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2022 - WPD Electric Vehicle Strategy

WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

a nationalgrid company

Contents

Glossary

Abbreviation	Term
A	Ampere
ACEA	European Automobile Manufacturers Association
BaU	Business as Usual
BEIS	Department for Business, Energy & Industrial Strategy
BEV	Battery Electric Vehicle
BEV HGV-SH	Battery Electric Vehicle Heavy Goods Vehicle-Short Haul
BEV HGV-LH	Battery Electric Vehicle Heavy Goods Vehicle-Long Haul
CBA	Cost-Benefit Analyses
CCC	Committee for Climate Change
CSE	Centre for Sustainable Energy
CCS	Combined Charging System
CO_2	Carbon dioxide
CPO	Charge Point Operator/s
DFES	Distribution Future Energy Scenarios
DfT	Department for Transport
DSR	Demand Side Response
DNO	Distribution Network Operator
DSO	Distribution System Operator
DWPT	Dynamic Wireless Power Transfer
EMS	Energy Management System
ENA	Electricity Networks Association
ESA	Electricity Supply Area
ES	Energy Storage (battery)
EU	European Union
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
GHG	Greenhouse Gas emissions
GWh	Giga Watt hour

Abbreviation	Term
HDV	Heavy Duty Vehicle (trucks, busses and coaches ≥ 3.5tonne)
HGV	Heavy Goods Vehicle
kVA	Kilo Volt Ampere
kW	Kilo Watt
kWh	Kilo Watt hour
LCNF	Low Carbon Network Fund
LCT's	Low Carbon Technologies
LV	240/400V Low Voltage
m	million
MCS	Mega Watt Charging System
MV	Medium Voltage
MVA	Mega Volt Ampere
MW	Mega Watt
MWh	Mega Watt hour
OEM	Original Equipment Manufacturers
Ofgem	Office of Gas and Electricity Markets
PLC	Program Logic Controller
PV	Photo Voltaic (Solar)
RIIO-ED1	Revenue = Incentives + Innovation + Outputs – Electricity Distribution 1
RIIO-ED2	Revenue = Incentives + Innovation + Outputs – Electricity Distribution 2
SCADA	System Control and Data Acquisition
SMMT	Society of Motor Manufacturers and Traders
TDH	Total Harmonic Distortion
UGC	Underground Cable
UK	United Kingdom
UKPN	United Kingdom Power Networks
VAT	Value Added Tax
WPD	Western Power Distribution
ZEV	Zero Emissions Vehicle

3 Introduction

This document sets out how Western Power Distribution will ensure the network exists so that drivers of electric vehicles (EV's) 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 and business initiatives. Further, it describes future activities including the transition of early-stage solutions into business as usual (BAU) 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.

The 2022 version of WPD's Electric Vehicle Strategy document is an updated document which outlines the time-bound commitments and plans that WPD intend to tackle during 2022 thus addressing the needs and issues of EV stakeholders.

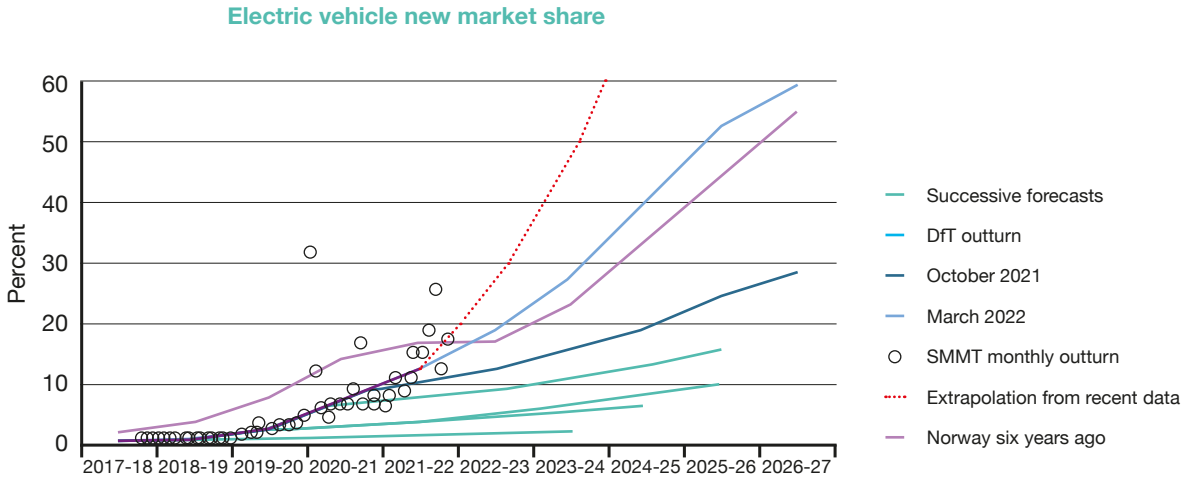
WPD's plans and preparations for each specific customer group are listed in Section 4 of this document and draw upon the stakeholder engagement that WPD has undertaken. In Section 8 of the document, WPD detail the time-bound short term commitments to accelerate readiness for the increasing uptake of EV's including BEV HGV's within the UK.

3.1 Uptake of BEV vehicles

Data taken from SMMT website clearly shows that the UK population is getting behind the UK's governments de-carbonisation of transport, with the uptake of electric vehicles (EV's) accelerating, the market share of car and light van battery electric vehicles (BEV) in March 2020 was 2.7%, and the market share in March 2021 has more than doubled to 6.9% of all new vehicle sales, but in January 2022 115,087 new cars were registered with 1 in 5 buyers going electric.

