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Electric Vehicle Strategy

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1 Introduction

1.1 About the document

This document sets out how Western Power Distribution will ensure the network exists so that drivers of electric vehicles are able to charge their vehicles in the manner convenient to them.

It describes research, development and deployment activities carried out by WPD during the current and previous electricity distribution price control periods. It also explains the rationale behind current innovation projects an business initiatives. Further, it describes future activities including the transition of early-stage solutions into business as usual practice.

This document also documents WPD's vision for electric vehicle recharging solutions for a range of customer types. It provides detail on the roadmap to achieve this vision.

Following the ENA/Ofgem Stakeholder Engagement events held in London and Glasgow during February 2019, WPD responded to Ofgem's request to produce the first Electric Vehicle Charging Strategy document in March 2019, this document is the WPD's updated Electric Vehicle Charging Strategy for 2020. The document outlines the time-bound commitments and plans that WPD intend to address during 2020 to address the needs and issues of EV stakeholders.

WPD's plans and preparations for each specific customer group are listed in Section 4 of this document and draw upon the stakeholder engagement that WPD undertaken. In Section 6 of the document WPD detail the time-bound short term commitments to accelerate readiness for the increasing uptake of EVs within the UK.

1.2 High Level Government Objectives for Cars and Light Vans

The uptake of Electric Vehicles (EVs) is accelerating, brought about by a greater range of vehicles for customers. The trend towards them is set to increase.

The Government's "The Carbon Plan" (2011) set out the UK's objectives to reduce carbon emissions, with an 80% reduction achieved by 2050[1]. This reduction of CO_2 levels will be achieved through the decarbonisation of heating and transport and the actions UK PLC need to take to support this transition of vehicle power from fossil fuel sources to electricity. The electricity networks need to be ready to accept this additional demand. We build networks with a 50 year asset life so will take steps now to ensure we build the right network for foreseeable future demands. The requirements of The Carbon Plan 2011 have been strengthened with targets to improve air quality and reduce Nitrogen Dioxide levels. In June 2019 Prime Minister Theresa May announced the UK will eliminate its net contribution to greenhouse gas emissions by 2050. The decision will amend the Climate Change Act 2008, which had committed to an 80% decrease of greenhouse gases from a 1990 baseline, by 2050. These targets will all support the transition to electric vehicles.

The Government set a target published in Driving the Future in 2015[2] to "ensure almost every car and van is a zero emission vehicle by 2050". In July 2018 the government published the Road to Zero Strategy which set an aspiration for "at least 50%, and as many as 70%, of new car sales and up to 40% of new light van sales being ultra-low emission by 2030"[3]. In Feb 2020 the Government announced that "it will end the sale of all new conventional petrol, diesel cars, vans and hybrids by 2035".

Alongside the UK government legislation the other drivers that are accelerating the adoption of EVs are in April 2019 the European Parliament adopted regulation (EU) 2019/631 which has introduced CO_2 emission performance standards for new passenger cars and for new vans for 2025 and 2030, these regulations start applying in January 2020 and has replaced and repealed the former regulations for cars and vans. This legislation brings an "Excess emission premium for manufacturers failing to meet their emissions target of €95 for every gram/km of excess emissions per vehicle within the original equipment manufacturers (OEM) portfolio". This driver is forcing OEMs to introduce vehicles which lower their complete portfolio of vehicles below the 95gm/km threshold.

[1] Page 3 of The Carbon Plan 2011: Delivering our low carbon future. HM Government.
[2] Page 4 of Driving the Future Today 2015: A strategy for ultra-low emission vehicles in the UK.
[3] Page 2 of Road to Zero 2018: Next steps towards cleaner road transport and delivering our industrial strategy.

Another driver for increasing the uptake of battery electric vehicles (BEV) is in the UK is that from 6th April 2020 Benefit in Kind tax (BiK) for company cars will change. It is calculated based on the P11D value of the vehicle, its CO_2 tailpipe emissions and the employees' income tax band. Company vehicle drivers driving BEVs will pay no benefit in kind tax during 2020-21, just 1% in 2021-22 and 2% in 2022-23. With approximately 50% of new cars being purchased by companies and because BiK makes a significant difference to an individual's monthly wages, BiK represents a potent lever for the government to encourage the adoption of BEVs

Most mainstream car manufacturers now offer electric models, at present in 2020 there are more than 130 models of full or part electric vehicles available to buy or lease in the UK. The choice of electric vans is more limited compared to electric cars, but the number is increasing.

1.3 High Level EU Parliamentary Plans for HGVs

The recent introduction of Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20th June 2019 setting CO_2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC. This regulation requires CO_2 emissions from heavy-duty vehicles such as trucks and buses to be reduced by 30%, by 2030, with an intermediate reduction target of 15%, by 2025, in addition by 2025, manufacturers will be required to ensure that at least a 2% market share of the sales of new HGV vehicles is made up of zero-and-low-emission vehicles, to counteract steadily increasing road traffic emissions, of which around one quarter is accountable to heavy-duty vehicles. Failure to meet these targets then the OEM will be hit with a fine 60 times higher than for cars.

The Chairman of the European Automobile Manufacturers Association (ACEA) has stated that to meet the 2025 and 2030 CO2 emission target in the truck segment, Europe and the UK need to install a massive charging infrastructure. It is forecast that 17,000 publicly accessible DC fast chargers specifically installed for trucks by 2025 and 90,000 by 2035, these numbers do not include depot charging infrastructure which would be of the order of 20,000 and 200,000 respectively. ACEA are expecting 200,000 battery electric trucks on European roads by 2030.

1.4 WPD's approach to facilitate EV charging

As an electricity system operator WPD's approach is to ensure that a suitable network exists for all charging requirements in all situations. This has many factors as charging requirements vary dependent on the type of vehicle and the owner's access to either their own or public charging infrastructure. Only 60% of car users have access to an off-street parking location which is likely to be suitable for charging[4].

In one sense the actual charging infrastructure is of less concern to WPD than the ability of WPD to provide the adequate and safe electricity connection which serves it. WPD's plans will vary depending on the application and where the EV chargers are being installed, this strategy document details various different options.

The principle is simple, the charging infrastructure requires higher volumes of energy and it is WPD's job to provide the conduit for this energy.

WPD predict that the majority of the larger local transformers will be able to accommodate one 35kWh charge for cars and vans every five days for each of the customers connected to it. This provides a charged range of around 150 miles in many EVs and it is likely that this will support the demands of home connected EV charging.

WPD also expect that the backbone 33kV network and primary transformers will be able to accommodate this level of charge point activity.

[4] Article "Five ways to solve UK's electric car charging conundrum" published in the Financial Times on 27/12/17.

According to the Centre for Ageing Better, 21% of all homes in the UK were built before 1919, 38% were built before 1946, and only 7% after 2000, making the UK housing stock the oldest in the EU[5]. WPD focuses into the specific cables which supply local streets or to the LV service cables which feed individual properties, there is more chance of the network becoming constrained. For example houses built during this era are most likely to have looped LV service cables shared with their immediate neighbours. Attaching an EV charger to a looped LV service cable is not recommended, WPD's default position is remove looped LV service cables prior to an EV charger is installed. WPD identified this issue and are already installing larger LV mains and LV service cables assets for new build states and have identified areas where the proactive uprating of cable networks is appropriate.

1.5 Flexibility and Charging

WPD expect that flexibility will provide a key role in delivering EV charging. This is likely to provide solutions for many customer types, from domestic users to fleet users who return their vehicles to a depot overnight.

As Smart Meters become more prevalent across the UK domestic users will be able to take advantage of time of use tariffs that WPD expect electricity suppliers to offer. Customers with home charging they will be able to use managed charging to charge their vehicle at times when price signals show it to be beneficial for the wider electricity network.

Fleet users with depots are most likely to make use of overnight charging to recharge their vehicles for the next working day. WPD expect a depot charging facility to require a larger electricity supply similar to a factory. This could cause a possible constraint on some parts of the WPD network at peak times if connected conventionally. However, it is expected the opportunity to make use of flexible connection solutions to allow charging at off-peak times without network reinforcement will be used by majority of businesses. This could make connections quicker and cheaper for customers.

