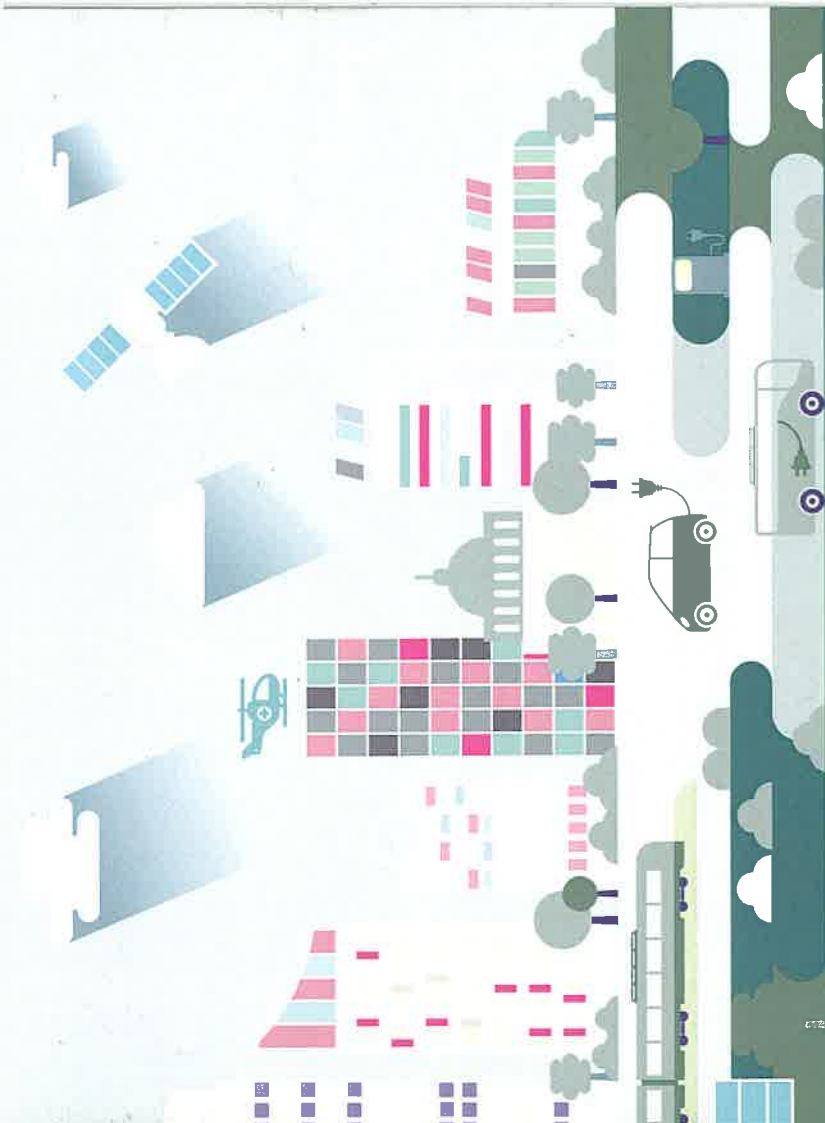


Find out more about our Electric Vehicle projects and other Innovation projects; request project data; and find out about our upcoming events at:
www.westernpower.co.uk/Innovation

Find out more about our Electric Vehicle Strategy at:
www.westernpower.co.uk/electric-vehicles

Find out more about connections for Electric Vehicle charge points or Heat pumps at:
www.westernpower.co.uk/connections-landing/connections-for-electric-vehicle-charge-points-or-heat-pumps

Contact our Innovation team at:
wpdinnovation@westernpower.co.uk
01332 827446



Electric Vehicle Project Portfolio

**WESTERN POWER
DISTRIBUTION**

Serving the Midlands, South West and Wales



Western Power Distribution (WPD) operates as the electricity Distribution Network Operator (DNO) for the Midlands, South West and South Wales.

We deliver electricity to more than 7.9 million customers over a 55,500 square kilometre service area.

We rely on innovation to maintain our position as an industry leader in network performance and customer service. Our Innovation Portfolio is targeted to ensure continuous improvement in all of the key outputs of safety, cost efficiency, customer service, reliability and environment. The future will see innovation continue these improvements while helping smooth the way for the transition to a smarter, more flexible energy system.

