions are ones that you can directly impact by choosing smaller vans, implementing a pro-electric company car policy and setting carbon emission limits on the cash allowance and grey fleet. Changing the carbon emissions embedded in the supplies you buy may be a lot harder and have less impact.

Why do we use these categories?

These categories are intended to avoid double counting. Only the organisation burning the fossil fuel will report its Scope 1 emissions. The Scope 2 emissions from using electricity become the Scope 1 emissions of the generating company that burnt the gas or coal to make the electricity. The Scope 3 emissions associated with a train journey become the Scope 1 emissions of the train operator who burnt the diesel to power the train.

So why bother reporting Scope 2 and Scope 3 at all? Because it is the end user, e.g. the consumer of the electricity or the user of the train, who creates the demand for the service. Without that demand the Scope 1 emissions would not be created by the service provider, so it is important companies focus on reducing the Scope 2 and 3 emissions because that puts pressure on suppliers to reduce their Scope 1 emissions.

Car/van GHG & kWh calculations (DBEIS 2019 data set)

This transport methodology has been developed and refined since its introduction by the Energy Saving Trust (EST), DfT and Defra in 2004 and is fully compliant with the UK's Streamlined Energy and Carbon Reporting (SECR) if the data used is for the company's financial year. Initially established to determine the carbon dioxide emissions it has been adapted to determine energy use as required for the Energy Saving Opportunity Scheme (ESOS) but again the correct period must be covered.

It is based on the DBEIS GHG fuel conversion factors for CO_2e/unit (litre, kg, kWh) and CO_2e/kWh which are published annually in June or July. The factors used must reflect the data year, so for the financial year 2019/20 you must use the 2019 GHG conversion factors published by the Department for Business, Energy & Industrial Strategy (DBEIS). Full data sets are available from 2014, new data sets are published every June.

This part of the methodology covers all vehicles up to 3.5 tonnes. There are five methods and they are used in order of diminishing accuracy:

Type of fuel and fuel used (litres, kg or kWh).

Mileage driven with published (OEM) gCO_2/km and "real-world" uplift.

Mileage driven with fuel type and car engine size or van size.

Mileage driven with fuel type.

Mileage driven with UK average car or van.

Methods 1 and 2 are based on data about the actual fuel used or the actual vehicle used. Methods 3 to 5 are based on data from the UK national fleet combined with diminishing information about the vehicle used and are a way of estimating GHG emissions and energy use in the absence of any specific data about the fuel usage or GHG emissions of the vehicle. It follows therefore that any improvement made to fuel efficiency or to the vehicles in the fleet will not be accurately tracked by using Methods 3 to 5.

Method 1: fuel use

This is the most accurate means of determining both energy use and GHG emissions. The following factors are used for the determination of GHG emissions and energy use from fuels.

Table 11-1 - GHG factors for fuels

Fuel	Units	GHG scope	kg CO_2e/unit	kg CO_2e/kWh	kWh/unit
Petrol	Litres	1	2.2090	0.2337	9.4513
Diesel	Litres	1	2.5941	0.2446	10.6047
CNG	Kg	1	2.5420	0.1839	13.8267
LNG	Kg	1	2.5500	0.1844	13.8266
LPG	Litres	1	1.5226	0.2145	7.0994
Electricity	kWh	2	0.2556	0.2556	1.0000
Electricity T&D	kWh	3	0.0217	0.0217	1.0000

There is an expectation that fuel data will be available for all directly operated LCVs (vans) and HDVs (lorries). It is sometimes available for company or lease cars where fuel cards are provided, and either staff receive private fuel as a benefit, or they reimburse the company for their private mileage. In the case of the opt-out or cash allowance car fleets and the grey fleet, fuel data will not usually be available, so will have to use Method 5.

When linked with mileage driven fuel use provides a measure of energy efficiency which in the UK is usually referred to as miles per gallon (mpg) but can also be represented as miles/kWh, litres/100km and kWh/km. Use of kWh is independent of the type of fuel or its delivery method (litre, kg or kWh). Electric vehicles use Wh (Watt hours) per mile (Wh/mile) or miles per kWh.

Method 2: Mileage and published g/km

In the absence of fuel data, the published GHG emissions of the vehicle in g/km are the next most accurate estimate of energy use and GHG emissions. The data has been available for all cars since 2001 (and for some cars since 1997) and for all vans since 2009. If the data is not held for Benefit in Kind income tax reporting (P11D) it can be obtained from the DVLA via agents such as CarweB using the vehicle registration mark.

