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EV Guide for Drivers

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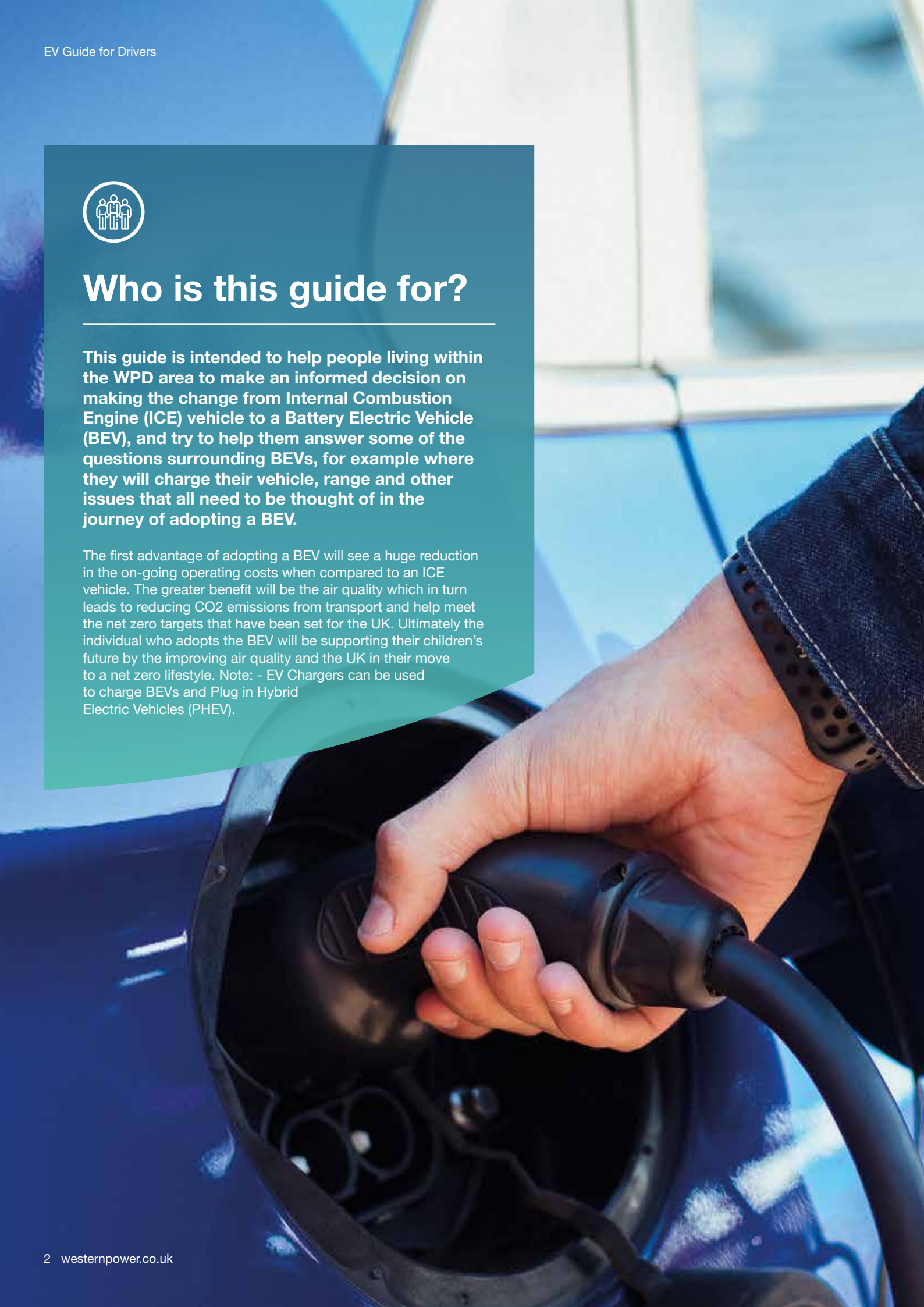


Who is this guide for?