Since the government published its Carbon Plan in 2011 there has been an increased focus on the decarbonisation of heating and transport. Low carbon technologies, including Electric Vehicles (EVs), are expected to play an important role in achieving the UK's targets for improving air quality and reducing carbon emissions.

With the number of EVs on the roads steadily increasing, it is crucial that we work towards solutions that enable their mass adoption.

As an electricity system operator our approach is to ensure that a suitable network exists for all charging requirements in all situations. Charging requirements vary and are dependent on the type of vehicle and the driver's access to either their own or public charging infrastructure.

The principle is simple: It's our job to ensure the electricity for people to charge their cars when and where they want to is available.

Some of our commitments to you...

Charging Hubs

Will be built in public car parks, supermarkets and taxi ranks



Consulted about EVs in 6

stakeholder workshops

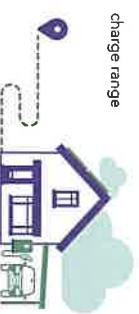
in February



Domestic Chargers will provide

150 mile

charge range



50 year

asset life on our network



217,000

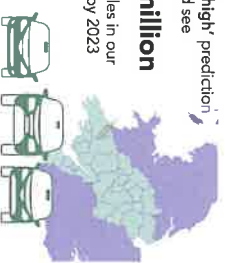
Chargers will be built on our network by 2023



Our 'high' prediction would see

3 million

Vehicles in our area by 2023



Over

£58 million

is allocated for EV chargers in our current Business Plan period



80%

Carbon emissions reduction by 2050



Super chargers at motorway services will provide full charge in

15 minutes



Completed Electric Vehicle Projects

CABLED (2009)

We partnered with the energy supplier E.ON and Birmingham and Coventry city councils on a project called CABLED (Coventry and Birmingham Low Emission Demonstrator).

The project was the UK's first ever at-scale demonstrator aimed at engaging the public about electric vehicles. Set in the heart of the Midlands motor manufacturing region the project had wide support from the automotive industry, local academia and public sector institutions.

The key objectives of the project where twofold: Firstly to engage with public about electric vehicles and understand their attitudes to recharging and journeys; Secondly, to assess the electrical impact of electric vehicle recharging infrastructure on the local electricity network.

The project was funded by the Technology Strategy Board (now known as Innovate UK). It involved the DNO installing 35 charging points in city centre locations, public car parks and out of town park-and-ride facilities. Power quality recorders were installed adjacent to a proportion of the charging points to assess and measure electrical harmonics. The energy supplier partner

installed over 100 smart meters in domestic properties to measure consumer behaviour.

The electric vehicles were supplied by a range of manufacturers including Mitsubishi, Mercedes smart, Tata and Jaguar Land Rover.

Key learnings from the project were:

- That harmonics and general power quality issues were less serious than feared.
- That drivers of electric vehicles with more limited battery capacity should be expected to recharge frequently both at home and on street.
- That DNOs are well equipped to install and connect electric car charging infrastructure in the public highway.
- That carpark charging of multiple vehicles simultaneously presents challenges for local electricity network infrastructure.

Learning from the project helped inform our design policies and the customer servicing approach for provision of connections. It also helped established long running close working relationships between Western Power Distribution and local authorities in the West Midlands.

Completed Electric Vehicle Projects

V2G Taxi (2011)

The project set out to understand how vehicle to grid (V2G) technology could be accommodated within the electricity distribution system.

The project provided an early insight into a technology now heralded by the energy and automotive sectors as having the potential to minimise customer bills and ensure a safe and stable supply of electricity for the nation.

The project directly informed industry design standards and has fed learning into subsequent demonstration projects. These include the significant number of vehicle to grid projects currently being funded by the UK Government under Innovate UK mechanisms.



Completed Electric Vehicle Projects

Electric Boulevards (2014)

Our Electric Boulevard project set out to demonstrate the UK's first ever use of inductive charging infrastructure. It also tackled the issue of recharging larger commercial vehicles. Working with Milton Keynes City Council and a range of other partners, Western Power Distribution installed inductive charging solutions at three locations across the city. The local bus operator, Arriva, converted one of its bus routes in Milton Keynes to a fully electric solution; the route used included the inductive charging loops.

The project proved that inductive charging is a viable and efficient way of recharging such vehicles. It also proved to be extremely reliable. The solution is still in use at the time of writing this report, and the city council has plans to convert all other bus routes in the city to pure electric with inductive charging.