The published factor must be uplifted to reflect the real-world performance of the vehicle and compensate for the manipulation of the NEDC test by the manufacturers. In the car fleet the variance between published data and actual emissions has been increasing steadily and since 2014 this annual variance has been reflected in the DBEIS GHG factors. The most accurate method is an age-related uplift based on the DBEIS data shown in Table 11-2.

Table 11-2 - DBEIS Real world uplift by year of registration

Year	2002	2003	2004	2005	2006	2007	2008	2009
Uplift	8.6%	9.7%	10.8%	11.9%	13.0%	15.65%	18.3%	20.95%

Year	2010	2011	2012	2013	2014	2015	2016	2017
Uplift	23.6%	26.25%	27.6%	29.0%	33.3%	41.5%	38.0%	31.5%

The calculation is therefore based on:

Published g/km x (1+% Uplift for Year) x Distance travelled (km) = gCO_2e

The fuel factor for kg CO_2e/kWh is then used to convert the calculated GHG emission into kWh of energy used, therefore, the fuel type must also be known. Where the year is not known an appropriate rolling average uplift can be used.

Method 3: Mileage plus fuel and a size factor

This method is used where no published emission data is available about the actual vehicles used but fuel type and engine or vehicle size is known.

Table 11-3 - DBEIS average emissions factors where vehicle type is known

Petrol cars	kg CO_2e/km	kWh/km
< 1,400	0.1537	0.6576
1400–2000	0.1923	0.8227
> 2,000	0.2830	1.2106
Diesel cars	**kg CO_2e/km**	**kWh/km**
< 1,700	0.1537	0.6576
1,700-2,000	0.1923	0.8227
> 2,000	0.2830	1.2106
LPG car	**kg CO_2e/km**	**kWh/km**
< 2,000	0.1807	0.8424
> 2,000	0.2659	1.2398
Petrol motorbikes	**kg CO_2e/km**	**kWh/km**
<125cc	0.0845	0.3613
125 - 500cc	0.1029	0.4402
>500cc	0.1350	0.5776
Petrol van	**kg CO_2e/km**	**kWh/km**
(Class I), <1.305 tonne	0.2374	1.0157
(Class II), 1.305 - 1.74 tonne	0.2283	0.9769
(Class III), 1.74 - 3.5 tonne	0.3846	1.6455
Diesel van	**kg CO_2e/km**	**kWh/km**
(Class I), < .305 tonne	0.1496	0.6114
(Class II), 1.305 - 1.74 tonne	0.1946	0.7953
(Class III), 1.74 - 3.5 tonne	0.2778	1.1355

Method 4: Mileage plus fuel type

If only fuel type is known the following factors are used:

Table 11-4 - DBEIS average emissions factors where only fuel type is known

Cars fuel only	kg CO_2e/km	kWh/km
Average petrol car	0.18084	0.7737
Average diesel car	0.17336	0.7087
Average LPG car	0.19901	0.9279
Average electric car	0.06020	0.2461
Van fuel only	**kg CO_2e/km**	**kWh/km**
Average petrol van	0.2365	1.0116
Average diesel van	0.2521	1.0307
Average LPG van	0.2724	1.2703
Average CNG van	0.2478	1.3478
Average electric van	0.0629	0.3419

Method 5: UK fleet average

In the absence of any data other than mileage driven the only option is to use UK fleet data. National data for England, Scotland and Wales is not yet available.

Table 11-5 - Average UK vehicle emissions factors

UK average	kg CO_2e/km	kWh/km
Car	0.1771	0.7438
Van	0.2516	1.0286
Motorbike	0.11551	0.4942

Electric vehicles and plug-in hybrids

The factor to use for a battery electric vehicle (BEV) is linked to the source of the electricity. If it is drawn from the national grid, then the current Scope 2 factor for GHG should be used to which should be added the Scope 3 factor for Transmission and Distribution (T&D). Because BEVs do not directly burn a fuel their Scope 1 emission is zero, hence they are correctly rated by the OEMs as 0 gCO_2/km.

Table 11-6 - DBEIS average emissions factors for BEVs

Fuel	Units	Scope	kg CO_2e/unit	kg CO_2e/kWh	kWh/unit
Electricity	kWh	2	0.2556	0.2556	1.0000
Electricity T&D	kWh	3	0.0217	0.0217	1.0000

If the electricity is generated from other sources, for example a combined heat and power (CHP) plant or an energy from waste (EfW) plant, then an appropriate factor must be determined for that plant.