Demand for BEV vans has risen from the year to date in January 2021 which had 922 BEV vans one year on to January 2022 has seen 12,759 BEV vans. Considering the OEM's of European HGV's only really started mass production of BEV HGV's in the last 18 months figures from Data from IHS Markit for 2021 shows the total of 346 of new BEV HGV's (> 16 tonnes) were registered in Europe, excluding the UK as no data was available, in the last 12 months although this number is small the growth rate is an amazing 193% year on year. BEV buses and coaches saw an increase in the 2020 compared to 2019 with 800 registered in 2020 compared to 500 in 2019.

This increase in sales of cars and light vans could well have been brought about by a greater range of BEV vehicles for customers to choose from, the increasing amounts of EV charge points now available, the government's 1% Benefit In Kind for the tax year 2021/2022, or a combination of all those factors. The trend of BEV ownership trend is increasing, as can be seen from the graph below, where forecasting is showing ever steeper adoption curves.



Source: DfT (Department for Transport), SMMT (Society of Motor Manufacturers and Traders), European alternative fuels observatory, OBR.

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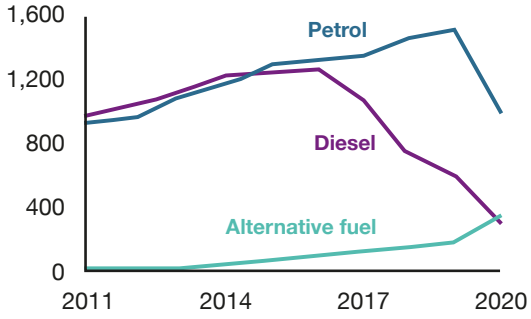
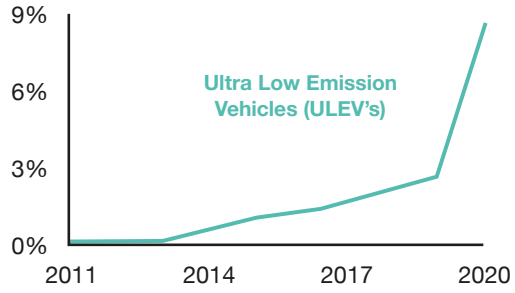
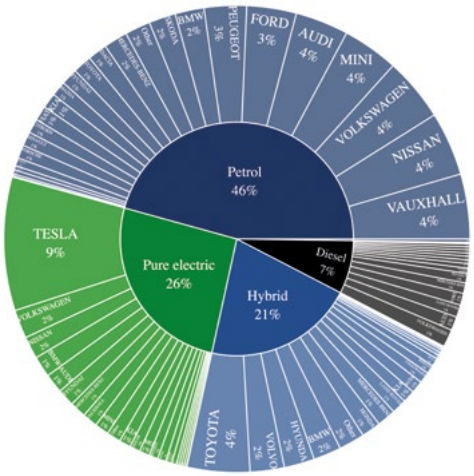
Thousands of cars registered for the first time - GB



Proportion of vehicles registered for the first time - GB



Both the above graphs for cars and light vans shown above are taken from DfT Vehicle Licensing Statistics: Annual 2020.



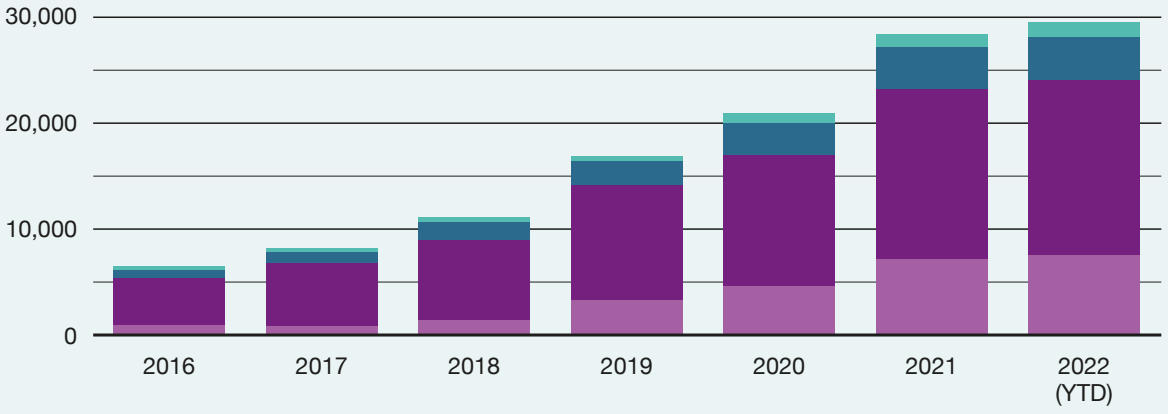
As can be seen from the graph to the left which is based on SMMT data the general public are firmly getting behind the government de-carbonisation of transport plan. With more than a quarter of vehicles purchased in December 2021 being full battery electric vehicles.

The increasing trend of BEV ownership is being matched by the increasing number of EV charge points in the UK, in February 2022 Zap Map reported there were 29,611 public charge points available, in the last thirty days Zap Map reported there were 892 devices installed across the UK.