We also developed solutions to enable large inductive charging units to be connected to the low-voltage network. Previously it would have been considered necessary to have an high-voltage connection. This solution means that charging infrastructure can be connected much cheaper and quicker than previously thought.

Completed Electric Vehicle Projects

Smart Charging and Vehicle Telematics (2015)

Working with the bus manufacturer (Wrightbus of Northern Ireland) the project set out to take data from the vehicle telematics system to understand the state of charge of the battery system and other factors such as ancillary power use and traffic conditions. With this data we were able to estimate the recharging requirements at each charging location. By assessing local grid capacity at the times the buses were forecast to arrive, we were able to ensure that all the vehicles would return to the depot at the end of the day with no less than 20% charge. Additional complex smart charging solution algorithms were used at the bus depot during the overnight recharging period to ensure that all buses left for their first journey with 100% charge. This was achieved using the minimum grid connection infrastructure, reducing the cost of connection and ongoing use of system charges.

Learning from this project has developed smart charging solutions which are now being tested at scale in our Electric Nation project.

EV Emissions (2016)

Our EV emissions project was established to check the compliance of modern electric vehicles. Electric passenger vehicles of all manufacturers currently sold into the UK market were tested. Working with the Transport Research Laboratory vehicles were tested at the Millbrook Proving Ground in Bedfordshire. They were cycled through a range of charging and discharging cycles in controlled conditions. Harmonic and power quality measurements were taken from the vehicles and the charge points.

Valuable insight was gained into the performance and compliance of vehicles with mandatory electrical emissions standards. These results are informing the refinement of the engineering standards and provided comfort that the automotive sector is designing vehicles within the limits set.

LV Connect and Manage (2016)

Low-voltage networks have traditionally been designed to accommodate household power and lighting. The network design methodology assumed natural diversity of consumption. In areas with electrical heating, such as storage radiators, the network may have been designed with an increased level of capacity.



Completed Electric Vehicle Projects

A typical after diversity maximum demand for a domestic property is between 1.5 and 2.5 kW. A typical electric vehicle will charge at 7 kW. Whilst the domestic wiring network, and the individual network connections, will already be sized to accommodate loads of this magnitude, the upstream distribution network and substation will not be able to accommodate all electric vehicles charging at maximum capacity simultaneously.

Smart charging solutions such as those demonstrated in Electric Nation, coupled with supplier time-of-use tariffs will ensure that some diversity can be relied upon.

Electric Nation also proves that there is a natural diversity benefit in challenging the behaviour of customers. Nonetheless the potential exists for the network to become overloaded in the low probability event that customers do decide to charge at the same time.

The LV Connect and Manage project is developing a solution to provide emergency overload protection for the distribution network. This is a form of Active Network Management. The solution will be deployed in areas with high concentrations of electric vehicles.

We expect smart meters, suppliers and aggregators to provide products with time signals which will attract charging away from times of system peak. Where this is successful we will not require LV Connect and Manage as the market drivers will have correctly reacted to signals. If these time of use signals do not provide a suitable level of load management and flexibility we do need to offer a solution which will mitigate constraint on our network.

Under the LV Connect and Manage process customers will be advised that their local distribution network is at capacity at times of peak demand. They will then be offered the opportunity of waiting for conventional network reinforcement to take place, or alternatively the installation of a LV Connect and Manage domestic load controller. The domestic load controller will be able to communicate with the local substation and in the event of an impending overload situation being detected, the device will communicate with the charge point or vehicle and reduce the charging level for a short period of time.

The LV Connect and Manage solution is viewed as a last resort mechanism which would only be implemented by Western Power Distribution when all other options have been exhausted.

Completed Electric Vehicle Projects

The solution is currently being trialled within Milton Keynes and Nottingham. In addition to the control of electric vehicles the domestic load controller will also integrate with other low carbon technologies such as solar panels and home energy storage units.

Alternative Connections for EV Charging (2017)

Western Power Distribution has developed a range of alternative connection solutions for customers wishing to connect new distributed generation such as solar, biomass and wind. Although initially developed for generation, the range of alternative connection solutions was adapted to cater for flexible demand, including electric vehicle recharging. During 2017 technological and process changes were implemented to our connection process. This enabled us to offer alternative connections to customers wishing to install charging infrastructure but where the cost of connection is prohibitively large. The first alternative connection under this arrangement was made during 2018 working with a car dealership in Lincolnshire.

