Document Type: External

Electric Vehicles
(Updated October 2021)

Author / Contact :

Julian Stringer
jules@teignenergycommunities.co.uk

Contents

1 Overview

Is this for me?

Are you a TECs Member who is considering getting an Electric Vehicle (**EV**)? You may already have an EV but want to know how best to use it. For example, to make sure you are contributing to CO_2 and other emission reductions.

The information provided here should help you make better, more informed decisions. It will also provide you with lots of details on EVs and their possible impact. You can decide how much detail you'll need.

If you only want to get a quick and general overview of the benefits/costs of owning an EV and how they compare to other options, this section provides it. The information in the rest of the document backs up these conclusions and recommendations.

Since the original version of this document was written in 2019 there have been significant changes, so the data used has been updated to the latest available in October 2021 for our calculations and comparisons. Although these will vary year on year, the comparisons are still a good approximation for an initial understanding of the subject. Please refer to ACT's Carbon Footprint Tracker and E-Pack to establish a more accurate annual greenhouse gas emissions and comparisons for different options.

Why would I want to buy an EV?

As with any expenditure, there are many personal reasons why we decide to buy something. Given quite a wide range of options, the one we choose will also depend on what we are looking to achieve and the budget we have available.

The main reasons for purchasing an EV tend to be:

1. Reducing my Carbon Footprint.
2. Reducing other harmful transport emissions like Nitrogen Dioxide (NO_2) and particulates.
3. Saving on transport costs.
4. As an area of interest/investigation and/or a social statement.

The first three reasons are probably the ones that are more difficult to evaluate, which is why they are covered here. They should be determined by calculating the overall reductions during the expected life of the EV and ensuring these are greater than for other options available, now and into the future.

The evaluation of the fourth reason listed above is more subjective and probably limited only by the balance between the desire to do something and its affordability. So, this is a lifestyle choice. Nevertheless, it is worth understanding what the various parameters are in making a particular decision as price and efficacy can vary significantly.

Is it worth it and how much will it cost?

Whether this is 'worth it' depends on the reasons for having it and how it compares to a comparable vehicle or other modes of transport.

In general, most modes of public transport, cycling or walking, if feasible, will have lower overall emissions and be cheaper. We will not be looking into these here, but please do ask Dr Watt if you are interested in finding out more.

Provided your annual private car mileage is more than ~5,000 mi, you are very likely to reduce your overall Carbon Emissions if you are able to charge your EV from a known low-carbon electricity source. Similarly, when charging from the current electricity grid, you're likely to reduce your life-time Carbon emissions, albeit at a lower rate and by a smaller total. You can find details on this, for your circumstances, in later sections.

EVs cost more to buy, but less to run. In general, you should expect to save on life-time costs when compared to equivalent petrol/diesel vehicles. The exact comparison will depend on the model you buy and how/where you drive it. Based on certain assumptions, we've provided some comparison figures of a range of vehicles.

One of the best ways to ensure you have the lowest possible emissions (CO_2e , NO_2 and PM2.5) are:

- Charge your EV from a known low-carbon source, e.g. spare generation from your PV system.
- Buy the lightest possible EV, this may not have the long range. So alternative modes of travel and/or intermediate charging facilities will be needed for longer journeys.

We all have different needs for what forms of transport we use. To take full advantage of the general information we've provided, it is important to know what your personal current usage is, and what changes you are prepared to make.

If in doubt, please contact Prof. Joules or Dr. Watt

2 Technical Introduction to Electric Vehicles

Electric Vehicles are powered by electricity stored in the vehicle's battery.

There are two types of vehicle that can be powered by charging from mains electricity.

- Plug-in Hybrid Electric Vehicles (**PHEV**)
- Battery Electric Vehicles (**BEV**)

In this document the abbreviation **EV** refers equally to BEVs and PHEVs.

EVs are much more efficient in their use of energy than Petrol or Diesel vehicles, at least twice as efficient. For the vehicles used in the comparison in section 3.4, electric vehicles use about 25% of the energy used by conventionally powered ones, but electric vehicles generally cost more than conventionally fuelled ones. This price relationship is likely to change fairly quickly as EVs are more mass-produced and are designed to be powered only by electricity.

The amount of energy that can be held in batteries of a given size and mass has also increased considerably over the last 10 years. In 2009 Mini produced a prototype EV whose battery took up the boot and back seat. In 2020 the Mini EV has a battery of the same capacity which fits in the transmission tunnel and does not compromise interior space.

The government has announced that new sales of Petrol and Diesel powered as well as self-charge hybrid vehicles will cease by 2030, sale of plug-in hybrids are expected to be restricted soon after.

An EV is much quieter for passengers and drivers than conventionally powered vehicles. When driving at low speeds you therefore need to be aware that pedestrians and cyclists may not notice you.

There are other vehicle types with electric motors working in conjunction with a petrol or diesel engine that cannot be charged from the mains. These are not considered further in this document.

Most car journeys are short. From the 2016 Analysis of national travel the average person did 814 trips and covered 6557 miles, so their average daily distance was 18 miles. This is about the real range of most plug-in hybrids, and much less than the range of a BEV. This means that in most cases an EV can be recharged overnight at home, which is more convenient than going to a filling station.

The average person in the South West does 10[1] trips over 100 miles per year by all modes, some of these will be by public transport (train or air). This means that for most journeys an effective range of 100 miles is adequate. For confidence you probably need a range of 150 miles based on Worldwide Harmonised Light Vehicle Test Procedure (**WLTP**) calculations.

BEVs have no tailpipe emissions, but may cause emissions if charged from an electricity supply that is not zero carbon, such as the current electricity grid.

2.1 Plug-in Hybrid Electric Vehicles

PHEVs have an internal combustion engine (**ICE**) as well as an electric motor (or motors) and battery. Typically, they are capable of travelling between 20 and 30 miles on electricity only, then the ICE takes over.

If most of your journeys are relatively short a PHEV can run on electricity most of the time, but longer journeys can still be undertaken without worrying about where to recharge. Charging will become less of a worry as BEVs become more common, and the charging network expands.

PHEVs are mechanically quite complicated, the ICE, motor and battery take up quite a lot of space (and weight). PHEVs are typically based on conventionally driven vehicles.

There is no longer a government grant available to assist with the purchase of PHEVs. Sales of new PHEVs will be banned from 2035.

According to the Society of Motor Manufacturers and Traders (SMMT) , July 2018 sales of PHEVs were 2.2% of the total market, and by September 2021 they represent 6.4%. Though this looks a significant increase, there were also increases in other hybrid types, and the increase in BEV sales was from 0.5% in July 2018 to 15.2% in September 2021.

Alternative solutions to addressing the need to do longer journeys are available, PHEVs are probably the least effective from an emissions and cost point of view. They will typically have higher emissions compared to an equivalent ICE vehicle.

2.2 Battery Electric Vehicles

BEVs are powered by an electric motor (or motors) and battery only. They typically have a range of 70 to 360 miles. Though some BEVs are based on conventionally driven vehicles, it is more likely they will be designed to be electrically driven only.

Electric motors are much simpler than ICE, so should be more reliable. Electric motors are also smaller than ICE, which can lead to more interior space in a vehicle design to be electric only. Most manufacturers are now producing BEVs.

The initial cost of a BEV is significantly higher than an equivalent conventionally driven model, but the running costs are much lower. The cost of electricity used can be much lower than the cost of petrol or diesel for the same distance. As the vehicle is simpler, servicing costs should be lower, and vehicle excise duty (VED) is also lower. However, insurance costs are likely to be higher. The cost of pure BEVs is reducing as new models are introduced and should eventually achieve parity.

Deloitte estimates that the market will reach a tipping point in 2022 – when the cost of ownership of a BEV is on a par with its internal combustion engine counterpart.

[1] National Transport Survey - Table NTS9911

From April 2021 the government grant available when a new BEVs is purchased is reduced to £2500 for vehicles whose recommended retail price is less than £35,000. For further information see here.

According to SMMT BEVs represented 0.5% of vehicles sales in July 2018, 1.4% of vehicle sales in July 2019, and by September 2021 new sales of BEVs represented 15% of all new car sales, according to Electric Car Count and SMMT.

2.3 Other smaller EV types

Other smaller EV types include:

- e-bikes
- e-scooters
- Electric Motorcycles
- Electric Quadriclyes

e-bikes

e-bikes are bikes that have a small electric motor that is used to boost the power to the wheels when the user pedals. You do not need a licence to use an e-bike, but must be over 14 years of age. An e-bike must:

- Only provide electric assistance below 25 kph (15.5 mph)
- Have a motor whose continuous rated power is 250W or less.
- The pedals must be in motion for motor assistance to be provided.

https://www.cyclinguk.org/cyclists-library/regulations/eapc-regulations

If an e-bike meets these rules it is classed as a normal pedal bike and can be used anywhere a pedal bike can go.

https://www.gov.uk/electric-bike-rules

Battery sizes for e-bikes range from 180Wh to 1000Wh.

https://www.cyclinguk.org/article/guide-e-bike-batteries

Bosch has a range calculator for e-bikes.

A 300kWh battery would provide a working range of 25km to over 100km depending on conditions, riding style and weight of rider and bike.

Larger batteries will have proportionately longer ranges.

e-scooters

In several cities abroad you will see e-scooters, which are scooters with a platform you stand on and electric motor. These are often available for rent using an App. These are not currently street legal in the UK, though there are legal rental trials in some authority areas

Electric Motorcycles

Most manufacturers (Vespa, BMW, Harley Davidson, etc.) are producing electric models. The obligation to do this is similar to that placed on motorcar manufacturers.

Electric Quadricycles

An electric quadricycle is a four wheeled vehicle which has a central driving position, with possibly a passenger seat behind the driver. The Renault Twizzy is an example of an electric quadricycle.

https://en.wikipedia.org/wiki/Quadricycle_(EU_vehicle_classification)

An electric quadricycle must:

- Have an unladen weight no more than 450 kg excluding batteries.
- Have an engine power no more than 15kW.

To drive a heavy electric quadricycle, you need a class B driving licence, the same as for driving a normal car.

2.4 History of BEVs

There have been BEVs for a long time, but these have not gained popular acceptance except for specialist applications (e.g. Milk float, Buggy, etc.)

The first modern BEV in mass production available in the UK was the Nissan Leaf introduced in 2012 with a 24KwH battery giving a range of about 80 miles.

The luxury Tesla model S was also introduced 2012 with a 60KwH battery and range of 200 miles. Tesla recognised that public charging would be an issue, and so built its own Supercharger network for exclusive use with Tesla vehicles. Initially the Supercharger network was available to customers at no charge.

These were followed by the Renault Zoe and Renault Twizzy in 2013; Renault adopted the practice of selling the car, but leasing the battery, this can be reassuring when buying secondhand. The Twizzy is classified as a quadricycle, rather than a car.