A more detailed interactive chart can be found at the following link.

https://newautomotive.org/ecc

Number of public charging points by speed (2016 to date)



Total devices: 29,611, updated: 21 February 2022

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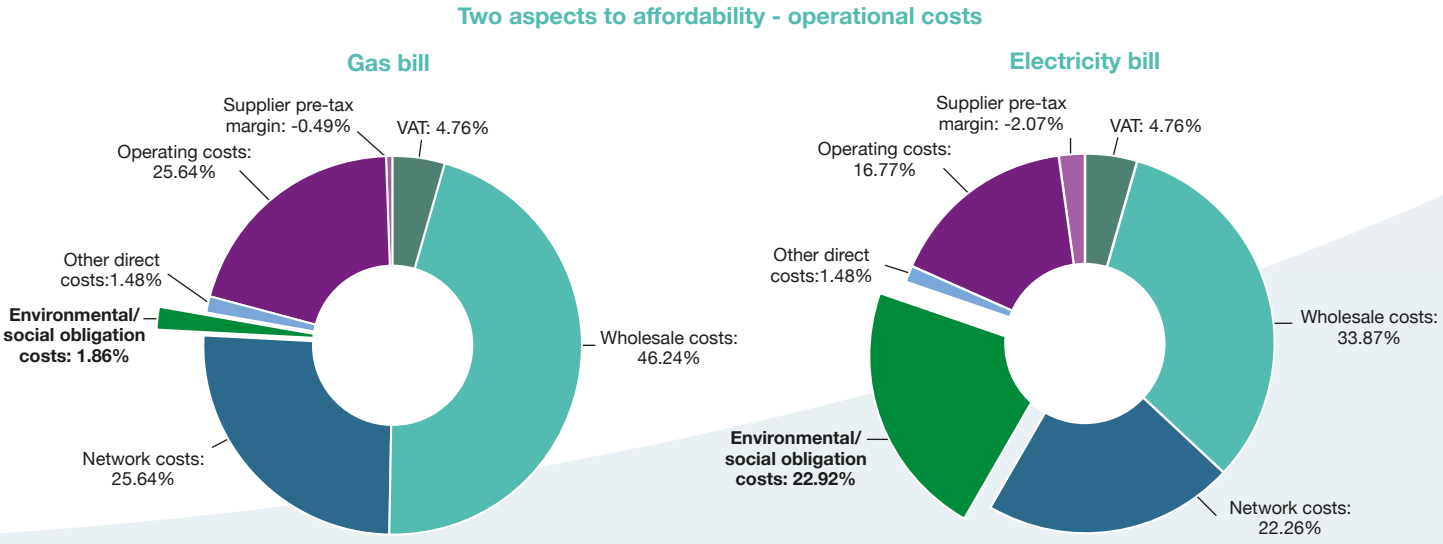
When one looks at the current costing of energy in the UK, the infographic shown below is from Ofgem (2021) and clearly shows the breakdown of the makeup of gas and electricity costs, some thought should be given to swapping the environmental/social obligation cost between the two energy systems to encourage the conversion to low carbon transport. The way the costs are currently split, the subliminal message being sent is to reward the polluters, to ensure that the government keeps the funding status quo the simple way to achieve the right message would be to swap the environmental/social obligation cost between the two energy vectors, this change would provide the impetus to encourage people to change to battery electric vehicles.



Source: Ofgem. (2021). Infographic: bills, prices and profits

3.2 High Level Government Objectives for cars, light vans and HGV's

Back in 2011 the Government set out its "The Carbon Plan" which laid out the UK's objectives to reduce carbon emissions, with an 80% reduction achieved by 2050[1]. This reduction of CO_2 levels would 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 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"[3]. 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"[2].

The requirements of all the previous legislation were further strengthened with targets to improve air quality and reduce Nitrogen Dioxide levels by the then Prime Minister Theresa May, who on 12 June 2019 announced the UK will eradicate its net contribution to climate change by 2050.

This decision would amend the Climate Change Act 2008, which had committed to an 80% decrease of greenhouse gases from a 1990 baseline, by 2050. In March 2022 the UK government extended the plug-in van and truck grants for a further two years.

These targets and measures will support the transition to electric vehicles. In November 2020 the Government announced that "it will end the sale of all new conventional petrol, diesel cars and vans by 2030 and by 2035 all new cars and vans be fully zero emission from the tail pipe".

On 15 June 2022 the UK government published Part S of the Building Regulations which sets out all new build and retrofit building need to be fitted with 7.4kW EV chargers.

All new heavy goods vehicles in the UK will be zero emission by 2040, the UK government has confirmed on 10 November 2021.

This, combined with the UK's 2030 phase out for petrol and diesel cars and vans, represents a world-leading pledge to end the sale of all polluting road vehicles within the next 2 decades.

The UK will become the first country in the world to commit to phasing out new, non-zero emission heavy goods vehicles weighing 26 tonnes and under by 2035, with all new HGV's sold in the UK to be zero emission by 2040.

Alongside the UK government legislation the other drivers that are accelerating the adoption of EV's 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.