LCT Detection (2018)

Electrical installers who fit charging equipment at customer homes are required to notify the Distribution

Network Operator. Western Power Distribution also receives information on new vehicle registrations from the Driver and Vehicle Licensing Agency. We are aware that there appears to be a significant mismatch in the number of electric vehicle notifications between the two sources. Working with the Energy Networks Association we are making improvements to the notification process to make it simpler for electrical installers to tell us where charge points have been fitted. This should reduce any mismatch. WPD are currently undertaking the project LCT Detection with Electralink and IBM.

The project will identify whether it is possible to automatically locate the installation of new charging equipment through the analysis of metering data. Using artificial intelligence techniques our project partners will evaluate the potential for such a solution together along with any regulatory and privacy controls which may be necessary.

This project will provide WPD with the most up to date information on LCT take-up within the licence areas and will negate the fact that some installers are failing to advise the host DNO that they have connected LCTs it is likely that this project should also highlight non-technical losses within the licence areas.

Completed Electric Vehicle Projects

IET Code of Practice

WPD was asked by the Institution of Engineering and Technology (IET) to assist in the production of a code of practice for electrical equipment installers. The code of practice on the connection of electric vehicle charging infrastructure formed an addendum to the IET wiring regulations. Specialist technical knowledge from our policy engineers was coupled with learning from innovation projects to ensure that the code of practice was both practical and comprehensive. The code of practice sets out safety standards for the electrical earthing of equipment and means of connecting to household and business electrical wiring.



For more information on this document please visit:

[www.shop.theiet.org/
code-of-practice-for-electric-
vehicle-charging-equipment-
installation-2](http://www.shop.theiet.org/code-of-practice-for-electric-vehicle-charging-equipment-installation-2)

Current Electric Vehicle Projects

Electric Nation

At its inception the Electric Nation project was Europe's largest domestic EV charging trial with 673 participants. The project will deliver learning on how electric vehicle customers charge their vehicles at home, and better understanding of their acceptance of smart charging. It is also producing a network assessment tool for our planning engineers to assess the most appropriate means of providing capacity.

It will additionally provide a longer term, more strategic view, of the overall implications for electricity network infrastructure of electric vehicles becoming mainstream.

These results include knowledge on the frequency of charging events (typically less than twice per week) and the amount of energy consumed each time (approximately 35 kWh). The project has also confirmed a consumer willingness to accept smart charging. Further we have proved that the technology to support such a solution is available and understand the degree to which we can rely upon it for network management purposes.

The final phase of the project tested consumer attitudes to time-of-use energy tariffs and the degree to which

they can be relied upon to shift peak electricity demands away from the traditional teatime evening peak.

In addition to gaining an improved understanding of the potential for smart charging, the project will also inform our planning standards. In particular future assessment of diversity and maximum demand.

Current Electric Vehicle Projects

Superfast Electricity – three phase services

Working with Innovate UK, Monmouthshire County Council, Wales and West Utilities, Cenex and the Welsh Government the group are in the design stage of the fitting of all LCTs to the combination of new build and retro-fit properties in Caldicot.

The project will install three phase service cables at all properties in this development in Wales. The project will demonstrate how this can be achieved and, crucially, make the final part of the network resilient to LCT demands. This will avoid us having to replace cables across customers' gardens and driveways in the future, due to foreseeable LCT needs.

Reinforcement Planning - Forecasting and Planning Interface Tool

The Electric Nation project provided a visualisation tool for WPD planners to show the penetration of electric vehicles on the WPD geographical map background. This project, in association with EA Technology, will build on the work completed and provide visualisation of smart meter data, consumption data and network conditions. The project will also investigate how much of this data can be automatically imported into design software to allow planners to undertake network assessments. Once this work is completed we will assess how the tool can be further developed to help our local planners identify local constraints and design solutions for them.

A final development of the tool is considering how this information can be provided directly to customers via our website, so that they quickly and easily assess the impact of their additional demand on our network.

