Gwasanaeth Ynni
Energy Service

Yn cefnogi ymgyrch Cymru dros economi carbon isel lwyddiannus.
Supporting Wales' drive towards a successful low carbon economy

ULEV Transition

Fleet Review

Croeso i Gyngor Castell-nedd Port Talbot
Neath Port Talbot Council

April 2021

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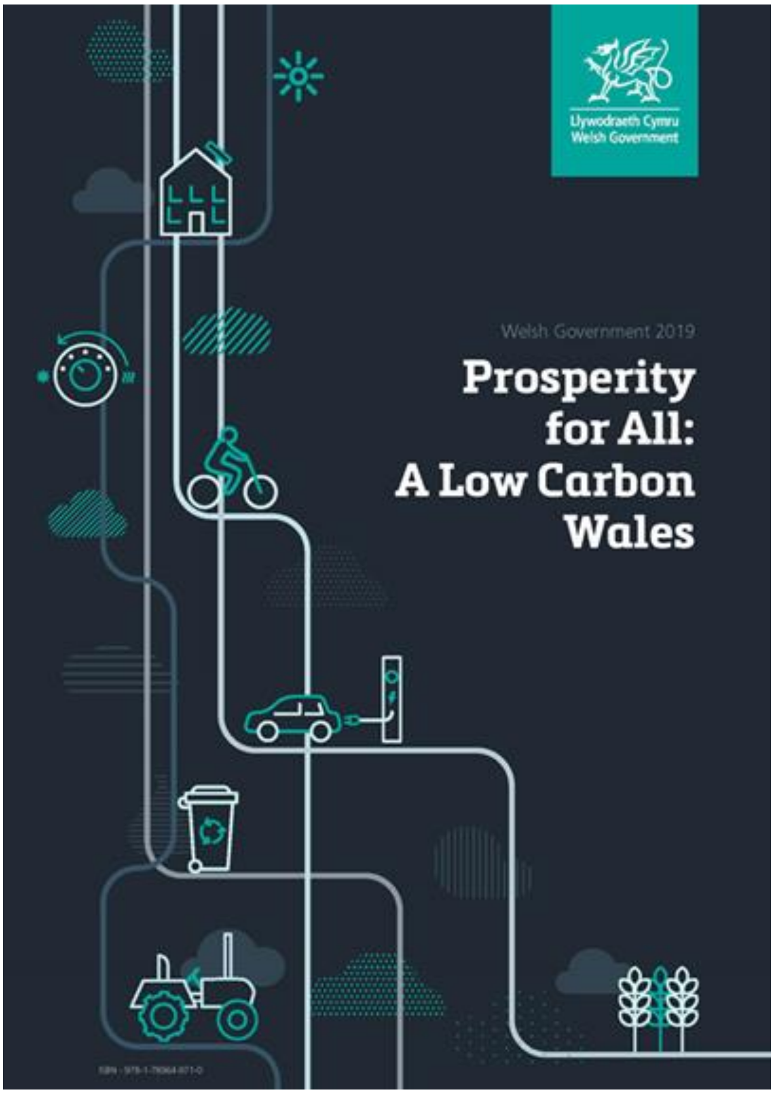

Within **Prosperity for All: A Low Carbon Wales**, the Welsh Government has set ambitious targets for the decarbonisation of the public sector fleet.

The key target of relevance to this report is:

Proposal 4 - All new cars and light goods vehicles in the Public Sector fleet are ultra-low emission **by 2025** and where practicably possible, all heavy goods are ultra-low emission **by 2030**.

2025 is within the operational life of cars and vans purchased in 2021.

2030 is within the operation life of some heavy goods purchased in 2021.

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Glossary of Terms

Abbreviation	Meaning
AC	Alternating Current – used in Charging Infrastructure
API	Application Programming Interface
AQMA	Air Quality Management Area
AWD	All Wheel Drive also known as 4x4
BEV	Battery-electric Vehicle
BIK	Benefit in Kind – applies to company cars and salary sacrifice
CAZ	Clean Air Zone (England and Wales, excluding London)
CCC	UK Climate Change Committee
DBEIS/BEIS	(Department for) Business, Energy and Industrial Strategy
DC	Direct Current – used in Charging Infrastructure
DVLA	Driver and Vehicle Licencing Agency
EV	Electric Vehicle - usually battery-powered (BEV)
EVCI	Electric Vehicle Charging Infrastructure
GHG	Greenhouse Gas - in transport usually CO_2, CH_4 and N_2O
GVW	Gross Vehicle Weight – Replace by MAM but widely used.
GWP	Global Warming Potential
H2FC	Hydrogen (H_2) Fuel Cell
HCV	Heavy Commercial Vehicle – also known as HGV – over 3.5t MAM
HGV	Heavy Goods Vehicle – also known as HCV – over 3.5t MAM
HVO	Hydrogenated Vegetable Oil
ICE	Internal Combustion Engine – Petrol/Diesel/Methane/Hydrogen
IDNO	Independent Distribution Network operator
LCV	Light Commercial Vehicle – Van – up to 3.5t MAM
LEZ	Low Emission Zone (Scotland)
MAM	Maximum Authorised Mass – replaces GVW Gross Vehicle Weight.
NAEI	National Atmospheric Emissions Inventory – Transport Factors
NCAP	New Car Assessment Programme - Safety
NEDC	New European Driving Cycle (now replaced by WLTP)
NPV	Net Present Value
OCPP	Open Charge Point Protocol (currently v2.0.1)
OEM	Original Equipment Manufacturer, for example Ford, Nissan, Toyota etc.
OZEV	Office of Zero Emission Vehicles
OSCP	Open Smart Charging Protocol (currently v1.0)
PHEV	Plug-in Hybrid Electric Vehicle
PM	Particulate Matter – associated with wide range of human illness
RCV	Refuse Collection Vehicle (eRCV - electric RCV)
REEV	Range Extended Electric Vehicle
RRV	Resource Recycling Vehicle (eRRV - electric RRV)
SECR	Streamlined Energy and Carbon Reporting
SoC	State of Charge (EV battery)
SOC	Substances of Concern (NO_X, PM) – air quality.
TTW	Tank to Wheel
ULEV	Ultra-Low Emission Vehicle
ULEZ	Ultra-Low Emission Zone (London only)
VA	Volt Amps – used in supply capacity measurement
V2G	Vehicle to Grid – Technical Guidance (UK Power Networks)
V2O/S	Vehicle to Office or Site: simpler than V2G, also V2H – Home
VCA	Vehicle Certification Agency
VED	Vehicle Excise Duty – also called Vehicle Tax or Road Tax.
VRM	Vehicle Registration Mark – Sometime VRN - Number
WAV	Wheelchair Access Vehicle
WLC	Whole Life Cost
WTT	Well to Tank
WTW	Well to Wheel

1 Executive summary

This report provides Neath Port Talbot Council (NPTC) with benchmark road transport greenhouse gas (GHG) emissions and energy consumption data for the financial year 2019/20. It includes a profile of the active fleet, recommendations for reducing its greenhouse gas (GHG) emissions and maps out a pathway to achieving a zero-emission NPTC fleet by 2030 and meeting the Welsh Government objectives of an ultra low emission vehicle (ULEV) car and van fleet by 2025 and an all ULEV fleet by 2030. The analysis was undertaken by the Welsh Government Energy Service (WGES) and funded by the Welsh Government Decarbonisation and Energy Division. The report contributes to Action Point 1.1 "Council Fleet" of the NPTC's Decarbonisation and Renewable Energy Strategy published in May 2020.

During 2019/20, NPTC operated 47 cars, 224 light commercial vehicles (LCVs), 135 heavy commercial vehicles (HCVs), of which at least 44 were involved in the collection of refuse and recyclables. NPTC also used at least 43 items of plant. These numbers will include short-term hires of all types, disposals, and replacements – any vehicle that recorded mileage or drew fuel in 2019/20. NPTC reimbursed a grey fleet of employee owned vehicles, which drove an estimated 2.07 million miles at a cost of £932,000. Based on the data supplied, we estimate the directly operated vehicles and plant (excluding grey fleet):

- drove at least 2.8 million miles (no mileage data was available for 111 vehicles, 27% of the fleet),
- produced at least 2,727 tonnes of greenhouse gases (no data at all for 45 vehicles – 10%),
- consumed at least 10,712 megawatt-hours of fossil fuel energy,
- emitted at least 6.1 tonnes of nitrogen oxides (NO_X) (this is calculated from mileage data),
- and at least 66 kg of particulate matter (PM) (also calculated from mileage data),
- was 54% clean air zone compliant (based on vehicles on fleet in September 2020).

If the whole NPTC road fleet could be transitioned to battery electric vehicles (BEVs), we would expect the energy use to fall by up to 75% from 9,990 MWh (excludes plant) to 2,500 MWh and for annual energy costs to fall from an estimated £1.028 million to £303,000 saving £725,000 each year. The annual fleet energy saving identified above can fund the higher purchase or lease cost of the BEVs and the charging infrastructure, and it is why the use of a whole life cost (WLC) procurement process is so important.

Further maintenance savings of an estimated 30% to 40% arise from the reduced service costs of electric vehicle chassis, but to realise these savings, structural changes in the operational maintenance of vehicles may be required, a full programme of staff training will need to be implemented (this has already started), and the reduced staffing requirement from the reduced workload may have implications for the long term viability of the workshop unless more BEV work is found.

Registration data was made available for most of the cars and vans used in the grey fleet, so it was possible to obtain their carbon dioxide emission data from the DVLA. The GHG emissions of the grey fleet are therefore based on claimed mileage and the GHG intensity (gCO_2e/km) of the car. The average UK car was used if the vehicle's registration was not valid or not made available. On this basis, we estimate that the grey fleet produced an additional 516 tonnes of GHG, 0.98 tonnes of NO_X and 14.6 kg of PM. The grey fleet is considered in detail in a separate report.

Even if the whole fleet is converted to BEVs by 2030, the GHG emissions associated with charging the fleet using UK Grid electricity will still be about 250 tonnes. The only way to get to carbon neutral with an all-electric fleet will be to generate at least 2,500 MWh each year from private wire renewables. This is equivalent to the estimated annual output from a 1.2 MW wind turbine or a 2.6 MWp solar photovoltaic array however NPTC is already the lead council in Wales for renewable generation, so this should be achievable.

It will take several years to switch the whole fleet to zero-emission vehicles. In the interim it is essential to use performance data to reduce fossil fuel use through improved driving standards and a focus on meeting new departmental GHG reduction targets. For example, a reduction in diesel fuel use of only 5% would save £50,000 per annum and 119 tonnes of GHG. However, when combined with targeted training and driver or team incentive schemes, the savings could be doubled to 10% or £100,000 and 238 tonnes of GHG.

Reporting of mpg data should be accompanied by GHG emission reporting, and departments should have fossil fuel and GHG budgets aligned with the Welsh Government target of an all ULEV fleet by 2030 and with NPTC's targets for decarbonising its activities. Consideration should be given to charging departments exceeding their GHG budget a Carbon Fee with the funds collected used for offsetting projects within NPTC.

For this review, the NPTC fleet has been split into four broad categories: Fleet Cars, LCVs, HCVs, and RCVs (including RRVs). In addition, each category has been further subdivided so that the fleets can be matched with suitable BEVs from original equipment manufacturers (OEMs) or, occasionally, specialist converters.

Analysis of the current fleet's energy consumption data suggests that, with adequate funding, and a suitable Electric Vehicle Charging Infrastructure (EVCI) in place, all of the NPTC fleet under 3.5 tonnes gross weight could be transitioned to BEV by 2025 and that all the fleet including HCVs can be transitioned by 2030.

Recent announcements by Volvo/Renault, DAF, Scania/MAN, and Daimler (Mercedes/Fuso) means that we expect a full range of rigid battery electric HCVs up to 33 tonnes to be available by the end of 2022 and all HCVs, including 44 tonne artic tractor units by 2025. The OEMs are working to ensure these will be supported by new rigs and bodies from manufacturers designed to work with the new battery electric drive trains. Using the average daily energy consumption of the diesel fleet and calculating from that the expected daily energy requirement of a much more energy efficient electric fleet does not identify any vehicles (other than the gritters) that could not be replaced with current battery electric vehicle technology.

The transition will require a planned, strategic approach that covers charging EVCI, power supply including on-site or private wire generation, vehicle procurement policy, ownership of the capital budget, vehicle retention policy, workshop staff training, and that will need a multi-disciplinary team reporting to senior management. NPTC should establish a team within the authority to carry out this project.

Using a whole life cost model is critical when comparing the cost of ICE with BEV. Our WLC models suggest that all the cars and most of the vans up to 3.1 tonnes could be replaced with BEVs at a small cost saving depending on annual mileage and operational life. We would recommend retaining the vehicles on fleet for their entire battery warranty period, typically eight or ten years depending on the model, to maximise savings.

More difficult to cost-justify replacing in 2021/22 are the 3.5 tonne vans as they are currently expensive, but many new models are due to enter the market in 2021/22, which may result in more competitive pricing. There are currently no electric 4x4 pickups available, but several are in development and should be on the market within two years.

The NPTC fleet has at least 73 low mileage vehicles – 27 under 3,000 miles per annum – and these will struggle to recover the additional capital cost of a BEV from lower running costs, even over long replacement cycles, because they do not consume enough energy (fuel) on which to make a saving. The requirement for all vehicles averaging less than 6,000 miles per annum should be robustly tested as low mileage diesel vehicles are also expensive.

NTPC is responsible for a large minibus fleet of up to 53 vehicles which is largely operated by schools and Community Services. The average age of this fleet is seven years, and the oldest vehicle is 15 years old. It is a concern that such old vehicles are used for the transport of vulnerable groups, and while they may be well maintained, they will lack modern accident prevention and occupant protection technologies. The old vehicles will meet superseded Euro emission standards and have high exhaust emissions , which can have an adverse impact on vulnerable adults and children. We strongly recommend that the use of minibuses in schools and by the council is subject to a comprehensive review with the aim of establishing a sustainable policy that enables regular replacement and the cost-effective implementation of zero-emission vehicles.

The HCV, RCV and RRV fleets account for 45% of NPTC fleet GHG emissions. Therefore, transitioning these vehicles to BEV has a significant impact on NPTC's GHG footprint. The average RRV/RCV produces about 22 tonnes of GHG each year. This is seven times more than an LCV (van) which produces about 3.1 tonnes.

The energy cost savings from using battery electric heavy-duty vehicles are significant. Replacing the oldest (2013) 12 tonne DAF RRVs fleet of seven vehicles with BEVs would, over ten years, result in energy cost savings of an estimated £410,000 and cut GHG emissions by 927 tonnes. Additional savings arising from reduced chassis maintenance costs, no requirement for AdBlue, no road tax, and no road user levy bring the total savings up to an estimated £628,000, which can offset some of the higher capital cost of the electric vehicles. Greater savings can be achieved by using private wire renewable electricity from photovoltaic arrays, wind turbines or an anaerobic digestor linked to a biogas generator.

Initial analysis suggests that, with adequate funding and using currently available technology, most of the NPTC fleet up to 3.5 tonnes could transition to zero tailpipe emission BEV by 2025 (as vehicles come up for renewal as part of the regular schedule of replacement) and that all of the fleet, including RRVs, RCVs and HCVs could transition by 2030.

That fleet will require new Electric Vehicle Charging Infrastructure (EVCI) to be installed at the main depots and at other locations where the vehicles are based overnight (including employee's homes). To achieve a zero emission fleet, additional sources of private wire, zero-emission electricity will need to be built, but NPTC already has the largest installed base of renewable generation of any public body in Wales, and there may be locations that could be connected by private wire to significant renewable generation.

2 Summary of recommendations

Item	Recommendation	Ease	Risk	Estimated % GHG reduction	Estimated annual £ saving (fuel)	Estimated emission reductions[1]		
						GHG (tonnes)	NO_X (kg)	PM (kg)
1	Ensure full, automatic, integration of fleet, telemetry, bulk fuel, and fuel card data systems. Aim to achieve accurate monthly reporting of both vehicle and driver performance (mpg, kg GHG) to all operational departments.	Moderate	Low	The savings in the ICE fleet identified in this report cannot be achieved without accurate performance data. It is also essential if the impact of a move to BEVs on the grid infrastructure is to be assessed and if the whole life cost models for BEVs are to be accurate.				
2	Set challenging departmental GHG reduction targets in line with NPTC and WG decarbonisation targets including annual reductions in fossil fuel (diesel) use. Penalise departments that do not meet their GHG reduction targets with a Carbon Fee. Introduce a full range of driver and vehicle performance indicators aimed at reducing emissions.	Moderate	Low	From 5% to 10%	£50K to £100K	119t to 238t	Not linked to reduced fuel use.	
3	**Establish Transition Team:** Ensure that as soon as practical the charging infrastructure at all the key depots has been reviewed and a plan is in place to ensure that all sites (depots and offices) can meet the demands of the fleet as it transitions over time to electric vehicles.	Can be Difficult	High	**This is an enabling step**. The fleet cannot transition to BEVs if they cannot be charged. The charging demands of a fleet of electric refuse vehicles will be significant. See separate EVCI report.				
4	From 2021/22: Establish BEVs as the default fuel type for all new cars and vans up to 3.1 tonnes. Require an exceptional use case for all procurements of fossil fuel vehicles other than 4x4s and minibuses. Challenge all 3.5 tonne chassis requests and evaluate downsizing.	Moderate	Medium	60% in 2021 rising to 90% in 2030	£269K by 2030 if transition complete.	640t by 2030	Zero emission by 2030 if transition complete.	
5	From 2022/23: Establish BEVs as the default fuel type for all new cars and vans under 3.5 tonnes. Require an exceptional use case for all procurements of fossil fuel vehicles other than 4x4 pickups. Challenge all 3.5 tonne chassis requests and consider downsizing.	Moderate	Medium	60% in 2021 rising to 90% in 2030				
	From 2021: Use tracking data to refine information about the daily energy use of the HCV, RCV and RRV fleets. Evaluate electric RCV/RRVs, begin programme of evaluating electric HCVs as they become available. Focus on sweepers, gully emptiers and tippers as well as all HCVs 7.5 tonnes and under.	Moderate	Medium	90% in 2030	£612K by 2030 if transition complete.	1,454t	Zero emission by 2030 if transition complete.	

GHG Greenhouse Gas (carbon dioxide equivalent: CO_2e), NO_X Nitrogen oxides, PM_{10} Particulate matter under 10 microns. Air quality emissions are based on performance of average vehicle and are indicative.

Proposed implementation programme for ULEV fleet - based on expected availability and fleet age

Category	2021	2022	2023	2024	2025	2026-30	Total
Car	7	2	0	9	8	5	32
LCV	8	7	11	59	25	44	154
Minibus	Insufficient data						36
HCV	6	13	8	10	11	33	91
Total	**21**	**22**	**19**	**78**	**44**	**82**	**313**

This programme is based on our best estimate of when suitable ULEV vehicles will become available in each sector using a seven year operational life for ICE vehicles. In the HCV fleet the programme of replacement is difficult to assess because many of the vehicles are specialist; for example, sweepers and gritters and depend on both a suitable electric chassis and a compatible body being available. The programme is dependent on EVCI being in place to charge the vehicles.

3 A ULEV fleet in 2030 – meeting the target

NPTC is directly impacted by climate change, the sea-level rise built into the Paris Agreement will have a significant impact on the NPT coastal region, and later in the century, perhaps as early as 2050, large areas of the coast are expected to flood every year unless expensive protection is put in place. Decarbonising the fleet is an important aspect of reducing the global warming impact of the council's operations, and switching to battery electric vehicles is the lowest cost, zero-emission option which can quickly deliver improved energy efficiency and real reductions in GHG emissions as well as emissions of particulates and nitrogen oxides.

Electric vehicles are significantly more energy-efficient than internal combustion engine (ICE) vehicles, and the energy use (MWh) of an all-electric fleet will be 70% to 75% less than the equivalent ICE fleet. Based on the data supplied, we believe that it should be technically possible for the whole vehicle fleet to be battery electric and zero-emission by 2030 and that a large part of the fleet could move to battery electric vehicles by 2025.

DBEIS data (Appendix B) shows that the GHG intensity of the UK grid has fallen from 494 gCO_2e per kWh in 2014 to 233 gCO_2e per kWh in 2019, a reduction of 53%. It is expected to fall to 100 gCO_2e per kWh or less by 2030. Table 3-1 shows that in 2030 an all-electric NPTC fleet, charged from the UK Grid, could reduce energy costs by up to 71% (2020 prices) and GHG emissions by 90% (2030 UK grid intensity of 100 gCO_2e per kWh).

Table 3-1: 2030 GHG emissions, energy use and cost savings from an all-BEV fleet (excludes plant).

Factor	ICE – 2019/20	BEV – 2030/31	Change	Reduction
Energy (MWh)	9,990	2,500	-7,490	-75%
Energy Cost (£^{2020})	£1,028,000	£303,000	-£725,000	-71%
GHG Emissions (t)	2,440	250	2,190	-90%

The fleet will still be associated with about 250 tonnes of GHG emissions, but over the next ten years, NPTC should evaluate expanding its renewable generation – 2,500 MWh is equivalent to the expected output of a 1.2 MW wind generator or a 2.6 MWp photovoltaic array.

By 2025 all types of BEV up to 3.5 tonnes are expected to be no more expensive to buy and operate than their ICE equivalent because they will not need expensive emission control and "light-weighting" technology to meet technically challenging new (Euro 7) air quality emission regulations which have led Audi and Daimler to announce they will not develop new ICE technology for cars. Over this time, the cost of batteries will continue to fall, their energy density (kWh per kg) will increase, and affordable battery electric cars and vans with a single-charge range of 300 miles or more will become available. In addition, technologies such as solid-state lithium and lithium-air batteries may be more widely used later in the decade, further extending the range, and significantly reducing charge times.

BEVs have many fewer moving parts; there are under 80 moving parts in the drive train of a BEV and over 2,000 in a typical ICE vehicle. As a result, chassis service costs are much lower (experience to date in car and van fleets suggests at least 40% lower), and reliability is much higher. BEVs already have lower energy (fuel) costs, but these could even lower if charged using photovoltaic (PV) generation with battery storage or offset by revenue from vehicle to grid services, including both power and frequency services.

In the van sector battery electric car derived vans (up to 2.6 tonnes) already offer a lifetime cost-saving when compared to ICE equivalents. The range of 3.1 tonne vans from PSA group and Toyota are cost competitive with diesel vehicles on a four year lease at 12,000 miles per annum (mpa). However, 3.5 tonne vans and large minibuses remain expensive over 48 month lease and do not yet achieve cost parity over their full warranty period. Some categories such as large 4x4 pickups with 3.5 tonne towing capacity are not yet available.

The BE heavy commercial vehicle (HCV or HGV) market has developed more rapidly than heavy vans. By the end of 2020/21 at least six UK local authorities collected domestic waste with 18/19-tonne and 26/27-tonne battery electric RCVs. DAF, Scania/MAN, Volvo/Renault, and Daimler (Mercedes/Fuso) have all announced full battery electric HCV ranges with series production expected in 2022, and the remaining truck OEMs are expected to make similar announcements soon.

Specialist electric vehicles like gritters, road sweepers, welfare buses and even fire tenders are also available or being developed and at least three electric fire engines were trialled in Europe in 2020. Over 500,000 single and double deck battery electric buses are already in use around the world. In Europe, the largest fleet of battery electric buses is found in Moscow with over 500 on the road operating in temperatures down to minus 40° centigrade. GoAhead London operates a fleet of 240 double and single deck electric buses. NPTC should plan on having an all-electric fleet by 2030 and this has significant implications for the charging infrastructure at depots, offices and at employees' homes where some vans may be parked overnight.