If the BEVs are charged on-site, then the GHG emissions may already be reported under the site's Scope 2 and 3 reporting of electricity consumed and it is important that this is not double reported.

If the cars are charged off-site (at employee's homes or on-the-road) then those emissions should be included in the vehicle's carbon footprint but reported separately to fuel burnt (diesel, petrol and gas).

HDV GHG & kWh calculations (DBEIS 2019 data set)

This is a standardised approach to estimating Heavy Commercial Vehicle (HDV) fleets' CO_2e emissions. HDV fleets should normally have full and accurate records of both fuel used and mileage driven (this may be recorded in kilometres).

The methods are presented in order of accuracy and the most accurate methodology should be used for each vehicle.

Method 1: Fuel consumption data

If comprehensive fuel consumption data is available from fuel card records and/or a bunkered fuel system, the GHG emissions and energy use should be calculated by applying the following factors to the quantity of fuel consumed.

Table 11-7 - GHG emissions factors for fuels

Fuel	Units	GHG Scope	kg CO_2e/unit	kg CO_2e/kWh	kWh/unit
Petrol[14]	litres	1	2.2090	0.2337	9.4513
Diesel[8]	litres	1	2.5941	0.2446	10.6047
CNG	kg	1	2.5420	0.1839	13.8267
LNG	kg	1	2.5500	0.1844	13.8266
LPG	litres	1	1.5226	0.2145	7.0994
Electricity	kWh	2	0.2556	0.2556	1.0000
Electricity T&D	kWh	3	0.0217	0.0217	1.0000

Methods 2 to 5: Mileage data but no fuel data.

If fuel data is not available, the methodology must be based on distance travelled (miles or km) and the appropriate conversion factor which depends on the additional data available (see Table 11-8).

Table 11-8 - HDV methodologies - mileage data

GHG Methodology	Mileage	Artic/rigid	GVW	Load factor
Method 2	✓	✓	✓	✓
Method 3	✓	✓	✓	
Method 4	✓	✓		
Method 5	✓			

To convert from kg CO_2e km^{-1} to kWh km^{-1} the GHG factor is divided by the fuel factor (diesel) in kg CO_2e kWh^{-1} to give kWh km^{-1}

Table 11-9 - Rigid HDV average GHG emissions (not refrigerated)

GVW Class	GVW	% Load factor	kg CO_2e km^{-1}
Class 1	>3.5-7.5t	0%	0.4570
		50%	0.4961
		100%	0.5352
		UK average 46%	0.4922

[14] *The diesel and petrol factors are for the biofuel blends sold in the UK.*

Class 2	>7.5-17t	0%	0.5529
		50%	0.6306
		100%	0.7083
		UK Average 39%	0.6010
Class 3	>17t	0%	0.7661
		50%	0.9311
		100%	1.0961
		UK Average 54%	0.9556
Average	Unknown	UK Average 53%	0.8001

Table 11-10 - Articulated HDV average GHG emissions (not refrigerated)

GVW Class	GVW	% Load factor	kg CO_2e km^{-1}
Class 1	>3.5-33t	0%	0.6407
		50%	0.7979
		100%	0.9551
		UK average 44%	0.7853
Class 2	>33t	0%	0.6626
		50%	0.8788
		100%	1.0951
		UK average 62%	0.9351
Average	Unknown	UK average 61%	0.9253

Table 11-11 - Average HDV GHG emissions - Any Type (not refrigerated)

GVW class	GVW	% load factor	kg CO_2e km^{-1}
	All Average		0.8665

Table 11-12 - Rigid HDV average GHG emissions (refrigerated)

GVW class	GVW	% load factor	kg CO_2e km^{-1}
Class 1	>3.5-7.5t	0%	0.5437
		50%	0.5903
		100%	0.6369
		UK average 46%	0.5856
Class 2	>7.5-17t	0%	0.6578
		50%	0.7504
		100%	0.8431

		UK Average 39%	0.7152
Class 3	>17t	0%	0.9110
		50%	1.1079
		100%	1.3047
		UK Average 54%	1.1371

Table 11-13 - Articulated HDV average GHG emissions (refrigerated)

GVW class	GVW	% load factor	kg CO_2e km^{-1}
Class 1	>3.5-33t	0%	0.7418
		50%	0.9244
		100%	1.1069
		UK average 44%	0.9098
Class 2	>33t	0%	0.7670
		50%	1.0180
		100%	1.2690
		UK average 62%	1.0832

Table 11-14 - Average HDV GHG emissions - Any Type (refrigerated)

GVW class	GVW	% load factor	kg CO_2e km^{-1}
All average (refrigerated)			1.0158

Electricity Renewable Energy Guarantees of Origin (REGO) and Gas Renewable Transport Fuel Obligation (RTFO) certificates.