1.6 Existing Charge Points and Capacity

WPD already have experience of installing charge points on the network to support the early adopters of Electric Vehicles. The table below shows the number and capacity of chargers as reported to Ofgem as part of the annual RRP returns.

The numbers of Fast Chargers are relatively high due to the reporting split used by Ofgem. Most of the newer domestic chargers are 32 Amp units and therefore are reported in the Fast Charge category.

	Number	Capacity
Slow Charge (up to 16 Amps)	4,866	17,751kVA
Fast Charge (over 16 Amps)	8,894	74,442kVA

(Total number as at March 2020)

[5] Page 1 More than 1m over 55s living in hazardous homes Home Care Insight study finds. Access/Intelligence/Studies by Sarah Clarke 09/05/2019 https://www.homecareinsight.co.uk/more-than-1-million-over-55s-living-in-hazardous-homes-study-finds/

2 Forecasting and Data

2.1 Forecasting for the ED1 business Plan (2015-2023)

In WPD's ED1 business plans use was made of national forecasts to tailor scenarios for WPD networks. WPD worked with the Centre for Sustainable Energy (CSE) to deliver the "Who's on our wires" report. This added socio economic factors to the national growth forecasts for all Low Carbon Technologies. For example, the numbers of electric vehicles are strongly predicted to grow in areas where the social demographic suits early adoption.

This means that it is highly likely that Low Carbon Technologies (LCTs) will be clustered closely together leading to a compound effect on specific parts of the network. This work led to WPD targeting the uprating of assets when other works take place over about 7% of the network, in locations where WPD could be confident of load growth.

The current population of EVs within the four WPD licence areas is matching the ED1 business plans – with EV adoption increasing at the current rate, it is expected some 217,000 chargers to be connected to the network by 2023.

However, to meet the requirements of the Government's 2035 deadline for the cessation of ICE cars and vans, this will see an extremely high, 70% uptake level of EV adoption, this is given in the governments Road to Zero 2018 document, and then this rate could see up to 3,064,000 EVs by the end of ED1[6].

2.2 Developing Distribution Future Energy Scenarios (DFES)

Since 2016 WPD have been producing Distribution Future Energy Scenarios (DFES) at a licence area level which predict the likely impact of EVs along with other new technologies.

The scenarios use a bottom up approach to provide future energy scenarios, at Electricity Supply Area (ESA) level, for the potential growth of distributed generation, electricity demand growth and electricity storage. These are then used to identify future constraints on the distribution network and develop strategic investment options to economically resolve those constraints, when triggered.

The analysis undertaken for each technology in the DFES involves the following four stages: -

1. A baseline assessment. Technology baselines are calculated from WPD's network connection database. This information is then reconciled with other market intelligence and external databases. In addition, further desktop research is undertaken to address inconsistencies.

2. A pipeline assessment. For technologies with significant lead times WPD's network connection agreement database is reconciled with the BEIS planning database and market research is undertaken. This allows an assessment of which commercial projects in the pipeline may go ahead and in what timescale. Domestic scale and demand technologies do not have an individual pipeline, but local council economic plans are reviewed to derive volumes and locations.

3. Resource assessment. Locational data from a wide range of data sources and GIS analysis is used to understand the geographical distribution, local attributes, constraints and potential for technologies to develop within the licence area and each ESA.

4. A scenario projection to 2032. The scenarios are based on National Grid's Future Energy Scenarios (FES) and interpreted for specific local resources, constraints and market conditions. Analysis of current market reports and the findings from a local consultation event is combined with interviews from developers, investors and other stakeholders.

[6] Page 9 of Road to Zero 2018: Next steps towards cleaner road transport and delivering our industrial strategy.

In the latest report WPD have aligned the four scenarios with National Grid's 2019 FES, which has the following four scenarios:

✕✕2050 carbon reduction target is not met

✓✓2050 carbon reduction target is met

Level of decentralisation

Consumers Evolution	
Electricity demand	Moderate-high demand: high for electric vehicles (EVs) and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Small scale renewables and gas: small modular reactors from 2030s
Gas supply	Highest shale gas, developing strongly from 2020s

Community Renewables	
Electricity demand	Highest demand: high for EVs, high for heating and good efficiency gains
Transport	Most cars are EVs by 2033: greatest use of gas in commercial vehicles but superseded from mid 2040s by hydrogen (from electrolysis)
Heat	Heat pumps dominate; high levels of thermal efficiency
Electricity supply	Highest solar and onshore wind
Gas supply	Highest green gas development from 2030s

Steady Progression	
Electricity demand	Moderate-high demand: high for EVs and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Offshore wind, nuclear and gas; carbon capture utilisation and storage (CCUS) gas generation from late 2030s
Gas supply	UK Continental Shelf still producing in 2050; some shale gas

Two Degrees	
Electricity demand	Lowest demand: high for EVs, low for heating and good efficiency gains
Transport	Most cars are EVs by 2033; high level of gas used for commercial vehicles but superseded from mid 2040s by hydrogen
Heat	Hydrogen from steam methane reforming from 2030s, and some distinct heat; high levels of thermal efficiency
Electricity supply	Offshore wind, nuclear, large scale storage and interconnectors; CCUS gas generation from 2030
Gas supply	Some green gas, including biomethane and BioSNG; highest import dependency

Speed of decarbonisation

2.3 Electric Vehicle Growth Factors

National and local legislation will be key drivers of future electric vehicle growth in the licence area. The UK government has announced a ban on new petrol and diesel sales in 2035. An increasing number of towns and cities across the UK plan to introduce restrictions and bans on vehicles in a bid to reduce pollution levels. Currently there are twenty locations in the UK where there will be vehicle clean air zones, driving charges and vehicle bans.

These are: -

Aberdeen	Low emission zone and ban on some vehicles;
Bath	Clean air zone for commercial vehicles in 2020;
Brighton	Ban for all passenger vehicles in 2023;
Bristol	Ban on all diesel cars and a clean air zone for commercial vehicles in 2011;
Cambridge	Clean air zone for vehicles date to be confirmed;
Cardiff	Daily charge for drivers who don't live in Cardiff and a clean air zone for vehicles date to be confirmed;
Derby	Traffic management measures or a clean air zone date to be confirmed;
Dundee	Low emission zone and ban on some vehicles in 2020;
Edinburgh	Two tier low emission zone and ban on some vehicles in 2020;
Glasgow	Low emission zone already in place that is extended to cars in 2022;
Leeds	Clean air zone for HGVs, buses, coaches and taxis in July 2020;
London	Ultra low emission zone already in place and due to expanded in 2021;
Manchester	Clean air zone for HGVs, buses, coaches and taxis in July 2021;
Newcastle	Clean air zone for HGVs, buses, coaches and taxis in July 2021;
Oxford	Red zone charge for vehicles in 2020;
Portsmouth	Clean air zone for HGVs, buses, coaches and taxis in July 2021;
Reading	Potential clean air zone or low emission zone at a date to be confirmed;
Sheffield	Clean air zone for HGVs, buses, coaches and taxis in July 2021;
Slough	Potential clean air zone or low emission zone at a date to be confirmed;
York	Clean air zone for buses in 2020.

From a consumer perspective, the key hurdle will be price. Lower running costs are not yet balancing out the up-front costs, even with the current purchase subsidy, unless drivers have a high mileage, such as use for fleet applications. There is limited evidence relating to the actual whole life savings or resale value. Increased investment and competition is needed between manufacturers to drive down costs.

Despite the current barriers, the FES 2019 presents a much higher growth projection for electric vehicles than FES 2018, reflecting the UK government's proposed ban on new diesel and petrol vehicles in 2035[7].

The two highest scenarios in FES 2019 (Two Degrees and Community Renewables) show a similar growth profile, with the UK electric car fleet reaching around 15 million units by 2032 rising to over 38 million by 2038.

To provide a wider profile for network analysis in this study WPD have amended the Two Degrees scenario to show a more explosive growth profile which sees growth accelerating ahead of the FES 2019 and then levelling by 2050. WPD would also assume that EV uptake in the licence area stays ahead of the national average uptake of EVs in the short and medium term but will return to national average by the end of the scenario period. This assumption reflects key factors driving early adoption such as; affluence levels, off-street parking and second car ownership along with emission reduction initiatives in and around urban centres.