BMW also introduced the i3 in 2013, this used light-weight carbon fibre, and had a 22kWh battery with a range of about 80 miles. It gave good performance at a fairly reasonable price.

Since then, these initial models have evolved to have greater range and better performance, and new models have been introduced.

The public charging network has been slow to develop, so in practice most charging is done at home.

At the same time PHEV versions of ICE models started to be introduced by many manufacturers. These accounted for the majority of the market in the mid to late 2010s, as they can run on conventional fuel as well as electricity. Many of these will now be available on the secondhand market.

Recent development of battery technology has led to greater energy density, which has enabled vehicles with greater range to be practical, and the public charging network is more mature. Government policy is now that new sales of ICE vehicles will have to end by 2030, plug in hybrids by 2035. Most manufacturers are now introducing pure electric models. Against this background, BEVs are the only sector of the vehicle market that is expanding.

Demand for BEVs is currently outstripping production.

3 Living with my BEV

Although many aspects of owning and driving BEVs are similar to a conventional 'automatic' ICE, there are several differences. We've included the most significant of these differences here.

3.1 Travel Range

The range of a BEV is the distance that it can travel starting with a fully charged battery.

The range of new BEVs is quoted using the World harmonised Light vehicle Testing Procedure (WLTP), which came into force in 2017. Prior to this, vehicles had been tested according to the New European Driving Cycle (**NEDC**). WLTP better represents real world driving conditions.

The introduction of WLTP has resulted in many models near the end of their lifecycle being withdrawn from the market, as manufacturers could not justify the cost of testing.

Range is quoted as:

- Combined Cycle
- City Cycle

A winter range is also sometimes quoted, generally for BEVs, the winter range is about 2/3 of the overall range. This reduction in range is due in part to lower battery efficiency at lower temperatures, and in part due to use of heating/lighting.

Unlike ICE vehicles BEVs are more efficient on the city cycle than the combined cycle. This is because vehicles average lower speeds in the city cycle, electric motors give most torque at start-up, and so require less energy in start-stop conditions; At the higher speeds encountered in the combined cycle wind resistance is a more important factor, the power needed to overcome wind resistance is proportional to the cube of speed, and so the energy required for a given distance is proportional to the square of speed. Travelling at 80mph requires ~31% more energy consumption compared to 70mph for the same vehicle/conditions to travel the same distance.

Technical explanation for this is:

Power at higher velocities is given by

$P = \frac{1}{2} \rho v^3 A C_d$ (https://en.wikipedia.org/wiki/Drag_(physics))

Where v = velocity, A = frontal cross sectional area, C_d is the drag coefficient, ρ is the density of air.

So, to travel at 80mph rather than 70mph requires 49% more power to travel a given distance at 80mph rather than 70mph requires 31% more energy (i.e. fuel consumption).

Recently manufacturers have introduced heat pumps which reduce heating demand in winter. According to https://www.greencarreports.com/news/1124387_can-heat-pumps-solve-cold-weather-range-loss-for-evs, this suggests that heat pumps can increase winter range by 30% depending on how often and at what temperature these operate.

The ev-database.uk site quotes a real range which is generally lower than the WLTP range, this is probably a more realistic figures. This is because manufacturers will run the WLTP tests under optimal conditions.

3.2 Emissions

When electrically powered there are no exhaust emissions directly from the vehicle, though there can be emissions at the power generator.

There are several Greenhouse Gas Emissions (**GHG**) which cause Climate Change. Collectively these are referred to as CO_2 equivalent (**CO_2 e**) emissions.

Emissions for UK grid electricity are published annually by BEIS[2], emissions for electricity consumed have two components (**WTT** refers to Well to Tank emissions):

[2] Conversion factors for GHG reporting 2019 - https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

Emissions source	$kgCO_2e/kWh$ (2019)	$kgCO_2e/kWh$ (2021)
Scope 2 – Electricity generation	0.2556	0.21233
Scope 3 – Transmission and distribution	0.0217	0.01879
Scope 3 – WTT emissions from fuel used for electricity generation	0.03565	0.05529
Scope 3 – WTT emissions from Transmission and distribution	0.00303	0.00489
Total	0.31598	0.2913

Normally, figures quoted for vehicle consumption are based on battery capacity, and do not take into account the efficiency of charging. It is assumed that most charging will be done with 7kW chargers, which are the most efficient way of charging and have the lowest installation costs. Scope 2 and 3 emissions account for electricity supplied to the meter, there are further losses between the meter and the battery. The most significant of these is the car's on-board charger. We assume that efficiency from meter to battery is 80%[3].

The range of emission rates caused by driving EVs using UK Grid Electricity 2021 is given in the table below:

Vehicle	EVDB Real Range Wh/mile	Wh/mile adjusted	g CO_2e/km
Fiat 500e 24kWh	235	294	53
Tesla Model 3	235	294	53
Mini Cooper SE	250	313	57
VW ID.3 58kWh	265	331	60
VW ID.4 77kWh	300	375	68
BMW iX	330	413	75
Audi e-Tron SUV	380	475	86
Vauxhall Vivaro e Life Elite 50kWh	405	506	92

[3]A charger needs to convert mains AC voltage (typically 240V RMS) to a DC charging voltage higher than the car's nominal battery voltage, this is similar to what a AC-DC power supply has to do. Power supplies for PCs are certified by the 80plus organisation (https://en.wikipedia.org/wiki/80_Plus) , there are 6 levels of certification, most certified reasonably priced supplied supplies are rated bronze or gold. A bronze rating means that across the load range the supply is at least 85% efficient, gold means at least 89%. It is likely that charger efficiency will lie in the range 85-89%, there will be some small losses in switchgear and cabling, there are also losses in battery charging, so we assume the process is 80% efficient overall.

Mercedes EQV	450	563	102

All the consumption rates in the above table come from ev-database (**EVDB**), the figures shown are vehicle consumption from the EVDB Real Range section. This figure is also shown in the EVDB vehicle summary. gCO_2e/km figures are derived by applying a carbon intensity of 364gCO_2e/kWh.

If an all renewable source is used, this drops significantly (please contact TECs if you want to find out more details about the Carbon Intensity of renewables and how to calculate/allocate this).

Here are some ICEV equivalents:

Vehicle	Fuel	Miles per gallon (mpg)	g CO_2e/km
VW Up 1.0 65PS	Petrol	55	145
Mini Cooper 1.5 3dr auto	Petrol	51.4	155
VW Golf 8 eTSI Life 1.5 auto	Petrol	51.8	154
VW Golf 8 TDI 2.0	Diesel	63.2	144
Audi Q7 45 Tdi auto	Diesel	34.9	261
Vauxhall Vivaro-e 1.5 120PS	Diesel	47.1	193

The g CO_2e/km are derived from fuel consumed assuming 280.75 g CO_2e/litre for petrol and 321.12 gCO_2e/litre for diesel. The mpg figures are WLTP combined figures sourced from a variety of sources as there isn't a reliable single source for ICE vehicles. Where a range is given for WLTP combined to allow for differences in equipment, the high value corresponding with the base standard model is taken.

There are emissions from the manufacture, maintenance and disposal of EVs. Apart from these, there is also some environmental pollution from BEVs due to things like tyre wear. Later sections cover cradle-to-grave emissions for a more accurate comparison. Also covered are pollutant emission comparisons, these are of course totally absent from a BEV when driven.

The pod-point.com/guides/vehicles site has a calculated g CO_2 e/km for each vehicle. Please note that these emissions tend to be optimistic. Although they use battery consumption figures for near 'real world' driving, they do not include battery charging losses or the full (scope-3) emissions for grid electricity in the UK.

3.2.1 NOx

NOx refers to the gasses Nitrous Oxide (N_2O), Nitrogen Oxide (NO) and Nitrogen Dioxide (NO_2).

The following table summarises the relevant effects of these gases.

Gas	Name	Global Warming Effect	Other environmental effects	Health Effect
NO_2	Nitrogen Dioxide	None	Acid rain	Toxic and is associated with a variety of environmental and health problems.
NO	Nitric Oxide	None	Acid rain, Ozone depletion	None

N_2O	Nitrous Oxide	Powerful greenhouse gas (**GHG**), which scavenges ozone. Global Warming Potential (GWP) 298 times that of CO_2		Laughing gas, can cause nausea, headache. Used as anaesthetic. Long term exposure can cause vitamin B12 deficiency.

NOx emissions from BEVs occur at fossil fuel generating plant, so our main concern is with N_2O.

NOx emissions from ICE vehicles (**ICEV**) occur at the tail-pipe as well as in the fuel supply chain, so there is a health concern from NO_2 as well as the global warming effect of N_2O.

Not only are these EV related emissions at power generation plant, even the worst emissions from BEVs are now better than the Euro 6 limit.

3.2.1.1 Euro 6 Limits

New diesel engine vehicles must comply with Euro 6, which mandates NOx emissions as follows:

Diesel	0.08 g/km	0.129 g/mile
Petrol	0.06 g/km	0.096 g /mile

These limits apply to tailpipe emissions from new cars since 2014.

3.2.1.2 NOx from ICEV

Here we consider all ICEV together, as there are simple UK figures that an emissions rate can be derived from.

	Item	Value	Source
1	NOx Cars 2019	145.18 kt	National Atmospheric Emissions Inventory - NOx. Passenger Cars
2	Car miles	278.2 bn vehicle miles	Road Traffic Estimates 2020 – spreadsheet tra0101.ods Cars & Taxis 2019
3	**NOx/mile**	**0.52g/mile**	=(1)/(2) kt = 1,000,000,000g; bn vehicle miles= 1,000,000,000 miles

This is the average for passenger cars, which is substantially higher than the Euro 6 limits. This shouldn't be a surprise because the total will include a significant majority of older vehicles.

The proportion of NO_2 in older diesel engines is about 5% of NOx, but in more recent engines it is between 12% and 70%. For a Euro 6 this would equate to 0.0096 - 0.056 g NO_2/km .

Until recently vehicles have been tested using the NEDC procedure where the emissions test has been passed. According to tests under real world driving conditions described in https://www.eea.europa.eu/publications/explaining-road-transport-emissions, the emissions from early Euro 6 diesel vehicles were 0.5gNOx/km and 0.56gNOx/km, which is little different from earlier diesels. This test finding is worse than our simply derived result above, which is for all passenger cars.

3.2.1.3 NOx from electricity generation

EVs can also cause NOx emissions, but these are at stationary electricity generating plant. The damaging effects of NO_2 are therefore not concentrated in urban streets. However, there may be a localised health risks which require calculating and monitoring in the proximity of high temperature combustion , (mostly gas) power plant, depending on the prevailing weather conditions. As this point relates to electricity generation in general it is outside the scope of this document.