4 Benchmark: GHG emissions

The carbon dioxide (CO_2e) footprint (often shortened to carbon footprint) details the tonnage of carbon dioxide that Neath Port Talbot County Council's road transport emitted during 2019/20. The 'e' in CO_2e stands for 'equivalent' and indicates that the estimate includes the other reportable greenhouse gases (GHG) emitted by the fleet (methane and nitrous oxide) expressed in terms of their carbon dioxide equivalence. For example, one tonne of nitrous oxide (N_2O) has a global warming potential (GWP) 265 times that of carbon dioxide and is therefore equivalent to 265 tonnes of CO_2. The GWP of methane (CH_4) is 28 (GHG Protocol, GWP Values), so one tonne is equivalent to 28 tonnes CO_2.

The estimate is based on tank to wheel (TTW) factors. This means that it does not include GHG emissions relating to the extraction, refining and distribution of the fuels, known as well to tank (WTT) factors, nor does it include the manufacture and disposal of the vehicles. No matter what type of vehicle, the carbon emissions from burning a litre of diesel (for example) will always be the same. WTT and TTW factors can be combined to give well to wheel (WTW) values but are always reported separately as the WTT GHG emissions are the responsibility of the fuel provider not the fuel consumer.

The footprint for the fleets (Table 4-1) is based on the fuel and mileage data NPTC provided. We have calculated this footprint using the 2019 GHG conversion factors published by the Department for Business, Energy & Industrial Strategy (DBEIS). The methodology complies with international GHG reporting standards and with SERC reporting guidelines. It includes the emissions from burning AdBlue in diesel exhaust systems.

Table 4-1: *GHG reporting scope, fleet size, mileage, GHG emissions and energy consumption*

Vehicle Fleet	GHG Scope[1]	Fleet size	Annual mileage	GHG (tonnes)[2]	Energy (MWh)
PSV – Passenger Service Vehicle (Bus)	1	1	18,293	9	35
HCV – Refuse and Recycling Vehicles	1	44	518,242	965	3,935
HCV – Rigid – Tippers, Gritters etc.	1	49	171,836	529	1,744
HCV – Minibus (9-17 seat)	1	41	253,690	112	458
LCV – vans up to 3.5 tonnes	1 & 2	224	1,456,701	709	2,882
Fleet Car – SUV, MPV, Estate etc.	1 & 2	47	385,799	63	259
Plant – Mowers, tractors, diggers etc.	1	43	0	177	721
Unknown – Vehicle not categorised	1	13	0	164	677
NPTC Operated Fleet	**1**	**462**	**2,804,561**	**2,728**	**10,712**
Grey Fleet - staff owned vehicles	3	1,775	2,070,722	516	2,164
Total	**1 and 3**	**2,237**	**4,875,283**	**3,244**	**12,877**

[1]International greenhouse gas reporting standards require emissions to be reported in three different scopes: Scope 1 is all direct emissions from burning fossil fuels purchased by the organisation. Scope 2 encompasses the emissions associated with the purchase of energy and includes the emissions from the generation of electricity to charge electric vehicles. Scope 3 includes all the indirect emissions, for example from vehicles owned by staff who are paid by the mile for business travel (grey fleet).

Table 4-2 shows the WGES GHG calculation methodology we have used to determine the carbon dioxide emissions and energy used. The method used is an indicator of the quality of the data: Method 1 is the most accurate as it is based on fuel burnt and Method 5 the least accurate as it based on the performance of the equivalent average UK vehicle and the mileage driven (the full WGES methodology is available on request).

Table 4-2: Method used for calculating the GHG footprint as a percentage of reported fleet emissions

Vehicle Fleet	Method 1	Method 2	Method 3	Method 4	Method 5	No Data
PSV – Passenger Service Vehicle (Bus)	100%	0%	0%	0%	0%	0%
HCV – Refuse and Recycling Vehicles	100%	0%	0%	0%	0%	0%
HCV – Rigid – Tippers, Gritters etc.	110%	0%	0%	0%	0%	10%
HCV – Minibus (9-17 seat)	88%	0%	0%	0%	0%	5%
LCV – vans up to 3.5 tonnes	100%	0%	3%	0%	0%	0%
Fleet Car – SUV, MPV, Estate etc.	96%	0%	0%	9%	0%	2%
Plant – Mowers, tractors, diggers etc.	77%	0%	0%	0%	0%	23%
Unknown – Vehicle not categorised	77%	0%	0%	0%	0%	23%
Grey Fleet - staff owned vehicles	0%	92%	4%	0%	0%	0%

The analysis of all directly operated fleets, including trucks, vans, and fleet cars, should be based on fuel burnt (Method 1). Thus, NPTC should know how much fuel it has purchased, and which vehicles burnt it.

Where only mileage data is available, the calculations are based on the vehicles' published gCO_2/km and kWh/km (Method 2), but an age-related uplift (see DBEIS Methodology Paper, p44, Table 14) must be applied to the published emissions of vehicles registered prior to 1 April 2020 to compensate for systematic manipulation of the NEDC test procedure. After that date, the reported emissions are based on the WLTP test procedure, which is expected to be more robust for the first few years.

Methods 3 and 4 use basic information about the vehicle like engine size, fuel type and weight linked to national average factors. Method 5 is based on the average UK vehicles of that type (Car, LCV, HCV) and is the least accurate.

Electric vehicle (EV) GHG emissions (Scope 2)

BEVs have no Scope 1 GHG tailpipe emissions from directly burning fossil fuel and therefore, they are classified as 0 gCO_2/km. They do have Scope 2 GHG emissions associated with the generation of the electricity used to charge them and Scope 3 GHG emissions associated with the transmission and distribution losses arising from the electricity supply.

Table 4-3. reports the Scope 2 GHG emissions associated with plug-in battery vehicles of all types. When data on the actual kWh used to charge the vehicles is not available, we use mileage and the 2019 DBEIS carbon emissions per km factors for the appropriate category of vehicle.

In 2019/20 there were four battery electric vehicles on the NPTC fleet, three cars (Peugeot ION and two Renault Zoe) and one Renault Kangoo van. NPTC was able to supply chargepoint energy consumption data but it did not relate to the benchmark year, was not for a full year and did not link back to the vehicle plugged in (no registrations). Fortunately, the fleet team was also able to supply mileage data, and so the GHG emissions of the BEV fleet have determined using mileage factors. There is a need to monitor the actual energy use (miles/kWh or Wh/km) of the BEV fleet, and consideration should be given how this can be achieved (see the section "Implementing future-proof telemetry" later in this document).

Table 4-3: *GHG emissions (tonnes) and energy use of EVs (Scope 2 and Scope 3)*

Vehicle Fleet	Fleet size	Annual mileage	GHG footprint (kg)	Total energy kWh (gross)
LCV – vans up to 3.5 tonnes	1	13,110	1,171	4,580
Fleet Cars	3	4,382	594	2,325
Total	**4**	**17,492**	**1,765**	**6,905**

Site metering should capture the electricity consumed from onsite charging of these vehicles. This means these emissions may already be included in the sites' Scope 2 GHG footprint and there is a risk of double-accounting. What will not be captured by site metering is any off-site charging whether at home or at public charge sites.

Summary of Scope 1, 2 and 3 GHG Emissions

Figure 4-1: Summary TTW GHG emissions (tonnes CO_2e), Scope 1, 2 and 3 (includes grey fleet).

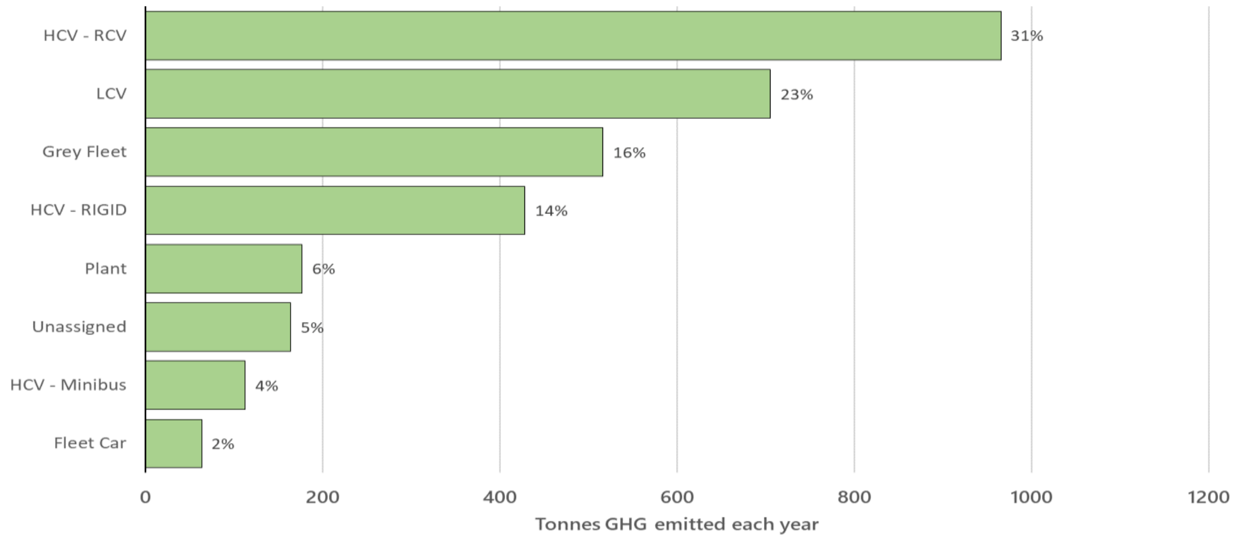


Table 4-4: Analysis of NPTC fleet size, mileage, GHG emissions and energy use (<u>excludes</u> grey fleet)

Vehicle Fleet	% Size	% Mileage	% GHG	% kWh	kg CO_2e/Vehicle
PSV – Passenger Service Vehicle (Bus)	0.2%	0.7%	0.3%	0.3%	8,619
HCV – Refuse and Recycling Vehicles	9.5%	18.5%	35.4%	36.7%	21,941
HCV – Rigid – Tippers, Gritters etc.	10.6%	6.1%	19.4%	16.3%	10,793
HCV – Minibus (9-17 seat)	8.9%	9.0%	4.1%	4.3%	2,738
LCV – vans up to 3.5 tonnes	48.5%	51.9%	26.0%	26.9%	3,163
Fleet Car – SUV, MPV, Estate etc.	10.2%	13.8%	2.3%	2.4%	1,348
Plant – Mowers, tractors, diggers etc.	9.3%	0.0%	6.5%	6.7%	4,106
Unknown – Vehicle not categorised	2.8%	0.0%	6.0%	6.3%	12,602

As is apparent from Figure 4-1 and Table 4-4 the waste fleet is the most GHG intensive. It produces 31% of NPTC's overall road transport GHG emissions (including grey fleet) and 37% of NPTC's fleet emissions. The average RCV/RRV produces about 22 tonnes GHG per annum, and the GHG emissions from the average waste vehicle is equivalent to seven average vans.

Because the fleet is large – 224 vehicles used in 2019/20 – the van fleet is in second place in the GHG league table producing 23% of the council's transport GHG and 27% of its fleet emissions. In third place is the large, high mileage, grey fleet (16% of overall emissions) and that is considered in full in a separate report.

While it is possible to replace almost all of the cars and vans with electric models – and in some cases reduce costs – the GHG emission reduction achieved per vehicle is relatively small and the total is capped at about 30% of the NPTC fleet total. Replacing the much smaller number of vehicles in the GHG intensive RCV and RRV fleet will result in significant GHG emission reductions.

Emissions of Substances of Concern (SOC)

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

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

We have determined the data in Table 4-5 using the average emissions of a 2018 UK car, LCV (van) or HCV adjusted for the area of operation (urban, rural or mixed) as published by the National Atmospheric Emissions Inventory. This analysis is based on vehicle mileage and cannot be determined from fuel data alone so where mileage is missing emissions cannot be calculated.

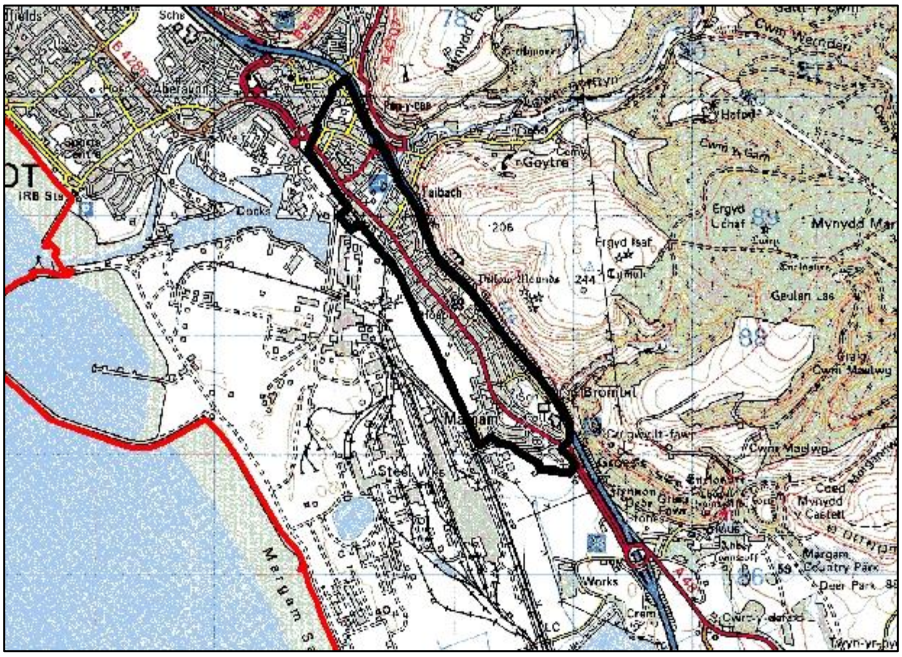
Table 4-5: Estimated annual emissions of nitrogen oxides (NO_X) and particulate matter (PM)

Vehicle Fleet	NO_X (kg)	PM (kg)	Notes
PSV – Passenger Service Vehicle (Bus)	103	1.0	
HCV – Refuse and Recycling Vehicles	1,539	15.9	This will be an underestimate
HCV – Rigid – Tippers, Gritters etc.	510	5.3	Missing mileage data will impact on this estimate.
HCV – Minibus (9-17 seat)	1,419	14.4	
LCV – vans up to 3.5 tonnes	2,138	24.1	
Fleet Car – SUV, MPV, Estate etc.	343	5.0	
Plant – Mowers, tractors, diggers etc.			No methodology available
NPTC Operated Fleet	**6,052**	**65.8**	
Grey Fleet - staff-owned vehicles	986	14.6	
Total	**7,038**	**80.4**	

A more accurate assessment of the air quality impact would require the use of the COPERT V5 model and much more detailed usage data about each vehicle. Specific fleets such as the RCVs will have very high emissions due to their slow operating speed, low engine temperatures, and stop/start operation which results in the exhaust clean up technology being switched off to avoid emissions of ammonia and other noxious substances; this is not reflected in the above figures.

Each year in Wales, 1,604 deaths can be attributed to PM 2.5 exposure, and 1,108 deaths to NO_2 exposure (Air Quality in Wales). Public Health Wales estimate the societal cost of poor air quality in Wales at £1 billion (made up of NHS costs and lost working hours). NPTC does have an Air Quality Management Area (AQMA) (Figure 4-2) but it is linked to the particulate emissions of the Tata Group Steel Works and not transport. However, a speed limit of 50 mph has been imposed on the M4 motorway at Port Talbot to reduce air pollution from transport.

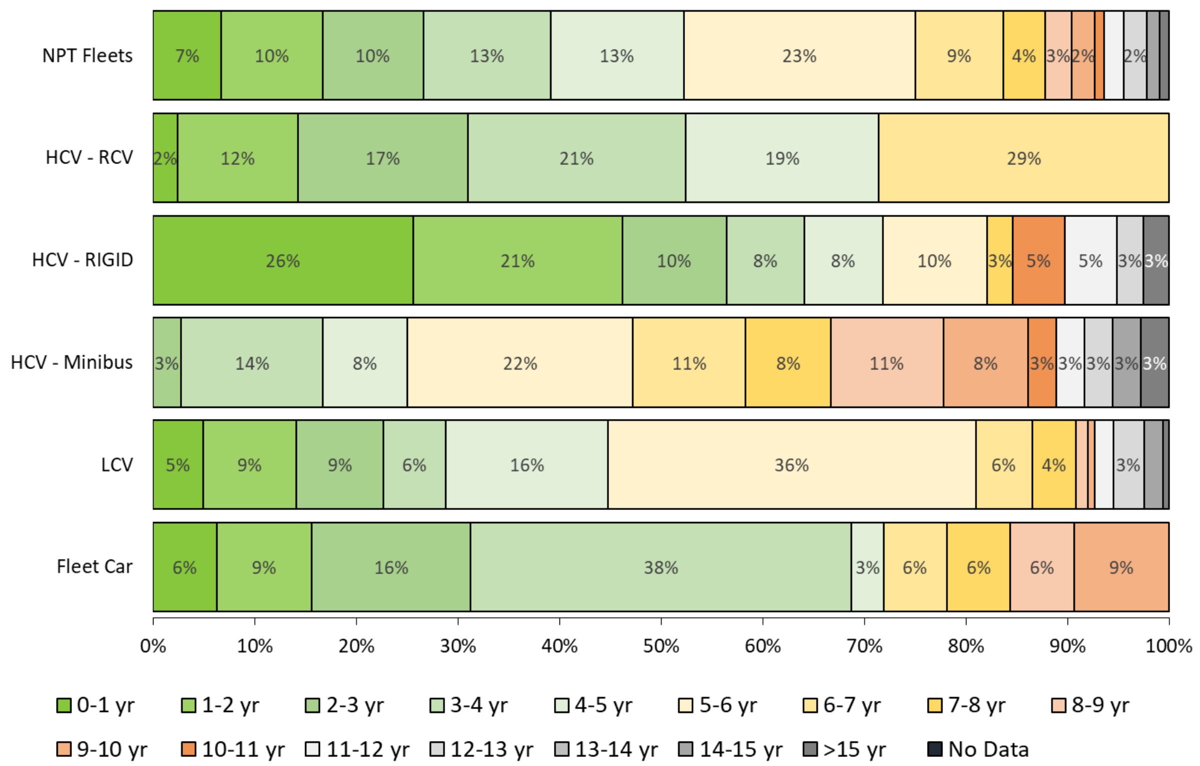
Figure 4-2: Location of NPTC AQMA between steel works and M4 motorway.



5 Benchmark: Fleet profile

5.1 Age distribution

This chart, and all the charts in the fleet profile, relate to the vehicles which were on fleet on 1st September 2020. That is also the reference date for the calculation of the age profile.



Fleet age (years)	Fleet size	Newest	Average	Oldest
HCV – Refuse and Recycling Vehicles	42	0.6	4.3	6.8
HCV – Rigid – Tippers, Gritters etc.	39	0.2	3.8	16.8
HCV – Minibus (9-17 seat)	36	2.1	7.0	15.2
LCV – vans up to 3.5 tonnes	163	0.2	5.0	15.0
Fleet Car – SUV, MPV, Estate etc.	32	0.2	4.4	9.6

Vehicle age matters because it impacts adversely on:

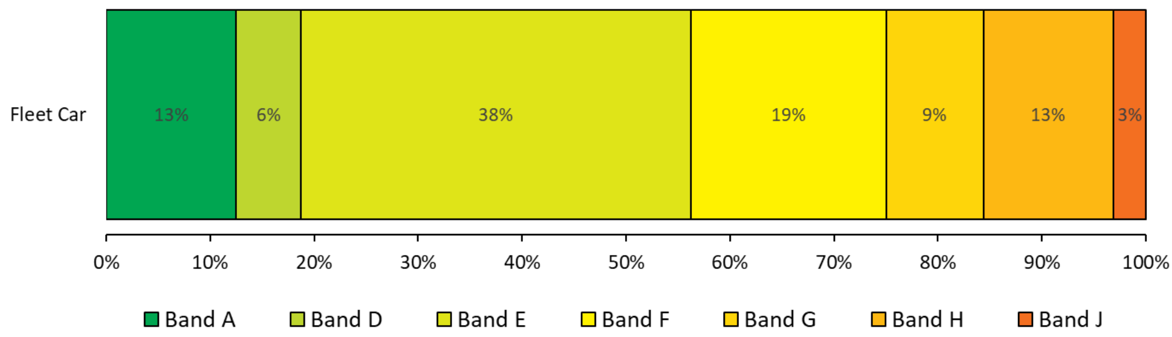
- fuel consumption – old engines are less efficient,
- air quality – old engines are significantly more polluting,
- safety – old vehicles are not equipped with modern accident avoidance technology,
- reliability – much more likely to break down,
- service delivery – when they break down it can be very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

This fleet has a wide age range and there is no pattern in the age profile to suggest a robust replacement cycle of five, seven or ten years is in place at NPTC. It is understood that it is the operating departments that are the budget holders and lead on fleet replacement. NPTC fleet had a robust replacement policy but that was abandoned after external consultants reported cost savings could be achieved by extending the operational life of the fleet. There are old vehicles in all the fleets except refuse and recycling and a significant proportion of the HCV minibus fleet (mainly “welfare” vehicles with wheelchair access) is old. Many of these vehicles are based in schools and will be used for the transport of children.

The data suggests that many of these minibuses are low mileage which makes them expensive to own and expensive to replace, so the temptation is to keep them going until they are no longer economic to repair. The two “old” cars are both operated by Social Services and are associated with a very low level of fuel use.

5.2 Car GHG intensity

The fleet has been categorised according to the 2017 HM Treasury Vehicle Excise Duty (VED) bands, which are based on the published emissions of the vehicles measured in grams of carbon dioxide per kilometre (gCO_2/km), this does not include other GHG emissions such as methane and dinitrogen oxide. If used for GHG reporting, this data must be adjusted to gCO_2e/km.



Band	Range g/km	Band	Range g/km	Band	Range g/km
A	0 (zero emission)	F	101 - 110	J	171 - 190
B	1 - 50	G	111 - 130	K	191 - 225
C	51 - 75	H	131 - 150	L	226 - 255
D	76 - 90	I	151 - 170	M	Over 255
E	91 - 100				

There are four zero emission electric cars in the current NPTC car fleet. Most of the vehicles are small diesel cars with emissions in the range 79 gCO_2/km to 99 gCO_2/km. The higher emission vehicles are large MPVs (people carriers) or SUVs such as the Peugeot 2008 and Skoda Yeti.