[7] Page 5 Uptake of Ultra Low Emission Vehicles in the UK 2015.

2.4 Vehicle Manufacturers plans for light EVs

As EVs become more main stream the number of vehicles that a customer is able to choose from will increase dramatically. Currently the EV market is covered by a few niche vehicles which early adopters are buying. This is all changing as EVs enter a new phase, current production forecasts are showing that most carmakers are embracing electrification and are leaving behind the fossil 'technology neutrality' approach. This is being brought about by the legislation cutting vehicle emissions to 95gms/km of CO_2 over the manufacturers complete portfolio, has had the effect of focusing the manufacturers on scaling up their electric car volumes instead. After a number of years of slow growth, the number of EV models produced across the UK is about to increase significantly this will then give the consumer greater choice and will see the uptake of EVs increase.

The graph below shows the how the range of EVs that have been available from 2012 to the range of new models of EV which will become available by 2025.[8]

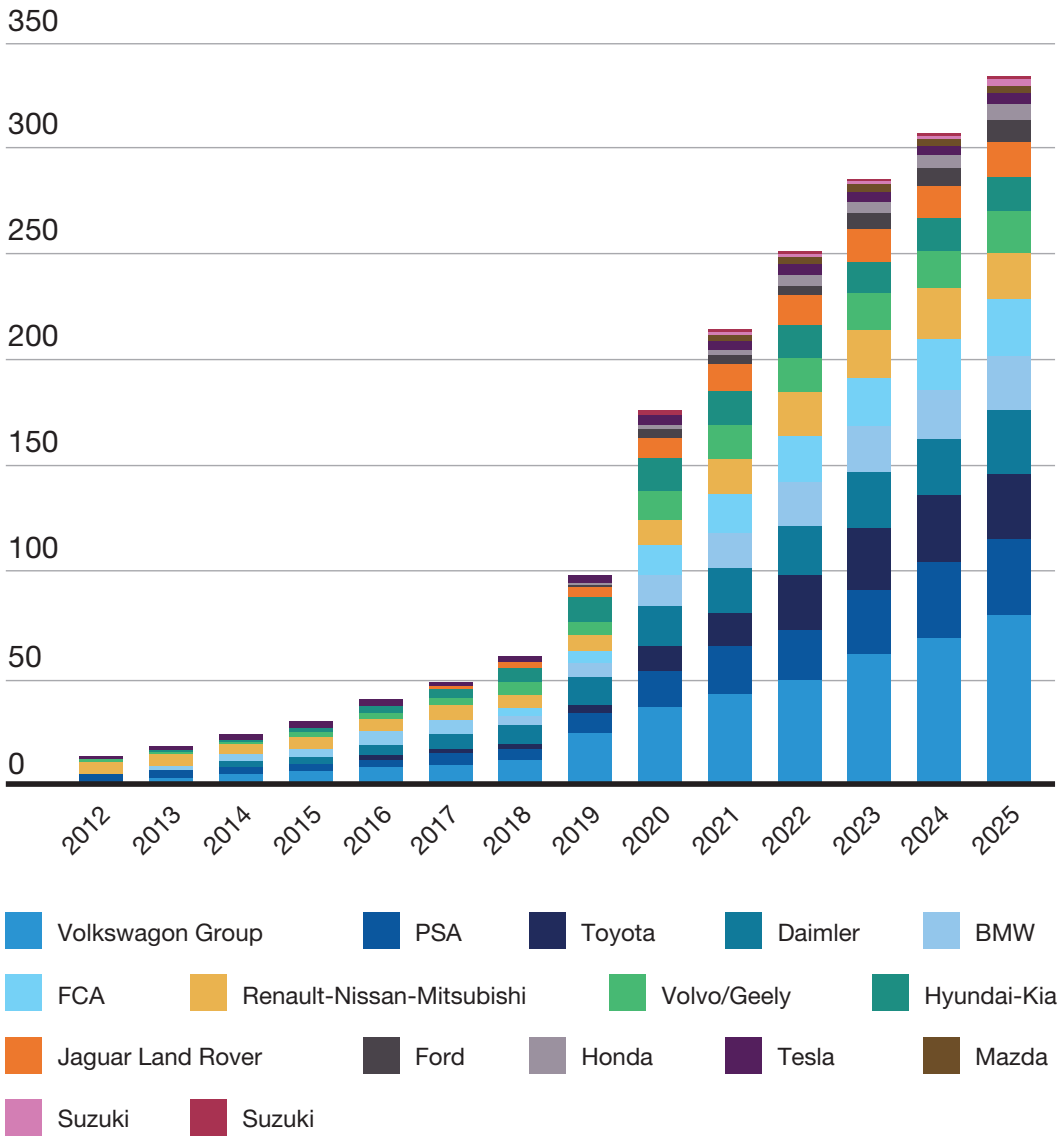


Figure 1: Total number of available EV models on the market in Europe

[8] Page 5 Electric Surge: Carmakers Plans across Europe 2019 to 2025 European Federation for Transport and Environment AISBL

2.5 Investment allocated within ED1

Within WPD's ED1 submission there is £112m allocated for socialised reinforcement attributable to LCTs. Of this over £58m was directly related to EV charging.

2.6 Forecasting local growth and pinpointing upgrades

In addition to the high level DFES work, WPD are working with EA technology to deliver a tool which will assess the impact on the local LV networks. The tool was originally developed as part of the Electric Nation project. In the project it was used to show where networks were becoming constrained as a result of local clusters of EVs.

The tool will be developed to help highlight where proactive reinforcement can help prepare the local networks for LCT connections and specifically EV connections. WPD will use this tool to support the business plan submissions for network upgrades.

2.7 Forecasting ED2 and informing specific ED1 plans

WPD's DFES are being used to target flexible solutions where they offer better value than conventional reinforcement. Load estimates will consider all demand growth but this will always include an element of EV growth. For higher voltage networks this educates and directs the reinforcement plans being considered in the next few years. For the local networks the scenarios can help refine the LCT hotspots identified by the work carried out with CSE.

3 Planning and Capacity Availability

3.1 WPD's expectation of EV charger installations

The size and type of charger varies with the application. Smaller size chargers might be expected to be seen in domestic situations where an overnight charge is likely. The smaller sized chargers may also form part of the street side car charging provision. Larger rapid chargers will be seen at public locations such as service stations and motorway service areas and car parks where a faster charge is required, they will also be seen where hubs of vehicles charge such as taxis.

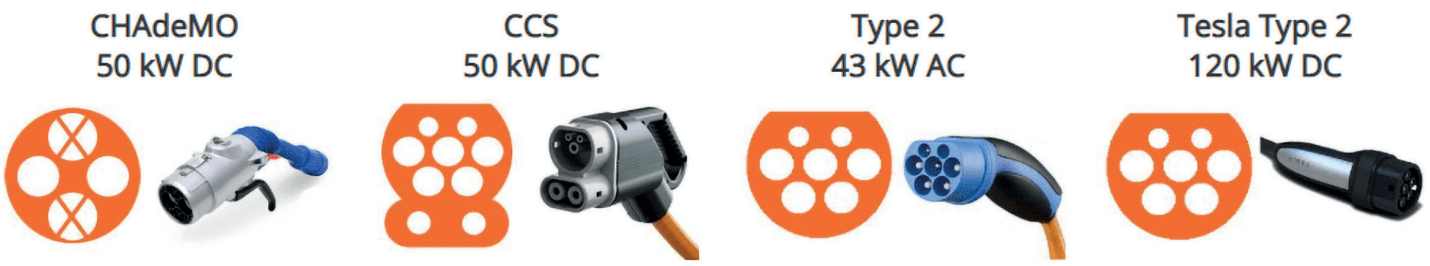
Chargers of 7kW are likely to be accommodated on existing house services but larger charger installations will often require a three phase service or other upgrades.

3.1.1 EV connector types

There are three main types of EV charging – rapid, fast, and slow.