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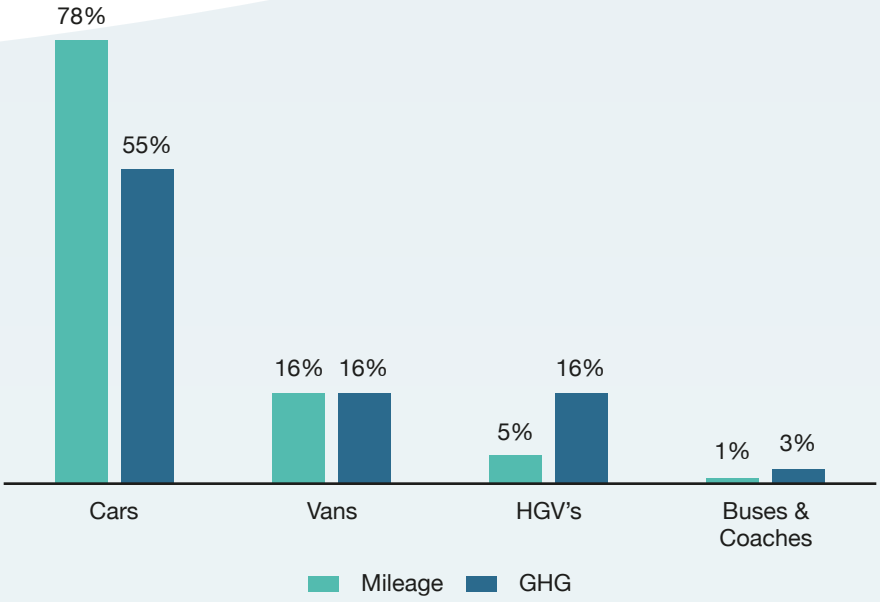
This legislation brings an “Excess emission premium for manufacturers failing to meet their emissions target of €95 for every gram/km of excess emissions per vehicle within the original equipment manufacturers (OEM) portfolio”. This driver is forcing OEM’s to introduce vehicles which lower their complete portfolio of vehicles below the 95gm/km threshold. The other mechanism which is driving the adoption zero emission vehicles is the fact cities are now adopting Clean Air Zones and Ultra Low Emission zones within cities.

Most mainstream car manufacturers now offer electric models, at present in 2022 there are 165 models, according to the February 2022 EV Database UK, of full battery electric vehicles available to buy or lease in the UK. The choice of electric vans is more limited compared to electric cars, currently there are about 34 models, according to Parkers Electric Van Guide in Aug 2021, of BEV vans, but both the numbers are increasing.

3.3 High level plans for HGV’s

The rise in E-commerce caused by the pandemic, has seen an increase in freight volume in cities and shifted logistics vehicles to local streets and A roads. Because of the urban population density, urban freight is responsible for one quarter of urban transport emissions in most cities and built-up areas. HGV’s only account for 5% of the total mileage by vehicles but produce 16% of the GHG emissions in the UK. As the BEV HGV market grows, electrification of logistics vehicles can play a significant role in reducing air pollution in cities and built-up areas.

Emissions and mileage for cars, vans, HGV’s and buses in 2019



As the majority of HGV’s purchased in the UK are made in the EU, 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 will impact the UK, therefore the UK needs to be proactive and start addressing this issue now.

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 and buses. Failure to meet these targets means that the OEM will be hit with a fine 60 times higher than for cars.

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The Chairman of the European Automobile Manufacturers Association (ACEA) has stated that to meet the 2025 and 2030 CO_2 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 rapid 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 and UK roads by 2030.

The European Automobile Manufacturers Association (ACEA) has also issued the following statement: - Brussels/Potsdam, 15 December 2020 – In an unprecedented science-backed statement, Europe's truck manufacturers have concluded that by 2040 all new trucks sold need to be fossil free in order to reach carbon-neutrality by 2050. It will be possible to meet this target provided the right charging/refuelling infrastructure is built and a coherent policy framework is put into place, including comprehensive CO_2 pricing to drive the transition.

To meet these targets set on the HGV OEM's the CharIN Organisation have produced the Mega Watt Charging System (MCS) which is a charging connector developed for large battery electric vehicles. There will be a single conductive plug capable of 1250V and 3000A DC which would be located on the left side of the vehicle at hip height. It will be capable to provide bi-directional supplies.

Public and destination charging points (EU27 & UK)

	Currently available	Needed by 2025	Needed by 2030
DC <350kW (CCS)	<10*	1,000 (4,000)**	5,000 (40,000)**
DC 350kW (CCS***)	0	12,000	15,000
DC >500kW (MCS)	0	2,000	30,000

* As of May 2021

** Required overnight chargers if charging points with 350/>500kW are not equipped to deliver low power at night or overnight parking is not possible

*** These should allow upgrades to megawatt charging (MCS,>500kW) as soon as standard definition is available

The CharIN Task Force Megawatt Charging System (MCS) is now focused on iterative testing and validation of the selected features. Ongoing regular technical meetings discuss details of the future standard, including initial voltage range, current capability, and associated thermal performance, plug/socket geometry, fit, function, etc.

- Megawatt Charging System (MCS) Up to 1250 V and 3000A.
- In compliance with power classes, as defined by CharIN.
- Usability of Megawatt Charging System (MCS) – Infrastructure for 1000V/500A medium power supply (current CCS connector).
- Vehicles equipped with Megawatt Charging System (MCS) should be able to charge from the existing CCS infrastructure.
- Coverage of Megawatt Charging System (MCS) power demand via add-on power extension modules to the existing connector.
- Communication and basic safety concept shall be compliant with CCS standard.
- Common set of documents at the interface EV-EVSE for requirements and test cases of Megawatt Charging System (MCS).
- Charging use-cases as baseline for requirements and definitions comparable to existing high/medium power solutions.
- Support of reverse power transfer for Megawatt Charging System (MCS).
- Automated Conductive Charging as a second step for Megawatt Charging System (MCS).

CharIN in conjunction with Scania and Alpitronic have launched the MCS, the Megawatt Charging System at the EVS35 event in Oslo in June 2022.