Many organisations have opted to have their grid electricity supplied from renewable sources backed by REGO certificates or grid biomethane backed by RTFO certificates.

The GHG emissions of the electricity or gas can be reported in line with the "market-based" (consumer) value calculated by the supplier (e.g. Zero gCO_2e/kWh if 100% renewable electricity) but it should also be reported alongside the "location-based" (national) figure.

This is because the zero-emissions benefit of the electricity or gas has already been accounted for in the national UK grid figure. The benefit cannot be taken twice, nor can the carbon factor for other consumers be adjusted upwards to compensate.

The requirement to do this is fully documented in:

HM Government: Environmental Reporting Guidelines (ERG): Including streamlined energy and carbon reporting guidance. March 2019, pages 48-49

"Where organisations have entered into contractual arrangements for renewable electricity, e.g. through Power Purchase Agreements or the separate purchase of Renewable Energy Guarantees of Origin (REGOs), or consumed renewable heat or transport certified through a Government Scheme and wish to reflect a reduced emission figure based on its purchase, this can be presented in the relevant report using a “market-based” reporting approach. **It is recommended that this is presented alongside the “location-based” grid-average figures** and in doing so, you should also look to specify whether the renewable energy is additional, subsidised and supplied directly, including on-site generation, or through a third party. A similar “dual reporting” approach should be taken for biogas and biomethane (including “green gas”)."

GHG Protocol, Scope 2 Guidance, Corporate Standard, Section 1.5.1, page 8

“Companies with any operations in markets providing product or supplier-specific data in the form of contractual instruments shall report scope 2 emissions in two ways and label each result according to the method: one based on the location-based method, and one based on the market-based method. This is also termed “dual reporting.”

What is permitted is time specific emission factors. The HM Government ERG state:

“Where available, time specific (e.g. hour-by hour) grid average emission factors should be used in order to accurately reflect the timing of consumption and the carbon-intensity of the grid.”

The carbon intensity of the grid varies throughout the day and the year. The grid data is publicly available in half hourly intervals, but organisations may have difficulty providing half hourly consumption data unless that is how they are billed.

Where a company generates its own renewables on-site or locally, for example by using photovoltaic, wind with “private wire” or an on-site anaerobic digester and does not supply the grid it can be accounted for as a zero or low carbon supply.

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Appendix 2 Euro standards

The vehicle emission standards in force in the EU are known as the Euro standards and are now widely used around the world although not always to the same timeline as in the EU. More stringent air quality standards apply in the USA where standards do not differentiate between fuel types and air quality is seen as a more important issue than carbon emissions.

The Euro standards were first introduced in 1993/94 to regulate and reduce the toxic emissions of vehicles. Carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOX), particulates under 10 microns in diameter (PM10) and the number of those under 2.5 microns in diameter (PM2.5) are all regulated. Carbon dioxide (CO2) emissions are not regulated as they do not have a direct health impact but may be included in the Euro 7 standard.

Prior to 1993 a range of national standards were in place across the EU and before 1988 there was little or no effective regulation of vehicle emissions.

In most cases the standard for all new vehicles sold came into force one year after the date for new type approvals. However, for Euro 5a cars and vans implementation was delayed until 01/2011 and for 5b cars and vans until 01/2013 Euro standards and dates they were introduced can be seen below in *Table 11-15*.

Table 11-15 - Euro emission standards implementation dates

<3.5t Euro standard	Cars	Vans
1	07/1992	10/1994
2	01/1996	01/1998
3	01/2000	01/2001
4	01/2005	01/2006
5a	09/2009	09/2010
5b	09/2011	09/2011
6	09/2014	09/2015
7	By 2021?	By 2021?

Euro 5b added a restriction on the number as well as the mass of particles (PM) from diesel and petrol engines. Euro 6c changed the test regime to one more representative of real-world performance and Euro 7 planning has begun. For small cars a Euro 7 diesel engine may be prohibitively expensive to make.