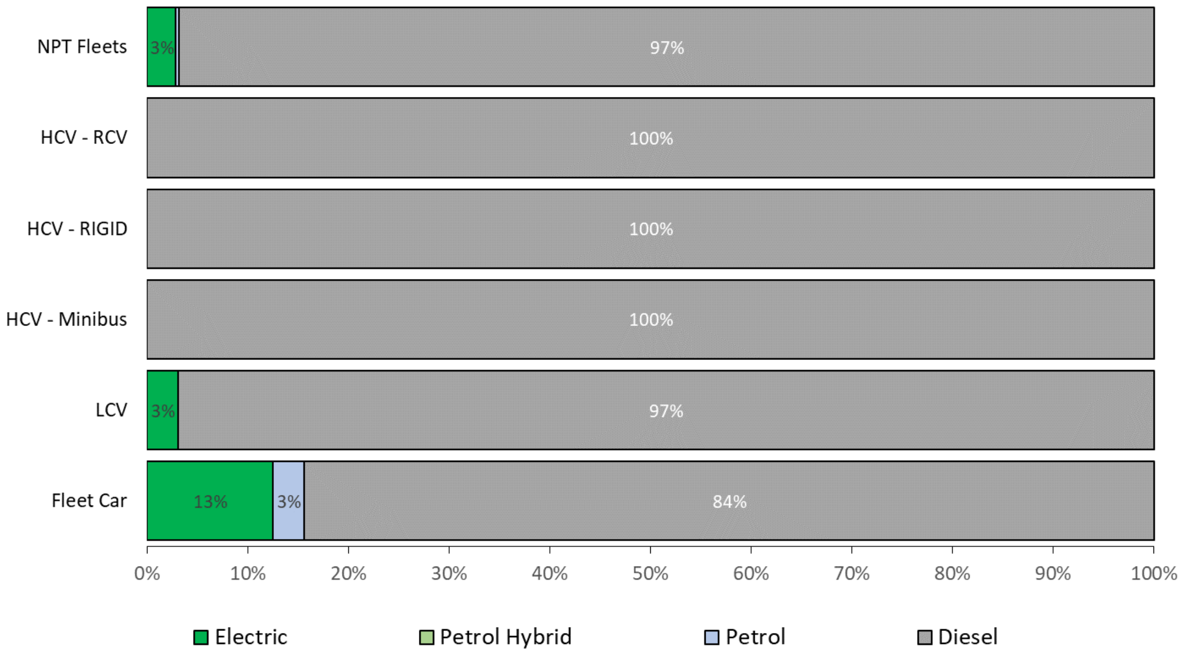
Table 5-1: CO_2 and GHG Intensity of a selection of Fleet Cars with real world adjustment

Category & Examples	Vehicles	Average OEM gCO_2/km	Real World Adjusted gCO_2e/km	Total GHG Emissions (kg)	Average Annual Mileage
BEV – Renault Zoe	2	0	0	968	5,420
Kia Rio – Small hatchback	7	93	125	14,912	Poor Data
Peugeot 2008 – SUV	2	111	147	New	New
Set Alhambra – MPV (7 seat)	1	130	187	2,480	Poor Data

During 2019/20 a total of 47 cars appeared in the fleet data, the bulk tank fuel data, or the fuel card data. Some drew significant quantities of fuel while others appeared to draw less than one tankful and may have been hire cars. The mileage data for this fleet was poor and if combined with fuel drawings many of the vehicles were achieving over 150 mpg which is clearly not credible. In the case of the ICE vehicles GHG emissions are based on fuel burnt not mileage driven.

5.3 Fuel types

In conjunction with the Euro emission standard, Fuel type affects the emissions of SOCs and therefore air quality.



Until recently diesel has been regarded as the preferred lower carbon, energy-efficient option when compared to petrol, but there are now significant concerns regarding the NO_X and PM emissions of diesel vehicles which have adverse health impacts. The failure of the Euro VI standard to completely address those concerns means that in urban areas, diesel is no longer the fuel of choice, especially if a zero emission option is available.

A range of “alternative” commercial vehicle fuels or energy sources are now available including battery electric, compressed natural gas, liquid natural gas, liquid petroleum gas, gas to liquid (GTL) diesel, HVO diesel, hydrogen dual fuel with diesel, hydrogen ICE and hydrogen fuel cell.

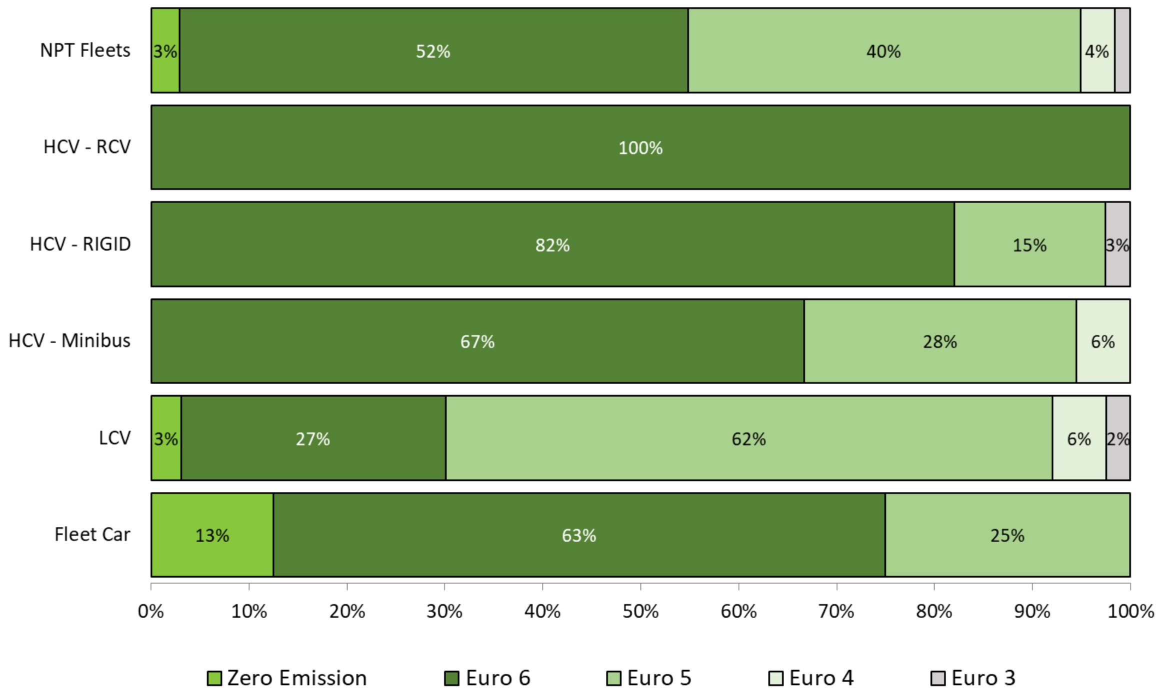
All have their strengths and weaknesses, and careful consideration should be given to all the lifecycle environmental impacts, independently published emission data, real-world carbon intensity, indirect land-use change, energy efficiency, use of RTFOs and the whole life cost associated with each fuel source before making a switch.

All ICE engines (including H2ICE) produce SOCs, so the only zero-emission options are battery electric and hydrogen fuel cell.

By mid-2020 the NPT fleet included nine BEVs; four cars and five vans. In common with most commercial fleets the majority of the fleet was diesel powered.

5.4 Euro emission standard

The Euro standard is a measure of the air pollution emissions from a vehicle; the Euro standard scheme does not regulate the GHG emissions although that may change with Euro 7/VII. From a public health perspective, the two key SOCs emitted by ICE engines are nitrogen oxides (NO_X) and particulate matter (PM). Poor air quality is the top environmental risk to public health in the UK[1] and poor quality air is the single biggest risk to human health in Wales[2].



The Euro standards for petrol and diesel engines allow different emissions of SOCs with diesel engines consistently permitted to be more polluting. As a result, a 2006 Euro 4 petrol car meets the same emission standard as a 2016 Euro 6 diesel. Some Euro 4 petrol cars were available from 2000.

Standards for cars and LCVs are numbered Euro 1 to 6 and emissions are measured in milligrams per km driven, standards for HCVs are numbered Euro I to VI and the emissions are measured in milligrams per kWh of engine output (for clarity, they are all shown using 1 to 6 in the chart).

The HCV fleet was the first market sector required to meet in Euro VI standard in January 2014. LCVs (vans) were the last market sector required to meet the Euro 6 standard in September 2016, so this is the fleet that often has the lowest proportion of Euro 6 vehicles.

Battery electric vehicles are zero-emission (DVLA still records them as Euro 6/VI but we show them separately as ZE). However, like all vehicles, they will produce particulates from both tyres and brakes as well as recirculated road surface debris. Brake dust production may be reduced by regenerative braking, but this could be offset by the greater weight of the BEV's batteries, increasing tyre wear.

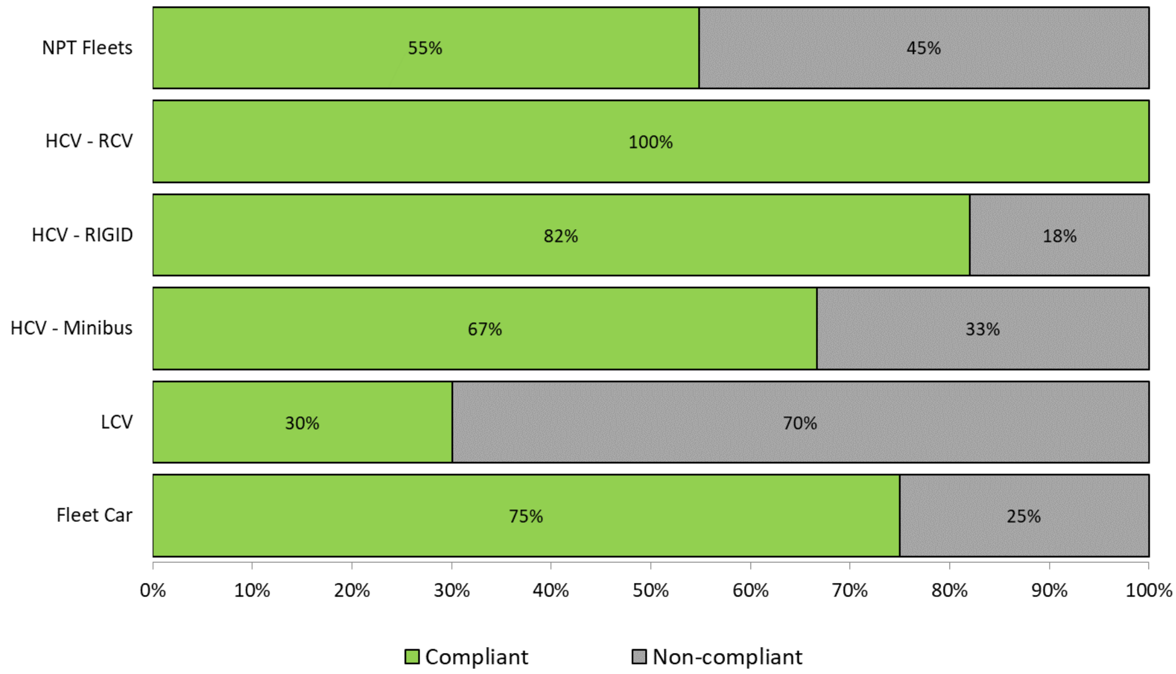
It is disappointing to see that a fleet operating in an urban area with known air quality problems has a low proportion of zero emission and Euro 6/VI vehicles and still has operational pre-Euro 5/V vehicles. Other Welsh public sector bodies have achieved a much higher percentage of Euro 6/VI vehicles, notably those where the fleet team has adopted a policy of leasing vehicles and has been able to maintain a rigorous cycle of vehicle replacement.

[1] Defra, Clean Air Strategy (UK), January 2019

[2] Welsh Government, Clean Air Plan for Wales, Healthy Air, Healthy Wales, August 2020.

5.5 Low emission/clean air zone compliance

Real time air quality information and detailed reports about the impacts of poor air quality are available on the web: Air Quality in Wales. In order to address the growing list of serious health concerns linked to poor air quality (including enhanced susceptibility to COVID-19) local authorities across Great Britain have implemented or are considering implementing low emission zones (Scotland), clean air zones (England and Wales) or an ultra-low emission zone (London).



To enter these zones without paying a charge, vehicles must meet these minimum Euro emission standards:

- Petrol engine: Euro 4 (Euro IV HCVs)
- Diesel engine: Euro 6 (Euro VI HCVs)
- Battery Electric or Hydrogen Fuel Cell (zero emission)

According to Public Health England (2014) during 2010 there were 66 premature deaths in the NPTC area attributable to particulate pollution with 662 life years lost. A similar but overlapping number of premature deaths would have been associated with NO_X pollution. More up to date regional data for Wales is not yet available online but, according to Centre for Cities data, in 2017 Swansea and NPT had the highest particulate-linked mortality of the three major South Wales conurbations.

It should be noted that the World Health Organisation fact sheet on air pollution states that there is no known safe level of particulate pollution: *"Small particulate pollution has health impacts even at very low concentrations – indeed no threshold has been identified below which no damage to health is observed."*

6 Fleet data management

6.1 Why does good data matter?

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

Where commercial vehicles and passenger services are involved, it is also important to record information about the work done; for example, the load carried (tonnes or cubic metres), bins emptied, households serviced, repairs completed, passengers transported. The performance of a fleet can then be linked back to the service it delivered and form part of a suite of Fleet Performance Indicators (FPI).

Systems have been widely available for some time to accurately monitor bulk fuel tank drawings recording both litres and mileage, record off-site fuel purchases using fuel cards, manage fleet workshops, manage the fleet itself, and track all vehicle movements. It is understood that the fleet management system at NPTC has been developed in-house but that further development is constrained by the council's IT resources. We are not in a position to comment on the suitability of the package as its functionality is not in the public domain.

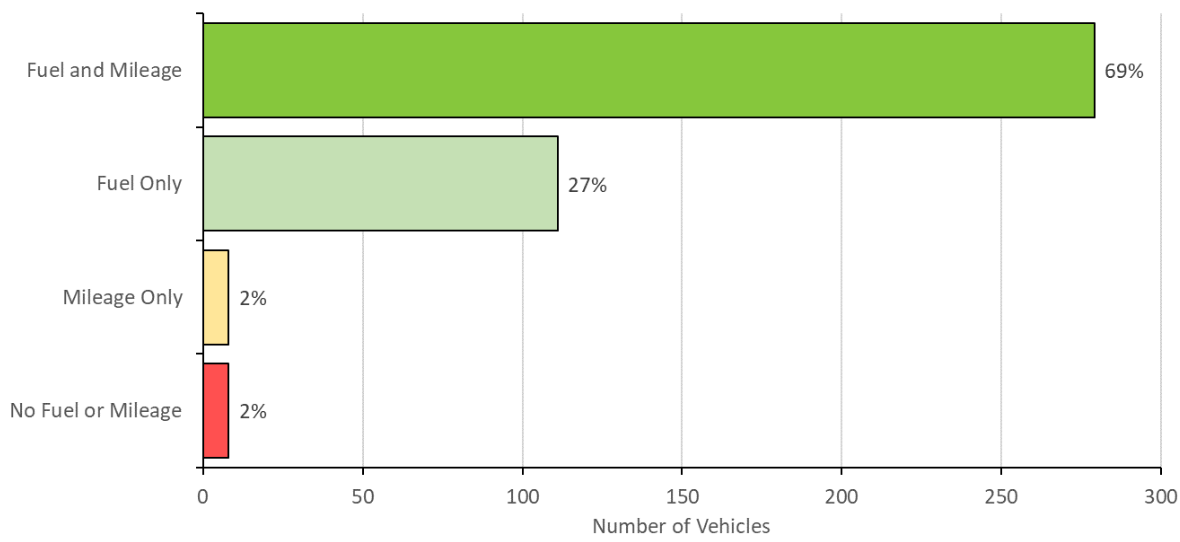
The quality of commercial systems is also variable. Some have not kept pace with developments in technology, and there is often a failure, or inability, to fully integrate the data from all the different sources. For example, combining the mileage from CANbus linked accurate tracking data with fuel purchased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

6.2 Quality of the data set supplied

The NPTC fleet team was able to supply data sets from the fuel cards, bulk fuel tanks, and the fleet management system. These three sources of data have been merged by the WGES team to provide a comprehensive view of all vehicles used and fuel drawn in 2019/20 while the current fleet list has been used to profile the fleet in late 2020. All vehicle registration marks (VRM) appearing in any source have been checked with the DVLA and the registered details of the vehicle obtained.

In 2019/20 only 69% of the fleet (279) had both fuel and mileage data, but 38 of those vehicles achieved over 70 mpg and 26 over 100 mpg. Other fuel consumption data was also suspect when the nature of the vehicle was considered with one 12 tonne kerbsider achieving 17 mpg while the rest of the fleet averaged 8 mpg. Only fuel data was available for 111 vehicles (27%), no mileage data could be linked to these vehicles.

Figure 6-1: Data set quality - fuel and mileage (excludes plant which record hours and "unassigned" fuel)



Excluded from this quality assessment is the unassigned fuel, these are the VRMs provided when the fuel was purchased/dispensed, but which are not recognised as valid registrations by the DVLA and so the type of vehicle drawing the fuel could not be determined; 1,909 litres of fuel was allocated to vehicles in this category. Also included in the unassigned group is 46,761 litres of diesel and 18,389 litres of petrol that could not be associated with any vehicle registration, however some of the petrol drawings were clearly cans for small plant, for example mowers and power tools.

6.3 Improving data quality

We understand that the operating departments reconcile fuel use on a monthly basis and that monitoring of fuel consumption and energy efficiency (mpg) is the job of all "accountable managers". However, the difficulties experienced linking fuel purchased to vehicles and mileage driven suggests that a robust audit trail of energy (fuel) purchase and use is not in place at NPTC and so there is a risk that not all the fuel procured is actually used for NPTC service delivery. It is understood that checks are made by "accountable managers" from time to time, and anomalies investigated but it would appear that the system is not systematically producing accurate energy management data (mpg or kWh/mile) based on actual fuel consumption, distance driven, or hours operated.

Integrated fleet maintenance, bunkered fuel, fuel card and telemetry data

When considering the transition to alternative fuels, the lack of accurate energy efficiency data matters. A diesel vehicle achieving 30 mpg has an energy efficiency of 1 kWh/km. The equivalent electric vehicle would be expected to use about a quarter of that and achieve 0.30-0.25 kWh/km on the same work cycle. This knowledge allows the optimum battery size of the replacement BEV to be determined and an estimate of the overnight charging capacity to be made. The information is of value whether considering battery electric, hydrogen fuel cell or any other zero emission technology as they all use energy which is measured in kWh.

It is also important that the departments that operate the fleet vehicles are on a clear pathway to ultra-low or zero carbon by 2030 in line with NPTC targets and the WG target for an ultra-low emission public sector fleet by 2030. It is therefore a requirement that the fleet systems can provide regular – at least monthly – and accurate energy efficiency, GHG emission and cost data for both service managers and drivers.

The best way to achieve this is to fully integrate the data from all possible sources – fleet management, service records, bulk fuel, fuel cards and telemetry – and make every effort to ensure that accurate data is entered when fuel is purchased. For example, staff who repeatedly enter "123" for mileage when purchasing fuel on behalf of the council must be engaged and warned that it is not appropriate behaviour and could indicate improper use of the fuel card. Organisations that have addressed this issue directly have achieved a very high level of compliance. The capture of mileage data can be further enhanced by using multiple sources, including the vehicle's telemetry, workshop service records, and data capture built-in to the recording of the daily walk-around vehicle check (which some systems now allow to be carried out using a smartphone App).

The NPTC fleet team should work with "accountable managers" to ensure that every fleet vehicle's mileage and fuel consumption is accurately recorded and is easily accessible.

6.4 Implementing future-proof telemetry

The telemetry system used on fleet vehicles should be able to accommodate both conventional ICE vehicles as well as battery electric vehicles. In particular it is very important that the system can report on the electric vehicles' consumption of electricity, the state of charge (SoC) of the battery, the number of times it has been charged, the type of charger used and the vehicle's energy efficiency in terms of miles/kWh or Wh/km. All this information should be accessible from the electric vehicle's internal information network known as the CAN bus.

Ideally, the system should also have an Application Programming Interface (API) to allow smart charging systems to access this data set to optimise charging and minimise the site's grid capacity. This is not yet commercially available, but several suppliers are working on this integration. Table 6-1 shows the result of an email and telephone survey of major UK telematics providers. Unfortunately, several have not responded to repeated requests for information about the capabilities of their systems

Table 6-1: Initial results of survey of telematic systems' EV capability

Company	Status	Battery SoC	kWh Received	Wh/mile	Charging Status	Type of Charger	Charger API
Masternaut	CAN bus	Yes	Yes	Yes	Yes	No	Unknown
Quartix	Due Q2 2021	Planned	Planned	Planned	Planned	Planned	
Teletrac Navman	CAN bus	Yes	Yes	Yes	Yes	No	Unknown
Verizon Connect	No reply						
Big Change	No reply						
Samsara	CAN bus	Yes	Not stated	Not stated	Not stated	Not stated	Unknown

Company	Status	Battery SoC	kWh Received	Wh/mile	Charging Status	Type of Charger	Charger API
Microlise	No reply						
EV Technology	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
CrystallBall	No reply						
CMS SupaTrak*	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
Pure Telematics	In development						
UK Telematics	CAN bus	Yes	Not Yet	Yes	Not Yet	Not Yet	Yes
Ctrack	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
Webfleet	CAN bus	Yes	Yes	Yes	Yes	Yes	Yes
Omnia	TBA						

* The CMS SupaTrak system is used by Dennis Eagle in all their refuse vehicles

The telemetry used by NPTC has been developed in-house but, as with the fleet management system, we understand the IT team do not have the resources to continue developing the software to accommodate the additional requirements of an electric vehicle fleet and its charging infrastructure.

NPTC must be able to determine the key parameters identified in Table 6-1 so that the electric vehicle fleet can be managed, its energy consumption monitored, and its status reported to the charging system, which will allow the optimum charging strategy to be determined.

As part of the move to a zero emission fleet, we would recommend that NPTC carries out a comprehensive review of the IT systems linked to bulk fuel tanks, fuel cards, charging infrastructure, tracking data, driver and fleet management to ensure that all these data sets can be integrated into a single system for the fleet management team and for the operating departments to use. This should allow regular reporting of driver, vehicle, and fleet performance indicators.

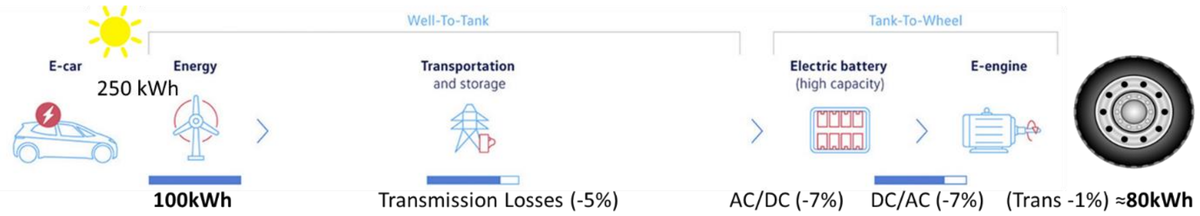
6.5 Using accurate fuel and mileage data

Accurate energy usage and energy efficiency are not only important when assessing the current environmental impact of a fleet, it is also critical when trying to determine the future energy requirements of a zero-emission electric fleet (battery, hydrogen, or possibly biofuel).

Figure 6-2: Energy efficiency of an internal combustion engine (ICE) vehicle

ICE vehicles are about 20% efficient (Figure 6-2) with the losses - mostly heat and friction - occurring in the engine and the transmission. Smaller ICE vehicles like cars and car derived vans can achieve a higher level of efficiency (up to 30%) especially if they are not used in a start-stop environment. ICE hybrids also achieve efficiencies in the order of 30% to 35% because they make use of energy recovery when braking and energy assist when accelerating to reduce the load on the ICE.

Figure 6-3: Energy efficiency of a battery electric vehicle



Business vectors created by macrovector - www.freepik.com
Other Images VW: Battery or fuel cell? That is the question

Electric vehicles are about 80% efficient (Figure 6-3) with most of the losses occurring in the conversion of AC to DC for the battery and back to AC for the motor. Other significant energy loses do occur in generating the electricity, but they are upstream of it entering the grid. As a result, BEVs will use one quarter to one third of the

ICE vehicle's energy, which gives us an indication of the battery size we will need for the replacement BEV and, therefore, whether a suitable vehicle is available.

The tracking data of the ICE vehicle should allow daily variations in energy use (kWh per day) to be determined and when aggregated across the fleet this can be modelled to provide an indication of the peak overnight charging demand (kWh) and the site Maximum Import Capacity (kVA) required.

There are approximately 10 kWh of energy in one litre of diesel and at the moment the cost of diesel excluding VAT is about £1 per litre so each kWh costs £0.10 which, coincidentally, is close to the commercial price for off-peak electricity so the 75% reduction in energy use should result in a 75% reduction in cost. These are indicative costs and can be accurately determined using the price currently paid but when considering the replacement of the fleet these costs must consider the future price of both fuels and the use off-peak tariffs which may go as low as £0.05/kWh overnight and with some experimental flexible tariffs can go negative.