This guide is intended to help people living within the WPD area to make an informed decision on making the change from Internal Combustion Engine (ICE) vehicle to a Battery Electric Vehicle (BEV), and try to help them answer some of the questions surrounding BEVs, for example where they will charge their vehicle, range and other issues that all need to be thought of in the journey of adopting a BEV.

The first advantage of adopting a BEV will see a huge reduction in the on-going operating costs when compared to an ICE vehicle. The greater benefit will be the air quality which in turn leads to reducing CO2 emissions from transport and help meet the net zero targets that have been set for the UK. Ultimately the individual who adopts the BEV will be supporting their children's future by the improving air quality and the UK in their move to a net zero lifestyle. Note: - EV Chargers can be used to charge BEVs and Plug in Hybrid Electric Vehicles (PHEV).

What is this guide about?

Anyone paying attention to the impacts of Global Warming will know that tackling emissions from transport is vital. This why the government is looking to bring forward the ban on ICE vehicles and hybrid vehicles to 2035.

During 2018 an estimated 33% of CO2 emissions were from the transport sector. It can be seen that transport accounts for a large proportion of the UK Greenhouse Gas emissions. This guide tries to address the topics that an individual has to decide on when they choose the BEV vehicle option.

Some of the items that the guide will attempt to address is the differential between EVs and ICE vehicles, their range, and provision of charging infrastructure to be the main barriers.

The guide will set out to explain the various types of charging available and how long the chargers take to charge a typical EV battery, the types of connectors to be found on EVs and chargers, and explain the UK's plans for setting a uniform method of payment and access to publicly available charge points. The range of the available charging options is rapidly expanding, with major technological developments and alternative sources of energy emerging over the last 10 years.

What is a Distribution Network?

A Distribution Network Operator (DNO) is a company licensed to distribute electricity in the UK. It is responsible for the distribution of electricity downstream from the national transmission grid, to industrial, commercial and domestic users. It also maintains and operates the underground cables, overhead lines and substations.

How can DNOs help?

The cables, overhead lines and substations that make up an electricity network are assets with a typical fifty year life. Networks installed today are the result of many years of planning and development. Additional connections to the distribution network will need to be assessed to determine if there is available capacity or if local upgrades will be necessary.

If you plan to charge your BEV at home, an early engagement with the DNO and a qualified electrical EV charging contractor can help identify whether the proposed location has adequate capacity to meet the demand.

A qualified contractor will also ensure that the EV charger is installed in accordance with the Institute of Engineering and Technology (IET) Code of Practice for Electric Vehicle Charging Equipment Installation.

If there is enough capacity from the existing supply, no network reinforcement will be required.

If any reinforcement is needed, it will be the local DNO who will provide this. The DNO will also provide quotations for new connections and upgrades to existing ones.

The scope of the upgrade and reinforcement could extend to include increases in capacity for existing transformers, distribution overhead lines and cables to meet the new higher peak demand and lower impedance connections. Cost calculations for grid network investments will vary depending on the local situation. For most domestic installations the cost of upgrade to parts of the network shared with others will be completed at no cost to the connecting customer.

When thinking about getting an EV charger installed and operational, it is important to think of the process from the energy system perspective – because the DNO will be providing the critical link to an electrical power supply. Put simply, any plan to install EV charging infrastructure needs to consider both the hardware installation and necessary network reinforcement.

Considerations for choosing a BEV

Purchasing any vehicle invariably involves a compromise of some sort, two doors or five, manual or automatic etc. This does not change, when choosing a BEV the choice will often involve a compromise. For example with an ICE vehicle it is normally selected based on the longest journey the vehicle will make.

For some customers this is a key consideration, others may see no difference to their driving habits.

The first points to consider are what's the primary function of the vehicle; is it for commuting to work or other short journeys, with the odd long journey? Or is the vehicle used for regular long distance trips? That will define which sector of BEVs provide the best solution.

In the case where the car is used for the work commute or short journeys then overnight charging at home is likely to fulfil all charging requirements. Where long journeys are added, or where home charging is not practical, then a whole new range of criteria need to be considered, for example does the BEV have the facility to use ultra-rapid charging and what is the maximum rapid charging is the battery capable of accepting?