Charge Point type and power output	Likely installation location	Specific connection requirements	Network considerations	Likely charge time for a 35kWh charge
Slow up to 3kW	Domestic	None – connects via household plug/socket	None	12 hours
Slow 3.7kW	Domestic or street side	Dedicated household circuit or on street equivalent	In some cases limited local reinforcement is required	9 hours
Fast 7kW	Domestic or street side	Dedicated household circuit or on street equivalent	Likely upgrade to service cable and local mains	5 hours
Fast 22kW	Street side or public charging location	Three phase dedicated supply point	Requirement for three phase connection and likely local mains upgrade	1.5 hours
Rapid 43kW	Public charging location	Three phase dedicated supply point	Requirement for three phase connection and likely local mains and transformer upgrade	45 minutes
Super 130kW or multiple rapid chargers	Public charging location	Supply point from dedicated transformer	In most cases a new transformer will be established	15 minutes

Rapid AC chargers provide power at 43 kW (three-phase, 63A) and use the Type 2 charging standard. Rapid AC units are typically able to charge an EV to 80% in 20-40 minutes depending the model's battery capacity and starting state of charge.



EV models that use CHAdeMO rapid charging include the Nissan Leaf and Mitsubishi Outlander PHEV. CCS compatible models include the BMW i3, Kia e-Niro, Jaguar I-Pace and Tesla's Model 3. Tesla Model S, and Model X are able to rapid charge via the Tesla Supercharger network using the Tesla Type 2 connector. The only model able to make maximum use of Rapid AC charging is the Renault Zoe. Currently CHAdeMO is the only connector type which supports V2G.

Slow charging is a method of charging electric vehicles used by some owners to charge at home overnight. However, slow units aren't necessarily restricted to home use, with workplace and public points also able to be found. If a vehicle remains stationary for a long period, such as at a Park & Ride or office car park, slow charging may provide the optimum solution. Because of the longer charging times over fast units, slow public charge points are less common and tend to be limited to street furniture that has a limited supply capacity.

Most slow charging units are rated at up to 3 kW with some lamp-post chargers being rated at 6 kW. Charging times vary depending on the charging unit, the LV supply capacity to the charger unit and EV being charged, but a full charge on a 3 kW unit will typically take 6-12 hours. Most slow charging units are untethered, meaning that a cable is required to connect the EV with the charge point.

While slow charging can be carried out via a three-pin socket using a standard 3-pin socket, because of the higher current demands of EVs and the longer amount of time spent charging, it is strongly recommended that those who need to charge regularly at home or the workplace get a dedicated EV charging unit installed.

3.2 Estimating Connection Cost and Timescales

The cost and complexity of the electricity network required to support new chargers will vary with size. At a domestic level only minimal works will be required to accommodate chargers but for larger installations and hubs of multiple chargers new transformers and substations are likely. The cost and works timescale will vary with the complexity of the works as detailed below.

Charge Point type and power output	Likely installation location	Typical approximate connection lead-times	Network and Third Party considerations	Approximate connection cost
Slow up to 3kW	Domestic	Immediate	None	None
Slow 3.7kW	Domestic or street side	Immediate in most cases	Usually none	Usually none
Fast 7kW	Domestic or street side	4 to 8 weeks	Likely upgrade to service cable and local mains	£1,000 to £3,000
Fast 22kW	Street side or public charging location	8 to 12 weeks	Streetworks and permissions	£3,500 to £12,000
Rapid 43kW	Public charging location	8 to 12 weeks	Streetworks and permissions	£3,500 to £12,000
Super 130kW or multiple rapid chargers	Public charging location	16 weeks	Streetworks, permissions and cost of land for transformer	£70,000 to £120,000

3.3 Simplifying the application processes

WPD have adopted the ENA application form for both EV and Heat Pump applications. This form helps customers by offering consistency across all Distribution Network Operators (DNOs). WPD are actively trying, via the ENA Wayleave group, to obtain an industry connection standard which would speed up the rapid EV charging connection process.

3.4 Making use of existing local capacity

WPD's network of transformers which supply local networks from the 11kV backbone network are sized to accommodate the demands of the area they serve. Since 2013 WPD have reduced the range of Ground Mounted and Pole Mounted transformer sizes available to connect to the 11kV network, so often there is an inherent level of additional capacity present for future load growth. It is envisaged that WPD will make use of this capacity as a tool to support the early adoption of Electric Vehicles and other LCTs.

This capacity is likely to be available in urban areas with a dense spread of ground mounted transformers. In rural areas where both three phase and especially single phase overhead networks are employed the opportunities are somewhat less.

It is predicted that the majority of the larger local transformers will be able to accommodate one 35kWh charge every five days for each of the customers connected to it. Depending on the battery density of the electric vehicle, typically this provides a charged range of around 150 miles in many EVs and it is likely that this will support the demands of home connected EV charging. The Department of Transport National Travel Survey 2017 indicated that the average annual mileage for all cars is 7,800 miles[9]. This figure has been dropping since the early 2000s.

[9] Page 14 National Travel Survey: England 2017.

A 500kVA transformer is capable of supplying 4.3 million kWhs of energy every year assuming it is fully loaded. Where the transformer is operating at 70% of its overall capacity this provides around 3.1 million kWhs of available energy, assuming that it is not required at times of the day when the load profile of the transformer makes it fully loaded. This capacity could support over 87,000 charging events at 35kWh. If correctly managed to optimise the delivery of these events, the transformers could provide one charge every five days for each customer connected.

3.5 Planning and Design Changes

When WPD design and extend the network it is expected that assets will remain in service for around 50 years. This means that WPD always look to predict future changes and assess how those changes can reasonably be accommodated in the plans and designs. The ED1 plans looked at changes that could be made to support the adoption of LCTs.

With the cable networks, the cost of excavation and reinstatement works are a large proportion of the overall costs so rather than potentially needing to overlay cables as LCT take-up increases, it was decided to increase the minimum cable size for all new installations. Similarly when working at substations, the plant cost of transformers meant that the minimum transformer size could be increased with only a marginal increase in installed cost. Both of these measures, to a degree, future-proof new networks at minimal increase in cost.

3.6 Technical Changes related to Electric Vehicles

To permit the connection of electric vehicle charge points there are typically three concerns to overcome, these are thermal capacity, earthing arrangements and harmonic emissions. They are detailed below: -

3.6.1 Thermal Capacity

To assist with the creation of thermal capacity within the low voltage network, we have increased the minimum size of the low voltage mains cable to have a cross sectional area of 185mm², increased the minimum size of service cables to 25mm² Copper or 35mm² Aluminium, the smallest rated ground mounted transformer to 500kVA and the smallest rated pole mounted transformer to 25kVA single phase.

3.6.2 Earthing

The current IET Code of Practice Ed 3 states earthing considerations for the connection of electric vehicle charge points are firstly the type of earthing arrangement (PME, SNE or TT) and secondly the required segregation between these different earthing types. The requirements of the Code of Practice for the installation of EV charging equipment makes the use of protective multiple earthing (PME) prohibitive and steers installations towards a TT earthing setup.

However the IET Wiring Regulations (Guidance note 7) requires segregation of a minimum of 10m between the PME and TT earthing systems. WPD understand that this requirement will restrict installations in the street and therefore have recalculated the requirement using modelling specifically for a street side application. As a result WPD have reduced the distance so that a balanced three phase demand utilising a TT earthing system will require segregation from the WPD earthing system by a minimum of 0.3m and a single phase or unbalanced connection would require a segregation of 3.6m.

3.6.3 Power Quality

Electric Vehicle chargers use power electronics which can cause interference and damage to the electricity network. As a result of the EV Emissions project WPD have assessed the effect of this interference and have concluded that it is insignificant for smaller size domestic type chargers up to 32A capacity. Therefore the planning advice for these charges is that the effect can be discounted and treated in a standardised way when designing connections, making them cheaper and quicker for customers.

The data has also been used to determine how many EVs can be connected onto a circuit subject to the impedance of the main conductor. As a result of the innovation project WPD have also decreased the prescribed maximum resistance of WPD mains conductors to a value of 190 mΩ.

4 Providing information to Customers

4.1 Guidance and Advice Documents published

WPD have already developed a guidance document for local authorities who are considering public and street side charging connections. The "Getting Electric Vehicles Moving" guide provides details including information on the different kinds of chargers available and how charging points can be connected quickly and efficiently to the network.