It is understood that NPTC has access to significant locally generated renewable electricity capacity, and it may be possible to establish private wire connections to several local sources of renewable electricity which could power the fleet with zero emission electricity. For example, the Vattenfall Pen y Cymoid Wind Farm can generate 228 MW and has a 22MW battery storage array associated with it. There are also the Awel Aman Tawe, Lynfi Afan and Mynydd Brombil onshore wind projects which may also be able to provide zero emission power to the council's fleet depots (NPTC Decarbonisation and Renewable Strategy, May 2020). A large fleet of electric heavy duty vehicles like RCVs and RRVs represent a significant battery storage array that could be integrated into the local renewable energy supply matrix.

With only fuel data, only mileage data or inaccurate data only part of the picture is available, and the analysis has to be based on "average" daily performance of similar vehicles which may not reflect the operating environment particularly if there are local challenges such as hilly topography, particularly cold winters, or peaks of use as occurs in gritting fleets and also "school-run" vehicles.

6.6 Impact of an all-electric fleet on data management

Fleet managers will need to implement even more sophisticated telemetry and remote management tools as the fleet transitions to battery electric vehicles.

The National Grid Electricity System Operator (ESO), working with partners, has already developed and published an open system called the Carbon Intensity API which makes available the UK grid's predicted carbon intensity up to two days in advance in half-hour periods.

In the future, this forecast could be used to adjust the price paid for electricity by lowering the cost (£/kWh) when renewable generation is high (carbon intensity low), or curtailment of wind generation may occur and increasing the cost when fossil fuel generation is high (carbon intensity high). This has the aim of modifying customer behaviour as well as directly managing the activity of "smart" appliances which could include electric vehicle charging systems. The objective is to eliminate the curtailment of wind generation and flatten demand throughout the day.

In December 2019, domestic consumers on Agile Octopus tariff were, for the first time, offered a negative electricity cost because it was more cost-effective to pay consumers to use electricity than to pay wind generators to curtail generation. During the first nine months of 2020 there were 80 hours of negative electricity pricing in the UK. The electric vehicle charging system must be able to respond to this information so that periods of low carbon intensity and low cost that occur outside the normal charging hours can be utilised if the vehicle is parked, plugged in, and has battery capacity.

A large fleet of electric vehicles, including heavy good vehicles like HCVs and RCVs with 300 kWh or larger batteries, is a large "sink" for surplus renewable generation and could play an essential part in balancing the local electricity system, providing grid frequency response, and balancing services including absorbing excess capacity from renewable generation and returning it to the grid at times of peak demand (Vehicle to Grid – V2G). All these functions have a commercial value in the electricity supply market and can reduce transport energy costs.

Real-time energy and battery state of charge (SoC) data linked to smart charging systems will be essential to efficient, low cost, low emission operation of an all-electric fleet fully integrated with the site energy management systems and the local grid.

7 Improving the performance of ICE vehicles

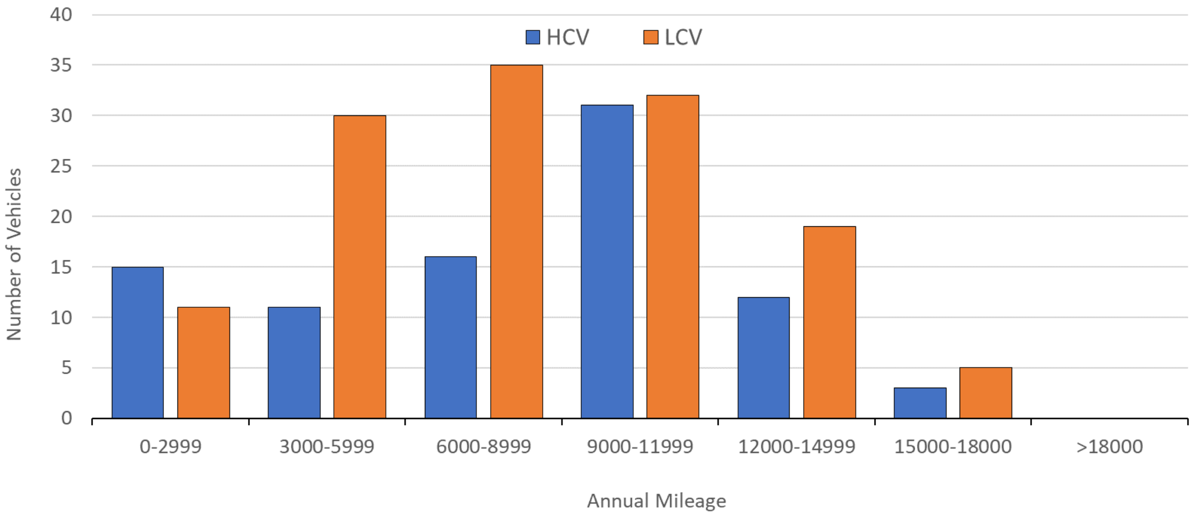
Until the whole fleet can be replaced by suitable zero emission vehicles it will be necessary to maintain the ICE fleet of diesel vehicles for five to ten years. Reducing fuel use, improving energy efficiency, and cutting costs in an ICE fleet is all about tight management of the vehicles, the drivers and fuel. The following sections focus on the type of actions needed, all of which will also benefit the efficient operation of an electric vehicle fleet.

7.1 Review vehicle utilisation

It is important to identify vehicles with a low level of use, for example, under 6,000 miles a year (average 25 miles a day). There may be a good reason for low utilisation (for example, trades working on site all day) or it may be a consequence of departmental 'silos' preventing the shared use of a resource that spends a lot of the week parked up. Departmental silos can also mean that one vehicle has a very low annual mileage while another is travelling thousands of miles, reducing its resale value. If the vehicles are treated as a corporate resource, they can be moved from low to high mileage tasks, the annual mileage evened out, and the residual value optimised.

Low mileage can have a very adverse impact on the whole life cost of battery electric ZEVs because the low mileage results in much lower cost savings from reduced energy use. Low utilisation also results in dragged out replacement cycles; a vehicle may have driven only 42,000 miles in seven years, but it is still an eight-year-old vehicle and, if it is diesel-powered, meets an old and superseded emission standard, which will have an adverse impact on local air quality as well as the health of operatives working in proximity to the vehicle.

Figure 7-1: Mileage profile of the HCV and LCV fleets (vehicles on-fleet all year with mileage)



The cars were excluded from this analysis because of limited mileage data.

Analysis of the NPTC fleet (Figure 7-1) shows that there were 27 fleet vehicles that were on fleet all year and drove less than 3,000 miles, 14 were school-based minibuses, two were mobile libraries the rest were a range of vehicles operated by several different teams. A further 46 vehicles drove between 3,000 and 5,999 miles during the year, 12 were school-based minibuses, 26 were vans associated with several departments but notably Waste (7) and Building Services (6), most were based at SRC Quays.

It is suggested that robust mileage data is obtained and an immediate review of all vehicles under 3,000 mpa is carried out and when this is complete the vehicles under 6,000 mpa are reviewed. The impact of the low mileage minibus fleets will be discussed in the section on decarbonizing this fleet, but it should be noted that large minibuses of any fuel type are expensive vehicles, more-so if equipped with wheelchair access, and if significantly underutilized are very expensive to operate. The old age profile of this fleet suggest that the high operational costs is off-set by a long operational life, but this will be associated with diesel engines meeting obsolete emission standards, high emissions of SOCs and a lack of modern driver-assist safety features.

All low mileage vehicles, diesel or electric, have a high whole life cost. Therefore, it may be more cost-effective to move some or all of these expensive low mileage vehicles to a central pool fleet or use daily rentals. In a relatively small geographic area like NPTC this may be more easily implemented than in a council servicing a large geographic area.

7.2 Introduce tight fuel management

Monitoring fuel consumption (energy efficiency) across the fleet is important as it can feed into both driver and fleet (vehicle) performance indicators as well as inform the transition to ZEVs and ULEVs.

Table 7-1: Fuel consumption (mpg) in the Car fleet.

There is almost no credible fuel consumption data available for this fleet so it as not possible to populate this table. One Kia Rio out of eight had an mpg "in range" (55.7 mpg), one Ford Fiesta out of six (25.6 – very poor and on the edge of credibility). Most of this fleet had only fuel data so it was impossible to determine energy efficiency.

Table 7-2: Fuel consumption (mpg) in the LCV fleet.

Size Class and model	Vehicles with Data	Worst mpg	Average mpg	Best mpg
3.5 t Citroen Relay	23	16.4	26.0	60.9
3.5 t IVECO Daily	37	8.3	23.6	46.3
3.1 t Vauxhall Vivaro	4	12.3	24.6	46.4
CDV - Citroen Berlingo	13	30.0	38.5	43.3
CDV – Ford Fiesta	17	42.0	49.6	62.3

This data set excludes vehicles for which either mileage or fuel was missing, or which gave 'out of credible range' results for mpg.

Table 7-3: Fuel consumption (mpg) in the HCV Minibus fleet.

Size Class	Vehicles with Data	Worst mpg	Average mpg	Best mpg
Ford Transit 17 Seat	21	12.3	30.8	52.4
Mercedes Sprinter 17 Seat	3	8.9	10.7	13.3

This data set excludes vehicles for which either mileage or fuel was missing, or which gave 'out of credible range' results for mpg.

Table 7-4: Fuel consumption (mpg) in the HCV fleet.

Size Class	Vehicles with Data	Worst mpg	Average mpg	Best mpg
Up to 7.5t IVECO 50C	6	12.2	14.6	17.1
18t Tipper	12	7.6	10.1	12.3

This data set excludes vehicles for which either mileage or fuel was missing, or which gave 'out of credible range' results for mpg.

Table 7-5: Fuel consumption (mpg) in the RCV fleet.

Size Class	Vehicles with Data	Worst mpg	Average mpg	Best mpg
26t Dennis Eagle RCV	11	2.8	4.2	6.9
12t DAF RRV	27	5.5	7.9	10.7

This data set excludes vehicles for which either mileage or fuel was missing, or which gave 'out of credible range' results for mpg.

Vehicles with fuel efficiency (mpg) in the range 61 mpg to 934 mpg (also a Ford Fiesta van) were excluded from this analysis. Even after the data has been "cleaned" the results reported in these tables are frequently at the edge of the credible range for the category of vehicle even if the average value is credible and if that's the only value reported it would not result in any further investigation.

Organisations that introduce tight monitoring of fuel use have achieved reductions of 5% to 15%, the range depending on how weak fuel management has been in the past. For example, a 5% reduction in diesel fuel use at NPTC across all fleets (excluding plant) would result in an annual cost saving of £50,000 and a reduction in GHG emissions of 119 tonnes.

This real-world saving would cover the cost of an additional resource in the fleet team focused on securing transport GHG reduction targets and any further data system improvements needed to improve analysis and reporting. A programme of regularly reporting mpg to drivers and setting departmental, fleet and vehicle-based performance targets should achieve the 5% reduction. If combined with a rigorous program of targeted training, action to reduce speeding, idling and severe braking, and driver or team incentives, it should be possible for NPTC to increase the saving to 10% or more – at least £100,000 per annum.

7.3 Downsize the LCV fleet

One way of reducing the emissions of a diesel LCV fleet and cut costs is to downsize the vehicles. NPTC has a large fleet of LCVs (224 used on fleet in 2019/20) and 109 were the largest 3.5 tonne vans.

Table 7-6: Impact of downsizing on cost, fuel consumption and carbon emissions

Model	Load kg	Load m^3	Urban mpg	NEDC CO_2	CO_2 Increase	OTR List*	Fuel £/mile
Fiesta 1.0 Ecoboost 95 Van	500	1	54.3	97		£18,169	£0.092
Transit Courier 1.5 TDCi	500-595	1.9-2.3	61.4	112	15%	£17,210	£0.089
Transit Connect 1.5 EcoBlue	580-880	2.6-3.6	56.5	117	4%	£20,204	£0.097
Transit Custom 280 L1 H2	1,200-1,600	6.0-8.3	42.2	162	38%	£30,469	£0.129
Transit 350 L3 H3 2.0 EcoBlue	1,400-2,200	9.5-15.1	32.5	201	24%	£42,415	£0.168

*The On The Road (OTR) list price is often subject to significant discount.

Table 7-6 illustrates the change in carbon emission and fuel use across the Ford range as size increases. A similar table could be produced for any of the major van manufacturers.

The cost of fuel increases by 15–25% at each major increase in size. There is also an increase in the capital cost. Research carried out by the engineering consultancy Ricardo for DfT shows that the impact on fuel efficiency of fully loading a van is a 9–10% increase in fuel consumption; therefore, it is much more efficient to have a fully loaded small van than a half-empty large one.

This means there is a GHG, operating cost and capital cost saving from using smaller vans wherever possible and avoiding the one-size-fits-all procurement model.

When vehicles are due for replacement, it is important to carry out a robust independent review of current usage and challenge the need for large vans. Factors to consider include:

- meeting the occasional need for a large van with a pool or rental vehicle,
- holding stock of spares or rarely used equipment in a central store or depot,
- using a bespoke racking solution in smaller vehicles to increase capacity,
- using local trade suppliers for ‘just in time’ delivery to site,
- using a roof rack or trailer to meet occasional need to transport large items,
- closely tailoring the tools and spares carried to the service being delivered.

The other big benefit of downsizing is that it facilitates the move to battery electric vans. There is a growing range of affordable battery electric vans up to 3.1 tonnes but the larger 3.5 tonne BEVs are expensive and at very low annual mileages can only be considered with significant additional financial support.

The 3.5 tonne vans used by NPTC during 2019/20, produced 447 tonnes of GHG, 14 % of the fleet total. The current 3.5 tonne fleet includes 34 chassis cabs or tippers (mostly IVECO Daily), and it is unlikely these could be downsized but the requirement should be tested. The rest of the current 3.5 tonne fleet, 44 vehicles, is made up of Panel/Luton vans and it may be possible to downsize some of the panel vans.

Downsizing in the HCV fleet is usually not a good option because the vehicles should have been carefully selected for their load carrying capability. Downsizing an HCV will reduce energy use but will also significantly reduce its maximum load and that can increase the GHG emissions per tonne or per cubic metre transported which is usually the purpose of the vehicle.

7.4 Establish Vehicle Performance Indicators (VPI)

The simplest VPI for an ICE vehicle is probably miles per gallon (mpg), it is certainly one most people understand but it is influenced by the driver and does not fully reflect the service the vehicle has delivered. It should be monitored, and ideally reported as both mpg and kWh or Wh per mile.

Other performance indicators can be linked to the service delivered. For vehicles moving materials the cost per tonne and the GHG emissions per tonne might be relevant. Similar indicators can be used for passenger vehicles where the usual metric is passenger-kilometre. In the RCV fleet there is the opportunity to introduce a range of metrics including kg GHG per household, per bin lift, per tonne waste collected. This can identify poorly performing vehicles or issues with round design.

Operational teams should be set targets for reducing the GHG intensity of their service – the benefit of measuring against tonnage of waste or number of passengers is that any change in the number of households serviced or passengers carried is reflected in the metric. In the LCV, fleets metrics could be linked to the mileage of roadway or number of properties maintained.

At NPTC it is understood that the departments responsible for the day to day operation of the vehicles do not have any specific improvement targets linked to fleet energy efficiency and GHG emissions. There appears to be no incentive for departments to improve driving standards and cut GHG emissions.

We would recommend that departmental fossil fuel (diesel) budgets are decreased year on year to zero, or close to zero, in 2030/31 and that the savings made are retained in the central budget and reallocated to other services and to the electricity budget, which will need to increase year on year to 30% of the current fossil fuel budget by 2030/31. Alongside these changes, every department should have an annual GHG emission reduction target in line with NPTC's GHG reduction ambitions, these could be imposed, or the department could be required to produce a plan or have them imposed. Consideration should be given to levying an internal Carbon Fee on every tonne over the target which is then used to fund NPTC GHG reduction projects.

When combined with the potential to make significant fuel cost savings of at least £50,000 per annum there is a strong business case for the creation of a fleet team role focused on fleet and driver data management as well as the ongoing review of the need for and size of fleet vehicles. This post should be a self-funding resource with the potential benefits in terms of fuel savings, reduced operational risk and even reduced accident rates (and associated costs) easily outweighing the cost of the post. In addition, departments should be required to act robustly where driver performance issues are identified.

7.5 Establish Driver Performance Indicators (DPI)

NPTC does not currently have any league tables or incentive schemes in place. We would strongly support the introduction of schemes to improve driver performance as experience across a wide range of organisations has shown them to be effective ways of improving the fleet's energy efficiency, reducing accidents, and improving driver, operator, and public safety. Accurate data is needed for any scheme to work.

These schemes tend to work best if they incorporate a range of factors, such as customer feedback (even if the 'customer' is in-house), punctuality, presentation, vehicle cleanliness, accident rate, minor damage cost, fuel consumption (mpg), harsh braking, rapid acceleration, and excessive idling.

League tables also identify good drivers who can then be given the role of 'lead driver' or 'fuel champion'. They can help promote good driving and fuel-saving initiatives across the fleet and benchmarking routes and rounds by establishing a target fuel efficiency.

7.6 Implement eco-driving training

Driver training that focuses on efficiency can be an effective and immediate way to save money by reducing fuel consumption and GHG emissions. It may also reduce service, maintenance, and repair (SMR) costs and bring safety benefits. As BEVs are introduced, it can also be used to ensure drivers make full use of the energy recovery capabilities of electric vehicles and are familiar with the procedures around charging the vehicles.

All training suffers from fade over time, so before implementing driver training, a robust fuel management system must be in place to provide regular (at least monthly) feedback to drivers and their managers on their performance. Ideally, this is supported by in-cab data to help reinforce good practice in real time.

Many new vehicles can display fuel consumption data on the dashboard, and it may just be a matter of making sure this is the default display. With robust monitoring of driver performance in place the training can be focused on those drivers who will benefit the most.

As soon as accurate data is available, a safe and fuel-efficient driver training programme should be introduced focused first on those drivers identified by poor fuel consumption or telemetry alerts as needing support.

8 ULEV transition 2021-2030

8.1 Establish a ULEV transition team

The successful transition of the NPTC road transport fleet to a ULEV fleet by 2030 will require NPTC to establish a team encompassing fleet management, the main vehicle operating departments, estates, energy management, human resources (for grey fleet), and finance. In addition, the robust appraisal of need and utilisation, changing procurement to a model based on whole life cost, funding the new fleet, putting in place the charging infrastructure to support new BEVs and addressing issues like home-based charging will require input and resources from all the groups identified above and a governance and reporting structure with full senior management engagement.

8.2 Install Electric Vehicle Charging Infrastructure (EVCI)

The specification of EVCI will be considered in detail in a separate report. We recommend that at depots and sites where fleet vehicles are based there is one charger for each vehicle. This ensures that all the vehicles are fully recharged for the next working day and allows pre-conditioning in summer and winter.

In most cases, low cost 7.4 kW AC chargers will be able to recharge all cars and vans overnight but 22kW devices could be used if there is not a significant cost penalty. Occasionally 11 kW or 22 kW AC chargers may be needed for large vans or minibuses with high daily mileage and 75 kWh or 100 kWh batteries. More substantial AC and DC systems will be required by electric HCVs, and their specification needs to be tailored to that fleet as some heavy vehicles use DC charging, but some use a pair of 22kW or 44kW AC chargers.

The EST Guide to Chargepoint Infrastructure (2017) has more information on EV charging as does the older Beama Guide To Electric Vehicle Infrastructure (2015). Also useful are the Beama Best Practice for Future Proofing Electric Vehicle Infrastructure (2020) and Making the right connections, UK EVSE, (2019).

To achieve an ultra-low emission fleet by 2030, it is essential NPTC's energy and estates teams start planning now for the move to BEVs and, when carrying out new developments or refurbishments, builds in the engineering required (for example, underground cabling ducts and site capacity) so that the charging infrastructure can be rolled out in response to a growing fleet with minimal disruption and additional cost.

8.3 Provide BEV maintenance training

For organisations with their own workshops, the Institute of the Motor Industry (IMI) provides an EV technician training programme. A full series of courses is available, and these have recently been fully revised and updated. NPTC have trained six Fleet Maintenance Technicians to City and Guilds Level 3 for repair and maintenance of full electric and hybrid vehicles. Further training of the whole team will be required as well as new workshop diagnostic equipment.

It is expected that the introduction of BEVs will reduce chassis maintenance costs by at least 40% and, while some of that saving comes from a reduction in both consumables and parts, most of the saving is reduced labour costs because servicing is so much simpler with fewer actions required. This inevitably means that a smaller workshop team is required, and this may result in a workshop that is too small to be viable.

If the whole fleet is to transition to BEVs, NPTC needs to have access to reliable servicing for the whole range of electric vehicles, including heavy commercials. This will be a requirement of other public sector bodies in the area and local companies transitioning to BEV fleets. To avoid closure of facilities, consideration should be given to broadening the service scope to maintain a viable in-house facility that can ensure the fleet is fully operational at all times.

Nottingham City Council has set up the UK's first local authority run Ultra Low Emission Vehicle (ULEV) service centre - Nottingham Electric Vehicle Services (NEVS). The website states, *"Our goal is to encourage the uptake of electric vehicles across Nottingham and the surrounding area – so that together we can reduce emissions, improve air quality, and support Nottingham's ambition to become the UK's first carbon-neutral city by 2028. Our aim is to create a regional hub for EV maintenance and knowledge sharing with local authorities, businesses, and the general public. As well as EVs, we maintain e-bikes and e-cargo bikes, making NEVS an all-round e-mobility maintenance centre!"*

8.4 Introduce a ULEV Procurement Policy

The assumption should be that all ICE vehicles will be replaced with ULEV models as part of the normal fleet replacement cycle – this policy requires a suitable electric vehicle charging infrastructure (EVCI) to be in place.

Zero emission battery electric should be the preferred technology. Other less energy efficient technologies such as hydrogen fuel cell and the very inefficient hydrogen ICE should only be considered after a full cost benefit analysis assessment in terms of the total cost of the technology per tonne of GHG emissions saved and the WLC (£/mile) of operating the vehicles.

For all cars and vans up to 3.1 tonnes, BEVs should be the default option with ICE vehicles only procured if it is demonstrated that a battery electric or plug-in hybrid vehicle is not capable of delivering the service and that the service cannot be reconfigured. It is recommended that procurement follows the process in Table 8-1 which starts with a review of the requirement and a check to see if it can be downsized.

Table 8-1: ULEV Procurement process – in almost all cases this will be a BEV

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

For vans over 3.1 tonnes, it is recognised that the electric replacements are currently expensive, but consideration should be given to long-term BEV ownership (eight to ten years in line with battery warranties) to spread the higher purchase cost over a greater total mileage. Downsizing is also important and requests for 3.5 tonne vans should be challenged to ensure the service cannot be delivered in a 3.1 tonne van or smaller saving over £20,000. Additional vehicles where current assets are underutilized should be robustly challenged because of the high capital cost of BEVs. A well utilized BEV can save money. An underutilized BEV costs money.

The HCV fleet is more complicated. A strong business case can often be made for replacing refuse collection vehicles (RCVs and RRVs) with electric models over a 10-year replacement cycle, but in some challenging operations – such as waste trunking to processing sites – there may not be an available BEV solution yet. However, the advent of powered axles known as e-axles and lighter, lower cost, more energy dense (kWh/kg) batteries should mean that within five years, 500 kWh battery electric RCVs and RRVs will be available. Buses with 525 kWh batteries are already in production in Europe (VDL Bus & Coach).

It should also be possible to build a WLC business case for other specialist heavy vehicles such as sweepers, gritters, tippers and tankers, but it could be up to five years (2025) before the full range of options with a whole life cost similar to or less than the ICE vehicle is available.

It is challenging to predict when new zero-emission vehicles will be available as the market is very dynamic. While a particular type of vehicle may be available, obtaining one with the required load and towing capability may still be a year or two away. In Appendix E we have attempted to give a picture of when different categories will be available from the OEMs based on recent announcements. In general, there is a progression over time from limited availability with limited capability to full availability and ICE-equivalent capability.