A very good place to check for non-biased information on all BEVs is: **https://ev-database.uk**

A quick look at the Cheatsheets at the bottom of the website will show the complete list of vehicles available shown with the typical range, for a starting position this gives a good overview. Once a selection has been made by clicking the chosen vehicle a detailed appreciation of that vehicle is given, which will then fine tune the selection process and help meet all the criteria the household had laid out previously.

Model	EV Type	Battery Capacity	Range	Power usage	Charge time@ 7.4kW	Rapid charge time	Rapid charge ability
Nissan Leaf https://ev-database.uk/car/1106/Nissan-Leaf	BEV	40.0 kWh	135 miles	265 Wh/ mile	6.5 hrs	40 mins	140 miles per hour
Tesla Model S https://ev-database.uk/car/1173/Tesla-Model-S-Long-Range	BEV	100.0 kWh	310 miles	305 Wh/ mile	15.25 hrs	38 mins	350 miles per hour
Kia e-Niro 64kW https://ev-database.uk/car/1260/Kia-e-Niro-64-kWh	BEV	64 kWh	235 miles	270 Wh/ mile	6.5 hrs	44 min	220 miles per hour
Tesla Model 3 https://ev-database.uk/car/1139/Tesla-Model-3-Long-Range-performance	BEV	75 kWh	275 miles	260 Wh/ mile	11.75 hrs	25 mins	520 miles per hour

All data shown in table above was obtained from the EV-Database.

The DfT National Transport Survey 2017 sets the average annual mileage for all cars at 7,800 miles, this equates to about 22 miles every single day, currently there is some 90 different battery electric vehicles to choose from the smallest useable battery electric vehicle has a 14.5kWh battery which gives a range of 55 miles in ideal conditions and the largest useable battery electric vehicle has a 95kWh battery which gives a range of 325 miles in ideal conditions.

Currently there is some 90 different battery electric vehicles to choose from.

Shown in the table opposite are a range of full electric vehicles and we have included a range of sizes and styles'. 'We have set the charge time on the basis of the typical single phase domestic charger size of 7.4kW.

A point to bear in mind is although a BEV comes with say a 75kWh battery not all of the capacity of the battery is useable, for example a car can have a 75kWh battery but only 72.5kWh is usable, because of the way EVs work, you'll never actually have access to the full battery capacity. That's because the car's management system prevents the battery from either becoming 100 percent fully charged or 100 percent discharged to preserve its efficiency and extend its usable life.

An average BEV with a battery capacity of 40kWh and a range of 135 miles will consume around 2,900 kWh if driven for 10,000 miles per year. This is a similar amount of electricity consumption to an average domestic house per year.

For 10,000 miles an electric car will cost £435 per year for energy, assuming 15p/kWh. A petrol car would cost £1,475, assuming 40mpg and £1.30/l.

These costs are typical and depend on how the respective vehicles are driven etc.

Considerations for the charging of BEVs

When purchasing a BEV the charging of the battery needs to be thought through, where, when, how fast and what cost are all factors in the choices drivers will make.

When WPD undertook Electric Nation, the largest electric vehicle project to date, 85% of all battery charging on that project was done at home. Unfortunately not every vehicle owner in the UK has the ability to charge at home, which will cause some thought being required to how to charge the BEV. Drivers without home charging might consider that the choice of BEV means a large range to cater for the lack of home charging.

There is also mitigation here, information that was also gathered from Electric Nation, which had almost 700 participants, was that once the owners of the BEVs understood their respective vehicle's range and battery characteristics they became more confident. This confidence meant that they were only charging their vehicles every two to three days, when battery capacity was low.

Charging can be broken down into four sectors

Each sector offers charging at different costs and charge rates.