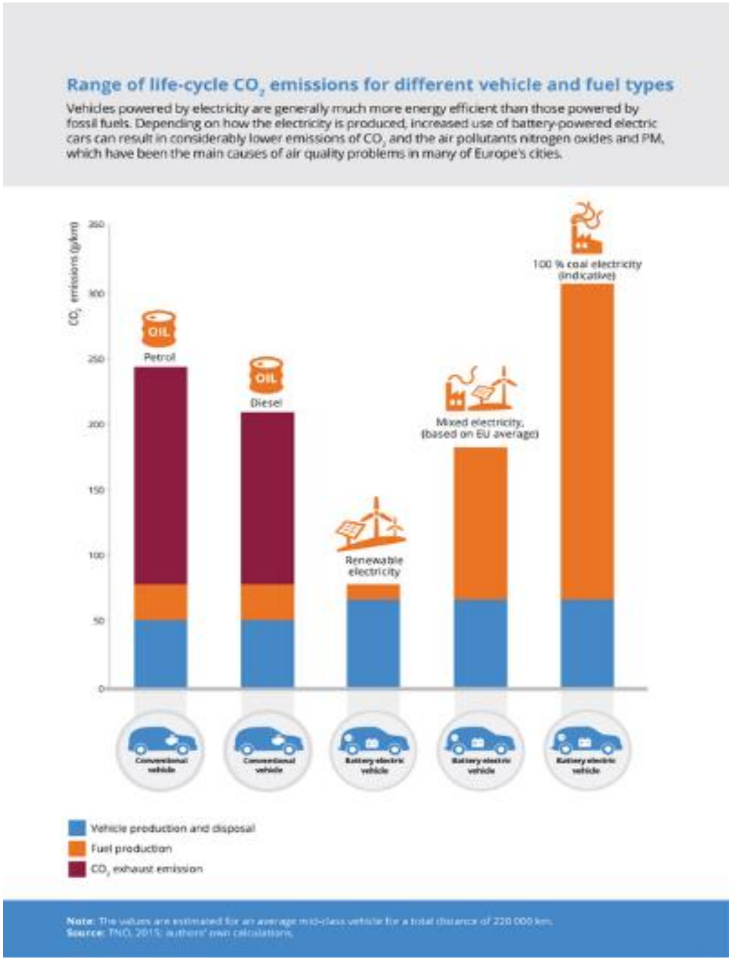
3.3 Manufacture and disposal

The following information is provided to suggest points you should consider when comparing EVs. EV manufacturers are aware of the reasons early adopters are choosing EVs, they normally respond to market forces so are working to reduce any harmful effects from EV production.

For example, you may find that a manufacturer using renewable energy in their production plant could be preferable to one that uses predominately fossil fuels to power production. You could apply further pressure by asking question about these aspects of EVs when you are considering a certain manufacturer.

3.3.1 Embodied (Embedded) Emissions

Emissions from manufacture of BEVs are generally regarded to be about 50% more than for an equivalent ICEV.



The graphic left shows lifetime CO2 emissions for different vehicle types in 2015. It shows that emissions from EV production are higher than for conventional vehicles. Most of these emissions are caused by use of more steel and aluminium in a heavier vehicle, together with emissions from battery production.

Reproduced from https://www.eea.europa.eu/signals/signals-2017/infographics/range-of-life-cycle-co2/view under creative commons licence.

https://www.sciencedirect.com/science/article/pii/S1876610217309049 compares ICEV and EV production. This paper suggests that CO_2 emissions in EV production in China are 14642kg/vehicle against 9172kg/vehicle for ICEVs. This is based on conditions at the time China, where only 11% of steel is recycled and electricity is assumed to have far higher emissions than other sources. This is not the European case. Emissions relate mainly to the increased weight and production of the Li-ion battery. Production of Li-ion batteries in the US leads to one third the emissions of a Chinese ones. Similarly use of recycled steel substantially reduces emissions.

3.3.1.1 Published Life Cycle Assessments (LCA)

Since the first version of this paper was published some manufacturers have published life cycle assessments of some of their vehicles, all these are to ISO 14040 and 14044, these include:

Manufacturer	Model	Type	Embedded Emissions tCO_2e	Notes
VW	ID.3 (58kWh)	BEV	13.7	Life cycle assessment certified by TüV Nord , figures from CO_2 balance of the electric vehicle. The 13.7 figure does not take into account the carbon neutrality measures at Zwichau, which probably reduce it by about a tonne. See 3.3.1.1.2
	Golf 8	Petrol	6.8	CO_2 balance of the electric vehicle.
	Golf 8	PHEV	7.6	Additional emissions from addition of 13kWh battery @ 62kg/kWh added to Golf 8 petrol.
	Golf 7 1.6TDi	Diesel	5.7	Paper on life cycle engineering based on practice at VW.
Mercedes	EQC	BEV	16.4	Mercedes press release, note that the units in the press release are CO_2 not CO_2e
Audi	e-Tron	BEV	19.13	Audi life cycle assessment for e-Tron 55, Q7 and Q5
	Q5 (2017)	Petrol	8.7	
	Q7 (2016)	Diesel	12.17	
BMW	iX3	BEV	23.5	X3 and iX3 life cycle assessment , see Mini for method of extrapolating production emissions.
	X3 30i	Petrol	8.81	
Volvo	XC40	Petrol	13.6	XC40 and XC40 Recharge carbon footprint, emissions are notably higher than other European production. This is because the assessment is for a globally sourced vehicle. The majority of production emissions are from materials.
	XC40 Recharge	BEV	26.4	
Polestar	2	BEV	26.5	Polestar 2 lifecycle assessment . Volvo and Polestar are related brands.
Mini	Mini Cooper	Petrol	4.94	Mini Cooper environmental report. BMW's published extract of the report does not include a figure for production

				GHG directly, but it does shows a comparative breakdown of emissions from these two vehicles. See 3.3.1.1.1 BMW publishes similar reports for other models, in each case a comparator model is included in the report, but no values are given for emissions!
	Mini Cooper SE	BEV	8.14	Mini Cooper environmental report. BMW's published extract of the report does not include a figure for production GHG directly, but it does shows a comparative breakdown of emissions from these two vehicles. See 3.3.1.1.1 BMW publishes similar reports for other models, in each case a comparator model is included in the report, but no values are given for emissions!

Other manufacturers are using LCA, but have not as yet published any figures or reports for their vehicles.

In general, LCAs for EVs show higher production emissions than ICEV, but lower lifetime emissions. A major factor in determining in use emissions from an EV is the carbon intensity of the electricity used.

The certified figures published so far seem to suggest that estimates used in the previous version of this document underestimate the true picture.

In general manufacturers seem to be reluctant to publish the embedded emissions from production, though these can be derived reasonably accurately from the information given.

3.3.1.1.1 Mini Cooper SE vs Mini Cooper

The graphic below has been extracted from Mini Cooper environmental report

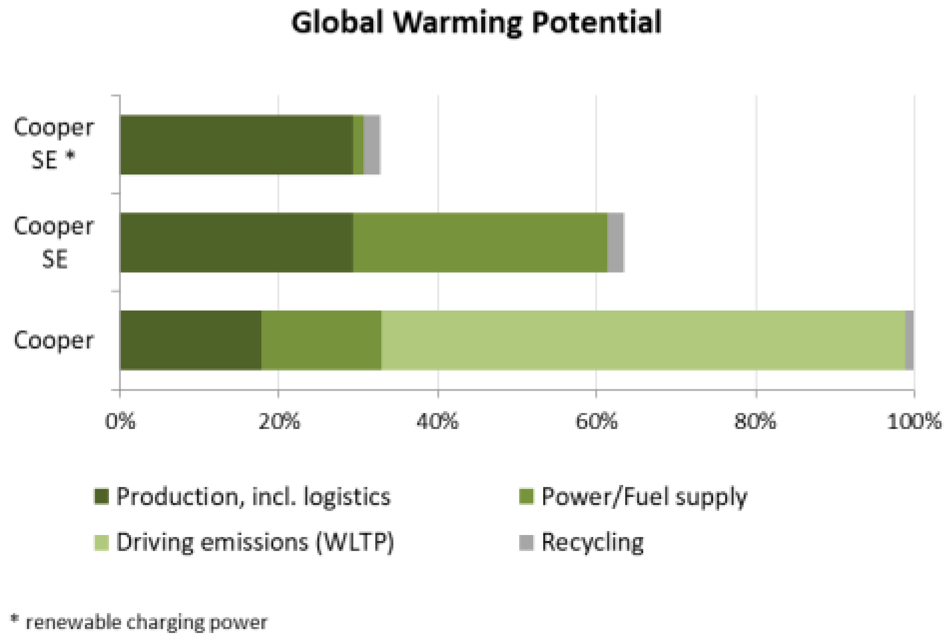


Fig. 2: Distribution of global warming potential over life cycle of MINI Cooper SE

The in-use phase (supply + driving) in the above graphic represents 150,000 km (93,200 miles). In the following text, production emissions are inferred from these in-use phase emissions of Mini Cooper. BMW do not publish the actual emissions figures, just this relative emissions graphic, so we have to interpolate using an approximate figure we do know.

Tailpipe emissions from Mini Cooper are known at 128gCO_2e/km, these understate in-use emissions. A better estimate of in-use emissions can be got from emissions from fuel consumed. WLTP combined fuel consumption is 51.4mpg. Fuel factor for petrol taking into account all emissions scopes is 2.80756 kg CO_2e / litre. Combining fuel consumption and this factor gives 155 g CO_2e/km.

So emissions for the in-use phase are 150,000 X 155 / 1000000 tonnes = 23.24 tonnes. Measuring from the graphic above driving and power/fuel emissions account for 8/9.8 of lifetime emissions, so 100% on the scale above represents 28.48 tonnes. Production emissions for Mini Cooper represent 1.7/9.8 (17.35%) of total emissions, which is 4.94 tonnes.