8.5 Use a Whole Life Cost (WLC) selection model

A WLC model calculates all of the predicted costs of owning and operating a vehicle over its operational life, including the funding method (outright purchase or lease), servicing (often included in the lease), vehicle excise duty (also usually included in a lease), minor damage repairs, National Insurance Contributions (when applicable), fleet management overheads, telemetry system costs, fleet insurance and the fuel or energy cost.

Why use Whole Life Cost for vehicle procurement?

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

Over a battery electric vehicle's operational life, the 70% to 75% reduction in energy cost may completely offset the higher purchase or lease cost and can result in an overall cost saving. Electric vehicles are also mechanically simpler, with significantly fewer components in the drive train and without a complex transmission and exhaust system. As a result, chassis maintenance costs are also much lower, up to 40% less. Still, over an extended operational life of eight to ten years the saving may be even greater as ICE vehicles can incur significant costs in later years. In addition, the failure of one component can be very expensive - for example, replacing a gearbox or an exhaust catalyst system. This saving can further help to offset the higher purchase cost or add to overall cost savings.

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

The charts in the following sections which cover ULEV cars and vans detail:

- fixed overheads – general repairs, management, insurance
- lease cost – includes purchase cost, residual value, grants, VED, servicing and tyres
- cost of fuel/electricity – cost of energy over the lifetime of the vehicle.

The GHG emission calculation of the BEVs assumes they are charged from the UK grid overnight and includes transmission and distribution (T&D) losses (Scopes 2 and 3).

The cost models we have used are based on leasing prices obtained from a public sector framework. We have assumed a nominal annual cost for repairs (for example a broken wing mirror) for insurance and for fleet management (Cars £1,275 per annum, Vans £1,475 per annum) but these have almost no impact on the final cost comparison as there is no reason to believe they will differ between propulsion types. These costs do have a role to play when comparing a pool fleet operating cost with grey fleet mileage or internal fleet costs with contracted out services.

With a BEV there will also be a significant reduction in GHG emissions and no exhaust emissions of SOCs. The fuel cost and GHG emission calculations in the WLC models that appear in this report are based on the cost assumptions and emission factors in Table 8-2.

Table 8-2: Costs and emission factors included in the WLC models presented in this report

Item Description (Cost period 2021 to 2024)	Value	Units
Four year average diesel cost (ex VAT)	£1.10	£/litre
Four year average petrol cost (ex VAT)	£1.00	£/litre
Four year average commercial electricity cost – peak (ex VAT)	£0.14	£/kWh
Estimated four year average electricity cost – off peak (ex VAT)	£0.10	£/kWh
Average GHG emissions of diesel (DBEIS 2020)	2.546	$kgCO_2$/litre
Average GHG emissions of petrol (DBEIS 2020)	2.168	$kgCO_2$/litre
Average emissions of electricity (CCC/DBEIS) (Appendix B)	0.180	$kgCO_2$/kg
GHG Shadow Price: HM Treasury Non-traded Central Cost	£72.17	£/tonne

If an organisation has access to low cost finance, it may be more cost effective to purchase vehicles and then transfer them to a head lease facility.

The quotes in these WLC calculations have been updated following the recent reductions in the OZEV grants for zero emission vehicles but we are not certain the impact of the change is fully reflected in the quotations.

As a result of the reduction in grants and the lowering of the maximum cost threshold some OEMs have already adjusted their list prices and others may also adjust their pricing over the next few months. Initial analysis suggests that the changes have raised the threshold for a BEV to break even with the equivalent ICE by 1,000 mpa to 2,000 mpa making low mileage vehicles even more challenging to replace economically but some prices have not changed at all which may be due to pre-registered stock or OEMs absorbing the changes.

8.6 Adapt the fleet renewal policy to ULEVs

With a diesel ICE fleet, it is important to establish and maintain a rolling fleet renewal programme although that does not seem to have been the case at NTPC which has a lot of older vehicles on the fleet. Pre-Euro 6/VI diesel engines have high emissions of NO_X and PM. Ongoing improvements in emission technology and standards mean that even Euro 6/VI vehicles will be superseded by cleaner models with Euro 7/VII now under consideration (Euro 7).

The same is not true of electric vehicles, which have no tailpipe emissions, although there are emissions associated with the generation of the electricity used to recharge them. BEVs, like all vehicles, do produce particulates from their brakes and tyres and recirculating particulates are drawn up from the road surface as they drive.

Unlike diesel vehicles, keeping BEVs for longer does not have a negative impact on either GHG emissions or air quality. Indeed, as the UK grid decarbonises, the BEV's GHG emissions will fall year on year. This means the higher procurement cost of an electric vehicle can be deferred over a longer period of ownership without adverse environmental impact.

Where the normal ICE replacement cycle in use at NPTC does not result in an overall cost saving for the BEV we would recommend aligning the replacement cycle with the vehicle's battery warranty, at NPTC this might mean extending the planned replacement cycles from seven to eight or, in some cases, ten years.

8.7 Consider including carbon accounting

Implementing GHG emission reductions may have associated costs. Deciding what costs are acceptable is best achieved by putting a price, or value, on every tonne of GHG (tCO_2e) saved.

The shadow price of carbon is an estimate of the cost to society of the GHG emissions. It can be used to assess the value for money of GHG reduction projects and the social cost of projects that increase GHG emissions. Many companies use a shadow price including ASDA, Novartis, BP, and Shell. Some use an "Internal Price" or "Carbon Fee" which is a charge is made to departments based on their GHG emissions, companies in this group include Microsoft, Disney, and Ben & Jerrys – the funds are then used to reduce GHG emissions, either within the company or by purchase of accredited carbon off-set.

There has been significant debate around exactly what this cost should be; the ten OECD countries with the highest emissions reported a carbon price from $5/$tCO_2e$ to over $400/$tCO_2e$.

In the UK, HM Treasury has produced a shadow price to be used in policy appraisal at a national level. The Treasury shadow price places a higher cost on future carbon emissions. For example, in 2021 the non-traded central price was £69 per tonne, in 2030, it rises to £81 per tonne. This reflects the greater impact of emitting a tonne of GHG in 2030 on the UK's ability to reach its GHG targets, and the higher social cost of cumulative emissions.

These prices are in line with the World Bank High-Level Commission on Carbon Prices who concluded: "The carbon-price level consistent with achieving the Paris temperature target is at least US$40–$80/tCO_2e by 2020 and US$50–$100/tCO_2e by 2030" Report of the High-Level Commission on Carbon Prices, May 2017.

9 Opportunities for using ULEVs at NPTC

9.1 ULEV technology in scope

This section looks at opportunities for replacing conventionally powered ICE vehicles on NPTC's fleet with ultra-low emission vehicles – usually this will be a zero emission BEV. We will occasionally recommend a plug-in hybrid electric vehicle or a range-extended electric vehicle where a BEV is not practical, and a hybrid or range-extended vehicle offers real GHG reductions because there is a significant opportunity to use it in electric-only mode.

Other technologies like Hydrogen Fuel Cell (H2FC), or even the very energy inefficient Hydrogen ICE, should only be considered where there is not a suitable battery electric technology available or expected to become available by 2030. Production H2FC HCVs are not expected to be made widely available by OEMs before 2028-30 and a reliable, affordable source of ultra-low (blue) or zero-carbon (green) Hydrogen will be needed to support a suitable H2FC vehicle. The WLC of the H2FC vehicle will also need to achieve similar energy cost savings to those achieved by BEVs.

WGES is aware of the hydrogen hub at Swansea University but with no suitable production vehicles available in the UK and no costings for the vehicles or the fuel it is not possible to include the H2FC option in the whole life cost models used in this report. Current H2FC vehicles cost a lot more to buy than their BEV equivalents and the current market price of green hydrogen (£10/kg) make the vehicles more expensive to operate (£/mile) than the diesel vehicles they replace. According to work covering North East Scotland carried out by Cenex the price of green hydrogen needs to fall below £6/kg for the operating cost (fuel only - not the whole life cost) to break-even with diesel.

9.2 Identifying suitable ULEV options

The factors to consider when selecting a suitable ULEV include:

- typical daily journey length and load – longest daily trip, maximum load.
- single-charge range – usually avoiding charging during the working day.
- carrying capacity – seats in cars and MPVs, weight, and volume in LCVs, functionality in HCVs.
- towing capacity – with BEVs under 3.5 tonnes this is currently limited to 1 tonne.
- whole life cost (WLC) – cost over the operational lifetime.
- grant funding available – any funding to cover whole life cost difference.

The first step is to identify vehicles that, based on type, annual mileage, average daily mileage, and average daily energy consumption (kWh adjusted for EV efficiency) might be replaced by a commercially available ULEV.

At NPTC, the poor quality energy efficiency data has made this process more difficult, and the results must be treated with caution. To produce a definitive ULEV Transition pathway for all the fleets more accurate data combined with use of telemetry (ideally CANbus linked) will be needed.

However, an initial analysis of the estimated average daily EV energy consumption of the principal fleets (Table 9-1) suggests that where models are available, and funding is not an issue, the whole fleet can be replaced by BEVs currently on the market and that by 2030 the whole fleet could be replaced by BEVs as a full range of suitable BEVs should be available by 2025 including HCVs up to 32 tonnes and 3.5 tonne 4x4 pickups.

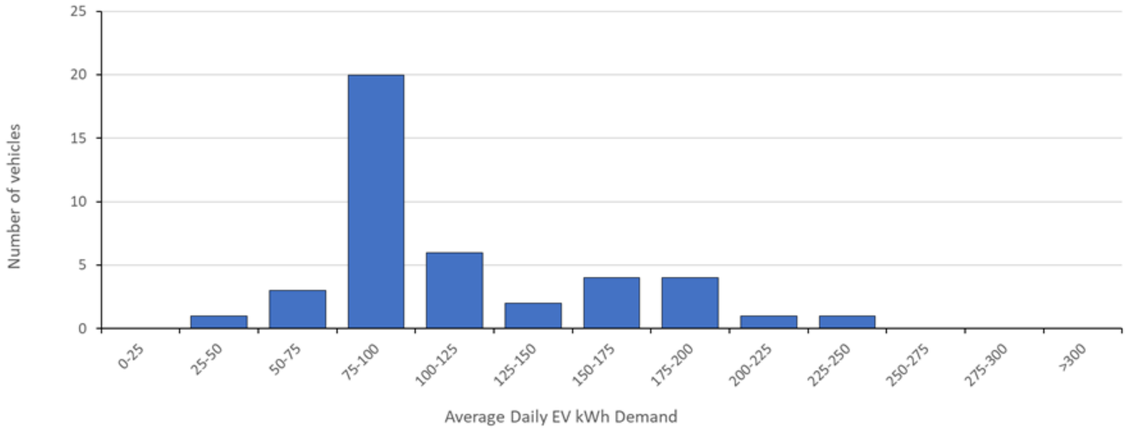
Table 9-1: Summary of annual mileage and estimated EV energy requirement across key fleets (30% ICE)

Fleet	Average Annual Mileage	Maximum Annual Mileage	Average kWh/WD*	Maximum kWh/WD*	Battery Sizes OEM Vehicles
HCV – Refuse and Recycling Vehicles	12,339	25,722	115	245	Up to 300 kWh
HCV – Rigid – Tippers, Gritters etc.	7,118	16,123	46	149	Up to 300 kWh
HCV – Minibus (9-17 seat)	7,248	nvd	14	53	Up to 75 kWh
LCV – vans up to 3.5 tonnes	9,163	27,268	18	53	Up to 75 kWh
Fleet Car – SUV, MPV, Estate etc.	No valid data (nvd)		10	20	Up to 100 kWh

*WD = Working Day, based on diesel energy use adjusted for BEV energy efficiency.

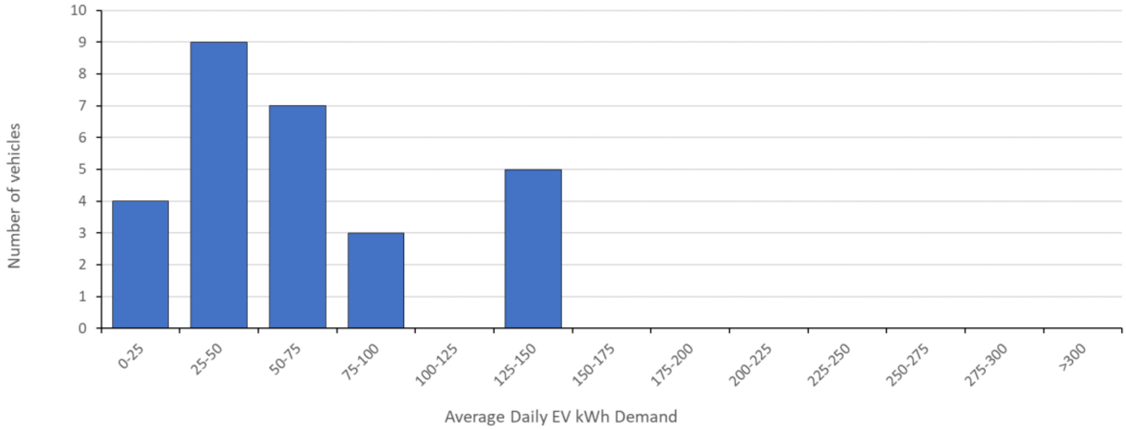
A vehicle by vehicle inspection of the base data indicated that in all fleets the high-mileage, high-energy vehicles are a minority case and in some cases the data may not reflect real world operation.

Figure 9-1: Average daily energy use (kWh) of an all-electric RCV/RRV fleet (30% ICE energy use)



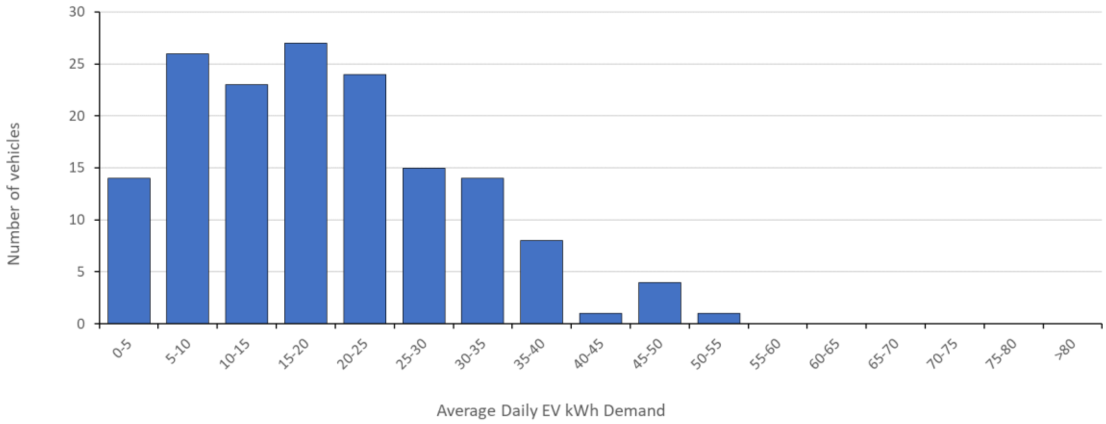
In the 12 tonne RRV fleet the BEV working day energy requirement ranged from 82 kWh/day to 99 kWh/day. The smaller 12 tonne battery electric RRVs are currently equipped with 160-180 kWh batteries so the data would suggest that all of the fleet could be transitioned to BEV with the available technology. In the 26 tonne RCV fleet only two vehicles exceeded 200 kWh/day, one requiring 241 kWh/day which may be marginal and requires further investigation.

Figure 9-2: Average daily energy use (kWh) of an all-electric HCV fleet (30% ICE energy use)



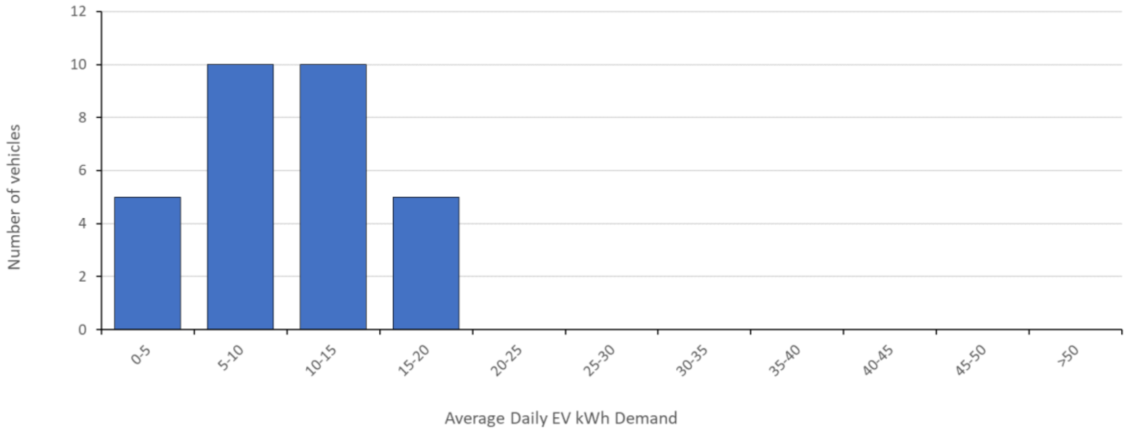
The HCV-Rigid fleet is very low mileage and the lowest mileage vehicles were the library units and the play bus. The vehicles with the highest energy requirement included the two gully jetters, a 15 tonne sweeper and a high volume tanker.

Figure 9-3: Average daily energy use (kWh) of an all-electric LCV fleet (30% ICE energy use)



In the LCV fleet only nine vehicles exceed 40 kWh/day, all were 3.5 tonne chassis cab tipper vans. In this size class battery sizes up to 79 kWh are currently available but 100 kWh batteries will be available within 2-3 years if not earlier.

Figure 9-4: Average daily energy use (kWh) of an all-electric car fleet (30% ICE energy use)



In the car fleet all the cars which had any fuel data were below 25 kWh/working day, but this may not reflect seasonal variation in use or the use of daily hires for long distance journeys – data quality was poor in this fleet. Most modern battery electric cars have 40-100 kWh batteries, and a 200 mile single charge range is not unusual. The Renault Zoe has a 55 kWh battery.

9.3 Detailed analysis of telemetry

The use of "average working day" data does hide daily variation in usage. Some vehicles identified as candidates for electrification may have days outside the operational envelope of currently available BEVs. In those circumstances, it may be necessary to reconsider the usage pattern of that vehicle to offload the unsuitable duties or rounds onto a residual diesel ICE fleet until a suitable BEV or other ULEV is available. Short term hire vehicles may also have a role to play in meeting a one-off requirement like a minibus needed for the annual school field trip.

It should be possible to use the fleet telemetry data to identify vehicles that have significant daily variation in usage. The next step is to extract the annual telemetry data for all the vehicles equipped with it, establish actual daily mileage, and link that to accurate energy consumption (fuel use). This will highlight any high-mileage or high-energy days which cannot be completed using available BEV technology. If combined with tracking data, it should also identify any opportunities for top-up charging during the working day (for example during the driver's statutory breaks).

Once a vehicle has been confirmed by telemetry as suitable for electrification using a BEV it will be necessary to agree with service managers and drivers that the evidence shows the single-charge range of a BEV is adequate (the user's perception of daily mileage is often inflated), determine whether the BEV is able to carry the required load and whether it is, or could be, based at a location where charging infrastructure can be installed or is already available.

A vehicle shuttling back and forth all day and all week between the waste transfer station and recycling processors may have a very high annual mileage but, because it spends some time at each site before starting the next journey, there are opportunities for rapid top-up charging during the day. In this operational case, the fuel, GHG, and energy savings of the BEV can be very significant.

A school bus used for the school run may have long periods during the day stood idle. This may mean it only needs sufficient single-charge range to complete the morning pick-up journey and it can then be recharged before the return drop-off journey in the afternoon, this will require charging infrastructure at the school.

These are both situations where the telemetry data can be used to identify periods during the day when the vehicle is at a location where it can receive a top-up charge.

Having identified vehicles that a BEV can replace, and agreed the replacement with the service delivery team, the next step is to use a WLC model to cost the ICE and BEV options over their expected operational life.

10 Moving to a zero emission car fleet

10.1 Description of the current car fleet

There were 32 cars on the fleet in September 2020 with the most common makes being Kia (9), Ford (7), Peugeot (7) and Renault (4). Most of the fleet (26) were hatchbacks.

Table 10-1: Sample of the range of cars on the fleet

Make	Model	Category	Qty	Fuel	Average OEM gCO_2/km	Uplifted* gCO_2e/km	Average Annual Mileage
Kia	Rio	Hatchback	7	Diesel	93	125	Data unreliable
Ford	Fiesta	Hatchback	3	Diesel/Petrol	106	140	Data unreliable
Peugeot	208	Hatchback	4	Diesel	89	117	Data unreliable
Seat	Alhambra	MPV – 7 Seat	1	Diesel	130	173	Data unreliable

*Uplifted: Real World GHG emissions adjusted using DBEIS methodology – typically 30% to 40% higher than NEDC OEM factor.

10.2 Electrification of the car fleet

There is now a very wide range of battery electric cars available (over 140), covering the full range of requirements from low cost pool vehicles to luxury four wheel drive models. The price premium over the ICE model has fallen significantly. If their annual mileage reflects their battery size (kWh) and single charge range capability, then they can cut GHG emissions, quickly recover the GHG embedded in the manufacture of the battery and cut costs.

Most of the vehicles in the NPTC car fleet could be replaced by equivalent models. The Renault Zoe would be a suitable replacement for the Kia Rio, Ford Fiesta and Peugeot 208 although a direct replacement for the 208 is the e208.

The Nissan e-NV200 Combi can accommodate up to seven occupants, the Renault Kangoo ZE five occupants (a new Kangoo is due later in 2021 with a larger battery) while the Citroen e-SpaceTourer (Vauxhall Vivaro e-Life) and Mercedes EQV300 can accommodate up to nine people (including the driver). These would be suitable replacements for the Seat Alhambra and Kia Sedona.