- **Charging at Home**
- **Charging at Work**
- **Charging at destination**
- **En-route**

Charging at Home

The typical EV charger that would be installed at home is the 7.36kW type 2 single phase charger. It is usually assumed that a home charger could recharge a vehicle in a single overnight period. When this type of wall box charger is fitted to your house it is currently possible to claim an OLEV grant towards the cost of the charger. The picture below shows the type 2 connector configuration for the 7.36kW fast charger.

The type 2 male and female connectors.

The Alfen Mini 7.36kW charger

It should be noted that there are other means of charging at home but by using these methods one would extend the time required to charge the electric vehicles battery as the methods shown below relate to what is known as Slow Chargers.

Most slow charging units are rated at up to 3kW. Charging times vary depending on the charging unit and EV battery being charged, but a full charge on a 3kW unit will typically take up to 12 hours. Most slow charging units are untethered, meaning that a cable is required to connect the EV with the charge point.

Slow charging is a common method of charging some of the older electric vehicles that are now becoming available on the second hand market. However, slow units aren't necessarily restricted to home use, with workplace and public points also able to be found. Because of the longer charging times over fast units, slow public charge points are less common and tend to be older devices.

While slow charging can be carried out via a three-pin plug and standard 3-pin socket, it will take a long time to charge because of the higher current demands of BEVs and the larger BEV battery size, it is strongly recommended that those who need to charge regularly at home or the workplace install a dedicated EV charging unit installed by an accredited installer.

If a BEV was being used for high mileage, more than 100 miles per day, and for example a customer had chosen a BEV with say a 75kWh battery to charge the battery to full with the a 3.7kW slow charger would take 23 hours 15 minutes. Whilst this reduces with a 7.36kW type 2 charger to 11 hours 45 minutes, it is likely that the BEV would not be fully charged the next day. High use customers who want to charge at home could upgrade their low voltage supply that feeds their house from single phase to three phase, more like the supply a DNO would fit to a small commercial premise. With this available and using a three phase 32A or 22kW charger this would mean that the BEV would take 7 hours 45 minutes to fully charge. WPD is planning to make three phase cables standard on all new build homes.

Charging at Work

For employees, charging at work is a convenient way to recharge an EV whilst parked during the day.

The typical EV charger that would be installed would be the 7.36kW type 2 single phase charger, this is for a number of reasons the first being the cost and secondly the vehicles will be charging almost eight hours so there is no real need for anything other than fast chargers. Alternatively a business might choose to have faster chargers and rotate vehicles through them.

From a business point of view, having charge points at the workplace will become increasingly important as a facility for employees and visitors, while for businesses with a BEV fleet it can be an essential operating factor. Where fleet vehicles return to a depot overnight domestic type chargers might be sufficient. Where their drivers only visit the depots for short periods a higher capacity charger is needed. It is most likely that at a work with a large BEV fleet there would be a rapid DC charger.

This type of charger adds charging speed and flexibility but also has the disadvantage as the cost of equipment is higher. Multiple chargers of this sort might also require an electricity supply upgrade from the DNO.

Charging at Destination

It is already noticeable that large store outlets have now installed charging points in their respective car parks e.g. Tesco's.

Generally using these EV chargers is for free as typically the chargers are the 7.36kW type 2 fast charger. Likewise large numbers of hotels have destination charging which can be added to the hotel bill.

En-route charging

The Office for Low Emission Vehicles (OLEV) is currently running Project Rapid Phase 1, which will see 130 Motorway Service Areas (MSAs) in England fitted with varying numbers of 150kW ultra rapid DC chargers.

The number of chargers will vary depending on the location of the MSA and the traffic volumes it serves. Project Rapid is looking at the short term, middle term and long term capacity of these MSAs and the numbers are planned to grow as time goes on. Phase 2 of Project Rapid sees an additional 14 MSAs selected in Wales and Scotland.

These rapid and ultra-rapid chargers typically take the EV battery charge from 10% to 80% of the capacity in a relatively short time. The length of time that the BEV will take is dependent on the rapid charge ability of each BEV and on whether the BEV uses the CCS connector or the CHAdeMO rapid charge connector system.

The CCS male and female connector.