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3.4 High level plans for cars and van charging

WPD have always stated that BEV charging for cars and vans would be carried out at the following four locations:

- At home.
- At work.
- At a destination.
- En-route.

To enable the circa 40% of future BEV owners who don't have the ability to park off the street and charge i.e. at home. The UK government has recently introduced the local electric vehicle infrastructure (LEVI) scheme which will support the rollout of electric vehicle (EV) charging infrastructure. Local authorities and partnerships in England can apply for funding under the pilot scheme.

The project must use technologies that meet the aims of the fund including: -

- On-street slow and fast chargepoints.
- Rapid chargepoints, if installed as part of a wider project that includes on-street slow and fast chargepoints.
- Street or site adaptations.
- Solar canopies and battery storage.

All new chargepoints must have a minimum payment method (a non-proprietary and non-phone payment method, such as contactless) installed.

The aims of LEVI are to: -

- To help enable strategic local provision of public EV infrastructure ahead of need and promote an equitable EV charging experience for those without off-street parking.
- Leverage additional private sector investment and promote sustainable and innovative business models to enable the delivery of local chargepoint projects that would not occur in the near term without public support.
- Increase consumer confidence in transitioning to EV's across England, ensuring increased uptake across regions.

As the rollout of EV charging infrastructure accelerates, the UK government are particularly interested in funding projects where there is scaled commercial innovation, such as new business models where multiple local authorities work together, or new charging technology.

The UK government are taking steps to ensure charging is as easy as possible for drivers. This includes mandating a minimum payment method, such as contactless, at all new chargepoints at or above 7.1 kW in power. The UK government plan on consulting on similar requirements for chargepoints below 7.1 kW in power.

The LEVI fund pilot requires that all new chargepoints must have a minimum payment method (a non-proprietary and non-phone payment method, such as contactless) installed.

To enable motorists undertake long journeys the UK government has created The Rapid Charging fund (RCF), also known as Project Rapid, which will help motorway and major A road service area operators prepare the network for 100% zero emissions vehicles.

Project Rapid is a £950 million fund to future-proof electrical capacity at motorway and major A road service areas to prepare the network for 100% zero emissions vehicles (ZEV) uptake.

The UK government will be working with the operators of major service areas to ensure that this charging provision is in place ahead of customer demand. The aim is to help support early adoption of electric vehicles and remove range anxiety concerns for drivers on long journeys.

The UK government's vision is that they expect that any new chargepoints will be easy to use and hassle-free.

That means:

- Drivers can pay for the cost of charging their vehicle using debit or credit card payment.
- Information about the chargepoints on motorways will be openly available, helping drivers choose when, where and how they charge.
- Chargepoints will be available 99% of the time;
- Drivers will be supported by 24/7 customer care to handle any technical issues.
- Sites will have chargepoints that support all types of electric vehicles.
- There will be clear pricing information available in pence per kilowatt hour.

Working with industry, the government will continue to monitor the number of chargepoints being installed across the motorways and the associated customer experience. The object of this programme will be to ensure that there is a rapid-charging network ready to meet the long term consumer demand for electric vehicle chargepoints ahead of need.

In May 2020, the Department for Transport (DfT) published a UK Government vision for the rapid chargepoint network in England. In that vision, we committed to achieving the following targets:

- By 2023, to have at least 6 high-powered, open-access chargepoints (150-350 kW capable) at motorway service areas in England;
- By 2030, we expect around 2,500 high-powered, open-access chargepoints across England's motorways and major A roads;
- By 2035, we expect around 6,000 high-powered, open-access chargepoints across England's motorways and major A roads.

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3.5 High level plans for HGV charging at MSA's and hubs

Even in an early stage of adoption of BEV HGV's with low fleet penetration levels, the maximum allowable distance between charging stations on the motorways and A roads will need to be set, not only due to the expected vehicle ranges of BEV HGV-LH trucks but, more importantly, because of the HGV Driver Regulation on driving times and rest periods.

The rules show a maximum daily driving periods of 9 hours (10 hours in exceptional cases) and minimum rest periods of (at least) 9 hours. In addition, mandatory breaks of 45 minutes every four and a half hours are legally required which can be split into two breaks of 30 and 15 minutes. These time windows will be used for recharging, at least to the extent that the vehicle can safely arrive at the next destination (including a reasonable safety margin so that the poor cold weather performance of the batteries is catered for).

Half of EU's total truck activity (in tonnes.km, which is a good proxy for CO_2 emissions) is driven over distances of less than 300km. These trips could be covered today by electric trucks, thanks to new models currently coming to the market with about 300km range (enough to cover nine trips out of ten). But limited supply and lack of charging strategy currently slows down the uptake. It is expected that the range of the electric trucks available will swiftly increase to 500km, covering about two thirds of kilometres and 19 trips out of 20.

With the right policy and charging infrastructure, UK road freight could be decarbonised to a great extent in the 2020s. With the UK government phasing out diesel truck sales by 2040 to achieve this level of decarbonisation, a number of legislative and policy changes will be necessary to accelerate both the production and supply of electric trucks and to urgently deploy charging infrastructure at the depots (overnight charging), opportunist charging (destination charging while dropping loads off) and at MSA's to enable en-route charging.

CharIN has developed and released to the market the High Powered Charging for Commercial Vehicles, also known as the Megawatt Charging System (MCS), chargers of up to 4 MW, which is supported by several stakeholders (from Europe and the USA) and is likely to become the most common high power charging standard at a global level. This new standard would be based on CCS communication protocols but the charging plug would be larger.