It is important to understand that the Euro standards are not the same for petrol and diesel and at all levels they permit diesel vehicles to be more polluting. The Euro 6 standard for a diesel car or van is like the Euro 4 standard for a petrol car or van and as a result a 10-year-old Euro 4 petrol car can have the same emissions as a brand-new Euro 6 diesel car.

Appendix 3 Air quality, public health and LEZs

Health impact of poor air quality

The impact of poor air quality on human health is under constant re-assessment. In December 2015 Defra[15] reported that each year 23,500 premature deaths are associated with NO2 and a further 29,000 with PM10 and PM2.5. This gives a total of 52,500 premature deaths each year due to the two pollutants.

The February 2016 report on Air Pollution by the Royal Colleges of Physicians, Paediatrics and Child Health[16] suggests 40,000 premature deaths per annum and attributed the difference in the total to an overlap between deaths caused by NO2 and PM.

In 2017, the number of road deaths was 1,793 and there were 24,831 serious injuries. Clearly the research would suggest that air pollution is responsible for many more premature deaths than road collisions.

Since 2000 the assessment of the impact of poor air quality has shifted from it being an antagonist to pre-existing medical conditions to it being a major cause of poor health and premature death. The number of deaths from asthma in England and Wales has increased by 25% since 2007.

There is evidence from around the world that children brought up within 100m of a main road suffer significantly more respiratory ailments (e.g. asthma). There is also evidence to link particulates in the air with particulates in the blood, blood clots, strokes and heart failure[2]. A study published in The Lancet Respiratory Medicine (November 2013[17]) has linked fine particulates to low birth weight. Particulates have also been linked to a form of dementia by a study in Taiwan.

Under the precautionary principle reducing these emissions in residential urban areas is important but it is also the case that people working in cities are subject to prolonged exposure at times when pollutant levels are at their highest.

A 2014 study from Public Health England looked at deaths from particulate air pollution in each UK borough. This has been published in graphical form by "The Guardian DATABLOG" and the map shows for each geographic area the

[15] *Draft plans to improve air quality in the UK, Tackling nitrogen dioxide in our towns and cities. UK Overview Document, September 2015, Defra.*

[16] *Every breath we take, the lifelong impact of air pollution, February 2016*

[17] *Ambient air pollution and low birthweight: a European cohort study (ESCAPE), The Lancet Respiratory Medicine, Vol 1, No 9*

percentage of premature deaths in 2014 calculated to be caused by fine particulate matter (ambient PM2.5).

Clean air in the workplace is now becoming an issue and there is the possibility of legal claims over employee exposure to diesel exhaust fumes. The Royal Mail and Christchurch Council are being sued by Unions for their alleged failure to protect staff from diesel exhaust fumes[18].

Air quality in the UK

There are over 200 local authorities with designated Air Quality Management Areas (AQMAs) in the UK and most are due to diesel engine emissions. The BBC Radio 4 programme "Costing the Earth" and the Channel 4 Despatches programme "The Great Car Con" have raised public awareness of the issue while the VW "dieselgate" crisis has focused attention on the very poor real-world performance of modern diesel engines. It is not unusual for a Euro 5 or 6 diesel car to have higher toxic emissions (mg/km) than a Euro VI lorry or bus.

In April 2015 the Supreme Court ordered the UK Government to bring forward long delayed proposals to comply with 2010 UK air quality standards. The plan produced by Defra in December 2015 envisaged Clean Air Zones (CAZ) in just five cities out of sixteen considered: Birmingham, Leeds, Nottingham, Derby and Southampton.

These CAZs would restrict access by the most polluting diesel buses, coaches, taxis and lorries. In Birmingham and Leeds, the zones were also expected to restrict the most polluting diesel vans. No restrictions on cars were envisaged although it soon became clear that all diesel vehicles would need to be included if the plans were to be effective.

In early November 2016, following legal action against the government by the lobby group ClientEarth, the High Court ruled the government's CAZ plan was "far too leisurely" used "over-optimistic" pollution modelling and was based on "flawed" lab tests.

In late November 2016 the High Court further ruled that an effective plan must be delivered in eight months; the draft by 24th April 2017 and the final by 31st July 2017.

The final plan[19] was released in late July 2017. It did not require any more cities to implement CAZs, but it did identify the CAZ as the most effective means of reducing nitrogen dioxide pollution. It required 23 additional areas to bring forward plans to improve air quality but did not mandate Clean Air Zones as the solution. The plan was widely criticised and led to further legal action by ClientEarth and this resulted in 33 more towns and cities being included.