Production emissions from the Mini Cooper SE represent 2.4/9.8 (28.57%) of 100% in the graphic, making 8.14 tonnes

3.3.1.1.2 VW ID.3 vs Golf 8

The graphic below is from [CO_2 balance of the electric vehicle.]()

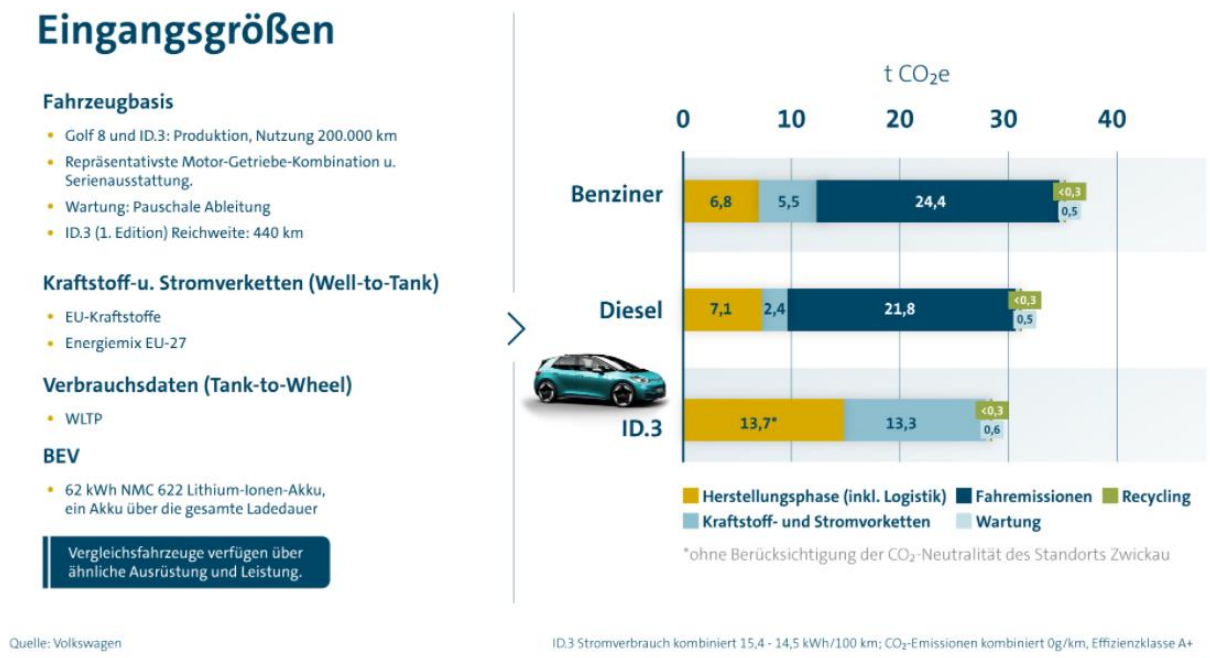


Fig.1 Comparison of the CO_2 balance of electric and diesel and gasoline vehicles in the European compact class.

From this the following figures for embodied emissions are:

Item	Value	Units
Golf 8 Petrol production emissions	6.8	t CO_2e
ID.3 58kWh Production emissions (before carbon neutrality measures)	13.7	
Usage distance	200,000	km

Notably, the reduction in calculated lifetime GHG emissions for a new BEV versions compared to a Diesel ICE version is 4.2 t CO_2e (~13% lower). This is based on today's average continental grid electricity Carbon Intensity, probably excluding scope-3 WTT emissions.

The same VW document also gives a figure of 62kgCO_2e/kWh for battery production, so we can approximate the production emissions for 45kWh and 77kWh versions of the ID.3

We can also estimate the emissions from battery production for Golf 8 1.4 eHybrid, which has a 13kW battery. The battery adds 13 X 0.062 tCO_2e = 0.806 tCO_2e, increasing the car's weight to 7.6tCO_2e.

3.3.1.2 Carbon Neutrality

Once a manufacturer has done life cycle assessment production emissions are known. A manufacturer can then offset emissions using a certified emissions scheme. These schemes cost between $5 and $10 per tonne of CO_2 offset. This means that the cost increase on a car with 15t of emissions is probably less than $150 (about £110).

A number of manufacturers have either certified that their models are carbon neutral, or plan to do so in the near future:

- VW have certified that all electric ID models are delivered carbon neutral
- Jaguar Landrover certified as carbon neutral by the carbon trust

- Daimler (manufacturer of Mercedes-Benz) CO_2 neutral production from 2022

Carbon neutrality does not mean no emissions from the production process, because carbon neutrality standards such as PAS2060 allow:

- Offsetting of emissions using certified schemes – the impact of offsets will reduce as we decarbonise.
- Use of Renewable Energy Generation Obligation certificates (**REGO**), which are accounted for on an annual basis, currently these can be bought for about 50p per MWh.

We should still look for evidence of certified emissions measurement to get an idea of the embedded emissions in a vehicle.

Greenpeace has examined VW's statements about carbon neutrality. VW currently discloses emissions before reductions (13.7 tonnes for an ID.3). Greenpeace estimate that the actual reduction in embodied energy is probably only about 10%. The remainder is offset, which if done via energy generation certification schemes (e.g. REGO), do not deduce any GHG emissions. They do however increase incentives to generating more low-Carbon energy, see TECs' information on Greenwash.

3.3.1.3 Manufacturer targets

Note that the Science Based Targets initiative (**SBTi**) does not accept carbon offsetting as valid carbon reduction, which explains the discrepancy between these statements and companies stating carbon neutrality now or in the very near future.

The following companies have registered targets on the SBTi site:

Manufacturer	Status	Target	Commitment
BMW	Targets Set	1.5C	BMW Group commits to reduce scope 1 and 2 GHG emissions 80% per vehicle produced by 2030 from a 2019 base year*. BMW Group commits to reduce scope 3 GHG emissions from use of sold products 40% per vehicle kilometre by 2030 from a 2019 base year. BMW Group commits to reduce scope 3 GHG emissions from purchased goods & services and upstream transportation & distribution services 22% per vehicle sold by 2030 from a 2019 base year. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to 1.5°C.
Ford	Targets Set	1.5C	Ford Motor Company commits to reduce absolute scope 1 and scope 2 GHG emissions 76% by 2035 from a 2017 base year. Ford Motor Company also commits to reduce scope 3 use of sold products GHG emissions 50% per vehicle kilometre by 2035 from a 2019 base year. The targets covering greenhouse gas

			emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to 1.5°C.
General Motors	Committed	1.5C	General Motors commits to reduce absolute scope 1 and 2 GHG emissions 72% by 2035 from a 2018 base year*. General Motors Company commits to reduce scope 3 GHG emissions from use of sold products of light duty vehicles 51% per vehicle kilometre by 2035 from a 2018 base year. *The target boundary includes biogenic emissions and removals from bioenergy feedstocks. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to 1.5°C.
Jaguar	Committed	1.5C	Business ambition for 1.5C
Mercedes	Committed	1.5C	German global automobile marque Mercedes-Benz AG commits to reduce absolute scope 1 and 2 GHG emissions 50% by 2030 from a 2018 base year. Mercedes-Benz AG commits to reduce scope 3 GHG emissions from use of sold products 42% per vehicle kilometre by 2030 from a 2018 base year. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to 1.5°C.
Nissan	Targets Set	Well below 2C	Nissan Motor Co., Ltd. commits to reduce absolute scope 1 and 2 GHG emissions 30% by 2030 from a 2018 base year. Nissan Motor Co., Ltd. also commits to reduce scope 3 GHG emissions from use of sold products 32.5% per vehicle kilometre over the same time frame. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to Well-below 2°C.
PSA	Targets Set	2C	PSA Automobiles SA commits to reduce absolute scope 1 and 2 GHG emissions 20% by 2034 from a 2018 base year. PSA Automobiles SA also commits to reduce scope 3 GHG emissions from use of sold products 37% per vehicle kilometre by 2034 from a 2018 base year.**The target boundary includes biogenic

			emissions and removals from bioenergy feedstocks. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to 2°C.
Renault	Targets Set	Well-below 2C	Multinational automobile manufacturer GROUPE RENAULT commits to reduce scope 1 and 2 GHG emissions 60% per car produced by 2030 from a 2012 base-year. GROUPE RENAULT commits to reduce scope 3 GHG emissions from use of sold products 41% per vehicle kilometre by 2030 from a 2010 base-year. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to Well-below 2°C.
Volvo	Targets Set	1.5C	Business ambition for 1.5C
VW	Targets Set	Well-below 2C	Volkswagen AG commits to reduce absolute scope 1 and 2 GHG emissions 30% by 2030 from a 2018 base year. Volkswagen AG further commits to reduce scope 3 GHG emissions from use of sold products of light duty vehicles 30% per vehicle km by 2030 from a 2018 base year. Volkswagen subsidiary Scania CV commits to reduce scope 3 GHG emissions from use of sold products 20% per vehicle km by 2025 from a 2015 base year. The targets covering greenhouse gas emissions from company operations (scopes 1 and 2) are consistent with reductions required to keep warming to Well-below 2°C.

Source: Science Based Targets initiative

3.3.2 Resources used in the production of EVs

Manufacture of EVs involves use of a number of resources that are contentious:

- Lithium
- Cobalt
- Graphite
- Rare Earths

Battery cells consist of anode, cathode and electrolyte. The anode is typically made from graphite, the electrolyte typically consists of organic carbonate solvents with dissolved lithium salts, the cathode differs between manufacturers[4]:

Cathode Type	Car model example	Notes
Lithium-nickel-cobalt-aluminium oxide (NCA)	Tesla	No manganese present
Lithium-manganese oxide (LMO)	Nissan Leaf	No cobalt present, almost entirely manganese
Lithium-nickel-manganese-cobalt oxide	BMW i3	Various compositions of 4 metals with Nickel being the most prevalent.

Electric motors require powerful permanent magnets, these use rare earths.

The use of these is discussed in the following sections.

3.3.3 Environmental impact of mining materials for EVs

Lithium

EVs use Lithium Ion batteries, the production and disposal of these has an environmental and social impact.

The two main sources of lithium are mines and brine water and mining, most coming from brine. According to Friends of the Earth, the main production areas are South America (Chile, Bolivia, Argentina), Australia, China and the United States. Lithium carbonate is recovered from brine by natural evaporation, which leaves lithium, magnesium, calcium, sodium and potassium. The production process can lead to severe water pollution and depletion near the extraction site, leading to contamination of streams used by humans, animals and for crop irrigation. There isn't much quantitative information available on this subject. Looking forward there are technological developments being researched which could improve the efficiency and side effects of lithium extraction. Lithium is present in sea water at very low concentrations, research is being done into its extraction.

Exploratory lithium mining is now being carried out in Cornwall by Cornish Lithium and British Lithium, with promising results.

Cobalt

Cobalt is used to stop batteries from overheating.

Cobalt supplies are limited and mining is concentrated in a few countries:

- Democratic Republic of Congo (DRC) (more than 50% in 2016)
- Russia
- Australia
- China (<6%)
- Canada (<6%)
- Cuba

[4] https://www.usitc.gov/publications/332/journals/the_supply_chain_for_electric_vehicle_batteries.pdf

Cobalt prices rose by 120% in 2017. There are concerns over the use of child labour in Cobalt mining in the DRC. AutoExpress[5] has published statements from a number of car and battery manufacturers, which indicate the actions they are taking to ensure that cobalt is ethically sourced.

The race is on to find ways of reducing the amount of cobalt in batteries[6].

Graphite

Graphite is used in the anode of Lithium ion batteries. The majority of graphite is mined in China (700 k tonnes 2019), followed by Brazil (96 k tonnes)[7]. Turkey has the largest known graphite reserves. Graphite mining generally has associated CO_2 emissions from heavy mining equipment.