Table 10-2: Safety, battery capacity, range, and charge time of suitable electric cars

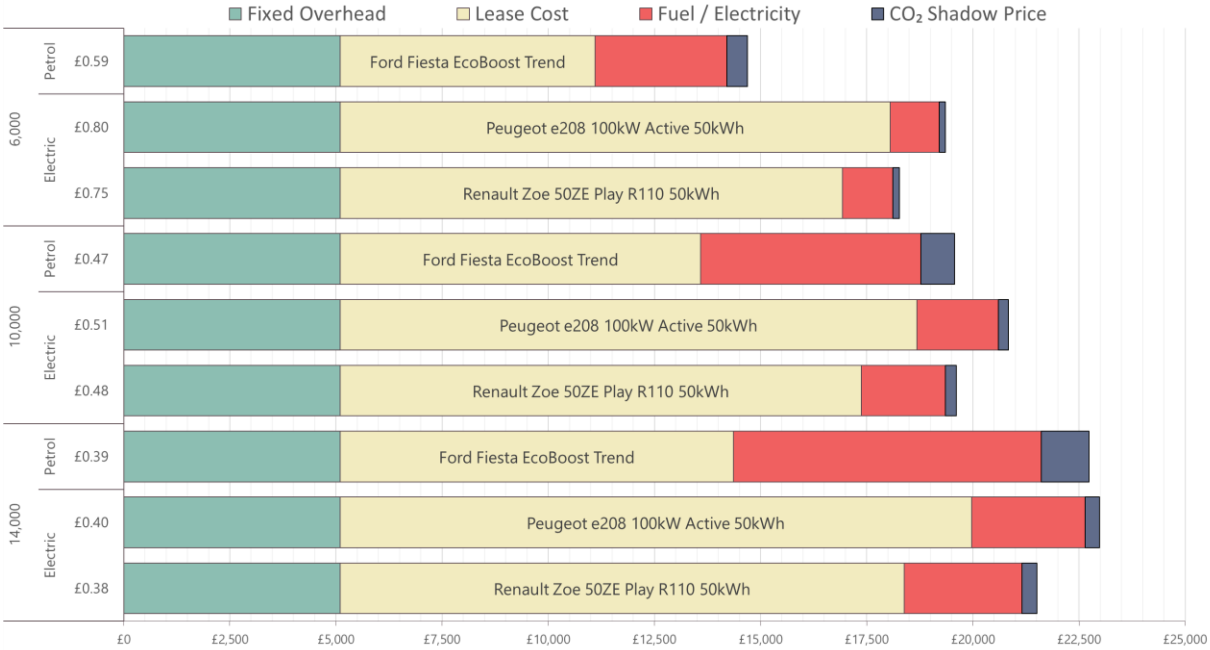
Make	Model	NCAP	Battery kWh	RW Range[1]	7.4 kW AC	DC
Peugeot	e208 (Hatch)	4 Star*	45	145-200	7.25 hrs	27 min 100kW
Vauxhall	e-Corsa (Hatch)	4 Star*	45	145-200	7.25 hrs	27 min 100kW
Peugeot	e2008 (SUV)	5 Star*	45	130-175	7.25 hrs	27 min 100kW
Renault	Zoe 50ZE R110 (Hatch)	5 Star	55	165-225	8.5 hrs	56 min 46kW
Nissan	Leaf (Hatch)	5 Star	62	170-230	7.25 hrs	35 min 100kW
Hyundai	Kona (SUV)	5 Star*	64	205-285	10.25 hrs	44min 77kW
Citroen	e-Space Tourer (MPV)	Not tested	50 or 75	95-125	7.5 hrs	30 min 100kW
MG	5EV (Estate)	Not tested	55	175-270	8.75 hrs	36 min 80kW
Skoda	Enyaq iV 80X	Not tested	82	205-270	12.25 hrs	36 min 125kW

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

10.3 Whole life cost – small hatchback cars

Comparison of the petrol Ford Fiesta Ecoboost hatchback which is a similar to the Ford Fiesta on fleet at NPTC with electric Peugeot e-208 and Renault Zoe (48 month lease, 6,000, 10,000 and 14,000 mpa).

Figure 10-1: WLC comparison of diesel and electric cars



No accurate mileage data was available for the NPTC car fleet. We have modelled whole life costs to cover 6,000 mpa to 14,000 mpa. The WLC model shows that the Renault Zoe is the lowest cost option at all mileages over 10,000 mpa if the shadow price is considered. Break even occurs at just over 10,000 mpa.

Table 10-3: Cost and GHG comparison at 10,000 mpa

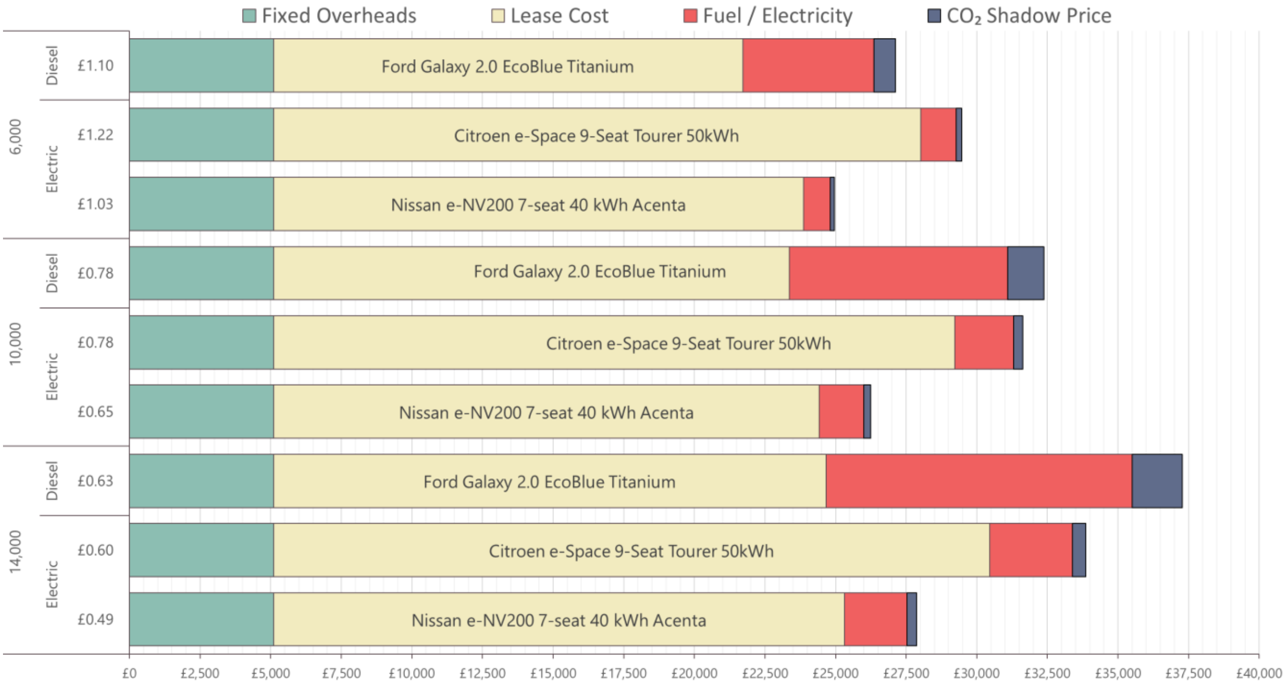
Make and Model	Power	Purchase	£/mile	Whole Life GHG (t)	GHG Shadow Price
Ford Fiesta EcoBoost Trend	Petrol	£11,103	£0.47	11.2	£798
Renault Zoe 50ZE Play R110 50kWh	Electric	£21,361	£0.48	3.6	£253
Peugeot e208 100kW Active 50kWh	Electric	£29,940	£0.51	3.4	£244

The Renault Zoe will reduce GHG emissions by an estimated 7.6 tonnes, over the 48 month lease period and 40,000 miles.

10.4 Whole life cost – large MPVs

Comparison of 7-seat Ford Galaxy diesel hatchback which is based on the same vehicle as the Seat Alhambra as used at NPTC with the electric 7-seat Nissan e-NV200 and the 9-seat Citroen e-Space Tourer (48 month lease, 6,000, 12,000 and 14,000 mpa).

Figure 10-2: WLC comparison of diesel and electric cars



We have modelled whole life costs to cover 6,000 to 14,000 mpa. The WLC model (Figure 10-1) shows that the Nissan e-NV200 is the lowest cost option at all mileages over 6,000 mpa and the larger Citroen e-Space Tourer has a similar cost to the Ford Galaxy at 10,000 mpa.

Table 10-4: Cost and GHG comparison, cars at 8,000 mpa

Make and Model	Power	Purchase	£/mile	Whole Life GHG (t)	GHG Shadow Price
Ford Galaxy 2.0 EcoBlue Titanium	Diesel	£22,281	£0.90	14.3	£1,017
Citroen e-Space 9-Seat Tourer 50kWh	Electric	£26,489	£0.95	3.8	£267
Nissan e-NV200 7-seat 40 kWh Acenta	Electric	£26,865	£0.80	2.8	£201

The Nissan e-NV200 will reduce GHG emissions by an estimated 11.5 tonnes, over the 48 month period and 32,000 miles. Even without the shadow price applied, the BEVs are the lowest cost option so the savings achieved by the electric vehicles represent good value for money.

10.5 Cars that could be transition to ULEV

Because of the quality of the mileage data, this transition strategy is indicative only. Moreover, it is based on the type of vehicle rather than a robust analysis of its suitability in terms of single-charge range. With better data – tracking and fuel use – a more refined analysis could be carried out.

Table 10-5: Proposed programme for ULEV car fleet (based on a seven year replacement cycle)

Category	Example Electric Vehicle	2021	2022	2023	2024	2025	2025-30	Total
Hatchback	Renault Zoe, Nissan Leaf	6	2		8	5	5	26
SUV	Peugeot e2008				1	3		4
MPV	Citroen e-Space Tourer	1				1		2
Total		**7**	**2**	**0**	**9**	**8**	**5**	**32**

11 Moving to a zero emission van fleet

11.1 Description of the current LCV fleet

During 2019/20 NPTC used 224 LCVs and at the end of September 2020, 163 were on the fleet. That fleet is split between 73 large 3.5 tonne vans and chassis cabs (small lorries), nine medium vans (2.6 to 3.1 tonnes), and 62 car derived vans (CDV – up to 2.6 tonnes). There are also ten four wheel drive pickups and nine small minibuses.

The more common makes are Ford (44), Citroen (37), IVECO (30), Vauxhall (19) and Peugeot (17). Seven other manufactures have between one and seven vehicles on fleet. The Ford fleet includes large 3.5 tonne Transit (3), medium Transit Custom (4), smaller Connect (10) and small Courier (3) as well as Ranger 4x4 pickups (5) and Fiesta CDV (19). The Citroen fleet includes the 3.5 tonne Relay (19) as well as the CDV Berlingo (12) while the IVECO fleet is made up entirely of the Daily (30). The most common Peugeot model is the 3.5 tonne Boxer (10) CDV.

The 3.5 tonne vans average 10,319 mpa, the medium vans travel an average of 9,952 mpa and the small CDVs average 8,672 mpa but the mileage data is not robust. Across all LCV categories the predicted average daily BEV energy consumption is estimated to be only 18 kWh. There are four vehicles over 40 kWh/day. All of which suggests the majority of the van fleet could be transitioned to BEVs with current models or, for those with more challenging load and towing requirements and the 4x4 pickups, over the next 2-3 years as more capable models become available.

11.2 Electrification of the LCV Fleet

In the small van size class (car derived vans up to 2.6 tonnes), Renault Zoe Van, Renault Kangoo ZE, Renault Kangoo Maxi ZE, and Nissan e-NV200 and Maxus eDeliver 3 are all available to order although there are shortages of supply and a new model of the Kangoo has just been announced which may mean that to old model becomes unavailable. New-model versions of the Stellantis/PSA group Peugeot ePartner, Citroen eBerlingo and Vauxhall e-Cargo, with significantly larger batteries and improved capabilities, should also be available in Q4 2021. These are all practical battery electric vehicles which achieve real world GHG emission reductions and at the right annual mileage can also reduce WLC.

Table 11-1: Payload (kg) and load space (m^3) of electric and diesel vans under 2.6 tonnes

Make	Model	Fuel	Battery (kWh)	RW Range[1] (Miles)	Maximum payload (kg)	Capacity Cubic metres
Renault	Zoe Van	Electric	50	150 - 233	368 – 380	1.0
Renault	Kangoo Maxi ZE	Electric	33	75 - 115	605	4.0
Nissan	e-NV200	Electric	40	80 - 130	705	4.2
Maxus	eDeliver 3	Electric	35 or 53	90 - 150	865 - 1020[2]	4.8
PSA Group	e-Partner/Berlingo/Cargo	Electric	50	170	800 (tow 750)	3.8/4.4
Ford	Fiesta Van	Petrol			508	1.0
Renault	Kangoo Maxi	Diesel			800	4.0
Ford	Transit Connect	Diesel			630 - 720[2]	2.9 to 3.6
Peugeot	Partner	Diesel			650 - 1,000[2]	3.3 to 4.4

[1]Real World Range – minimum based on winter use (-10°c) with heating.
[2]Depends on the motor/engine power output chosen and vehicle length.

In the Medium LCV size class (Table 11-2) the joint-venture 3.1 tonne van from Toyota (e-Proace) and the PSA Group (Vauxhall/Opel Vivaro-e, Peugeot e-Expert, and Citroën ë-Dispatch) is available. These vans have a good range with two battery size options, a good carrying capacity and a good towing capacity. The vehicles are competitively priced which means that an affordable and practical medium sized electric van is available. Centrica (British Gas) have ordered several thousand of the larger battery 75kWh Vauxhall Vivaro-e.

Table 11-2: Payload (kg) and load space (m^3) of electric and diesel vans, 2.6- 3.1 tonnes.

Make	Model	Fuel	Battery (kWh)	RW Range[1] (miles)	Maximum payload (kg)	Size[3]
PSA Group	e-Expert/Dispatch/Vivaro	Electric	50 or 75	140 - 205	1,000 - 1,250[2]	L1, L2, L3
Toyota	e-Proace	Electric	50 or 75	140 - 205	1,000 - 1,250[2]	L1, L2, L3
Mercedes	e-Vito	Electric	41	81 - 110	920	L2, L3

Make	Model	Fuel	Battery (kWh)	RW Range[1] (miles)	Maximum payload (kg)	Size[3]
PSA Group	Expert/Dispatch/Vivaro	Diesel	-	-	1,400	L1, L2, L3
Ford	Transit Custom	Diesel	-	-	1,575 - 1,725	L1, L2

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

In the 3.5 tonne van size class (Table 11-3), the practical choice is more restricted. The first generation vehicles such as the Renault Master ZE are expensive and have limited capabilities because of small batteries. Newer vehicles such as Fiat E-Ducato and Maxus Deliver 9 are more capable with a longer range and greater carrying capacity. The recently launched Ford E-Transit also appears to be a very capable vehicle but will not be available until early 2022 and UK pricing has not been released. Stallantis/PSA Group have announced the e-Boxer and e-Relay which will be joined by the Movano-e (currently based on the Renault Master platform) but no on-sale date has been released for the Stellantis/PSA range.

Figure 11-1: Peugeot e-Boxer due out later in 2021

Table 11-3: Payload (kg) and load space (m³) of electric and diesel vans, 3.5 tonnes.

Make	Model	Fuel	Battery (kWh)	RW Range[1] (miles)	Maximum payload (kg)	Size[2]
Fiat	E-Ducato	Electric	47 or 79	91 - 148	1,900	L1-3/H1-3
PSA Group	e-Boxer, e-Relay	Electric	37 or 70	124 - 211	1,890	L1-4/H1-3
Maxus	eDeliver 9	Electric	50, 72, 88	136 - 150	1,400	L1, L3
Mercedes	eSprinter	Electric	55	96	774	L2 H2
Renault	Master ZE	Electric	33	50 - 75	1,000	L1, L2, L3
VW/MAN	eCrafter/eTGE	Electric	36	65 - 70	1,700	L1-3/H1-2
PSA	e-Boxer/e-Relay/Movano-e	Electric	37 or 70	124 - 211	1,260 - 1,890	L1-L4/H1-H3
Ford	E-Transit	Electric	67	108 - 126	1,470 - 1,970	L1-3/H1-3
Renault	Master	Diesel	-	-	870 - 1,480	L1, L2, L3
Peugeot	Boxer	Diesel			1,125 - 1,570	L1-L4/H1-H3
Ford	Transit 350	Diesel	-	-	1,280 - 1,825	L2/H2-L4/H3

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

Some of these vehicles are conversions of the existing ICE chassis, for example the VW eTransporter is produced for VW by ABTe and the Stellantis/PSA range is produced by BEDEO. Of all the vans in this size class only the LDV EV80 (recently replaced by the Maxus eDeliver 9), has seen large scale commercial uptake in the UK (for example Milk and More) but DPD has recently placed an order for 100 of the 2021 model MAN eTGE for use in urban deliveries in the UK and Amazon Europe has ordered 1,800 Mercedes electric vans; 600 eVito and 1,200 eSprinter for use across Europe.

If the larger 3.5 tonne NPTC vans can be downsized to 3.1 tonnes the new range from Toyota/PSA Group are a suitable and very cost-effective replacement. Even if a suitable electric 3.5 tonne version is available (for example Fiat E-Ducato) downsizing will still deliver bigger cost, energy, and emission reductions.

11.3 eBikes and eCargo bike logistics

There are 10 small vans on the fleet that, based on the data provided drive no more than 5,000 miles a year or an average of 20 miles a day. This is within the daily range of an electric-assist bike or cargo bike (eBike or eCargo bike). Providing the load carried is small, this may represent a viable alternative to the use of a car or small van and can be very effective in congested urban areas.

There are significant health benefits from using bikes (WG Active Travel Guidance 2020) and organisations that have adopted eBikes report improved employee attendance and wellbeing. More information about cargo bikes of all types is available from the European Cycle Logistics Federation website.

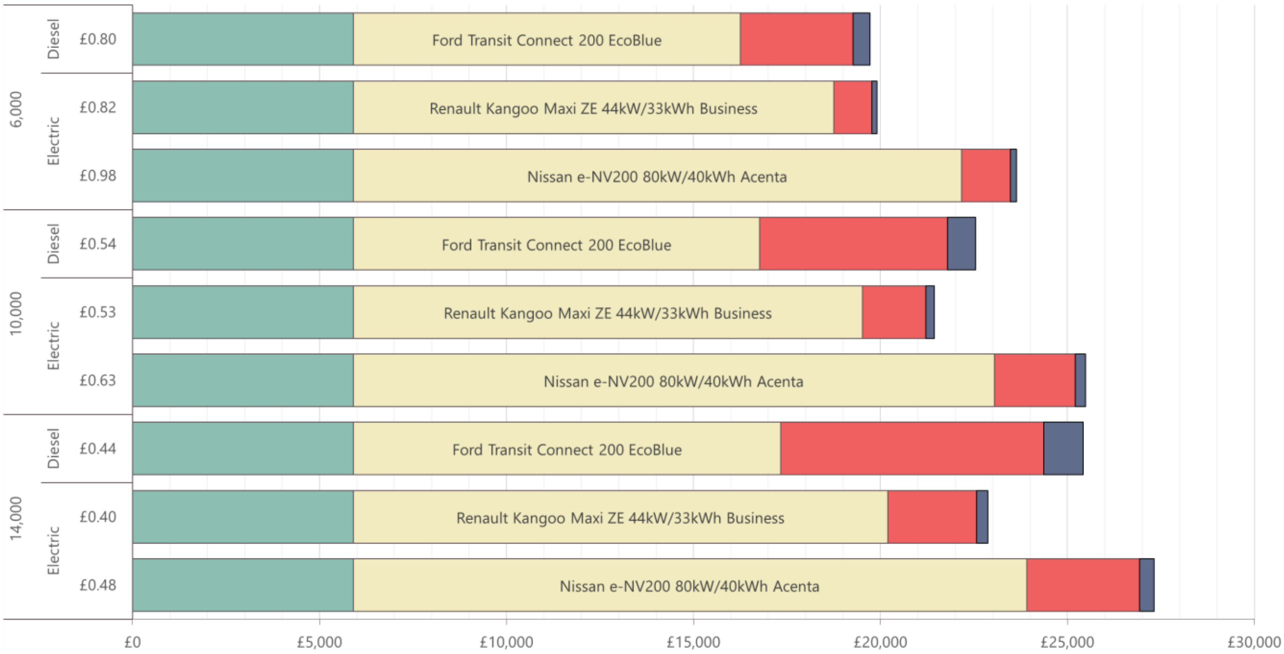
When Copenhagen's hospitals transitioned their blood sample operations to cargo bike (picture left). Logistics costs decreased, number of daily trips increased, and the number of sick days of their employees was reduced.

Drings of Greenwich, a butcher shop, was able to complete 95% of deliveries under 5 km by eCargo bike, saving more than £830 in fuel costs in a year (equivalent to two tonnes of GHG emissions).

11.4 WLC – Car derived vans (CDV) – up to 2.6 tonnes

In this fleet of 62 vehicles NPTC operates a range of vehicle types from small Ford Fiesta vans (which can be directly replaced by the electric Renault Zoe van) to Peugeot Partners and larger Ford Connects. The new PSA Group e-Partner, e-Berlingo and Cargo-e will not be launched until Q3 2021 and pricing is not yet available, but the assumption is that these vehicles will be suitable replacements for the equivalent diesel CDVs in the NPTC fleet. Until the Stelantis/PSA vehicles are available this fleet could be replaced with either the Nissan e-NV200 or the Renault Kangoo Maxi (both of which are also due to be replaced with new models in 2021/22). The WLC model compares the Ford Connect used by NPTC with the electric Kangoo and e-NV200.

Figure 11-2: Comparison of diesel and electric car derived van options



The car derived van fleet at NPTC averaged 8,672 mpa in 2019/20 with a range from under 1,400 to 22,248 miles (at 99 mpg) but only six vehicles exceeded 14,000 miles and in all cases the mileage may be suspect. In view of this we have modelled costs to cover the range 6,000 to 14,000 miles. The WLC model shows that the Renault Kangoo Maxi is the lowest cost option at all mileages over 8,000 mpa.

Table 11-4: Cost and GHG comparison, Car Derived Vans at 8,000 mpa

Make and model	Power	Purchase	£/mile	Whole Life GHG (t)	GHG Shadow Price
Ford Transit Connect 200 EcoBlue	Diesel	£11,689	£0.642	8.5	£605
Nissan e-NV200 80kW/40kWh Acenta	Electric	£25,425	£0.761	3.1	£221
Renault Kangoo Maxi ZE 44kW/33kWh Business	Electric	£20,213	£0.641	2.4	£174

The Renault Kangoo MAXI will reduce GHG emissions by an estimated 6.1 tonnes, over the 48 month period and 32,000 miles. Even without the GHG shadow price applied, the Kangoo has the lowest WLC.

11.5 WLC – Medium vans – 2.6 tonnes to 3.1 tonnes

The medium van fleet at NPTC is very small suggesting there may be some room to downsize some of the 3.5 tonne panel vans. It consists of only nine vehicles, three are 2.8 tonne Vauxhall Vivaro vans and there are also other PSA Group medium vans in the fleet. We have compared a diesel PSA Group Vauxhall Vivaro, and the electric Vauxhall e-Vivaro (48 month lease, 6,000, 12,000 and 18,000 mpa), these models are now based on the same chassis as the Peugeot Expert and Citroen Dispatch. There are currently no chassis-cab electric vehicles available in this size class.

Figure 11-3: WLC comparison of diesel and electric medium weight vans

The medium van fleet at NPTC averaged 7,014 miles in 2019/20 with a range from 2,573 miles to 14,714 miles. The WLC model (Figure 11-3) shows that the e-Vivaro breaks even with the diesel equivalent at about 18,000 mpa.

The difference in cost at 12,000 mpa is £1,044 over four years and extending the life of the electric vehicle to the battery warranty life of eight years would result in a lower WLC than the diesel vehicle.

Table 11-5: Cost and GHG comparison, medium vans at 10,000 mpa

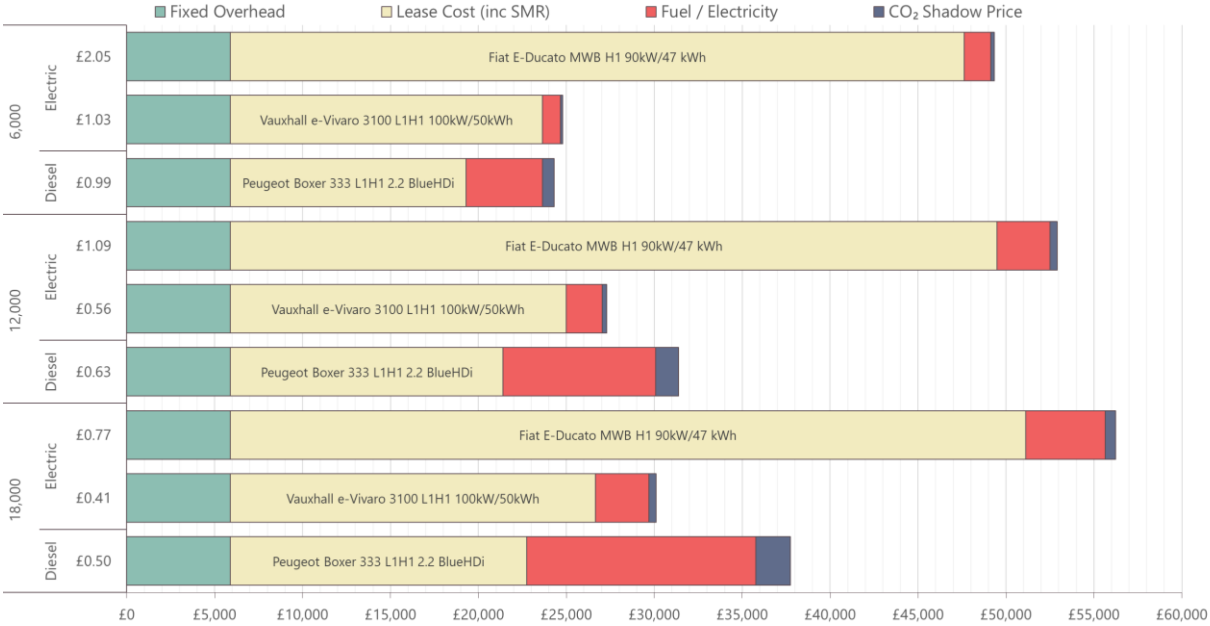
Make and Model	Power	Purchase	£/mile	Whole Life GHG (t)	GHG Shadow Price
Vauxhall Vivaro 3100 L1H1 2.0D Dynamic	Diesel	£14,259	£0.593	11.5	£817
Vauxhall e-Vivaro 3100 L1H1 100kW/50kWh	Electric	£30,826	£0.653	3.1	£217

The Vauxhall e-Vivaro will reduce GHG emissions by an estimated 8.5 tonnes over 48 months and 40,000 miles.