In order to enable long-haul operations, high-power charging stations with at least 350kW – but focusing on the megawatt charging (MCS) above 500kW – needs to be rolled-out. Ideally while the UK government's en-route charging program Project Rapid is still in the design stage so that the requisite infrastructure e.g. underground circuits are being installed on a dig once till 2050 basis. The technical specifications of MCS are currently being defined but it needs to be highlighted that the operation of long-haul battery electric trucks will require this level of high-power charging.

The revised Alternative Fuels Infrastructure Directive (AFID) should require at least one high-power charging station with a minimum of four charging points every 100km by 2025, and at least one site every 50km by 2030 on the Trans European Transport Network (TEN-T) core network. At least one charging point per station has to be accessible for coaches.

Data taken from the study of "Grid-Related challenges of high-power and megawatt charging stations for battery electric long-haul trucks 2021" on behalf of the Transport and Environment by Dr - Ing. Karsten Burges of RE-xpertise and Dr - Ing. Stefan Kippelt of ef.Ruhr GmbH states in this study, where they focused on public and semi-public charging and analysed three prototypes of charging infrastructure, covering and illustrating the range of requirements:

A. Highly frequented public charging station (MCS and CCS, prototype 1): a public charging station along the motorway network with intense BEV HGV traffic, representing the upper bound of public charging demands.

B. Remote, less frequented public charging station (MCS and CCS, prototype 2): a public charging station along the motorway network with minor BEV HGV traffic, representing the lower bound of public charging demands.

C. Commercial logistics hub (MCS and CCS, prototype 3): a medium-sized logistics hub with multiple haulage companies combining long and short-haul trucks.

The study considers different penetration rates of BEV HGV trucks. These levels may be associated with the years 2027, 2030 and 2040. The simulations show that, as a rule of thumb, one high power MCS charger per 50 to 60 BEV HGV customers per day has to be installed.

The MCS chargers require a grid connection capacity at the level of the installed capacity. If more than100 MCS customers per day have to be served, with the given assumptions, the number of lower power overnight 150kW CCS chargers grows proportional with the number of high power MCS chargers by a ratio about 15 to 1.

MCS are offered at special stands that can be used for the duration of the charging process only. Overnight parking and charging are available at separate bays. Standing times for overnight charging are determined by the mandatory rest period and not by the duration of the charging process.

What the study found was that running the simulations, various charging strategies have been applied which allows to reduce the peak load at the grid connection point, without compromising customer satisfaction. The results show that – for the given ratio between MCS and NCS – the total grid connection capacity does not need to exceed the installed power of the MCS chargers.

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From a UK perspective on the routes HGV's use in the UK then the TenT map showing the main routes used by HGVs, shown over leaf, would be a good base starting position. Liaison with the HGV OEM's or Wejo, and acquiring the telematics data for HGV's and overlaying that data onto the aforementioned map would highlight where HGV's stop, then using this data you can then establish HGV number per day per site, this data would then give you the capacity for those sites, if the sites overlap with Project Rapid then the capacity for that site will need increasing.

But one also has to be mindful that the UK is an island and as such some 95% of the UK's cargo movement and transportation comes from the shipping industry. In 2019, the total shipping cargo movement was about 475.34 million Metric Tonnes through sea-going ships. Almost 65% of this cargo comes from the incoming bulk traffic, containers, and liquid cargo nature, the busiest ports being Grimsby & Immingham, Felixstowe, London, and Milford Haven have the highest cargo share.

A total of 45% of the total shipping trade of the UK takes place with its neighbouring countries throughout Europe, then the BEV HGV charging points should incorporate the roads that lead to the main ports and ferry terminals, such as:

Main ports in the UK	
Port of Immingham	Port of London
Port of Felixstowe	Port of Liverpool
Port of Tees	Port of Milford Haven
Port of Southampton	
Ferry ports - England	
Dover	Newcastle
Felixstowe	Newhaven
Folkestone	Plymouth
Harwich	Poole
Heysham	Portsmouth
Hull	Purfleet
Immingham	Ramsgate
Killingholme	Sheerness
Liverpool	Southampton
Liverpool Birkenhead	Teesport
Lymington	Tilbury
Ferry ports - Wales	
Holyhead	Pembroke Dock
Fishguard	

It should be noted that transport is devolved to both Scotland and Wales, therefore there will be differing plans of action in those two areas of the UK.