An alternative to mined graphite is synthetically produced graphite, which is produced from calcinated petroleum coke and coal tar pitch[8]. These are baked at 2800˚C. This process will also have associated emissions.

Graphite has other significant uses, such as steel production.

Currently there is excess graphite production capacity in China[9]. Whilst there is no short-term problem, predicted demand means that production will eventually need to increase.

Rare Earths

Rare earths are used to produce powerful permanent magnets, used in electric motors. The term rare earths does not mean that these are scarce resources, rather that they are found in small concentrations in most earth.

Rare earth magnets come in two types[10]:

- Neodymium ($Nd_2Fe_{14}B$) – Neodymium, Iron, Boron
- Samarium-cobalt ($SmCo_5$)

Neodymium magnets have the strongest magnetic field, so are most commonly used in EV motors.

In China rare earths have been extracted by injecting ammonium sulphate or ammonium chloride into the ground to separate metals from the surrounding soil. This has left extensive water pollution and soil pollution in the areas mined[11]. In 2016 China passed legislation to clean up rare earth extraction.

Recent research has found a way of extracting rare earths from phosphate rock waste, that is produced phosphoric acid used in fertilisers. A clean process using bio-acids is being researched to extract rare earths from phosphate rock waste[12]. Phosphoric acid is used in fertilisers, soaps and detergents, food, water treatment and toothpaste[13].

---

[5] https://www.autoexpress.co.uk/car-news/105573/is-cobalt-the-electric-car-s-dirty-secret

[6] FT Article: Electric Cars: the race to replace cobalt - https://www.ft.com/content/3b72645a-91cc-11e8-bb8f-a6a2f7bca546

[7] https://www.statista.com/statistics/267366/world-graphite-production/

[8] https://www.sciencedirect.com/topics/chemical-engineering/artificial-graphite

[9] https://www.northernminer.com/news/minerals-commentary-the-graphite-opportunity-within-the-ev-boom/1003798139/

[10] https://en.wikipedia.org/wiki/Rare-earth_magnet

[11] https://e360.yale.edu/features/china-wrestles-with-the-toxic-aftermath-of-rare-earth-mining

[12] https://www.designnews.com/electronics-test/rare-earth-elements-phosphate-waste/136417098260397

[13] https://en.wikipedia.org/wiki/Phosphoric_acid

Until recently Tesla Model S and X cars used induction motors, which do not require these magnets, but recent production has switch to use permanent magnets, improving motor efficiency by 4%[14].

New motors are being developed which have less dependence on rare earth magnets, for example BMW has been developing its 5th generation electric motor which does not use permanent magnets[15].

3.3.4 Recycling Li-ion batteries

In 2010 the quantity of Lithium ION batteries that were recycled was only 5% of those manufactured, at that time there was no plant in the UK. There are now plans to develop Lithium battery recycling plant in the UK. Fortum in Finland claim a low carbon process to recycle 80% of Lithium batteries. Again, there is little quantitative information available.

When EV batteries fail it is likely that a small number of cells will have failed, and only these will need to be replaced. When an EV batteries capacity drops to 80% of its original capacity it can still be used for other purposes, for example as a domestic storage battery which are still usable down to 50% Depth of Discharge (**DoD**).

3.3.5 Lifespan

As BEVs are much simpler than conventional vehicles, it is likely that their useable lifespan is longer. It is even possible that vehicles can be kept up to date by software upgrades, and occasional hardware upgrades. Most manufacturers guarantee the battery for 8 years or 100,000 miles; this is because the vehicle electronics limits the State of Charge (**SoC**) so that the battery is never completely discharged or completely charged. According to https://insideevs.com/news/368591/electric-car-battery-lifespan/ many of the original Teslas are still running on their original batteries with little sign of deterioration.

3.4 Payback calculations for replacing an existing ICEV

3.4.1 Comparison with an existing old car

If you already have a car and would not otherwise change it, is it worth buying a new EV?

From both a carbon and finance point of view almost certainly not! Better wait until your existing cars needs to be replaced.

Suppose that you have an old diesel car that does 35mpg causing 165g/km emissions at tailpipe, runs and has an MOT, but has negligible value. You do 5,000 miles a year. Your costs from running it are:

Item	Amount	Annual Cost £	Emissions tCO_2e
Vehicle Excise Duty		210	
Servicing and maintenance		260	0.152
Fuel	649 litres	889	2.047 (@3.156kg/litre)
Total		1379	2.199

Note that tyre replacements are ignored as these are assumed to also be required by a replacement vehicle. The embedded emissions in tyres are considerable.

[14] https://roskill.com/news/rare-earths-tesla-extends-ev-range-using-permanent-magnets/

[15] https://www.automotive-iq.com/electrics-electronics/articles/developing-electric-motors-less-dependable-on-rare-earth-magnets

You propose to replace this with a new EV costing £30,000 with embedded emissions of 14t CO_2e and using 16kWh/100km of electricity, then financial payback would occur after 22 years and carbon payback after about 7 years, if zero carbon electricity was used.

If UK Grid 2021 electricity were used carbon payback would occur about 9 years.

3.4.2 Second hand EVs

If you buy an existing (second hand 2 years old or more) EV, then the production emissions have already been accounted for, so by that reckoning the carbon payback will be immediate, providing the electricity you use is cleaner than the petrol or diesel you were previously using.

3.5 Efficiency Calculations for a new vehicle

If you need to buy a new car, having considered other options, a BEV is almost always a better option than an ICEV or a PHEV. That is in terms of lifetime GHG emissions and costs. Nevertheless, it is worthwhile assessing factors such as annual mileage, charging source and several other aspects of owning a BEV to make sure this would apply to your circumstances. The following should help you make an informed decision.

Please refer to section 3.4 if you are unsure whether or when to replace an existing ICEV with an EV.

EVs are much more efficient in their use of energy than Petrol or Diesel vehicles.

In general, lighter weight BEVs would be more efficient, because:

- The energy required to accelerate a vehicle is proportional to its mass (proportional to its weight)
- The energy required to go up a hill is proportional to mass and the height of the hill.

As the battery has significant mass, vehicles with larger batteries should be less efficient. It's difficult to quantify this as vehicles where the only difference is battery size are difficult to find. A possible comparison is the Kia e-Nero 39kWh and 64kWh. The following table summarises these:

Battery kWh	Unladen Weight	WLTP range	Wh/mile
39	1592	180	260
64	1812	282	270

This suggests that though there is a significant weight and range increase consumption is not that much higher. However, the WLTP test conditions (e.g. elevation, acceleration, speed) may be such that the influence of these is marginal in terms of averaged consumption. For example, if the test conditions included minimal elevation gain, the additional weight would only register as the vehicle is accelerating.

3.5.1 Updating the comparison table for 2021

A number of things have happened since the original table was produced in earlier versions of this document:

- Oil prices have changed and so petrol and diesel prices have increased
- The electricity price used looks unrepresentative for the following reasons:
    - Electricity prices have risen considerably up to October 2021
    - Several specialist EV tariffs have become available, in practice many drivers will use these.
    - Charging at public charging points is in many cases substantially more expensive than at home

  - If you have your own PV charging, the marginal cost of charging from that is 0, subject to availability of surplus electricity and ignoring the capital cost of the PV system.
- The pricing differentials between equivalent conventional vehicles and EVs have reduced.

It is also likely that as EV take-up progresses that some form of additional taxation will be introduced:

- To counteract the reduction in Fuel duty
- To introduce a disincentive for higher vehicle mileage.

Since the government wants to encourage EV take-up it would be counter-productive for any potential tax to disincentivise EV ownership, so its effect on the payback calculation will probably be neutral.

3.5.1.1 Vehicles compared

Most of the EVs in 2019's comparison were BEV versions of a model that also had conventional versions, in these cases the EV design isn't optimal, and the cost differentials are larger. We include a couple of plug-in hybrids in this comparison to draw out points made earlier.

In this release, some different vehicles have been chosen for comparison:

- VW Golf 8 1.5 eTSi petrol 150PS against VW ID.3 Life Pro 145PS 58kWh
- VW Golf 8 1.4 TSi eHybrid PHEV petrol 204PS 13kWh vs VW ID.3 Pro Performance 204PS 58kWh
- Kia Nero 2 trim:
  - Self-driving hybrid 139PS, 1.56kWh
  - PHEV 139PS, 8.9kWh
  - e-Nero 134PS, 39kWh
- Mini Cooper S 131kW compared with Mini Cooper SE 135kW 28.9kWh

The relevant data for these vehicles is shown in the following table:

	Car			Power			Range			Consumption			Emissions			Weight
Manuf.	Model	Variant	Price	Power (PS)	Power (kW)	Power/ Weight PS/kg	Battery capacity (kWh)	WLTP Range miles	WLTP Range km	Petrol mpg	Electric (kWh / 100km)	kWh / 100km	exhaust g CO_2e/km	Use g CO2 e/km	Embedded tCO_2e	Kerb Weight
VW	Golf 8	eTSI Life 1.5 130PS	26390	130	96	0.086			0	51.8		52.19	126	153.79	6.8	1365
VW	ID.3	Life Pro	29635	145	106	0.078	45	217	347.2		15.4	15.4		56.08	12.9	1706
VW	Golf 8	1.4 eHybrid Style	33640	204	150	0.117	13	62	99.2	49.9	13	54.18	21		7.61	1590
VW	ID.3	Family Pro Performance	34975	204	150	0.104	58	260	416		15.7	15.7		57.17	13.7	1812
Kia	Nero 2	Self Charging Hybrid	25445	139	102	0.085	1.56		0	58.9		45.90	110	135.25	Unknown	1490
Kia	Nero 2	PHEV	30815	139	102	0.080	8.9	30	48	58.9	18.54	45.90	31		Unknown	1594
Kia	Nero 2	Electric	30395	134	98	0.074	39	180	288		15.3	15.3		55.71	Unknown	1667
Mini	Cooper	Petrol	20205	136	100	0.105				51.4		52.60	124	154.99	4.94	1150
Mini	Cooper S	Petrol	23605	178	131	0.136				45.6		59.29	124	174.70	4.94	1160
Mini	Cooper SE	Electric	26000	184	135	0.116	28.9	140	224		15.2	15.2		55.35	8.14	1440

In the above comparisons, we have tried to match power and trim levels for each pair, this is easy for Kia as they are the same model. This is much more difficult for VW and Mini.

Since all the consumption data used here are from the same WLTP source, mismatch to real-world consumption figures does not impact the comparison between EV and ICEV.

It is also worth noting that the cheapest VW Golf does not have a near equivalent ID.3, so it could be said that a VW Golf costs £23,860 against £29,635 for the cheapest ID.3, however, that is not a like for like comparison.

Both Mini Cooper and Mini Cooper S have been compared with Mini Cooper SE because Mini Cooper SE has a power/weight ratio between these, so neither is a direct comparator.