In addition the "DNO engagement for local authorities guide" provides information specifically tailored to local authority customers delivering public charging points. The guide covers some of the technical considerations related to public connections as well as offering advice on how to make applications and discuss plans with WPD.

www.westernpower.co.uk/smarter-networks/electric-vehicles

4.2 Guidance and Advice Documents planned

During 2019 WPD had planned to extend the range of guides to include advice for fuel station operators and fleet users with depot locations. Unfortunately this did not happen for a number of reasons, but this is still an aspiration of WPD to achieve, consequently it is currently listed as a project to undertake.

WPD will continue to review the number and content of the guides to help customers when they are considering EV options for their homes or businesses.

4.3 Capacity Indication for customers

WPD have a capacity map down to local distribution substation level on the WPD website which shows customers the level of generation capacity at their local substation for the local scope for connection of electric vehicles.

At this local level there will always be specific considerations which can affect our ability to connect individual charge points, but this map will provide a generic view of the capacity which is available in local streets.

4.4 Connections Surgeries

Local authority customers have the opportunity to request one to one connection surgeries with the various local teams within WPD. At a local level the teams will be able to discuss plans for EV charging and how the electricity network can be adapted and or uprated to accommodate future plans.

4.5 Customer Knowledge

Charging rates when using a fast charger will depend on the car's on-board charger, with not all models able to accept 7 kW or more. Charging rates also vary depending on whether a charge point has a tethered cable or accepts the customer's cable.

Should a cable be tethered to the device, only models compatible with that connector type will be able to use it; e.g. a Type 1 tethered cable could be used by a first-generation Nissan Leaf, but not a second-generation Leaf, which has a Type 2 inlet. Untethered units are therefore more flexible and can be used by any EV with the correct cable.

Even if an EV is only able to accept a maximum of 50 kW DC, the EV could still use an ultra-rapid charge point, as the battery is equipped with charging safeguards which would restrict the power to whatever the vehicles battery can deal with. These models can still be plugged in to the charge point, but will only draw the maximum power accepted by the on-board charger.

5 Stakeholder Engagement

5.1 WPD's Approach to Stakeholder Engagement

The approach WPD has to engagement varies depending on the requirements of individual stakeholders. In some cases a company level strategic engagement is needed and in other cases a more local engagement is required.

WPD provide a front end service using locally based teams that are responsible for the local networks and the local customers connected to them. At this level a more informal engagement is the most efficient solution and complements the more formal strategic stakeholder event engagements.

5.2 Business Plan Strategic Stakeholder Engagement

WPD has an excellent track record of stakeholder engagement across the range of topics contained within the business plans. Since 2010 WPD have included elements of LCT readiness and EV charging. In the early years the focus was on pragmatic steps that could be taken to support what was a small population of electric vehicles, subsequently EV charging has become a topic in its own right.

These engagement sessions have helped formulate the EV charging plans and have also informed innovation projects related to EV charging.

Following from themes explored in 2019 the 2020 strategic stakeholder engagement sessions included specific EV readiness topics.

5.3 Strategic Engagement with local authorities

As approximately 40% of vehicles don't have off street parking to utilise EV charging, Local Authorities are having to take the lead on EV charging in public areas such as car parks and park & ride sites. In 2018 WPD developed an EV guide for local authorities to help them with their plans, this document is due to be updated by April 2020.

In November 2018 WPD became the first DNO to hold a bespoke stakeholder engagement events for local authorities. Across two events in Bristol and Birmingham WPD were able to share the EV charging plans with 186 local authority representatives. As a result of what was learnt from these sessions WPD updated the EV guide.

With the demand for EV charging at hub locations such as car parks, WPD in conjunction with manufacturers have developed equipment to allow the efficient connection of multiple rapid DC chargers in these hub locations.

5.4 Local Engagement with local authorities

WPD's strategic local authority engagement highlighted a requirement for more local engagement. Local authority customers now have the opportunity to request one to one connection surgeries with the local teams. These local surgeries are able to discuss plans for EV charging plans and how the electricity network can be adapted and uprated to accommodate future plans. In 2020 our surgeries will expand to consider all aspects of the transition to Net Zero.

During 2019 WPD's normal programme of local based stakeholder engagement included specific sessions covering EV charging. These depot based engagement sessions took place at eleven locations across the WPD area.

5.5 Engagement with EV Charge Point Operators

WPD now offer a DNO leading service in providing supplies to the EV charge point operators. As DNO equipment is designed for a fifty year life it is generally the case that that the host DNO will seek a long lease or wayleave to install the substation, plant and cables. Where supplies are for buildings this is normal but with an EV charge point the charge point operator might only have a shorter lease of, say, fifteen years. In these cases WPD plan to offer a back-to back lease, make the connection agreement sole use and at the end of the lease have first refusal to supply the new lessee. This process makes the connection process easier for the EV charge point operator and speeds up the connection process to get more EV charge points installed in the UK. Many of these sites are at public charge locations and quicker more efficient connections here will ultimately smooth the adoption by the public of electric vehicles. Visible and plentiful charge points will help reduce range anxiety from EV users

5.6 Engagement for Fuel Station Operators

WPD have engaged with the Petrol Retailers Association to understand how their members are approaching the change to electricity as a road fuel. The approach varies between Motorway Service operators and A road or local road fuel filling stations.

With motorway services WPD are part of the OLEV's Phase 1 of Project Rapid which is rolling out 130 rapid motorway service area sites in England, 48 of these sites in England fall into the WPD licence areas, on average WPD have provided pricing for 7MVA supplies. Phase 2 of Project Rapid it is envisaged that a further 14 sites will be nominated and these fourteen sites will be in Wales and Scotland. With local forecourts WPD are expecting to see small numbers of EV chargers per site as the space available for additional infrastructure is more limited, especially outside of the zones controlled by liquid fuel refuelling regulations.

WPD are already working with Moto Services on plans for a demonstration project at one of their motorway service areas.

5.7 Engagement for Housing Design

Using data from the recently started Superfast Electricity project in Tonyrefail in South Wales WPD plans to increase the house service cable design, WPD recently gave a presentation on this at the Renewable Energy Association (REA). WPD have shared stakeholder engagement with the REA on this subject and are continuing discussions with relevant government departments.

The Superfast Electricity project was developed in conjunction with Pobl Housing Association and Sero Homes, an innovative Welsh based provider of Energy Positive homes.

5.8 Engagement with Vehicle Manufacturers and Transport Operators

WPD using the links that have been developed by the fleet transport department to engage with HGV manufacturers, WPD were invited to Stuttgart to attend the Daimler Benz Utility seminar where Daimler Benz introduced the recent introduction of Regulation (EU) 2019/1242 of the European Parliament and of the Council of 20 June 2019 setting CO_2 emission performance standards for new heavy-duty vehicles and amending Regulations (EC) No 595/2009 and (EU) 2018/956 of the European Parliament and of the Council and Council Directive 96/53/EC. It which requires CO_2 emissions from heavy-duty vehicles such as trucks and buses to be reduced by 30%, by 2030, with an intermediate reduction target of 15%, by 2025. This regulator change is discussed in section 1. The change will be significant for manufacturers of buses and lorries. As an example of volumes, during 2019 Daimler Benz saw Daimler trucks sell 488,500 HGV vehicles worldwide, Daimler Buses sell 32,600 buses worldwide for 2019 and 438,400 vans worldwide for 2019.

Whilst commercial Hydrogen based solutions remain relatively rare, Daimler Benz are using the HGV EV as this is a proven technology which can meet the 2025 deadline providing the electrical networks have the infrastructure in place. Electric trucks will pose a new issue for the energy sector due to their large batteries, relative short range of around 150 miles, large charger sizes and high charging speeds. The Daimler Benz aim was one of helping their customers achieve a quick and smooth transition from diesel to electric vehicles. The vision of Daimler Benz was for understand electric trucking and how electric trucks charge. Understanding the necessary information exchange between customers and DNOs in order to ensure the swift upgrade of network connections. Understanding the costs and timelines of such upgrades to improve customers' decision-making. Establishing cooperation between WPD and Daimler Trucks to support the guidance of customers through grid connection topics.