11.6 WLC – Large vans – 3.1 tonnes to 3.5 tonnes

This is a fleet of 73 vehicles, many of which are chassis cab versions. The most common models are the PSA Group Citroen Relay, Peugeot Boxer, Vauxhall Movano, and the IVECO Daily. The current e-Boxer has a limited range, but an upgrade is due. We have chosen to compare the diesel Peugeot Boxer with the medium sized 3.1 tonne electric Vauxhall e-Viviaro L1H1 and the more capable 3.5 tonne electric L2H1 Fiat E-Ducato.

Figure 11-4: WLC comparison of diesel and electric large van options.



The high WLC of the large 3.5t electric Fiat E-Ducato van is apparent in Figure 11-4, where it can be seen it is much more expensive to operate over four years than the diesel alternatives, even at 18,000 mpa.

The large vans in the NPTC fleet average 10,319 mpa with a range from under 1,552 mpa to 27,268 mpa but only five vehicles exceed 18,000 mpa (about 75 miles per day) and all of these had an mpg which suggests the mileage is wrong. 75 miles/day is close to the limit of the 47 kWh battery real world range (80-90 miles) of the Fiat. The larger 79 kWh battery would add about £12,000 to the discounted purchase price but gives the vehicle a range in excess of 140 miles. At 12,000 mpa the difference in WLC between the Fiat and the Ford is £22,000 so it will be difficult to achieve break-even by extending the operational life of the Fiat to eight or ten years (the larger 79 kWh battery has a 10 year warranty).

Table 11-6: Cost and GHG comparison, at 10,000 mpa (fleet average)

Make and model	Power	Purchase	£/mile	Whole Life GHG (t)	GHG Shadow Price
Peugeot Boxer 333 L1H1 2.2 BlueHDi	Diesel	£15,787	£0.626	18.4	£1,308
Fiat E-Ducato MWB H1 90kW/47 kWh	Electric	£52,128	£1.094	5.5	£387
Vauxhall e-Vivaro 3100 L1H1 100kW/50kWh	Electric	£30,826	£0.563	3.7	£260

Clearly the GHG saving of 12.9 tonnes over the four years and 40,000 miles is large, but the Fiat has high operating costs due to high capital costs. The expectation is that the price will fall over the next two years as more large electric vans become available, competition increases, and battery prices reduce.

Even with the shadow price applied, the ICE vehicles remain lower cost to operate than the 3.5 tonne BEV so the savings achieved by the electric vehicle may not represent good value for money.

The benefit of downsizing if at all possible is clear as the e-Vivaro is lower cost to operate at all mileages above 6,000 mpa.

11.7 LCVs that could be transition to ULEV

Table 11-7 is based on the age of the current fleet, replacing all the vehicles over eight years old first, this will bring the replacement cycle in line with the more common battery warranties. The 4x4 fleet replacement has been deferred until 2023/24 to allow OEMs to bring new battery electric models to the market. Consideration should be given to deferring 3.5t van replacement until 2022 when a much greater range of suitable BEVs should be available and prices may have been reduced.

Table 11-7: Proposed Implementation programme for ULEV LCV fleet

Category	Example ZEV	2021	2022	2023	2024	2025	2026-30	Total
3.1 - 3.5 t	Fiat E-Ducato	3	1	5	29	12	23	73
2.6 - 3.1 t	Vauxhall e-Viviaro	1			1	3	4	9
CDV - 2.6 t	Renault Kangoo Maxi	4	6	3	26	10	13	62
Minibus	See Next Section							
4x4 Pickup	Not available – 2022-23			3	3		4	10
Total		**8**	**7**	**11**	**59**	**25**	**44**	**154**

12 Moving to a zero emission minibus fleet

12.1 Description of the current minibus fleet

There were 36 large minibuses (4.6 tonnes to 5.6 tonnes) in use on the NPTC fleet in 2019/20 and 24 were based in schools, the rest were operated by Community Services. The fleet is mostly (21) Ford Transit 17 seaters but there are also Mercedes (6), VW (2), Renault (2) and IVECO (3) models on the fleet. Some of the vehicles have wheelchair adaptions.

Mileage data for the school buses was very variable and there is a concern regarding the quality of this data set, but it suggests that these expensive assets were averaging, at most, 3,500 mpa. The minibuses operated by Community Transport average 14,256 mpa but this data set includes annual mileages that result in a calculated energy efficiency of 618 mpg so this figure must be treated with caution and may be significantly inflated as it is not supported by the fuel purchase data.

There is also a fleet of nine smaller (under 3.5 tonnes) minibuses, one is used by the Youth Offender Team, one by the Road Safety Unit and the rest are in schools. While there appears to be some high mileage vehicles in this fleet that is not supported by the fuel purchase data (one vehicle achieves 213 mpg) and the average annual mileage of the fleet is about 3,000 mpa.

Each year the minibus fleets contribute an estimated 25 tonnes of GHG to NPTC transport footprint, this is about the same as one 26 tonne RCV. A large number of expensive vehicles are making a small impact which means that the cost of mitigating the impact per tonne of GHG saved will be high. However, it is the age of both these fleets that is the biggest concern with many vehicles over 10 years old and powered by diesel engines that meet Euro emission standards that have been superseded at least three times. These old vehicles will also lack modern driver-assist safety features such as the pedestrian and cyclist detection system now available on many new minibuses and particularly relevant to a school operating environment.

The issue with the continued operation of old vehicles is best illustrated by considering the MoT history (Table 12-1) of Ford Transit GX08HKN purchased in July 2008 and operated by Ysgol Hendre. This MoT data is in the public domain and can be accessed at https://www.check-mot.service.gov.uk/.

Table 12-1: MOT history of GX08HKN operated by Ysgol Hendre, 2009-2020

Test Date	Result	MoT Commentary (DVSA Public Access Database)
2009-2017	**PASS**	With one exception in 2013 when it failed due to an offside rear fog light not working
11th October 2018	**FAIL**	Nearside Front Brake disc in such a condition that it is seriously weakened (1.1.14 (a) (ii)) Offside Front Brake disc in such a condition that it is seriously weakened (1.1.14 (a) (ii)) Nearside Rear Brake disc in such a condition that it is seriously weakened (1.1.14 (a) (ii)) Offside Rear Brake disc in such a condition that it is seriously weakened (1.1.14 (a) (ii))
4th October 2019	**FAIL**	Passenger compartment passenger compartment in such a condition that it permits the entry of exhaust fumes Suspect diesel / exhaust fumes entering cab. (6.2.1 (c) (i)) Nearside Other passenger door catch deteriorated so the door cannot be readily opened or closed n/s sliding door handle snapped (6.2.3 (c) (i))
1st October 2020	**FAIL**	Nearside Inner Integral body structure or chassis has excessive corrosion, seriously affecting its strength within 30cm of a body mounting Hole in sil (6.2.2 (d) (i)) Offside Front Outer Integral body structure or chassis has excessive corrosion, seriously affecting its strength within 30cm of a body mounting Hole in sil (6.2.2 (d) (i)) Offside Front Outer Integral body structure or chassis has excessive corrosion, seriously affecting its strength within 30cm of a body mounting Various holes in sil (6.2.2 (d) (i)) Power steering pipe/hose excessively corroded (2.1.5 (g) (i))

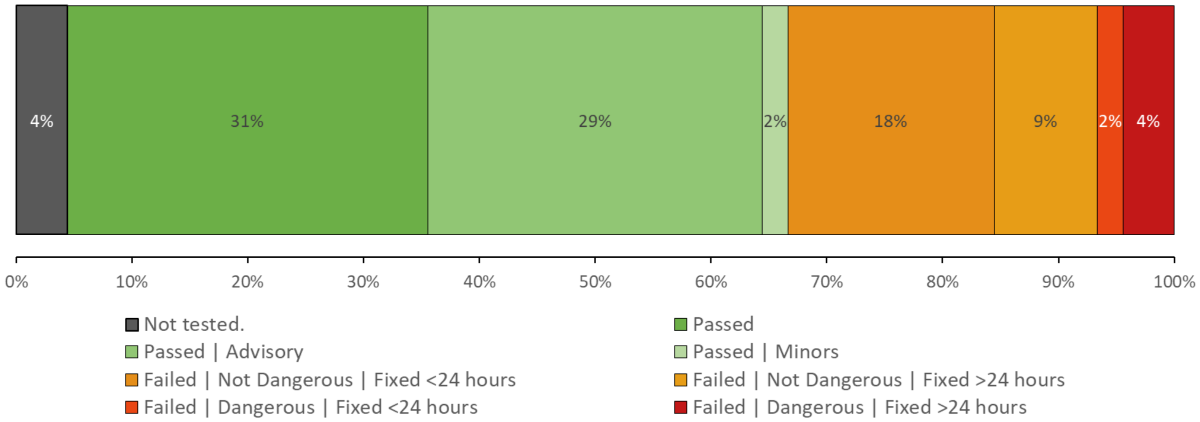
There is a reason why most fleet operators dispose of vans at seven to ten years, and it is clearly illustrated by this MoT history. In the first nine years of operation, it only had one fail and that was for a faulty fog light which should have been picked up in daily walk-around checks by the drivers. In Year 10 it fails because all the brake disks are worn beyond safe tolerance - so thin that they could disintegrate when the brakes are applied. In

2019 it fails because of structural issues which allow exhaust fumes into the passenger compartment and again in 2020 it fails due to structural issues. It has been repaired and currently has a valid MoT.

Of all these reasons for failure the one of greatest concern is the ingress of exhaust into the passenger compartment (2019) because of its long term impact on the children. Due to their stage of development children's lungs are particularly susceptible to the impact of pollutants and in extreme cases can have an adverse reaction leading to death (Air pollution a factor in girl's death, inquest finds).

Ysgol Hendre is a school for children with moderate leaning difficulties and has a unit for autistic spectrum disorder. That these children should also be challenged by the environment they are transported in is a concern and the school's governors should be made aware of their potential liability in this regard.

Figure 12-1: MOT history of the NPTC and NPT Schools' minibus fleet (2019-20)



In 2019/20 one third (33%) of the minibus fleet failed its MoT when presented for test. Of these failures 12 were categorised as "Not Dangerous" which means the vehicle can be driven away for repair but included faults like "*Rear Cab steps in such a condition that it is likely to cause injury*". Three vehicles had "Dangerous" fails and would not have been allowed to be driven away and these related to significant brake system faults, tyres with the ply or cords exposed and corrosion of suspension component mountings (14 year old vehicle).

The limited data available suggests these are very low mileage vehicles which is not unusual for schools and community use. This makes them expensive (£/mile) to operate as diesel vehicles and even more expensive to replace and operate as ULEVs.

12.2 Electric minibuses (including wheelchair access)

The Renault Master ZE, LDV EV80 (now Maxus eDeliver 9) and Fiat E-Ducato are available as minibus WAV conversions and the E-Ducato will be available from Fiat as a minibus later in 2021. These are expensive vehicles with the base chassis costing over £50,000 before conversion and the full cost after conversion approaching £95,000 (E-Ducato).

Unless the vehicle has a high annual mileage, there is a pressing requirement for a minibus to operate in a zero-emission zone (ZEZ), or funding is available to cover the gap in cost, it is hard to cost-justify the switch to BEV minibuses in 2020/21 or even 2021/22 but it is expected those costs will have fallen by 2025.

Figure 12-2: Renault Master ZE minibus conversion in use a Kent County Council (9 seat)

Kent County Council has acquired a Renault Master ZE minibus (Figure 12-2) on a long term trial. It can carry two wheelchair users and their escorts.

Figure 12-3: LDV EV80 minibus conversion from Euromotive (9 seat)

Euromotive demonstrated an electric minibus based on the LDV EV80 (Figure 12-3), now superseded by the Maxus eDeliver 9, at the 2019 Commercial Vehicle Show.

Nottingham City Council has ordered five LDV EV80 wheelchair access minibuses converted by Courtside Conversions who use lightweight flooring and seating to maximise load and range.

Figure 12-4: Fiat E-Ducato nine seat minibus due 2021

The Fiat E-Ducato (Figure 12-4) will be available as a 5 to 9 seat minibus version later in 2021. Prices have yet to be announced but the base model vehicle van is over £50,000.

Vic Young, a WAV conversion specialist, also offers the E-Ducato as a conversion based on the currently available electric van. The total cost of the conversion is an estimated £25-£30,000 more than the equivalent ICE vehicle.

Figure 12-5: Mellor Orion-E 16-seat electric minibus based on Fiat Ducato

Mellor Coachcraft make the low-floor 16-seat Orion E (Figure 12-5) which is also based on the Fiat Ducato chassis but with an electric drive train kit from EMOSS.

It can be configured for 16 seated passengers and then in a range of layouts up to five wheelchairs and two seated passengers.

The estimated cost of electricity per mile (Table 12-2) is based on an overnight charge costing no more than £0.10/kWh. A typical diesel minibus achieving 25 mpg will cost about £0.18/mile for fuel while a larger vehicle like the Mellor may only achieve 15 mpg and cost £0.30/mile. Fuel cost savings can be made but with a price difference (compared with diesel ICE) of at least £45,000 for the smaller vehicles and more for the Mellor it may take many years at low mileage to recover the additional capital spend.

Table 12-2: Specification of electric minibus options

Factor	Renault Master ZE	LDV EV80[1]	Fiat E-Ducato	Mellor Orion E	Units
Battery Capacity	33	56	79	72	kWh
Real-World Range	75	120	148	100	Miles
Fast AC Charge	7.4	30	7 or 11 or 22	22	kW
Fast Charge time	6	1.5	4	3.5	Hours
Maximum speed	72	72	62	56	Miles per hour
EV Energy Cost	£0.049	£0.045	£0.052	£0.070	£/mile
Diesel Cost	£0.18	£0.18	£0.18	£0.30	£/mile
Cost Saving	£0.13	£0.14	£0.13	£0.23	£/mile

[1]The LDV EV80 has been replaced by the Maxus e-Delivery 9

12.3 Minibuses that could be transition to ULEV

We cannot make any recommendations regarding the replacement of the minibus fleet with ULEV vehicles due to issues with the quality of the mileage data and concerns that the very low annual mileage of many vehicles results in a high operating cost – even when diesel powered – and that in turn leads to the vehicles being maintained on fleet beyond a reasonable operating life.

We would propose that a robust review of all minibus provision at the council and in schools is carried out and consideration is given to operating a pool fleet of minibuses, the use of short-term (day) hire vehicles, or the use of contractors. This review should include full engagement with the governing bodies of schools to ensure they are fully aware of the reputational risk to them arising from the continued operation of old vehicles.

If a minibus can be justified, either because of daily use or because of special adaptations then a robust replacement strategy needs to be in place. While old battery electric minibuses will not produce tailpipe emissions harmful to children they still rust, the brakes can still degrade (although wear is significantly reduced by regenerative braking) and other age-related faults not related to the method of propulsion can still develop. There will also be issues with the battery condition after 8-10 years of low level use.

13 Moving to a zero emission HCV fleet

13.1 Developments in the electric HCV marketplace

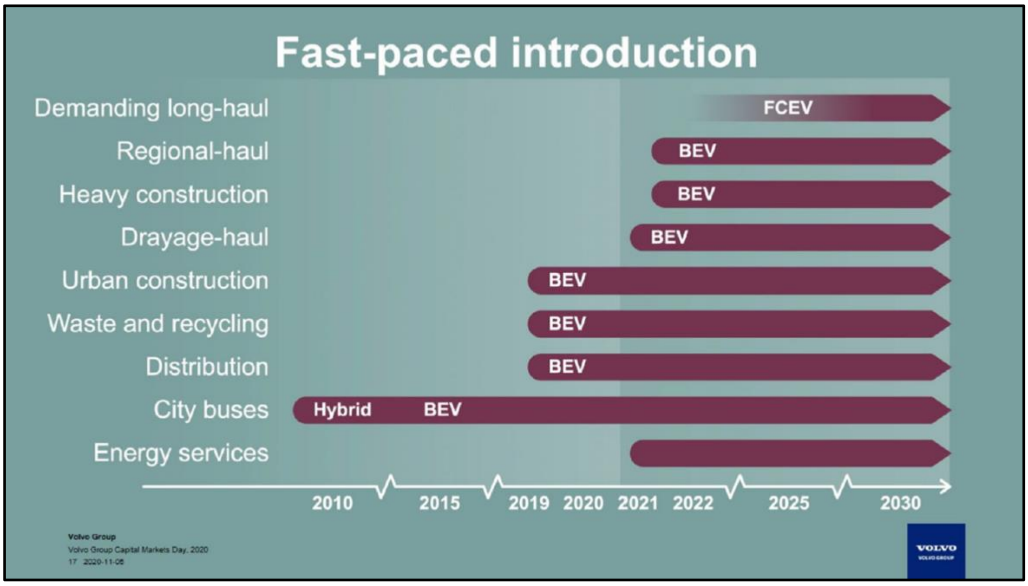
Nottingham City Council is operating a fleet of eight small electric sweepers (Boschung). Companies like Whale (tankers and gully cleaners) and Johnston/Bucher (sweepers) have used electric drive kits from the Dutch company EMOSS to convert donor vehicles. Edinburgh recently took delivery of an electric street sweeper manufactured by Bucher Municipal which is estimated to reduce fuel costs by £18,000 per annum. More and more public bodies are steadily introducing a wide range of specialist electric HCVs to their fleets.

The Scottish Government commissioned an electric gritter from Electra for the new Forth Crossing (Figure 13-1) and it is now in use. Electra also have an electric tanker/gully cleaner under development.

Figure 13-1: Electra Gritter developed for Transport Scotland use on the Forth Bridges

Daimler, DAF, Scania and Volvo have announced extensive ranges of electric rigid and articulated HCVs covering all weights from 7.5 tonnes to 44 tonnes, these will become available in 2021 and be in full production in 2022/23.

Figure 13-2: Volvo's vision of the role of Battery Electric Vehicles in the heavy goods sector (November 2020).



"Demanding Long Haul" should be seen in an international context – Volvo manufactures "Semi" trucks in the USA.
Download full presentation from: Volvo Group Capital Markets Day 2020

It may be a few years before a full range of battery electric HCVs is available in volume, at an affordable whole life cost, and with the required bodies. However, Volvo have recently stated that they can deliver their BEV vehicle range more quickly than diesel as they are given priority on the production line.

Another company that has made its views clear on the future of zero emission heavy vehicles is Scania (part of the VAG Group) which has announced a full range of BEVs while scaling back its development of hydrogen fuel cell drive trains. The full statement from Scania can be read here: "Scania's commitment to battery electric vehicles". It states: *"In a few years' time, Scania plans to introduce long-distance electric trucks that will be able to carry a total weight of 40 tonnes for 4.5 hours, and fast charge during the drivers' compulsory 45-minute rest."* Scania's sister company MAN have made a similar announcement.

Daimler Trucks (Mercedes/Fuso) has announced plans to offer electric vehicles in all its main sales regions by 2022 with series production starting in 2021: the FUSO eCanter in the light-duty segment, and the Mercedes-Benz eActros in the heavy-duty segment. The low entry Mercedes-Benz eEconic – the chassis used in many 26 tonne RCVs – will go into series production in 2022. Daimler Trucks sees hydrogen fuel cell as an option for 44 tonne or larger vehicles requiring a 1,000 km range but believe it may require liquid hydrogen stored at -253°c in cryogenic tanks to achieve the energy density needed to differentiate the product from long range 44 tonne battery electric vehicles.

The only factor that seems to be restricting the wider availability of all types of battery electric HCVs is their high capital cost and the time it takes for the body manufacturers to convert their hardware to operating with an all-electric power source. Over the next two years many more battery electric HCV options will be available from the major manufacturers and by 2025, if not before, a full range of battery electric HCVs, and specialist vehicles based on OEM chassis, will be on the market.

13.2 Description of the HCV Rigid fleet at NPTC

The HCV Rigid fleet is everything over 3.5t tonnes that is not a refuse vehicle. At NPTC it includes three Gritters (18 tonne MAN/Mercedes), five 18 tonne DAF tankers, seven tippers/dropsides, 11 sweepers (including eight Schmidt) as well as eight small IVECO Daily trucks. There are also specialist library services vehicles.

The only OEM on this list that has not announced its intention to supply a full range of battery electric vehicles by the end of 2022 is IVECO, but the Daimler subsidiary Fuso has the 7.5 tonne eCanter which will go into full production in 2021 and that could a be suitable replacement for some of the IVECO vehicles.

Based on the anticipated availability of HCVs over the period 2021-2030 (Figure 13-2 and Appendix E) we believe NPTC should actively monitor the market and plan for the replacement of all of the HCV fleet with the equivalent battery electric models as the diesels reach the end of their normal replacement cycle.

However, the gritters may be difficult to replace in the short term because of their pattern of intensive seasonal use and their energy intensity will need to be modelled from tracking data as using average daily energy use does not reflect typical operational use. Two were replaced in 2020 so will not need to be replaced until 2030, one may need to be replaced in 2025.

The Land Drainage fleet which includes gully jetters and high volume tanker are the most energy intensive vehicles in daily use but do not exceed an average of 150 kWh/day. Again, detailed tracker analysis will determine if there are days when the energy requirement of this fleet falls outside the capability of currently available battery electric heavy duty vehicles.

Now is the time to engage with the manufacturers of any specialist bodies in use at NPTC including Sweepers to determine their plans for electrification of their designs and the integration of their rigs with the electric HCVs from Mercedes/Fuso, DAF, Scania/MAN, Volvo/Renault, and others.

The data supplied for this project indicates that over the next five to ten years all the rigid HCVs in the NPTC fleet could, with adequate funding, be replaced with battery electric vehicles and it is possible that by 2030, if not before, electric HCVs could become the lowest cost option to buy, refuel and maintain across all the categories in use at NPTC. In the short term the priority must be to ensure that the principal NPTC depots have the capacity to charge a 100% BEV fleet. This issue will be covered in full in the separate EVCI report.

HCVs are usually kept on fleet for seven to ten years, so it is important to build this rapidly evolving market into the procurement strategy for the fleet. Deferring purchases or entering into short term leases will allow the switch to electric to be made when suitable vehicles become available later in the decade.

13.3 Electrification of RCVs in the UK

In 2018/19 Electra introduced a prototype all-electric eRCV based on a 26 tonne, three-axle Mercedes Econic chassis with a 200 kWh battery. During 2019 the chassis and rig was widely trialled around the UK in several cities. In Manchester it was operated by Biffa on the City Council domestic contract for a six month trial and has continued in use as part of the Biffa fleet. During the trial, the Electra eRCV was used for the collection of all domestic waste streams including garden & food waste, recyclables (plastic, glass, paper, cardboard) and residuals (anything that cannot be recycled).