The CHAdeMO male and female connector.

The connector system which appears to be gaining the most traction in Europe is the CCS system, the maximum amount of power that can be transferred on the CCS system is 350kW. Whereas the maximum power the CHAdeMO system can transfer is 62.5kW. Car manufacturers are also bringing out newer models which can take advantage of this greater charge rate.

With all rapid and ultra-rapid EV chargers the leads and connectors are referred to as tethered chargers, this means the there is no need to carry a bespoke charging lead in the car as it would be a case of selecting the correct tethered lead and plugging it into the charging port on the BEV and activating the charger.

How does one pay for using EV chargers?

There are about forty charge point operators currently operating in the UK. An issue that has been raised on numerous occasions has been the need for reciprocity or roaming between the various charger point operators otherwise there would be a need to sign up with a number of charge point operators to enable one to charge their BEV at various locations.

There's an App for that

A small selection of the apps are shown here. On the 15th July 2019 the UK government said that it wants to see all newly installed rapid and ultra-rapid charge points provide debit or credit card payment by the spring of 2020.

The government expects the charge point industry to develop a roaming solution across the charging network, allowing BEV drivers to use any public charge point through a single payment method without needing multiple smartphone apps or membership cards.

Understanding where EV charge points are sited?

Even if you have off street parking and carry out the majority of your charging at home it would be expedient to download a EV charging App to your smart phone, for example Zap Map, it should be noted that there are other Apps available, this will show you at a glance where the nearest charge point is in relation to where you are. In addition the App categorises the size of the charger available to charge.

For example Zap Map shows that there are three main types of EV charging - Rapid Charger, Fast Charger, and Slow Charger. These represent the power outputs, and therefore charging speeds, available to charge an EV. Each charger type has an associated set of connectors which are designed for low or high power use, and for either AC or DC charging.

Rapid Chargers

- 50kW DC charging on one of two connector types
- 43kW AC charging on one connector type
- 100+kW DC ultra-rapid charging on one of two connector types
- All rapid units have tethered cables

Fast Chargers

- 7kW fast charging on one of three connector types
- 22kW fast charging on one of three connector types
- 11kW fast charging on Tesla Destination network
- Units are either untethered or have tethered cables

Slow Chargers

- 3kW slow charging on one of four connector types
- Charging units are either untethered or have tethered cables

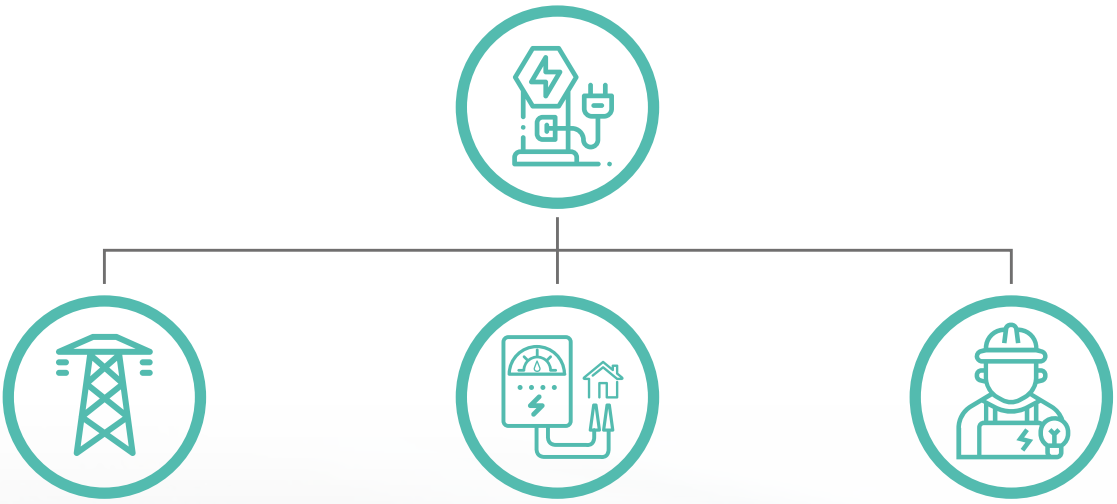
Installing an EV charger at home

Any EV charger point installed on a property needs to comply with the latest edition of the IET Code of Practice for Electric Vehicle Charging Equipment Installation.