WPD's Fleet department also engages with relevant transport trade bodies to help develop the future views for wider road transport.

WPD have also discussed the X Storage system with Nissan to understand their plans in the area of EV charging and home generation or battery storage.

5.9 Engagement with Depot Based Fleet Operators

Fleet operators who return their vehicles to a depot overnight can offer DNOs specific benefits by charging their fleet at times which avoid the traditional early evening peak of demand. WPD's engagement in this area so far has been with bus operators such as with Arriva as part of the Electric Boulevard project as an early demonstrator for wireless charging. More recently with Cardiff Bus as they have 32 BYD electric buses and will be using 40kW rapid chargers in a depot charging hub in their Sloper Road, Cardiff depot. WPD have been working with them to support the change. As the buses are generally at the depot overnight a flexible connection may allow this capacity to quickly connect.

5.10 Engagement with UK Government

WPD and various other parties have been involved with OLEV and BEIS in their Stakeholder engagement, this engagement has been brought about by the change to the Building Performance Regulations which the EU modified in April 2018. WPD are trying to pursue changes to the building regulations for the introduction of EV chargers to new building should also accommodate other LCTs and provide a holistic approach.

WPD along with all the other DNOs are involved with OLEV's Project Rapid. The project plans to install 130 rapid EV charger sites in England at the Motorway Service Areas (MSAs), of these 130 sites WPD provides supply to 48 of the sites within England. Phase 2 of the Plan will include a further 14 sites in Wales and Scotland, which will see WPD's share increase. Currently OLEV is suggesting the WPD should make on average 7MVA of capacity per MSA site, it should be noted that this capacity has only been earmarked for cars and light vans. At this time HGV EVs has not been considered by OLEV. WPD will be supplying these sites at 33kV and will be using the NIA Innovation fund to prove there is a smart solution to meet the OLEV capacity requirements.

It is essential bearing in mind that electrical plant has a service life of fifty years that all criteria are taken into consideration and that it follows the Committee for Climate Change view of “touch it once till 2050”.

WPD have worked with Catapult Energy Systems, Low Carbon Vehicle Partnership and Innovate UK for the Electric Vehicle Energy Taskforce. This has been formed at the request of Government to make suggestions to Government and industry to ensure that the GB energy system is ready for and able to facilitate and exploit the mass take-up of electric vehicles.

WPD have engaged with BSI and BEIS on Smart Device Standards which will allow products to communicate with each other and be controlled to manage network demands.

We have also held sessions for civil servants and public sector workers to share our knowledge on EVs specifically and the electricity network in general.

5.11 Engagement with Welsh Government

WPD’s projects to demonstrate Superfast Electricity and On Street Charging have all been developed with the help of the Welsh Government. WPD were able to engage early with the Welsh Government and have followed their plans for decarbonisation alongside UK Government plans. The Welsh Government is also trialling the use of Hydrogen as a road fuel and WPD have used learning from this project to develop a balanced view of future requirements.

5.12 Engagement with Go Ultra Low Cities (GULC)

Three of the four Go Ultra Low cities, Nottinghamshire & Derby, Milton Keynes and Bristol, are within our operating area. Between them they have plans to install 410 charge points, many of which will be high capacity rapid chargers. They are all supporting free or discounted parking for EVs which is likely to increase early adoption.

Using many of the specific delivery plans listed above, WPD will work with each city at a local level to help them deliver their targets.

5.13 Engagement with Local Enterprise Partnerships (LEPs)

Ensuring WPD’s future network investment plans are aligned to developments being planned at a local level is a key priority for the company as a distribution business. WPD’s Electricity Supply Areas (ESA) are local areas which match the higher level network feeding areas. WPD engage with customers each ESA to build in the local stakeholders plans for high level network growth.

Every 6 months, under WPD’s Strategic Investment Options work, the company undertake a workshop led consultation with local stakeholders from a licence area to understand their pipeline of projects and ensure WPD are capturing the correct data to feed into the various investment strategies. WPD then build a bottom up vision of demand, generation and storage growth by absorbing the locally published plans and other market intelligence to enable WPD to study the network under future growth scenarios. This includes specific distribution data on BEV and PHEV numbers in the WPD area.

The data that WPD accrue is also shared back with Local Enterprise Partnerships, local authorities and other stakeholders and has been used to inform local energy plans. To date WPD have shared data for around 50% of the network area and are continuing to make this information available as when it is updated.

5.14 Stakeholder Engagement Plans for 2020

Following on from the success of our face-to face general stakeholder engagement sessions in February we are planning more events. Many of them will have an Electric Vehicle theme running through them. The will include

- Versions of the annual workshops via an online panel/consultation during April and May, of which EVs will be a component.
- Co-creation sessions with end user customers in June
- Directly engaging all 130 local authorities in our area before June 2020 on their local energy plans. Whilst this will cover all LCTs, electric vehicles and decarbonisation of transport will be a major topic.
- Local network investment sessions in the summer with the focus being Net Zero and local energy plans.

WPD will continue to engage with both the UK and Welsh Governments. With OLEV in particular with Project Rapid as this project evolves.

Our work with new customer groups will continue. Initial discussions with Motorway Service Operators will develop into more formal industry wide engagement managed through the Energy Networks Association.

With the on-going Superfast Electricity project in Tonyrefail WPD will develop new company standards as part of BAU and will engage with house builders through the Renewable Energy Association.

6 Plans to support Electric Vehicle Charging

6.1 WPD's approach

Using data generated from the Electric Nation project, a typical average mileage per year electric vehicle uses, on average, the same volume of electricity as a gas fired centrally heated domestic house. As a network operator, WPD have a wealth of experience in designing housing networks and recognise the need to evolve the design methodologies to include new use cases. WPD will use this experience to ensure that electric vehicle charging can be accommodated in the most efficient and economical way.

Where existing network architecture is not best suited to permit electric vehicle charging WPD will take steps to mitigate this and, if upgrades are required, use innovative solutions to allow faster and efficient connections.

When WPD build new networks they are designed for them to be ready for the future demands that LCTs will place upon them.

6.2 Releasing existing network capacity

With the low voltage network this already includes a finite volume of available capacity. Since 2013 WPD have reduced the number of Ground Mounted and Pole Mounted transformer sizes available to select as local transformers for new developments. This means that there is often capacity available between the designed demand of the network and the size of transformer which feeds it.

WPD predict that the majority of the larger local transformers will be able to accommodate a 35kWh charge every six days for each of the customers connected to it. This provides a charged range of around 150 miles in many EVs and it is likely that this will support the demands of home-connected EV charging.

WPD also expect that the backbone 33kV network and transformers will be able to accommodate this level of charge point activity.

WPD have developed a heat map of capacity at each of our local distribution transformers. This will show which of the transformers can offer capacity and where constraints are likely. It is expected that these early constraint signals to help WPD develop flexibility solutions which can be taken up by aggregators or signalled to customers via smart meters or time of use tariffs. In addition to looking at flexible solutions WPD will undertake a CBA to compare the cost of flexibility compared to reinforcement of the network, if flexibility is left unchecked then a bow-wave is produced which takes extensive expenditure to overcome.

6.3 Motorway Services and Major Road Filling Stations

Through the Road to Zero Strategy and the Automated and Electric Vehicles Act 2018, there is a requirement for large fuel retailers and service area operators to provide public charging points. In addition to this OLEV are undertaking Project Rapid with the average power assigned to each of the sites in WPD's area as 7MVA. To meet this load WPD expect to supply the sites at 33kV and have developed an NIA project to provide a novel solution. In most cases these installations are currently supplied by bespoke high voltage connections but it is likely that these will not offer the level of capacity predicted. A 33kV solution offers flexibility for demands to increase without creating redundant networks.

Major Road Filling Stations can be located in more urban locations. They can be supplied by our local low voltage mains. As these increase their demands we will uprate low voltage mains as required. We have already established policies that allow a second point of supply to be made available on forecourts to support the charging infrastructure.

In some cases the number of charging points may mean that a substation needs to be provided at the forecourt. WPD are working on an innovative method of providing this network capacity for filling stations, using our Hub Charging and EV Filling Stations projects.