The comparisons of fuel consumption are made using manufacturer's published WLTP combined data, so do not take into account 'real world' conditions or actual driving/charging conditions. gCO2e/km are derived directly from fuel emissions as this takes into account non tailpipe emissions. Fuel consumption figures should be considered as 'optimistic'.

Comparing the kWh/100km, petrol models use at least 3 times as much energy as electric.

Energy lost in charging is much higher when using rapid DC charging than standard 7kW charging. Charging at 7kW is generally about 80% efficient (from comparing metered charge energy with indicated consumption), the quoted consumptions for EVs in the table above have been divided by 0.8 to account for this.

The Exhaust CO_2 and quoted consumption for PHEVs are normally published for combined use, without specifying that ratio. In practice short journeys in a PHEV will be all electric, whilst longer trips will be petrol. We believe that a better estimate for PHEV consumption for longer distances is that of the equivalent ICE model. In the table above we have given both an electric consumption and an ICE consumption for PHEV models.

Because of the unrealistic and undefined combined consumption figures for PHEVs, comparisons can only be indicative, figures quoted for PHEV are likely to be significantly over optimistic. .

3.5.1.2 Electricity prices

As mentioned earlier it is quite unlikely that a standard tariff would be used to charge an EV, so a range of electricity prices need to be considered in the payback calculation:

- 'Free' electricity – such as surplus electricity from an existing PV system
- Specific EV tariff – for example Good Energy Green Driver 5p / kWh off peak
- Ofgem Capped Standard variable rate – 20.5p / kWh, 24.5p daily rate
- Public motorway service station 50kW DC Charger (Gridserve) 30p /kWh
- Typical public 50kW DC Charger 40p/kWh
- Ionity charger 150kW DC Charger – 69p / kWh

To complicate matters further some manufacturers offer deals on charging when you buy a new car, these are ignored in the comparisons.

3.5.1.3 Cost Break even mileage with different electricity tariffs

In the following table cost payback mileages are given for different electricity tariffs and vehicles from the table in 3.5.1.1, excluded from the following table are:

- The most expensive tariff of 69p / kWh the cost per mile, as in all our vehicles this is more expensive than petrol for the equivalent vehicle, so at that tariff an EV will always cost more regardless of mileage.
- The Kia Nero PHEV, which costs slightly more that the e-Nero with the same trim, so would always cost more to run than the electric version.

All the calculations shown below assume that petrol costs £1.36 / L.

The table below also includes carbon payback mileages for vehicle pairs where the embedded emissions for both are known. The calculation of these is in following sections 3.5.1.4.1 and 3.5.1.4.2

			Price Diff.	Cost payback mileage for Electricity Tariff (p/kWh)					Emissions difference	Carbon payback mileage for	
Manuf.	**Model**	**Variant**		**0**	**5**	**20**	**30**	**40**	**Production tCO_2e**	**Zero carbon**	**UK Grid**
VW	Golf 8	eTSI Life 1.5 130PS									
VW	ID.3	Life Pro	3245	27224	30390	46677.6	72626.3	163541	6.1	24646	38789
VW	Golf 8	1.4 eHybrid Style									
VW	ID.3	Family Pro Performance	1335	10789	12019	18265.1	27947.7	59478.3			
Kia	Nero 2	Self Charging Hybrid									
Kia	Nero 2	Electric	4950	47220	53519	89231.5	160734	808976			
Mini	Cooper	Petrol									
Mini	Cooper SE	Electric	5795	48242	53724	81513.8	124420	262693	3.2	12829	19955
Mini	Cooper S	Petrol									
Mini	Cooper SE	Electric	2395	17688	19449	27729.1	38719.5	64142.1	3.2	11382	16659

This comparison only takes into account new price and consumption. No account is taken for:

- Vehicle Excise Duty (VED) payable on conventionally fuelled cars
- Servicing costs
- Depreciation

When the comparison is close these factors will make a significant difference.

3.5.1.4 Carbon break even mileage

Where the vehicle's life cycle emissions have been accurately assessed, these figures can be used to calculate a break-even point for a BEV against its ICEV equivalent.

The table in 3.5.1.3 also shows the Carbon payback mileage for:

- When charged from zero carbon electricity, e.g. surplus electricity from an existing PV system
- When charged from UK Grid electricity in 2021

3.5.1.4.1 Mini Cooper SE

BMW's life cycle assessment for the Mini Cooper SE shows a carbon comparison with the Mini Cooper, this suggests carbon break-even, depending on electricity source, between 13,500 and 22,500 miles. These are higher than shown in the table above because:

- Renewable electricity for the 13,500 mi figure includes some associated emissions.
- The higher figure of 22,500 mi uses 2019 grid electricity from a different source than UK grid (probably European average)

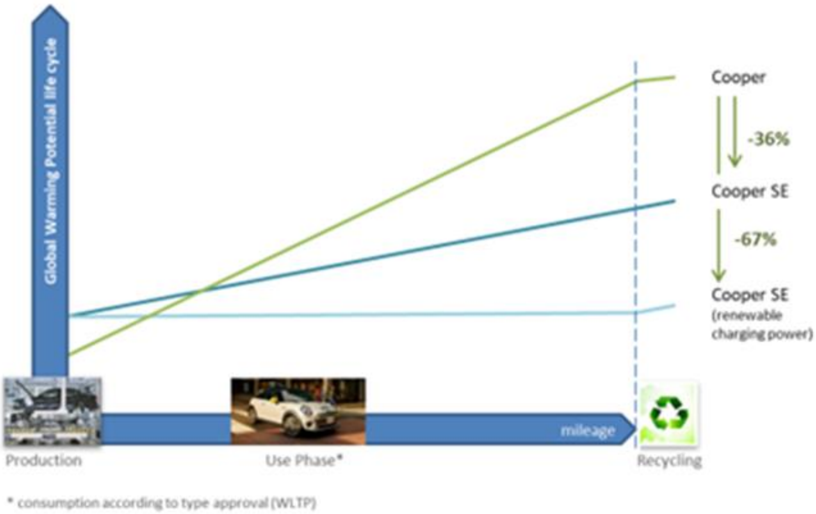


Fig. 3: Classification of the MINI Cooper SE in relation to a conventional vehicle concept (Cooper)

The lifetime used in the above illustration is 150,000 km (93,000 miles).

The figures shown in the table in 3.5.1.3 are derived from the difference in production emissions (4.94t for petrol and 8.14t for BEV giving a difference of 3.2t). The BEV in use emissions from a zero carbon source are put at zero, and the in use emissions from grid electricity are 55.347gCO_2e/km. In use emissions from the ICEV are derived from fuel consumption at 154.99gCO_2e/km.

If the electricity used in the Mini Cooper SE's lifetime was zero emissions, then its production emissions would be paid off in 100000 * (8.14-4.94)/154.99 km = 12,829 miles.

If instead the electricity used is UK Grid 2021 as was used to calculate emissions/km then the difference in emissions rates is 99.64gCO_2e/km, in which case payback occurs in 1,000,000 * (8.14-4.94)/99.64 km = 19,955 miles.

If instead the higher consuming Mini Cooper S is used in the calculation payback emissions are achieved even earlier.

3.5.1.4.2 VW Golf and VW ID.3

VW give production emissions for ID.3 of 13.7 tCO_2e and 6.8t CO_2e for Petrol Golf 8.

The ID.3 model used in VW's graphic is a First edition one which has a larger battery (58kWh) than the vehicle in the cost comparison table (45kWh). VW state that emissions per kWh for battery production are 62kg CO_2e/kWh. So the production emissions are reduced by 0.8 tonnes to 12.9 tonnes.

Our example Golf emits 153.79 g CO_2e/km

If the electricity used in the ID.3's lifetime was zero emissions, then its production emissions would be paid off in 100000 * (12.9 – 6.8) / 153.79 km = 39,664 km = 24,646 miles

If instead the electricity used is UK Grid 2021 as was used to calculate emissions/km then the difference in emissions rates is 97.72 gCO_2e/km, in which case payback occurs in 1,000,000 * (12.9-6.8)/97.72 km = 38,789 miles

3.5.1.4.2.1 Effect of a larger battery

ID.3 comes with 3 different battery sizes. Increased battery size has a corresponding increase in both production emissions and kerb weight. An increased kerb weight will also increase electricity consumption and so emissions per km on UK grid electricity. Carbon payback mileages for each battery size against a petrol Golf 8 are given in the table below.

				Carbon payback mileage for electricity source	
Battery Size kWh	**Kerb Weight kg**	**Production emissions**	**Emissions / km**	**Zero Carbon**	**UK Grid**
45	1706	12.9	56.07525	24646	38789
58	1812	13.7	57.167625	27878	44372
77	1934	14.9	59.352375	32638	53149

3.6 Efficiency of Rapid Charging

Rapid charging is charging at 50 kW and above. With Rapid charging a useful amount of charge can be gained in 10s of minutes. Rapid charging is generally stopped when the battery is 80% charged, as charging past this point becomes inefficient and high currents when the battery is near fully charged can damage the battery.

Evaluation of Fast Charging Efficiency under Extreme Temperatures studies efficiency of a number of chargers ranging from 20kWdc to 120kWdc. At 25°C and higher charging rates (37.6kW to 48.9kW) the chargers were between 90% and 92% efficient. At -15°C efficiencies were between 43% and 89% efficient. This study measured the efficiency of converting electricity from a 400V, 125A 50Hz supply to DC voltage for charging.

Other factors need to be considered:

- How the charging rate affects the useful charge returned from the battery.
- The effect of high demand on the electricity supply network.
- How high charge rates affect the life of the battery.

Battery University's article on Fast and Ultra-fast chargers discusses the relationship between charge rate, efficiency and battery life. If a battery is charged in an hour, after 500 cycles it would retain 83% of its capacity. If it charged in 30 minutes, after 500 cycles it would retain 48% of its capacity. If it charged in 20 minutes, it would be dead before 400 cycles had passed.

A high charge rate is only applied during the first few minutes of charging. https://batteryuniversity.com/learn/article/bu_1004_charging_an_electric_vehicle states that tests show that charging with a 24kW dc charger takes 30 minutes, whereas charging with a 50kW dc charger only reduces this to 20 minutes.

Always read the manufacture's advice on charging rates and any associated warranty statements.

3.7 Non-Tailpipe emissions from ICE vehicles

Emissions figures for EVs based on grid electricity have been calculated. Emissions quoted for ICEV are measured during testing at the tailpipe[16], and do not take into account embedded emissions in the fuel production process.

[16] See https://motorway.co.uk/guides/car-co2-emissions for a good explanation of how quoted vehicle emissions are calculated.

In order to make a fair comparison embedded Well to Tank emissions for ICEV need to be accounted when comparing CO_2e emissions of ICEV with EV.