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[18] *UK legal claims grow over exposure at work to toxic diesel fumes, The Guardian, September 2017*
[19] *UK plan for tackling roadside nitrogen dioxide concentration, Defra and DfT, July 2017*

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Standards

Table 11-16 - Minimum standards for charge-free access to Glasgow LEZ

Fuel & category	Minimum standard
Petrol – all types	Euro 4/IV
Diesel – all types	Euro 6/VI
Motorcycles	Euro 3
Electric – all types	All charge free

The proposed minimum emission standards for unrestricted and charge-free access to a UK Low Emission/Clean Air Zone from 2020 are shown in Appendix 3. Penalties for non-compliant vehicles could eventually be as high as £200/day (London LEZ charge for non-compliant HDV).

However, to meet the 2010 UK air quality standards, it may prove necessary to ban all internal combustion engine vehicles from polluted town and city centres, but this may not occur until 2025 - 15 years after the air was meant to meet the standard - and then only after all the other options have been tried and shown to be unsuccessful.

Further information about LEZs in Scotland can be found Low Emission Zones Scotland.

Categories

According to the Transport Scotland, Defra and the Department for Transport Clean Air Framework there will be four UK-wide categories of Low Emission/Clean Air Zone each differing in the scope of vehicles included:

Class A - Buses, coaches, taxis and private hire vehicles (PHVs),

Class B - Buses, coaches, taxis, PHVs and heavy commercial vehicles (HDVs),

Class C - Buses, coaches, taxis, PHVs, HDVs and vans (LGVs),

Class D - Buses, coaches, taxis, PHVs, HDVs LGVs and cars.

In theory there can also be charging and non-charging LEZ/CAZs. It is not clear how a LEZ/CAZ would be enforced without some form of charging or fines.

LEZs in Scotland

> According to the LEZ Leadership group terms of reference: "Air quality is a priority for Scottish and local government. The Programme for Government has set out a commitment to establish Low Emission Zones (LEZs) in Scotland's four biggest cities by 2020, with the first LEZ being in place by 2018."

Glasgow

Scotland's first Low Emission Zone (LEZ) came into effect in Glasgow city centre on 31 December 2018. Glasgow's LEZ is being phased in and to start with, will only apply to local service buses which are required to meet the Euro VI emission standard. Phase two is expected to launch on 31/12/2020 an on 31 December 2022 a Class D zone will be implemented which will apply to all vehicle types.

Edinburgh, Aberdeen & Dundee

LEZs are due to be launched in Edinburgh, Aberdeen and Dundee between February/May 2022. This is due to be a full Class D Zone covering all vehicle types.

energy saving trust

Appendix 4 ZEV HDVs, RCVs and SPVs

HDVs

Table 11-17 - Non-exhaustive list of ULEV HDVs

Make and model	GVW (tonnes)	Notes
DAF CF Electric (4x2 tractor unit)	up to 37 tonnes	170kWh battery, up to 100km range and around 3x the cost of a diesel truck
DAF LF Electric	19 tonnes	Up to 222kWh battery pack, 220km range (for fully laden truck) Around 3x the cost of a diesel truck
Eforce Trucks	26-44 tonnes	Modular batteries up to 340kWh, comes in many different models and as an RCV, 91% battery to wheel efficiency, possible range of over 450km, DC charging up to 350kW
IVECO Daily Electric	Up to 5.6 tonne	3.5,11 and 22kW charging and a charging time within 2 hours. Up to 200km range
IVECO Euro Cargo Hybrid	7.5 or 12 tonnes	Fuel savings of up to 30% in the urban cycle, compared with conventional diesel engine vehicles. 1.9kWh battery pack
MAN eTGM	26 tonnes	6x2 truck, 190km range, 185kWh battery pack, up to 150kW DC charging
Mercedes-Benz eActros	18 - 25 tonne	Range of up to 200km, two battery packs totalling 240kWh, up to 150kW charging speeds
Mitsubishi Canter Eco Hybrid	7.5 tonne	2kWh battery (Hybrid), 23% reduction in fuel consumption
Mitsubishi Fuso eCanter	7.255 tonne	82.8kWh battery, 80 miles of range, 30% less maintenance costs
Paneltex (Isuzu)	7.5 tonne	Only a 9kW or 18kW charger, no rapid charging, 80, 120 or 160kWh battery packs, range of up to 240km
Volvo FE	27 tonnes	Can be fitted with up to four battery packs. Each pack has an energy capacity of 50 kWh and an estimated lifetime of 8–10 years. Range: Refuse and light construction up to 120 km, distribution up to 200 km
Volvo FL	16 tonnes	Can be fitted with up to 6 battery packs at 50kWh/pack and an estimated lifetime of 8-10 years. Up to 186 miles of range