6.4 New Homes

Since 2013 WPD has stopped tapered network and standardised on larger cross sectional area cables. When considered in conjunction with the diversity of the network, which allows for the fact that all customers do not use all of their installed demand at the same time, many of these newer networks will be able to accommodate charging.

The service cable, which runs from the street to an individual property, cannot make use of this diversity as it needs to provide the whole supply for that specific customer. WPD have already identified that increased LCT demands could require larger capacity service cables and since 2013 have done away of the smaller service cable designs in addition WPD, with Sero Homes and Pobl are in the process of building about 250 new homes where the new Superfast Electricity project will be monitored.

WPD do not want today's purchasers of new properties to be faced with service upgrades in the future because designs of networks did not think ahead.

6.5 Existing Homes

Over the 100+ years of electricity supply there are sections of the existing networks which were designed for varying standards and conditions of use all associated with the time the network was extended/built, in addition the electricity usage assumptions at the various times of installation would have been lower than those used as the current standards. Whilst most new homes connected from the mid-1990s will have a service provision which can accommodate a normal domestic demand and the new demand of a smaller car charger, large chargers and older installations will need to be assessed. For example some housing estates were still looping service cable in the late 2000s, and house with a looped service cable needs to be de-looped for the fitting of LCTs.

There will be issues on older networks where there were tapering of the mains and the use of small cable sizes, which was prevalent in the 1970's.

WPD appreciate that the capacity of a house service and the cut-out is the last thing on a customer's mind whe they choose an electric vehicle so WPD are working with all the other DNOs and the ENA to produce a common methodology and assessment process thus making acceptance as simple as possible. In addition the ENA LCT group are currently undertaking a project/contract to generate a definitive rating for each cut-out that has been used in the UK over the years this will remove inconsistencies across the DNOs.

The ENA LCT group self-assessment project will allow charge installers a simple way of identifying the capacity of a service cable; the project will create an application which can be used across the UK and for any DNO network.

Where an existing service cable is deemed inadequate for the requirements of an EV charger, then retro-fit Superfast Electricity project being undertaken in Swansea will demonstrate how this can be achieved with minimal inconvenience to individual customers.

6.6 On Street Charging

As approximately 40% of all vehicles on the UK roads don't park in an off-street location WPD are using the Road to Zero Strategy requirements to give Local Councils the ability to provide new street lighting installations or bespoke EV charging installations to their streets. This requirement will change the way WPD design connections for street lights, which have historically been sized and connected for the relatively low demand of a single lamp head.

To prepare the infrastructure required for charging WPD are expecting to provide bespoke street lighting mains cable in new streets. This is being developed through the On Street Charging Solutions.

For established networks the solution will vary depending on the existing mains infrastructure. In some cases uprated services can be made available to street lights but in other cases a more widespread scheme to uprate mains will be required. In order that WPD can undertake these uprating works in a logical and efficient manner, triggers are developed which will help the company identify reinforcement requirements.

6.7 Depot Based Fleet Users

Where a fleet user returns their vehicles to a depot location depending on the size of the fleet and individual battery sizes, WPD envisage a number of possible solutions from them requiring a relatively large electricity supply to support their charge requirements to using off peak charging to achieve their respective requirements. The connections we offer will vary on a case by case basis, but if the number of vehicles requiring charging are large then it is likely to be similar in design to those for larger commercial buildings or factories, either with on-site transformers or taken at HV.

With the majority of charging for these customers taking place overnight at times of likely low demand for the network, then WPD will offer flexible solutions such as Alternative Connections to these customers to make most efficient use of the network.

6.8 Workplace and Off Street Charging

It is expected that charging points will be established at workplaces and other communal locations. These may be at park and ride sites, supermarkets and retail parks. It is also expected that hotels and other leisure locations will also establish charging points as the demand for EV charging grows.

The approach will be a mixture of the approach used for fleet charging and the approach to urban fuel stations. Where the existing supply to the location is capable of supporting the additional load then full use will be made of this. Where an upgrade is required WPD will either reinforce the local low voltage network or add an additional high voltage networks based on the local conditions.

It is expected that third party EV charging sites will be developed at car parking locations. The EV Hub Charging project that WPD are leading will look at how this demand with bespoke load centres can be established directly in the car parking areas.

6.9 Vehicle to Grid (V2G)

As part of our Electric Nation project WPD conducted a mini V2G trial. The flexibility that is potentially available is restricted to specific models of car and also only tied into the CHAdeMO connected EV charger at present. An issue that will need to be resolved is the ESQCR regulations clause 22 in particular restricts the maximum amount of "generation from the Electric Vehicle" to 16A, bearing in mind that the EV chargers that are being connected are 7kW chargers. WPD were also involved in the V2GB Innovate UK project. WPD also helped connect the first domestic V2G charger 2019 with OVO following existing industry practices. During Electric Nation there was a small trial of V2G using a handful of V2G chargers. WPD have, as a continuation of Electric Nation themes, started the Electric Nation – PowerUp project where approximately 100 V2G charger will be monitored. This project will develop through 2020.

The X Storage system provided by Nissan brings together local generation, storage and use of electricity. It uses batteries at the home and in the vehicle. Nissan has a holistic view of a better connected home environment and the electricity network will need to support this change. The system has features, such as the ability to charge or discharge batteries, which could be of use to DNOs when managing networks that are nearing their maximum capacity.

6.10 Smart Charging

WPD working with Pobl a Welsh Housing Association and Sero Homes on the Tonyrefail project, where all the new homes will be fitted with three phase cables alongside PV, ES, HP, EV charging and smart white goods. All are connected to a Program Logic Controller (PLC) which then takes into account all the various inputs like the demands of the house appliances, needs of the householder and signals from the network to minimise the electrical cost to the householder.

Therefore the charging of the electric vehicles are able to follow price signals and charge when demand is low, helping to smooth out daily electricity demand. This could help DNOs manage the electricity network more efficiently and reduces the need for reinforcement.

The Electric Nation project has shown how price can affect charging. As a consequence WPD have held workshops with other industry participants to explore how the learning from Electric Nation can be developed into products and services that suppliers and aggregators may offer to their customers.

6.11 EV clustering

The low voltage networks rely on a level of diversity between connections. Where there is a cluster of EVs this diversity can be eroded, especially where overnight domestic charging is prevalent. From the Electric Nation project has shown that once the owner of the EV has used the vehicle for a short period they then only charge their EV every two to three days, this means that the impact of the EV has been reduced by the natural spread of charging behaviour which means all EVs rarely connect every night.

In addition to the forecasting work WPD have done, notifications of installed chargers are being used to identify hotspots and clusters of EVs and other LCTs. The recent LCT detection project provided information of 20,00 LCT connections that had not been notified to WPD by the installers, as a consequence WPD are now endeavouring to start a second round of LCT detection with IBM and Electrolink to further enhance this identification to include additional locations where notifications were not received.

WPD are using this clustering information to direct our proactive reinforcement of networks.

6.12 Mitigation of local network constraints

There may be isolated locations where a cluster of new EVs will exceed the capacity of the local network. This is most likely to happen with domestic EV charging. It is hoped that many of these clusters will be identified with the clustering modelling. Where clusters are not identified and WPD have not anticipated the change in demand, the results could be blown fuses and customers being inconvenienced.

Delivering the upgraded network will take a finite duration and, whilst these works are being planned and executed, it is not acceptable for customers to continue being inconvenienced by supply interruptions therefore WPD through the Electric Nation project have found a method to mitigate the demand increase by making use of equipment developed to manage load demands within known limits. This equipment has been further developed through the WPD Innovation Connect and Manage project which provides a “throttling back the load” response to local overload situations. This solution has been developed into a BAU product which is now available for all WPD teams to use as they require it. It must be stressed that the Connect and Manage equipment will only be used while WPD are in the process of upgrading the network effected by the overload.

WPD’s local teams have shown themselves to be the industry leaders in response to supply interruptions and this technology will allow them to provide this same high level of service where the connection of LCTs have created a specific problem.