Well to Tank emissions arise from:

- Refining crude oil to petrol or diesel is about 82% efficient, the remaining 18% of source fuel is used in the refining process and so has associated emissions.
- Extraction of crude oil from low grade sources such as tar sands involves significant energy use and therefore emissions.
- Transport of crude oil also has emissions.

The kg CO_2e/km column in the comparison table is now derived by multiplying fuel emissions factor by the fuel consumption. This aligns with the method used by ICCT[17] to compare NEDC emissions with various sources of real-world emissions. ICCT state that emissions are directly proportional to fuel consumption. The results of ICCT's work were adopted by BEIS when compiling emissions factors for vehicles.

3.8 Driving

There are some important differences when driving a BEV:

- The motor has most torque (pulling power) when it is starting, which means that a BEV accelerates much faster from a standing start.
- All BEVs are automatic, pure BEVs normally only have one gear. So, the drive experience is much smoother than even the most sophisticated automatic ICE.
- Many newer BEVs incorporate semi-autonomous features such as adaptive cruise control, collision avoidance, speed limit recognition.
- Most BEVs implement regenerative braking, when braking the motor functions as a generator which charges the battery. Some can be driven most of the time using just the accelerator pedal.
- All BEVs need charging with electricity which can be done at home, destination or at a rapid charger.
- The battery in a BEV is heavy and is usually placed low down in the vehicle, this lowers its centre of gravity. Some drivers may notice the increased weight.
- BEVs are quiet so other road users may not hear your approach, particularly pedestrians and cyclists. From 2019 newly approved models have to emit a sound of at least 56 db when reversing and at speeds less that 20kph (12mph). From 2021 this will apply to new EV sales.

3.9 Towing

When the first version of this paper was written most EVs did not have type approval for towing, so towing would invalidate your insurance and warranty. There are some exceptions at the high end (Tesla Model X, Jaguar i-Pace, Mercedes EQC and Audi e-Tron). Since then, the situation has improved as is shown in the Autocar and EV Database links.

There are a number of reasons why manufacturers have chosen not get vehicles type approved:

- EVs are heavier because of the battery.

[17] https://www.theicct.org/sites/default/files/publications/Lab-to-road-2017_ICCT-white%20paper_06112017_vF.pdf

- Weight of vehicle and trailer places additional loads on brakes and suspension.
- Damage to the drive-train when using regenerative braking.
- Adverse publicity caused by reduced range.

If a vehicle does not have approval for towing nobody knows how it will handle in situations likely to be found when towing.

For more information see:

EV Database includes braked and unbraked towing weights for each vehicle.

https://www.rac.co.uk/drive/advice/know-how/can-electric-cars-tow/

https://www.drivingelectric.com/your-questions-answered/131/can-i-tow-caravan-electric-or-hybrid-car

https://www.autocar.co.uk/car-news/electric-cars/top-10-best-electric-cars-towing

3.10 Insurance

BEVs are more expensive than an equivalent ICE. The insurance premium is therefore likely to be higher. As insurance premiums vary significantly, we recommend that you investigate this before you decide to buy.

Some points to consider as well as cost when insuring an EV are:

- Is a leased battery covered?
- Is recovery to the nearest charging point covered if you run out of charge covered?
- Do you have public liability cover for use of charging cables at public charging points?
- Is use of a vendor loaned petrol or diesel vehicle covered for longer journeys?

Comparative quotes from LV have been included in the vehicle comparison table.

As EVs become more common it is likely that insurance companies will offer equivalent deals.

Zap map provides further advice on electric car insurance

https://www.zap-map.com/electric-vehicles/electric-vehicle-insurance/

3.11 Taxation

3.11.1 Vehicle Excise Duty

Zero emissions vehicles are normally exempt from Vehicle Excise Duty, but any vehicle costing more than £40,000 is subject to a surcharge currently £320 for the first 5 years. In the March 2020 budget, the chancellor of the exchequer announced that zero emission cars will be exempt from this surcharge until 2025.

3.11.2 Benefit in kind for company car drivers

The government has announced that for the 2020/21 tax year the rate for benefit in kind for BEVs registered after April 6, 2020 will be 0%, this will also apply to BEVs registered earlier. But the rate will increase to 1% in 2021/22 and 2% in 2022/23

4 Charging an Electric Vehicle

BEVs and PHEVs need to be charged. This can be with:

- A plug-in charger
- A home charger
- On street residential chargers
- A charger at work
- At a public charging point

The charging circuitry for an EV consists of:

- Stationary charging unit
- Charging cable
- On-board charger which converts incoming AC from the mains to a DC voltage to charge the battery.
- Battery.

Most home and destination charging use either single-phase or three-phase mains electricity. This requires rectification and voltage conversion to charge the battery.

Rapid charging is often DC electricity, where the static charger does the conversion from mains to DC. A converter to handle the high currents required by rapid charging is expensive (and substantial), so is provided by a static unit, rather than the car. Rapid charging requires a lot of current from the grid, and so may be backed by storage batteries.

Charging with a 7kW wall unit is reasonably efficient and best for the battery, see next section for more detail.

4.1 Charging efficiency and battery life

The efficiency of charging depends on several factors including:

- The state of charge of the battery (SOC). When nearing fully charged (over 80%) the rate at which batteries can safely accept charge drops, more heat is generated, making the process less efficient.
- The charging rate – higher charging rates cause more heat to be generated
- Temperature of the battery – batteries perform best at about 25°C, they charge slower as the temperature reaches 0˚C. Also charging a lithium battery too fast at a high temperature can cause thermal runaway, which in extreme cases can cause the battery to catch fire.
- The efficiency of AC to DC conversion in the charger, which should be in the region of 85% under optimal conditions.
- DC losses in charging the battery, these probably amount to between 5 and 10% depending on charge rate (higher rates will have higher losses)
- Losses through running the car's electronics whilst charging.
- Very small AC losses between the meter and charger.

Many of the losses above will appear as heat that needs to be removed.

A couple of articles that discuss this are:

https://www.caranddriver.com/features/a36062942/evs-explained-charging-losses/

https://www.quora.com/How-efficient-is-an-electric-car-charger-Do-you-only-use-20kwh-to-charge-a-20kwh-battery

4.1.1 Using the car's AC charger

When an AC charger is used the most of the above losses will occur, it is unlikely that a charging efficiency above 80% can be achieved. This type of charging is best for the car's battery, particularly if the state of charge can be kept between 20% and 80%. It is ok to charge to 100% but the battery should not be left fully charged for a long time.

4.1.2 Using a static DC charger

When an DC charger is used the electricity going into the car is measured, this will have been converted to the right DC voltage by the static charger. In this case the efficiency appears to be higher as only the car's AC charger losses do not enter the calculation. As DC chargers are used to achieve higher charging rates, they will cause more battery heating, which will need to be controlled.

Users of DC chargers have noted that times to achieve the first 80% of charge are about linear with the increase in charge, but above that, charging times extend. For example if charging to 80% takes 40 minutes, then if the relationship was linear you would expect reaching 100% to take 50 minutes; this isn't what happens in practice because the charging current needs to be reduced to protect the battery so reaching 100% will take considerably longer.

Regular rapid DC charging can have an adverse effect on battery life. See 3.6 for further discussion.

4.2 Connector Types

There are a number of different connector types so you will need to use a charger with an appropriate connector for the vehicle. The most common is a generic type 2 connector.

The following table summarises the available connector types:

Connector Type	Supplies	Notes
IEC Type 1	3 kW or 7kW AC	Compatible with old Nissan Leaf and some other early models. No current new models use this type of connector.
IEC Type 2	3 kW, 7kW single phase AC 22kW, 43kW three phase AC Also Tesla 120kW DC	This appears to be the most common connector, and is used by the majority of new models.
CCS	50 kW DC	The CCS connector is an IEC Type 2 Connector with an extra 2 pin connector for DC. Compatible vehicles include BMW i3, VW e-Golf and Hyundai Ioniq Electric.
CHAdeMO	50 kW DC	A separate connector normally in addition to a type 1 connector. Compatible vehicles include Nissan Leaf, Mitsubishi Outlander PHEV, Kia

		Soul EV.

4.3 Plug-in chargers

These are chargers that plug in to a normal 3 pin socket (delivering ~2.2kW of power). They are the slowest means of charging, e.g. a PHEV with a 7kWh battery takes nearly 4 hours to charge with one of these.

A plug-in charger can be useful if you are away overnight and there is no other means of charging available. However, they are not recommended as they could reduce the charging efficiency to ~75%.

These chargers plug into a 3 pin sockets which are often on a ring main, with a single fuse or circuit breaker covering several sockets. Other loads in combination with the vehicle charger may cause the ring main to be overloaded, so best to avoid having other loads on the same ring main.

It is very important that any power supply to an EV is adequately earthed, as the body of the vehicle is insulated from the ground by its tyres. It is not possible to check this automatically with a plug-in charger, whereas dedicated chargers automatically check the quality of the earth.

4.4 Home chargers

If you have off street parking, then you should get a home charger. This is a dedicated charger that has its own circuit which is typically rated at 32 Amps. This means that a home charger can charge at 7kW from a single phase supply. 7kW is the highest charge rate that is available/safe from a single phase supply.

A 7kW charger can completely recharge most currently available EVs in 12 hours (up to 84kWh), this should be enough for a large BEV to do about 250 miles.

A government grant is available to fund up to 75% of the cost (up to a maximum of £500) of a home charger. From July 2019 funding will only be available for smart chargers which are capable of being remotely controlled, this will enable loading of the grid to be controlled so that charging at peak times is avoided. The charge-point must be installed by an authorised installer. This grant will no longer be available to freehold owners of houses from March 2022, instead the grant money will be directed to private landlords and those living in leasehold flats.

If you have a 3 phase supply a 22kW charger can be installed.

In practice most EV charging is done at home.

Between 72 and 85% of overnight parking in Teignbridge is either in a garage or on private property, so most parking is suitable for home charging. See 4.5.3 for further information.

4.4.1 EVSE

When we refer to home chargers in this context, we really mean Electric Vehicle Supply Equipment (**EVSE**). An EVSE controls the supply of AC electricity to the AC charger in the vehicle, so is not really a charger at all. An EVSE is normally on a dedicated 32 Amp circuit, and a higher standard of earthing is required. An EVSE will:

- Check that the vehicle is connected to correctly before allowing charging
- Check that the earth is functioning correctly
- Provide a pilot signal to the car to indicate the rate at which it should charge
- Optionally meter the power/energy going to the car

4.4.2 Solar charging

If you have solar PV, then the cheapest and lowest carbon way of charging a car is to use surplus solar energy that you would otherwise export. A number of EVSEs are now available with a solar divert mode. These EVSEs switch on when sufficient solar is available to provide a charging current of at least 6 Amps, vary the charging rate to match surplus solar generation, and switch off when the surplus solar has been too low for a period.