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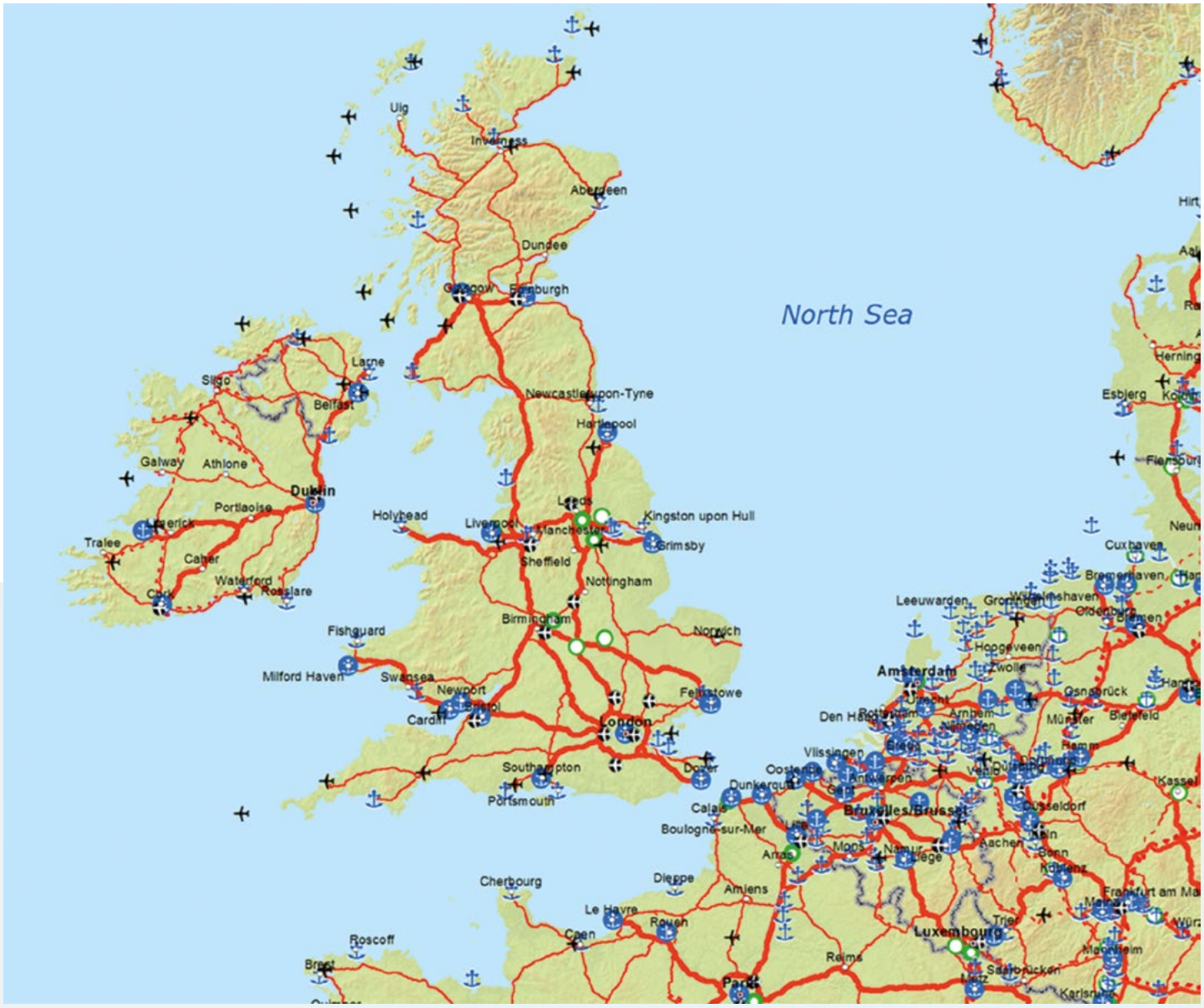

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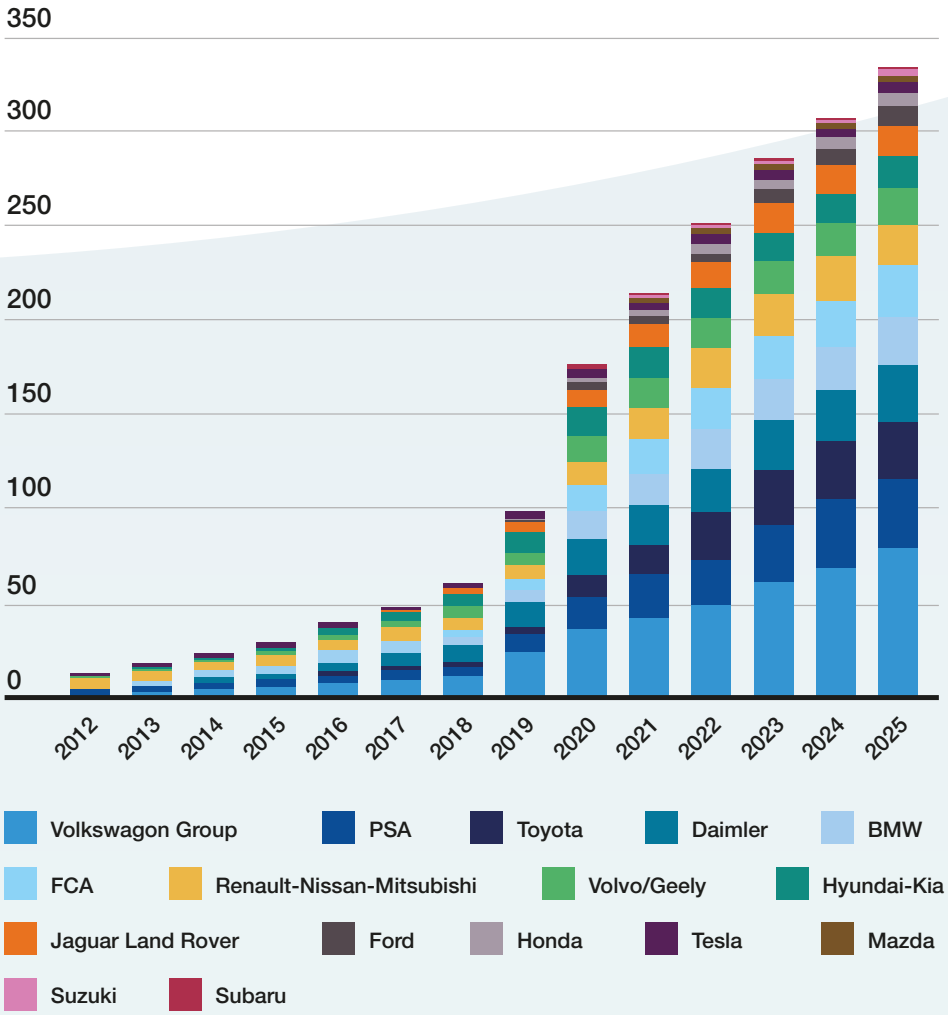
3.6 Original equipment manufacturers plans for BEV cars & light vans

As BEV's become more mainstream the number of vehicles that a consumer is able to choose from has increased dramatically, currently the BEV car market is covered by 165 models which motorists are buying.