All the necessary work needs to be carried out by a suitably qualified contractor, part of the installation process is to notify the host DNO.

Who is involved in the electricity connection process?

Electricity connections require a number of different services. The DNO, the electricity supplier, EV charge point installer and an electrical contractor need to be contacted and involved.



DNO

Electricity Supplier

Provision of required network capacity and electrical infrastructure

Suitably Qualified Contractor

For the installation of the charging point

When? Who? Why?

The following steps should be followed when considering the installation of any charge point: -

1 Before you start the installation

- Decide on a manufacturers make and type of charge point
- Appoint a suitably qualified electrical contractor for the charge point installation
- Download the ENA EV and HP Application form from the Electrical Network Association website, you will need your MPAN number which you can obtain from your electricity bill
- Your suitably qualified electrical contractor will need to undertake the IET maximum demand survey of your house. Complete and submit the application. In some cases the application is a simple notification to the DNO.

2 Once you have completed the installation

- Check that the charge point installer has notified the DNO of the charge point installation
- Check your supplier tariff is suitable for your new electricity usage
- Energise your EV charger.

3 In situations where a service upgrade or new three phase service is needed

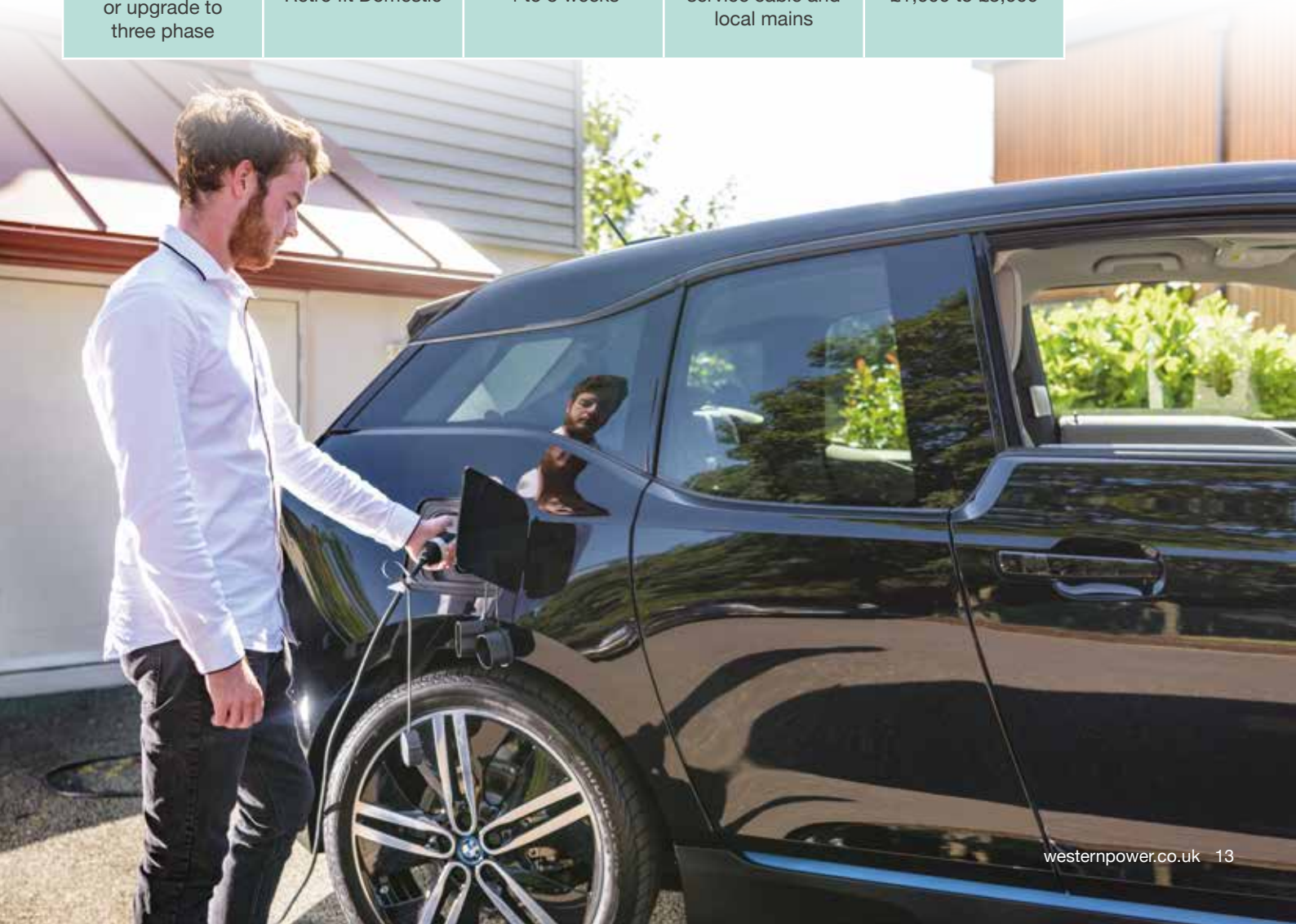
- Apply for an electrical network connection from your DNO, and submit a map where the preferred location is marked along with the MPAN number from your electricity bill
- Provide your DNO with the technical data sheet for the charge point make and type you are planning to install
- Review and accept the DNO design and quotation received
- Install the EV charger.