Future Projects

EV Filling Stations

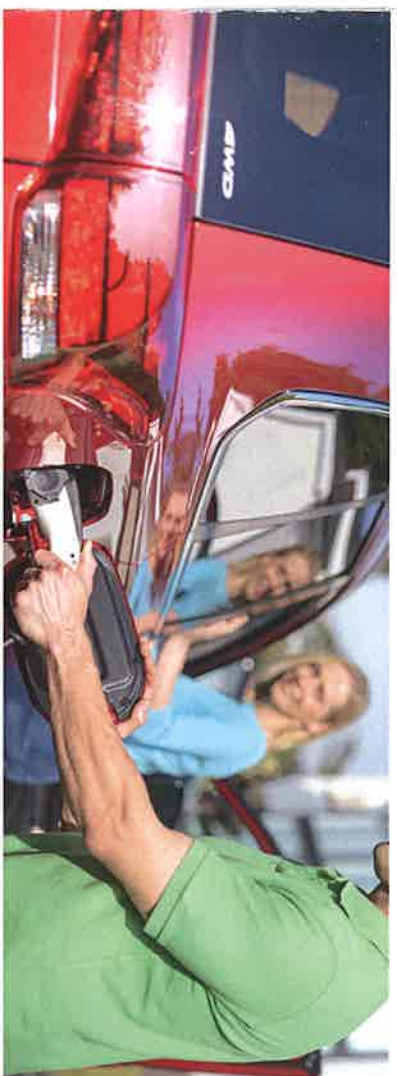
Although we expect many electric vehicles to be charged at home and at the workplace, some 40% of vehicle owners do not have driveway or designated parking therefore en-route charging is also an important service for owners of electric vehicles. The connection of multiple fast and rapid chargers at a single location can require a substantial capacity to be provided. This can be costly and/or take time to deliver.

This project will explore a number of innovative solutions for the provision of network capacity for electric vehicle charging stations. This will include locations adjacent to major trunk routes as well as locations such as supermarkets and city ring-roads.

Options to be explored include increasing the voltage level at the point of connection, DC rather than AC connections, inclusion of co-located batteries and poly-phase options. This project is still at the development stage and we would therefore welcome expressions of interest from partners wishing to work with us in this field.

On Street Charging Solutions

This project will look at solutions for charging vehicles in residential locations on the street or at communal parking areas. We intend to work with local authorities and other regional bodies to design and demonstrate dedicated infrastructure for electric vehicle charging.



Future Projects

Where local authorities deploy on-street charging we will need to change the way we provide electricity supplies to street furniture such as street lights. Conventional networks are built to provide low wattage connections to lamps only. Earthing and technical issues will also drive us to changing the connection type.

Our project will show how a bespoke low voltage mains cable can be used to provide supplies to charge points and other street furniture. We will also establish triggers which will allow for mains cables to be upgraded ready for future demands.

Smart Homes – EVs and Storage

This project will utilise the three phase cables installed in our “superfast electricity” project and show how a domestic installation can make use of locally generated power and storage to provide the energy required to charge an electric vehicle. The equipment could also be used to balance the network and mitigate peak demands.

This builds on our industrial and commercial storage project with Tesla which has demonstrated three new variants for the connection of batteries to the WPD system.

These connection options rely on the operating mode of the battery being restricted to a defined purpose. These are self-sufficiency, supply resilience and flexibility market operation. Through this new project a further variant will be developed entailing the combination of energy storage with electric vehicle charging.

Smart Meter Load Control

This project follows on from our LV Connect and Manage project, which developed a domestic load controller which will ensure that the low-voltage network is not overloaded. It will demonstrate how SMETS2 smart meters can be used to control specific load within a property.

Working with an energy supplier offering specific electric vehicle tariffs, we intend to determine whether the smart meter can be used for this overload protection function.

Self-Assessment

When a customer chooses an Electric Vehicle their next task is to consider charging options. Where they have off street access they are likely to install a domestic charger and will need to ensure that their service cable is sufficient for the demand it will generate.

Future Projects

Through the Energy Networks Association this project is being developed in conjunction with the other DNOs to provide a centralised way of providing us with pertinent information about their service which will allow us to quickly assess if it is suitable to accept a charger.

Hub Charging Solutions

Local authorities are likely to establish charging hubs in car parks and other off street locations. These offer the advantage of being able to provide a large single point load connection to our network using a bespoke transformer. However it is also likely that the locations will not be in continual use and there will be times of the day when no charging occurs.

We are working with a transformer manufacturer to develop a low loss version of our standard units which will reduce the network running costs of these locations. WPD already have designated sites where installation of charging hub is proposed.

It will be used to charge passing vehicles and also provide the facility to charge local terrace house owners' EVs. WPD also expect that this hub approach will be used by commercial and public transport operators so will investigate how we can apply our technology to these locations.