Scania BEV	Up to 29 tonnes	BEV with battery capacity of 165kWh or 300kWh and gives a range of up to 250km. Available with the L and P-series cabs and body types such as refrigerated box, tipper, concrete mixer and refuse collector, as well as special vehicles for fire and rescue services. Can charge at up to 130kW.
Scania PHEV	Up to 29 tonnes	Can cover 60km on electricity only. Available with the L and P-series cabs and body types such as refrigerated box, tipper, concrete mixer and refuse collector, as well as special vehicles for fire and rescue services. can charge at up to 130kW.
Renault D wide Z.E.	26 tonnes	available with up to four, 66kWh modules, allowing ranges of up to 180km. This is only available in a 3.9-meter wheelbase. Can charge at 20kW AC and 150kW DC.
Renault D Z.E.	16 tonnes	available with up to six, 66kWh modules, allowing ranges of up to 400km. This is available in two wheelbases (4.4 and 5.3 meters). Can charge at 20kW AC and 150kW DC.

Table 11-17 outlines some of the zero-emission and ultra-low-emission HDVs that are either on the market or coming to the market soon. The sizes and capabilities of these vehicles vary widely, so it is important to be specific in your requirements and trial vehicles where possible to determine their operational suitability.

RCVs

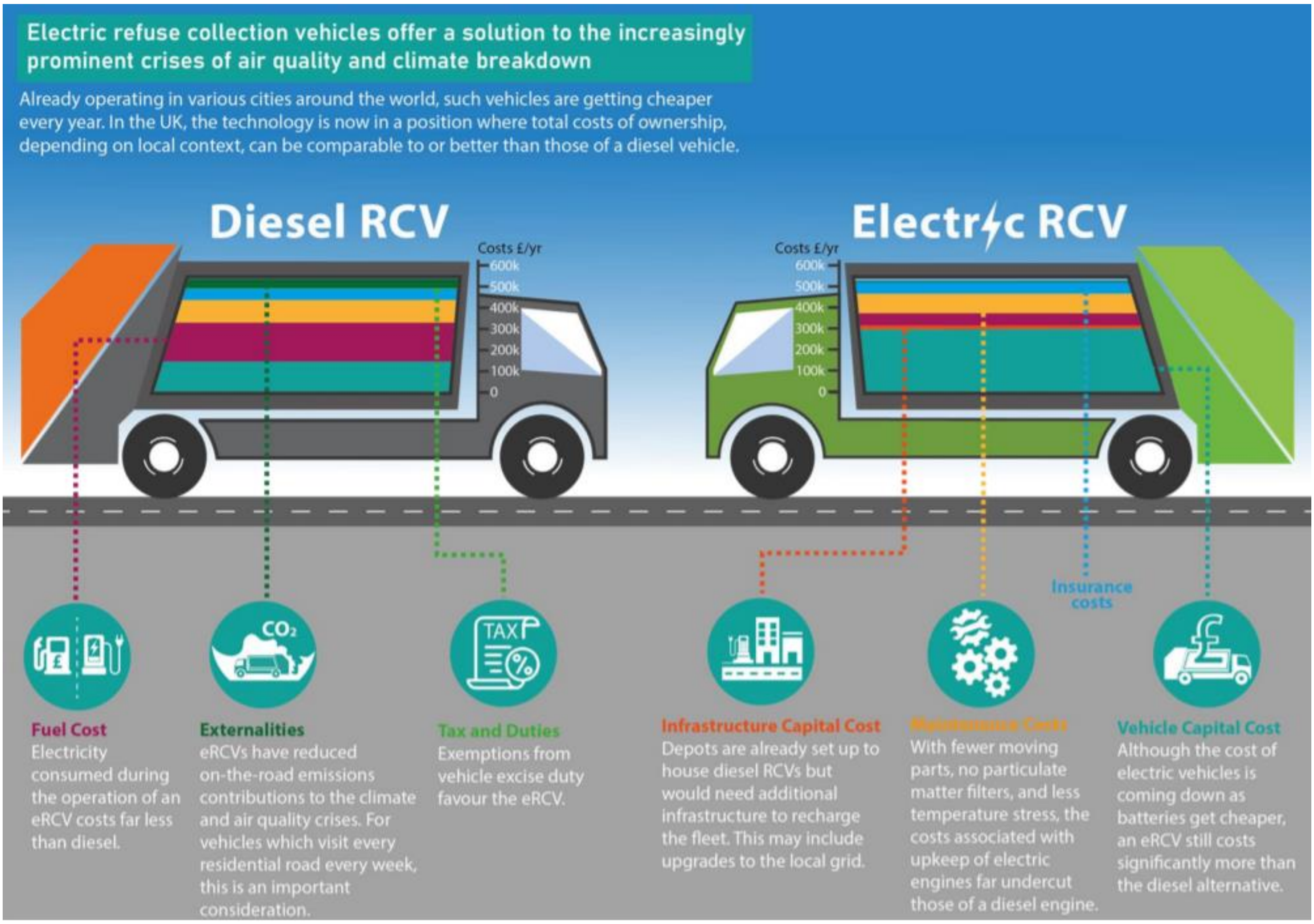
Table 11-18 - Non-exhaustive list of ULEV RCVs