Estimating connection cost and time

The new or retro fit of a 7.36kW EV charger to buildings can have an impact on the electricity network, this section provides illustrative costs and time for the power supply to be connected to the low voltage network.

Typical DNO lead times, actions, and costs

7.36kW EV charger	Likely installation location	Typical approximate connection lead-times	Network and Third Party considerations	Approximate connection cost
House service shared with neighbour	Retro fit Domestic	Immediate in most cases but service upgrade needed	None	None
House No other LCTs fitted	Retro fit Domestic	Immediate in most cases	Usually none	Usually none
House Other LCTs fitted or upgrade to three phase	Retro fit Domestic	4 to 8 weeks	Likely upgrade to service cable and local mains	£1,000 to £3,000



Points to consider

The location of where you fit your home charge point is fairly critical, because the EV charging lead that is supplied with the car is a finite length and the location of the charge point on the car all need to be considered otherwise it could be that where the charge point is installed the lead could be too short.

A secondary consideration could be the aesthetics of the EV charger in relation to the house, it might save problems if all parties are consulted, as the likely position of the charger is on the front of the house. Unfortunately, all electric vehicle batteries will degrade somewhat over time and lose a bit of their ability to maintain a full charge. This is not as dire a warning as it sounds, however. According to the organization Plug in America, the average Tesla Model S loses only 2.3 miles of range for every 10,000 miles driven.

Tesla itself reports that in controlled testing its batteries retained 80 percent of their range after running for a simulated 500,000 miles. Shorter-range EVs, on the other hand, may suffer added deterioration, as draining most or all of a battery's charge on a regular basis will tend to cut into its capacity more quickly over time.

When you're buying or selling a used EV, keep in mind that any remaining part of the battery's original warranty will transfer to a subsequent owner. Importantly, an EV's state of charge will decrease more quickly in extremely cold or hot weather.

Cold temperatures in particular can substantially hamper both a battery's performance and its ability to accept a charge. What's more, while gasoline engines generate large amounts of heat that can be harvested to warm a car's interior, most EV's climate control system relies solely on battery power. A recent study found that when the mercury dips to 0°C and the vehicle's heater is in use, an average EV's range drops by 41 percent.

That means a model that's rated to run for 150 miles in combined city/highway driving would only be able to muster around 88 miles on a charge. The same study determined that when outside temperatures hit 35°C and air conditioning is in use, an EV's range will drop by an average of 17 percent.

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