The 200 kWh battery of the prototype completed all the Manchester rounds, but had less than 10% charge left when used on the garden waste collection because of a 20 mile run to the composting centre. The vehicle is now available with a range of battery packs up to 300 kWh and can be supplied on 18 tonne and 26 tonne chassis. It is fully supported by Mercedes who provide a glider chassis pre-prepared for the electric power train directly from the factory in Germany. The range of the 300 kWh vehicle is up to 100 miles (160 km).

Also available is the Dennis Eagle eCollect, which is a 300 kWh battery electric version of the company's popular 26 tonne "Narrow" model. It has been extensively tested with local authorities by Dennis Eagle and will be in full production during 2021/22. Its capital cost and operating costs are very similar to the Electra model. Two eCollect are now in service with Nottingham City Council and vehicles are also operational with Newport, Cardiff, Dundee, York, Cambridge, and Islington. An initial review of the performance of the Nottingham eCollect showed they were completing the rounds an average of one hour quicker due, it is thought, to improved and smoother acceleration.

The City of London (Veolia) and Manchester City Council (Biffa) have begun the roll out of substantial fleets of the 18 tonne (2-axle) and 26 tonne (3-axle) Electra (*Table 13-3*Figure 4-1). In the analysis of both business cases there was considerable uncertainty about the future cost of diesel, carbon taxation of diesel, the introduction of road pricing, whether Euro VI diesel vehicles would still be permitted to enter a clean air zone without charge beyond 2025 (London) or 2027 (Manchester) and what the impact of the Euro 7 emission standard will have on the future price of diesel RCVs.

Figure 13-3: One of the City of Manchester's 27 Electra/Mercedes 26 tonne 300 kWh electric refuse vehicles

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

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

The Geesinknorba group have developed an electric RCV in collaboration with GINAF using a DAF LF chassis. The vehicle has a 200 kWh battery and a 44kW on-board charger.

It is understood that a battery electric RRV is now available from Romaquip based on a DAF glider chassis and that Terberg (owners of Dennis Eagle) are working with Electra to produce a RRV based on an IVECO glider chassis for their Kerbsider/loader range.

13.4 Description of the current RRV and RCV fleet

The refuse collection vehicle (RCV) and resource recovery vehicle (RRV) fleet at NPTC consists of 42 vehicles. There are twenty six 12 tonne RRVs (all except one DAF), three 22 tonne Dennis Eagle RCVs and eleven 26 tonne Dennis Eagle RCVs. There are also two 5 tonne IVECO Daily tippers.

The 12 tonne DAF RRV is commonly used by Welsh local councils as the base for RRVs and kerbside sort is seeing wider uptake across the UK. The DAF model on which it is based is one that will be made available with an OEM battery electric drive train in 2021 or 2022. Romaquip have developed an electric 12 tonne RRV based on a DAF glider chassis to a Conwy Council and Welsh Government Resource Efficiency and Circular Economy specification. The first vehicle will be delivered to Conwy in 2021 for evaluation. Terberg/Electra claim the range of their RRV which we understand will have a 160 kWh battery will be 160 km. It will be available with either two or one 22kW AC on-board chargers and using both (2 x 22kW) can full recharge from fully depleted in four hours, however with an overnight charging window of 12 hours the use of one 22 kW charger would reduce the peak load on the depot site.

Replacing the refuse fleet with zero emission vehicles is very important as, on average, one RCV has the same GHG impact as at least seven vans and the small RCV fleet was responsible for 31% of NPTC's GHG emissions in 2019/20 (this rises to 37% if the grey fleet is excluded). In 2019/20 waste vehicles accounted for 965 tonnes of GHG emissions.

There are twelve 2013 model year vehicles on the fleet and seven are 12t Kerbsider RRVs, in 2019/20 they drove a total of 85,530 miles, consumed 48,693 litres of fuel (8 mpg) and 1,704 litres of AdBlue. They emitted about 126 tonnes of GHG. As a BEV we estimated they will consume up to 115 kWh/working day. We understand the electrification of the RCV/RRV fleet at NPTC will be subject to a detailed analysis by the Welsh Government Resource Efficiency and Circular Economy team in conjunction with Cenex.

13.5 Example energy cost savings - RRV fleet

On average the fleet of seven 2013 12 tonne DAF RRVs drive 12,219 mpa at an average energy efficiency of 7.99 mpg. Our analysis of the energy and GHG reductions achieved by a BEV model assumes the BEVs will use no more than 30% of the energy required by the diesel.

Table 13-1: eRRV fleet – factors used in the energy cost model

RCV Factor	Electric	Diesel	Notes/Units
Project Life	10		Years
Number of RRV vehicles	7		Vehicles
Average annual mileage (eRCV)	12,219		mpa per vehicle
Energy efficiency	1.69	8.55	kWh/mile, mpg
Cost of energy in year one	£0.10	£1.10	£/kWh, £/Litre
Fuel price inflation	3.24%	1.79%	From DBEIS

In *Table 13-2* we have summarised the key elements of the WLC energy consumption calculation.

Table 13-2: Comparative energy, exhaust additive and tax costs of a diesel and electric RRV fleet

Cost Summary	Electric	Diesel	EV Cost (-Saving)	Notes
Total Energy Cost	£190,919	£601,535	-£410,616	Includes inflation
AdBlue Cost	£0	£5,965	-£5,965	No inflation applied
SMR Cost	£672,000	£840,000	-£168,000	Chassis only– 20% less
VED + Road User Levy	£0	£43,050	-£43,050	DVLA V149/1 - 2020 Policy
Euro VI Diesel CAZ Levy	£0	£0	£0	No local CAZ proposed
Total Energy & Tax Costs	**£862,919**	**£1,490,549**	**-£627,631**	**eRRV energy & tax Saving**

We would expect the seven electric RRVs to reduce the energy cost of the fleet by about £410,000 over 10 years, it would also eliminate the need for “AdBlue” exhaust additive and the eRRVs would be zero-rated for Vehicle Excise Duty and Road User Levy. Other savings would arise from reduced chassis maintenance costs (20% of overall vehicle maintenance costs) giving a total saving of £628,000. These savings may offset some or all of the additional capital cost currently associated with electric RRVs as well as the initial cost of their charging infrastructure.

Table 13-3: Energy Use and GHG Emissions of an ICE RCV and eRCV fleet over ten years

Energy Use & GHG	Electric	Diesel	EV Cost (-Benefit)	Notes
Energy consumption (kWh)	1,545,614	5,152,047	-3,606,433	Assumes 30% reduction
Scope 1 kg CO_2e	0	1,239,428	-1,239,428	DBEIS Factors
Scope 1 AdBlue kg CO_2e	0	3,711	-3,711	Used by SCR
Scope 2 kg CO_2e	290,505	0	290,505	UK Grid - Predicted
Scope 3 T&D kg CO_2e	24,983	0	24,983	UK Grid - Predicted
Total GHG Emissions	**315,488**	**1,243,139**	**-927,651**	**-927 tonnes**

Over the ten year lifetime of the seven eRRVs GHG emissions will reduce by 927 tonnes and by at least 90% in the final year (2030). The eRRVs have no Scope 1 emissions from burning fuel or AdBlue and all the GHG emissions are Scope 2 from the generation of electricity and Scope 3 from transmission and distribution (T&D) losses.

Air quality improvements

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

Table 13-4 below has been determined using the COPERT5 model for a Euro VI diesel operating at an average speed of 5 km per hour reflecting urban operation. This is a vehicle specific model and very different from the “Average UK HCV” values presented in Table 4-5.

Table 13-4: Air Quality: Emissions over the 10 year life of the ICE and BEV RRV fleets (kg)

Air Quality (Project Life)	Electric	Diesel	BEV Emission reduction	Notes
Nitrogen Oxides (NO_X) kg	0	9,977	-9,977	NAEI COPERT5 (5 km/hr)
Particulate matter (PM) kg	0	20.3	-20.3	NAEI COPERT5 (5 km/hr)

Benefit to Society - HM Treasury Net Present Value

When the increased electricity usage and reductions in diesel consumption are input to the HM Treasury Green Book model for assessing the net present value (NPV) of projects in terms of GHG reduction, energy reduction and improved air quality, the total NPV benefit is £183,970 (*Table 13-5*).

Table 13-5: Output from HM Treasury Green Book – IAG[1] tool for valuing changes in GHG Emissions.

eRCV Project - Results Summary	Value (£^{2020})
Net change in energy use (kWh)	£67,856
Net change in emissions (GHG)	£67,628
Net air quality impact (NO_X and PM)	£48,486
NPV (Net Present Value)	**£183,970**

[1]Interdepartmental Analysts' Group

With a potential £183,970 societal benefit, and a £627,631 energy, additive and road tax saving the introduction of eRRVs has the potential to offer good value for money, but a final analysis will depend on the cost differential between the two types of vehicles.

13.6 HCVs that could be transitioned to ULEV

We understand a detailed analysis of the RCV/RRV fleet at NPTC will be carried out by Welsh Government Resource Efficiency and Circular Economy team in conjunction with Cenex. The figures in this report are indicative only and based on a standard lifecycle model using the age of the current fleet and not tailored to the operation of individual vehicles. A detailed analysis will require access to vehicle telemetry, ideally linked to the vehicle's CANbus.

Table 13-6; Indicative replacement programme for the HCV and RCV fleets 2021-2030

Vehicle Category	2021	2022	2023	2024	2025	2026-30	Total
HCV – Refuse and Recycling Vehicles	3	9	8	9	7	6	39
HCV – Rigid – Tippers, Gritters etc.	3	4		1	4	27	42
HCVs (excludes minibuses)	**6**	**13**	**8**	**10**	**11**	**33**	**91**

We have based this table on the current age profile of the fleet assuming a seven year life cycle for RCVs and HCVs. We would also expect a much greater range of suitable electric HCVs to be available by the end of 2022 and because of their greater reliability we would suggest keeping electric vehicles on fleet for up to 10 years. Replacement of the first gritter has been deferred to 2025.

The HCV fleet (RCV and Rigid) is responsible for 53% of NPTC's road transport GHG emissions so the GHG reductions achieved by replacing vehicles in this fleet are significant.

Appendix A: Grid sourced renewable energy

Concept of "Additionality"

A key factor that comes into play when determining if a low-carbon fuel purchase can be "included" in an organisation's reporting is the concept of "additionality". Has the purchase of that fuel resulted in more low-carbon fuel being produced than would otherwise have been the case? For example, if you plan to buy your electricity from a 20-year-old hydroelectric power station the answer would be no, and the fuel would not be regarded as zero carbon as it is already in the UK Grid mix and has been for many years.

Purchasing electricity on a renewable electricity tariff does not usually result in additionality and the same is true of consuming grid biomethane which - if a transport fuel - will normally have been supported under the renewable transport fuel obligation and certified. The key word being obligation – it would have been produced anyway to meet a statutory obligation, buying does not change anything and the risk is being accused of "Greenwash".

REGO and 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 (for example Zero gCO_2e/kWh if 100% renewable electricity) but it should be reported alongside the "location-based" (national) figure which is the actual GHG impact of the energy used.

This is because the zero-carbon benefit of the electricity or gas has already been accounted for in the national UK grid figure. The benefit cannot be taken twice as the grid carbon factor for other consumers would need to 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, for example 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."

Use of "Private Wire" renewables

Where a company generates its own renewables on-site or locally, by using photovoltaic and/or wind with "private wire" or an on-site anaerobic digester and does not supply the power via the UK Grid it can be accounted for as a zero or low carbon supply, but the carbon intensity needs to be robustly audited.

Time Specific Emission Factors

Also permitted are time-specific emission factors. The HM Government ERG state:

"Where available, time specific (for example 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 calculating this as it requires half hour consumption data.

Appendix B: UK Grid carbon intensity 2020-2030

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

Table B-1 shows:

- The DBEIS emission reporting factor for the year, which is about two years behind real-time emissions because of the verification process.
- The real time performance of the grid in year (or year to date) as calculated from the Elexon data set.
- The Committee on Climate Change (CCC) and DBEIS projections from 2018.
- The average of the CCC and DBEIS data sets.

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

Year	DBEIS GHG Scope 2 Factor	Year on Year Change	Actual in year from Elexon Portal	CCC cost-effective path projection	DBEIS Energy and Emissions Projections	CCC - DBEIS Average
2014	494.26		415.7			
2015	462.19	-6%	364.2			
2016	412.04	-11%	277.1			
2017	351.56	-15%	247.1			
2018	283.07	-19%	227.8			
2019	255.60	-10%	204.3	218.8	201.5	210
2020	**233.14**	**-9%**	**184.9***	**210.8**	**189.1**	**200**
2021	*211.58*	*-9%*		199.5	184.3	192
2022	*192.51*	*-9%*		188.3	179.5	184
2023	*174.93*	*-9%*		177.1	174.7	176
2024	*159.06*	*-9%*		165.9	170.0	168
2025	*144.58*	*-9%*		154.6	165.2	160
2026	*131.44*	*-9%*		142.5	153.5	148
2027	*119.48*	*-9%*		130.3	141.8	136
2028	*108.62*	*-9%*		118.2	130.2	124
2029	*98.74*	*-9%*		106.1	118.5	112
2030	*89.77*	*-9%*		**93.9**	**106.8**	**100**

*January – December 2020 (so includes impact of COVID-19). *211.58 = Projected future DBEIS emission factors.*

Source: CCC. An independent assessment of the UK's Clean Growth Strategy. 2018

Data: Charts & Data, Technical Annex Power (B1)

When calculating the future emissions of an EV fleet it is important to use these predictions to ensure the potential carbon saving is fully assessed.

It should be noted that in October 2020 the UK Government announced the intention to power all UK homes with renewable energy by 2030. This is not the same as powering the whole UK Grid and it is not clear what percentage of the Grid will be renewable by 2030, whether it has changed significantly as a result of the announcement, and how this impacts the predictions of DBEIS and CCC shown above. The official statement says it will "boost" [increase] the renewable target from 30 GW to 40 GW.

Appendix C: Whole Life Cost (WLC) in practice

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

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

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

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

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

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

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

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

Minor Damage Contingency: Over the lifetime of a vehicle, it is likely that some repairs will be required due to minor damage such as broken wing mirrors and these are not usually covered by the SMR cost which focuses on predictable replacement of mechanical parts. These costs will definitely not be covered by the SMR element of a lease and you should make a best estimate.

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

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

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

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

Table C-1 WGES whole life cost model – the factors you need to consider.

Factor	Units	Calculation	Example	Notes/Observations
Make			Electric	
Model			Van	
Operational Period	years	Y	5	
Annual Mileage	miles	AM	10,000	This needs to be realistic.
Discounted On-The-Road Price	£	A	£25,000	All these costs are included in the lease cost giving a fixed lifetime cost. This is based on the expected condition of the vehicle at the end of the lease and the annual mileage.
ULEV grant if not in OTR Price	£	B	Included	
Residual value battery	£	C	£2,000	
Residual value vehicle	£	D	£3,000	
Capital Cost or Lease Cost	£	CC=A-B-C-D	£20,000	
SMR & Tyres	£/annum	E	£150	Usually included in lease cost
Vehicle Excise Duty	£/annum	F	£0	Usually included in lease cost
Minor Damage Contingency	£/annum	G	£250	Best based on experience
Fleet Management Charge	£/annum	H	£550	Same for ICE and BEV
Insurance Cost	£/annum	I	£500	Usually same for ICE and BEV
Class 1A National Insurance	£/annum	J	£0	Only if private use
CAZ/LEZ/ULEZ charges	£/annum	K	£0	Any zones in operational area?
Energy/Fuel Cost (see Table 8-2)	£/annum	L	£300	Try to source real-world figures
Overhead Cost	£/annum	OC = SUM (E to L)	£1,750	Total annual overhead costs
Whole Life Cost	£	WLC=CC+(OC×Y)	£28,750	Capital plus Overheads (WLC)
Total Mileage over period	Miles	TM=Y*AM	50,000	
Cost per mile	£/mile	WLC/TM	£0.575	Use this for evaluation

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

Table C-2 Costs and emission factors to use in WLC models 2021-2024 project period.

Item Description (Cost period 2021 to 2024)	Value	Units
Four year average diesel cost (ex VAT)	£1.10	£/litre
Four year average petrol cost (ex VAT)	£1.00	£/litre
Four year average electricity cost – peak (ex VAT)	£0.14	£/kWh
Four year average electricity cost – off peak (ex VAT)	£0.10	£/kWh
Average GHG emissions of diesel (DBEIS 2020)	2.546	$kgCO_2$/litre
Average GHG emissions of petrol (DBEIS 2020)	2.168	$kgCO_2$/litre
Average emissions of electricity (CCC/DBEIS) (Appendix B)	0.180	$kgCO_2$/kg
GHG Shadow Price: HM Treasury Non-traded Central Cost	£72.17	£/tonne

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

Appendix D: Sources of Information

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

DBEIS UK GHG Emissions
DBEIS UK GHG Emission Reporting Factors
DBEIS/Defra Streamlined Energy and Carbon Reporting (SECR)
World Resources Institute: GHG Reporting Protocol
DfT UK Vehicle Statistics
DBEIS Predicted UK Grid GHG Intensity
HM Treasury Green Book: Valuation of energy use and GHG emissions (IAG Spreadsheet)

Hydrogen in a low-carbon economy – UK Committee on Climate Change (CCC -2020)
Zero Emission HGV Infrastructure Requirements, Ricardo. For UK CCC (2020)
Decarbonising the UK's Long-Haul Road Freight – UK Centre for Sustainable Road Freight (2020)
Determining the EI of conventional and alternatively fuelled vehicles through LCA, Ricardo, For ECDG Climate Action (2020)
The carbon credentials of hydrogen gas networks and supply chains, Imperial College (2018)
Separating Hype from Hydrogen – Part One: The Supply Side (BNEF - 2020)
Separating Hype from Hydrogen – Part Two: The Demand Side (BNEF - 2020)
Hydrogen Is Big Oil's Last Grand Scam (2021)
End of the road for pioneering hydrogen buses (2020)
Hydrogen Mobility Europe (H2ME) – Emerging Conclusions (2021)
JIVE (Joint Initiative for Hydrogen Vehicles across Europe) (2017)
Global EV Outlook 2020 – International Energy Agency (2020)
VW: Battery or fuel cell? That is the question (2020).
Volvo Group Capital Markets Day (2020)
Scania's commitment to battery electric vehicles (2021)
Toyota Mirai: As Easy as a Conventional Car (2015-20).
Global EV Outlook 2020 – International Energy Agency (2020)

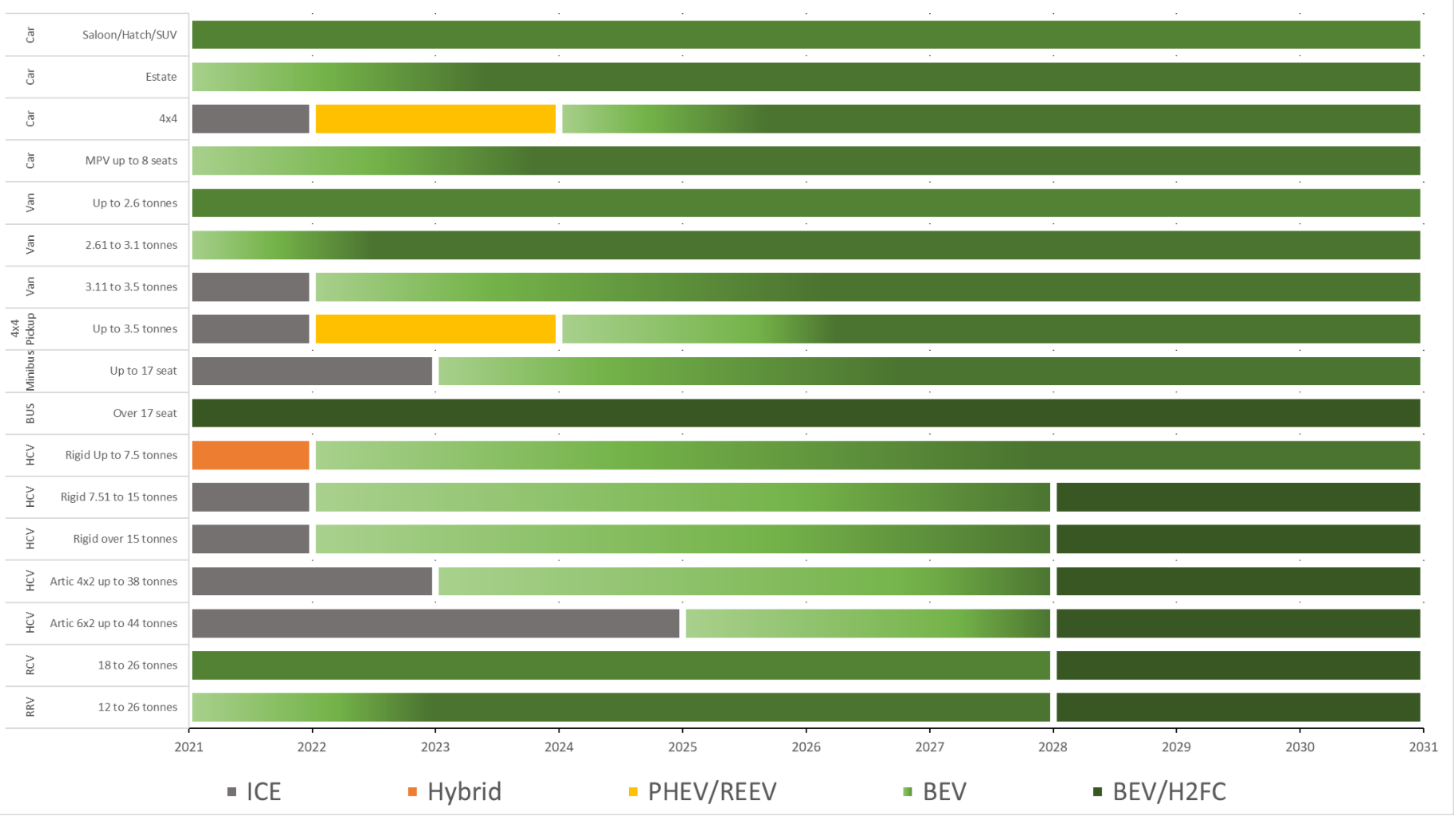
Lithium-Ion Vehicle Battery Production, Swedish Energy Agency (2019)
Volkswagen joins blockchain for cobalt supply (2019)
Mercedes to source cobalt and lithium with "Standard for Responsible Mining" (2020)
"Cobalt for Development" Project Started, (2020)
The curse of white oil: electric vehicles' dirty secret, Guardian, (2020)
From dirty oil to clean batteries, Transport and Environment, (2021)

Energy Saving Trust Guide to Chargepoint Infrastructure (2017)
Beama Guide to Electric Vehicle Infrastructure (2015)
Beama Best Practice for Future Proofing Electric Vehicle Infrastructure (2020)
Making the right connections, UK EVSE, (2019)

The Uninhabitable Earth: A Story of the Future. David Wallace-Wells, Penguin, 2019

EV Newsletter Subscribe at: www.electrive.com

Appendix E: Availability of OEM Zero Emission vehicles



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

Most vehicle categories are already available as BEVs but some are currently expensive and the full range of specialist body types is not yet available. Not all vehicles can carry the same load or tow as well as their ICE equivalent – but that will change over time. By 2027/28 it is expected that most vehicle categories will be available as a BEV with equivalent load carrying capability and that in the last few years of the decade fuel cell models may come to market although that may not happen if new energy-dense battery technology like solid state or semi-solid state lithium is available by then. Both battery and fuel cell buses are already available but battery buses account for the majority (over 98%) of the world's zero emission bus fleet, fuel cell vehicles currently require significant financial support to be viable. This chart is indicative and may be pessimistic in some categories but optimistic in others.

Llywodraeth Cymru
Welsh Government

Gwasanaeth Ynni
Energy Service