Make and model	GVW (tonnes)	Notes
Volvo FL	16 tonnes	Can be fitted with up to four battery packs. Each pack has an energy capacity of 50 kWh and an estimated lifetime of 8–10 years. Range: Refuse and light construction up to 120 km
Volvo FE	26 tonnes	Can be fitted with up to 6 battery packs at 50kWh/pack and an estimated lifetime of 8-10 years. Up to 186 miles of range
Dennis Eagle eCollect	26 tonnes	300kWh batteries
Geesinknorba electric GPMIV	26 tonnes	200kWh batteries
Magtec	-	Retrofitters of ICE HGVs and RCVs to electric, hybrids and hydrogen
Electra Commercial Vehicles	26 tonnes	Retrofitters of ICE HGVs and RCVs to electric, generally retrofit Mercedes Benz Econics and Dennis Eagle Elites. Currently in use in London.
Eforce	26 tonnes	Modular batteries up to 340kWh, retro fit to a Geesinknorba body. Up to 450km range, up to 350kW DC charging using CCS, urban consumption of 800-1200Wh/km

There are several electric RCVs (eRCVs) on trial and in active service across the country. Most noticeably in London where Veolia have commissioned seven zero-emission 26-tonne eRCVs from Electra Commercial vehicles. These eRCVs are based on the Dennis Eagle Elite Chassis. Edinburgh (MRW, 2019), Sheffield (Veolia, 2020) and Greenwich (DG Cities, 2018) are also trialling eRCVs.

A recent report by eunomia “Ditching Diesel, A Cost-benefit Analysis of Electric Refuse Collection Vehicles” (Eunomia, 2020) suggests that the total cost of ownership of an eRCV is only £29,608 greater than a diesel equivalent and if including the monetised impact of emissions they produce a saving of £12,365. There is also a CO_2e saving of up to 88%. This is based on RCVs collecting household residual waste five days a week on a 60-mile round trip and over a vehicle lifetime of eight years. Figure 8-1 below outlines some of the cost differences between the models.

Figure 11-1 - Diesel and electric RCVs - How do they compare? (Eunomia, 2020)



SPVs

Table 11-19 - Non-exhaustive list of ZEV SPVs

Make and model	GVW (tonnes)	Notes
Boschung Urban-sweeper S2.0	3.5 tonnes	Street sweeper. Currently being operated by Nottingham City Council, 8 hours of operation
Dulevo D.Zero2	-	Street sweeper. Battery electric, 8 hours of operating on a full charge
Global Environmental Products M4 ZE-Series	7.5 tonnes	Street sweeper. Driven by a hydrogen Fuel-cell
Glutton Zen	-	Compact street sweeper ideal for town centres, alleyways, pedestrian zones, town squares, historic centres, marketplaces, confined or inaccessible places.
Schmidt eSwingo 200+	5 tonnes	Street sweeper. 75kWh battery, 10hr running time, 4hr charging time
Tenax International (MaxVac) Electra 2.0 neo	4.3 tonnes	Compact Street Sweeper, available with Li-ion, Lead acid or gel batteries