EVSEs of this kind include:

- Zappi offers a number of charging modes settable in its own App. Once set, this charger does not require much user input.
- Mennekes Amtron Premium and Xtra chargers integrate with SMA inverters to allow the user to set a number of charging scenarios which operate autonomously..
- emonEVSE , is an open source EVSE. Being open source makes it suitable for integration with home automation systems, this is suitable for those who tinker with hardware and software to create their own charging scenarios and automation.

Domestic battery systems can be used in conjunction with these solar chargers where surplus PV can be temporarily stored until the vehicle is plugged in, and the charger can draw power from the battery when the available solar drops below the minimum 6A charging rate of the charger. This double battery charging will introduce additional charging inefficiency compared to direct charging the vehicle from the surplus solar charge. This reduction in efficiency, however, is insignificant given the low-carbon source being used.

4.4.3 Electricity tariffs

If you have a smart meter, then a number of tariffs are available designed for EV drivers. These typically enable you to charge overnight, when general electricity demand is low. Charging off-peak is being encouraged by electricity network operators to prevent additional load occurring at during peak periods.

EV specific home tariffs typically have either a cheap overnight rate, a guaranteed number of cheap hours in a month or are agile (meaning that they vary according to the wholesale price of electricity).

There are a number of companies offering this kind of tariff to those with a smart meter including:

- Octopus Energy
- EDF
- Good Energy
- British Gas

See https://www.smarthomecharge.co.uk/guides/energy-tariffs-how-to-keep-ev-charging-costs-low for further information.

In order to use these tariffs you will either need:

- A car which interacts with the tariff, or at least allows charging periods to be set.
- A smart charger that interacts with your tariff.

4.5 On street residential chargers

A barrier to EV take up is dwellings that do not have off street parking, and so cannot have a home charger. To deal with this there is a government grant available to local authorities. This scheme is supported by the Energy Saving Trust.

The Office for Low Emission Vehicles (OLEV) has allocated £1.5m of funding for 17/18 and £4.5m for 18/19 and 19/20 for on-street residential projects. This funding is available to Local Authorities for eligible projects, on a first come, first-served basis.

By 2019 there was only one authority in the South-West that has successfully applied under this scheme (see map).

The energy saving trust have just published a guide, which gives more information for authorities.

By 2021 the charging picture has started to change with a number of initiatives for public charging in Devon:

- Devon Low-carbon Energy & Transport Innovator (DELETTI) will install car parks in Devon.
- Teignbridge have bid for the government residential charging scheme, this will bring additional street chargers to Newton Abbot, Buckfastleigh, Chudleigh, Bovey Tracey, Moretonhampstead, Shaldon, Dawlish, Teignmouth, Ashburton, Starcross and Widecombe.

It is likely that the rates paid for electricity using street/car park charging would be significantly more expensive than the rates available at home for off-street charging.

4.5.1 Running a cable across the footway

In some situations, it may seem reasonable to run a cable from your mains socket to a car parked in the street. If this is done you should take steps not to endanger or inconvenience members of the public. You could be liable for damages if a member of the public tripped over your cable. In any public liability case damages could be considerable.

This article in This is Money discusses the subject in much more detail. It quotes the Local Government Association (LGA) as saying that there isn't any legislation to stop you running a cable across the footway.

Hampshire CC has published guidance to residents wishing to charge in this way. Devon CC has not published any guidance, so the situation in Devon is uncertain.

4.5.2 Innovations in on street charging

Some ideas that have been implemented to deal with the on-street charging problem include:

- Ubitricity have modified lamp posts to provide a charging point.
- Urban Electric offer charging points that rise up out of the ground.

To use these, you need to have a type 2 cable with you and the appropriate App.

4.5.3 Estimate of on street residential parking

In the previous version of this document an estimate of 20% on-street parking was stated, this was a weighted average of the MSOAs in Teignbridge. This section gives a slightly more detailed analysis, which estimates on street parking in Teignbridge between 28% and 15%.

An attempt has been made to estimate the amount of on street residential parking in Teignbridge based on National Transport Survey Table NTS0908 (which can be found here), which is a survey of where vehicles are parked overnight:

2020	Percentage				
	Rural-Urban Classification[2] of residence				
	Urban Conurbation	Urban City and Town	Rural Town and Fringe	Rural Village, Hamlet and Isolated Dwelling	All areas
Garage	*12*	*11*	*14*	*13*	*12*
Private property (not garaged)	*53*	*61*	*71*	*71*	*61*
Street	*32*	*24*	*12*	*14*	*24*
Other	*3*	*4*	*3*	*2*	*3*
Total	*100*	*100*	*100*	*100*	*100*
Unweighted sample size: vehicles	1,038	1,821	521	654	4,034

It has been noted that the sample size in NTS is quite small, so this weighting may produce misleading results.

The urban rural classification comes from https://www.gov.uk/government/collections/rural-urban-classification. Lookup tables were published in 2011 which enable the classification to be determined for:

- Small area geographies
- Local authority areas
- Higher level geographies

Using the classification for local authority areas Teignbridge is classified as largely rural (rural including hub towns)

Applying the Rural Town and Fringe category to Teignbridge gives 85% private property or garage, leaving the remaining 15% street or other. Earlier tables are used then the proportion of on street parking is higher.

Anecdotal evidence seems to suggest that numbers with only on street parking are higher in Teignbridge than suggested in this survey.

Village centres in Devon have narrow streets and few footways, so the general figure of 14% on street parking is probably more like 50%. However villages represent about 13.37% of dwellings. If 28% is assumed for on street and other parking, then villages are underestimated by 22% X 13.37% = 2.94% of the total. But also rural town on street and other parking is overestimated by 13% or 13% X 26.37% = 3.43%. So 28% on street and other is probably a reasonable high estimate.

A lookup table showing the urban rural classification for lower level areas is also available giving lookups for:

- Census Output Areas (OA)
- Census Lower Super Output Areas (LSOA)
- Census Middle Super Output Areas (MSOA)
- Census Wards

Using the MSOA table Teignbridge is divided into 19 areas, the classifications of these are:

- Rural village and dispersed
- Rural town and fringe
- Urban city and town

As the amount of on-street parking in 'Urban city and town' areas is double that in 'Rural town and fringe', a better estimate lies somewhere between 15% and 28% on-street and other.

If a firmer estimate is needed this could be determined by:

- Calculating an average for MSOAs weighted by population
- Visual inspection using a combination Google Street View and properties records derived from Land Registry index polygons.

The breakdown of Teignbridge from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/239069/2001-la-class-dataset-post0409-boundaries.xls

Is

Urban	8.69%
Large Mkt town	41.85%
Rural town	26.37%
Village	13.37%
Dispersed	9.71%

When we had previously produced a weighted average we had said that Large Market Town and Rural Town were both classes as rural town and fringe.

4.6 Workplace chargers

The Workplace Charging Scheme is a voucher based scheme that provides support towards the up-front costs of the purchase and installation of electric vehicle charge-points, for eligible business, charities and public sector organisations. This scheme is for up to 20 sockets across all sites for each applicant.

4.7 Destination chargers

Some businesses are making chargers available for the use of their customers. This makes sense where you are likely to spend a considerable amount of time at a business. Businesses offering these include:

- Hotels and accommodation
- Leisure centres
- NHS Properties
- Retail
- Sports grounds

4.8 Public Charging Points

Public charging points are available in many places. ZapMap publishes a map which shows the current location of these and includes the current status of each charger. Many of these chargers require registration with an app before they can be used. Although the status of these is updated on search apps such as ZapMap, this can often be different by the time you arrive at the charging point.

As well as the 7kW and 22kW charging types described for home use, there are Rapid charging points which charge at much faster rates 43kW for AC and up to 150kW for DC, even 350kW is mentioned on the ZapMap site. These can charge compatible BEVs to 80% in 20-40 minutes. Though fast, this method of charging is less efficient than slower chargers. It potentially places significant loads on the electricity network, so expect to see rapid charging points associated with storage.

There are a number of operators for charging points, access to these varies:

- Some operators have a membership scheme, though they may also offer a pay as you go scheme.
- Some provide access via a Smartphone App.
- Some provide access via an RFID card.
- Most Tesla points are for the use of Tesla drivers only, though Generic Type 2 7kW and 22kW points on the Tesla Destination network can be accessed by non-Tesla drivers.

For more information on charge-point operators see here. Though the situation is improving planning is still essential when using public charging.

ZapMaps claims there are now more charging points than filling stations in the UK. Though that isn't really a fair comparison because each filling station probably has 10 or more pumps and the pumps are occupied for significantly less time.

Many manufacturers offer charging packages when purchasing a new vehicle, these provide access to specific charge network operators.

There needs to be significant growth in provision to deal with the expected growth in BEV sales. Provision in Teignbridge is below the national average. Although there are initiatives in Teignbridge to increase public charging points, these fall short of what is likely to be needed. The lack of plans to significantly increase public charging points is another hurdle to BEV ownership for the majority who do not have access to a private charging point.

Some useful links:

https://www.zap-map.com/live/ gives the locations of all public chargers and some status information.

This Which article gives a lot of information about public charging, and includes a summary of the major providers.

4.8.1 Major Chargepoint Providers

The following table summarises the major chargepoint providers as of October 2021:

Provider	Contactless?	App?	RFID	Overstay Fee	PAYG rate/kWh	Subscription	Notes
BP Pulse	Y	Y	Y		0.35p	£7.85/mo	Some free 3.6kW and 7kW chargers at supermarkets. CCS chargers 50kW in South West
GeniePoint		Y	Y	£10	0.42p		Overstay fee applies after 90 minutes
Gridserve	Y	N	N		0.30p		Used to be Electric Highway, available at most motorway services, currently just turn up and charge
Instavolt	Y	Y	N		0.40p		
Osprey	Y	Y	N		0.40p		Accepts third party RFID cards
Pod Point		Y	N		?		Most chargers are free at destinations. Others are per hour or per kWh
Shell	Y	Y	Y		0.41p		Shell also owns Ubitricity who provide lamppost charging
Ionity		Y			0.69p	£16.99/mo	Charging network where Audi, BMW, Ford, Hyundai, Kia, Mercedes-Benz, Mini, Porsche, Skoda, VW offer specific terms. Also other Mobility Service Providers. Subscription rate 0.35p
Mer	Soon	Y			0.39p		Common in Dorset, and specific LA areas
Tesla					?		Tesla Superchargers only available to Tesla Owners at present, though they have announced it will be available to other makes Some Tesla Destination 7kW and 22kW chargers are Type 2 and accessible to anyone. Cost if any depends on the destination.

5 Available vehicles

Places you might look for information about currently available BEVs models include:

- Manufacturer's brochures and price lists.
- https://ev-database.uk/
- https://pod-point.com/guides/vehicles?