7 Smart Solutions and Flexibility

7.1 WPD's approach

Flexibility is already an established network management tool for WPD, developed under the Flexible Power brand name. Where constraints are identified WPD look at a range of solutions to rectify them, including smart and flexible solutions. Flexible Power has traditionally looked to larger customers to provide the flexibility responses required but the Flexible Power model used for the large customers has been adapted to include aggregators and others who could provide a response from EVs and the domestic market.

Electric Vehicles via V2G and deferred charging can offer networks a great opportunity for flexibility where they are plugged in for an extended period. Be this overnight, either at home or at a depot location or in a long term car park. The industry as a whole need to consider the flexibility that will be available at Park & Ride sites or long stay car park locations.

There is less flexibility where customers require a quick and immediate charge, such as at motorway service stations.

7.2 Domestic Flexibility

The Electric Nation project has confirmed willingness for customers to accept smart charging. This flexibility will be valuable for WPD to facilitate the quick and efficient connection of EVs. It was found that customers were relatively comfortable with a reasonable level of managed charging so long as it did not impact their lifestyle or vehicle use.

The trial did investigate how price signals affect flexibility but showed that smart charging solutions such as those demonstrated in electric nation will be the domain of electro-mobility service providers. E-mobility service providers will include energy suppliers, market flexibility aggregators and potentially automotive companies (both manufacturers and leasing companies). WPD will interface with these service providers through the provision of grid capacity visibility and signals to ensure that smart charging is done in harmony with the local electricity network capacity.

We expect that this flexibility will be delivered in a hierarchy which starts with simple time of use demand shifting through supplier signals, moving on to Passive and then Active products as required. Where short term flexibility requirements are needed to overcome local constraint where reinforcement is planned we will deploy active network management tools such as Connect and Manage.

7.3 Commercial Flexibility

Where larger clusters of EV charging exist, such as depots and long stay car parks, there is the potential for site operators to participate in WPD's flexibility markets. Through Flexible Power the Operators could operate within the constraint managed zones, thus assisting with the more general level of network constraint. WPD will continue to deliver projects which will demonstrate how flexibility can be used to enable EV charging capacity to be made available without the need for conventional reinforcement, provided the relevant CBAs show value for money for the customer.

Flexibility in this area will follow the format of WPD's Alternative Connections products. At its simplest level WPD plan to re-create the "Timed Connection" model to allow EV charging to coexist with other conventional demands. For example where a depot facility requires charge capacity at night it may be possible to provide this without reinforcement by sharing network capacity which is already present for daytime industrial use.

The Alternative Connections model then move towards a fuller Active Network Management solution where constraints are measured and customers react with constraint. This system has already been delivered by a car showroom in Lincolnshire to restrict charging at times of network peak.

7.4 Whole System Flexibility

As vehicle to grid solutions and smart charging develop WPD will have the opportunity to make use of these flexible solutions on the network. In fact, a customer who makes use of local generation, storage and EV charging could actually reduce their impact on the network and help avoid conventional reinforcement.

8 Projects to demonstrate EV connections

8.1 Developing a balanced portfolio of projects

Our projects are developed through our Innovation Strategy. We always look for projects which cover our three main themes of Assets, Customers and Operations. We ensure our projects retain this balance by the regular review of our Innovation Strategy which is supported by our more general Stakeholder Engagement.

In the specific area of Electric Vehicles, we have used our Local Authority Stakeholder Engagement and focused EV surgeries during our 2019 stakeholder engagement sessions to ensure our projects are providing the right blend of technical and flexible solutions.

8.2 Completed Projects

8.2.1 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 car park 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.

8.2.2 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.

8.2.3 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 technical aspects of the project included studies into the electrical implications of installing inductive charging solutions, including the challenges of installing such infrastructure in public highway. 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 a high-voltage connection. This solution means that charging infrastructure can be connected much cheaper and quicker than previously thought.

8.2.4 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.

8.2.5 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.

8.2.6 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.

8.2.7 Electric Nation (2019)

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

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 has modified WPD's planning standards. In particular future assessment of diversity and maximum demand.

8.2.8 IET Code of Practice for Electric Vehicle Charging Equipment Installation, 4th Edition

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 within the 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.

8.2.9 LV Connect and Manage (2019)

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.

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. The solution is currently been 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.

8.2.10 LCT Detection (2019)

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.

8.2.11 Superfast Electricity – feasibility of three phase services (2019)

Working with Innovate UK, Monmouthshire County Council, Wales and West Utilities, Cenex and the Welsh Government the group looked at the feasibility of the fitting of all LCTs to 20,000 properties, the combination of new build and retro-fit properties in Caldicot, in addition the project would have installed three phase service cables at all properties in this development in Wales.

8.3 Current Projects

8.3.1 Reinforcement Planning - Forecasting and Planning Interface Tool (2020)

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.

8.3.2 Smart Homes – EVs and Storage

With the Tonyrefail “superfast electricity” project as all the homes will have the complete suite of LCTs fitted along with a PLC being used to manage all the LCT assets in the house to “live within the generation of the house” it is envisaged that one of the side effects of having a full LCT connected house it is possible to manage the “fuel bills” of the house thereby minimising fuel poverty to the householder. To achieve this Sero Homes will create an” electricity co-op” with a view to be able to offer the all the battery storage of the houses on the estate to National Grid in the event of a frequency response issue on the greater electricity network and that the monies generated would then be ploughed back into the “electricity co-op” to reduce the fuel bills. Therefore by using this data it would then be able to show how a domestic installation can make use of locally generated power and storage to provide the energy required to power the house and charge an electric vehicle. Ultimately the equipment could also be used to mitigate peak demands.

8.3.3 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 have a third party install a domestic EV charger, the installer will need to ensure that the service cable is not a looped service, plus the service cable and cut-out is sufficient for the demand that the EV charger will generate.

Through the ENA LCT group there is a project that is being developed to provide a centralised way of providing the DNOs with the pertinent information required which will allow the DNOs to quickly assess if it is suitable to accept a charger but also ensure that the “journey the customer“ needs to endure is as easy, smooth and trouble free as possible.

8.3.4 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.

8.4 Future Projects

8.4.1 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 end-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.

8.4.2 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.

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 uprated ready for future demands.

9 Targeted Commitments in 2020

9.1 Realising benefits

Work completed in projects only becomes fully valuable once the findings from the projects transition into business as usual. WPD have already made changes to the technical design and minimum cable designs but there are more changes that are expected to be made as a result of the projects currently underway.

The section below detail changes that are expected to be made in 2020.

9.2 2020 – "Superfast Electricity"

Once the demonstration project in Tonyrefail has been running for a finite period of time it is envisaged that there will be sufficient information to show that three phase service cables are the correct design to be used is supplying new housing estates and that with the Swansea retrofit project WPD will have learned how to effectively retro fit three phase service cables into an existing domestic environment. With this knowledge WPD plan will amend the design policies to standardise on three phase service cables.

9.3 2020 – Design capacity assumptions

For many years WPD have used a set of After Diversity Maximum Demand (ADMD) figures to design the backbone network that supports housing developments. It has allowed for the efficient and economic connection of traditional gas and electrically heated homes. The impact of LCTs will change this design model. Using data from Electric Nation has given WPD the ability to calculate a new ADMD which includes allowances for EV charging and other LCTs. The new ADMD assumptions are now part of our standard low voltage network design tool used by WPD planners. We have also shared this detail with planners who work for Independent Connection Providers designing networks that we will adopt.

9.4 2020 – Public charging hub infrastructure

WPD have developed a hub charging solution to help the deployment of charging infrastructure in car parks and other public locations. With the completion of our hub charging project we will create a design specification for bespoke charging transformer deployments. There is a wayleave/lease issue around EV charging locations which WPD, all the other DNOs and Ofgem are trying to resolve, resolution of this issue will mean a far quicker turn around in supplying connection agreements with all the DNOs, it is more than likely the issue will impact Project Rapid if not addressed early.

9.5 2020 – Using Connect and Manage to overcome Clustering

Using the equipment proven in the LV Connect and Manage project WPD will be able to provide controls to allow EVs to charge on a network which could be constrained due to clustering of EVs, using the Connect and Manage equipment will provide WPD a rapid response to "buy time" whilst a more enduring solution is developed and installed. WPD have started to produce procedures so that this equipment can be deployed in a consistent way by the local teams.

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