But this is all changing as BEV's enter a new phase, current production forecasts are showing that most carmakers are embracing electrification and are leaving behind the fossil fuel 'technology neutrality' approach, this is being brought about by the legislation cutting vehicle emissions to 95gms/km of CO_2 over the OEM's complete portfolio, the reduction of emissions has had the effect of focusing the OEM's 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 and EU is about to increase significantly this will then give the consumer greater choice and will see the uptake of BEV's increase.

The graph shown below shows the how the range of BEV's that have been available from 2012 to the range of new models of EV which will become available by 2025[4].

Total number of available EV models on the market in Europe



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3.7 WPD's approach to facilitate EV charging

As a company WPD is committed to convert all its company cars to BEV's by 2025, and all its light van fleet to BEV's by 2028, to meet these commitments WPD is building one of the largest private charging networks in the country, which employees can access via the WPD Pay As You Go app and is a huge resource for people without off-street parking.

Currently WPD have 248 CHAdeMO/CCS rapid charging bays which have been installed across 48 depot sites with more planned.

As an distribution 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 about 60% of car users have access to an off-street parking location which is likely to be suitable for charging[5].

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. A key commitment laid out in WPD's ED 2 Business Plan is to ensure our customers can easily connect their BEV's, heat pumps and other LCT devices to the network.

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 125 miles in many EV's and it is likely that this will support the demands of home connected EV charging. WPD also expect that the backbone 33kV UGC network and primary transformers will be able to accommodate this level of charge point activity.

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.[6] As WPD focuses into the specific cables and distribution transformers which supply local streets and the LV service cables which feed individual properties, there is more chance of the earlier built network becoming constrained. The primary reason for this is the design principles were totally different in the early 1900's compared to today. For example houses built during the early 1900's through to the late 1990's 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 we un-loop retrospectively so allowing an EV charger to connect to a looped cable initially for a period of up to 12 months to remove the looped LV service cables to an EV charger or other LCT device. WPD have already identified this as an issue and are installing larger LV mains and LV service cables assets for new build estates and service alterations and have identified areas where the proactive uprating of local distribution transformer and cable networks are appropriate.

It can be shown that having an LCT notification service which records all LCT devices as and when they are connected in a DNO area is essential as this immediately highlights to the DNO where chargers, heat pumps and other LCT devices are being installed and the DNO can be proactive in dealing with the issues that arise, rather than being reactive when the equipment fails due to overloading. It should be a national priority to get the asset notification system working nationally to all relevant parties thus ensuring the journey to net zero is a smooth one for all parties.

3.8 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.

With the penetration of Smart Meters figures being given by Ofgem, as 50% across the UK, electricity customers will be able to take advantage of time of use tariffs that WPD expect more electricity suppliers to offer.

Data from Electric Nation show customers respond to Time of Use tariffs to control the cost of charging, so that customers with home charging 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 that of 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 business customers.

3.9 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.

The current number of EV car charger points installed in WPD are shown below:

Description	Number	Capacity kVA
Slow charge (up to 16A)	5,386	19,567.93
Fast charge (up to 32A)	46,120	357,470.31
0	2,004	30,000

As of March 2022

3 Introduction

3.10 Battery Electric Vehicle recycling

The hydro battery recycling joint venture Hydrovolt has commenced commercial recycling operations in Fredrikstad, in southern Norway.

Hydrovolt is Europe's largest electric vehicle battery recycling plant, capable of processing approximately 12,000 tons of battery packs per year (around 25,000 EV batteries). With the plant now online, a sustainable solution for handling Norway's entire volume of electric vehicle batteries being retired from the market, or reaching end-of-life, is now available.

Integrated with a novel process design, Hydrovolt can recover and isolate some 95% of the materials in a battery including, plastics, copper, aluminium and black mass (a compound containing nickel, manganese, cobalt and lithium). Several novel concepts designed to maximise recovery of materials are found within the plant, including a dust collection system which ensures valuable material typically lost through mechanical recycling steps is captured.

Hydrovolt is exploring an expansion of recycling capacity within Europe, with a long term target to recycle approximately 70,000 tons of battery packs by 2025 and 300,000 tons of battery packs by 2030, equivalent to approximately 150,000 EV batteries in 2025 and 500,000 in 2030.

4 Forecasting and data

4.1 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 (LCT's) 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 EV's 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 Hybrid 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 3,199,371 EV's by the end of 2030[7].

4.2 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 EV's 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.

4 Forecasting and data

4.3 Electric vehicle growth factors

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.

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 some twenty eight locations in the UK where there will be vehicle clean air zones, driving charges and vehicle bans. These are: -

Aberdeen	Low emission zone & ban on some vehicles.
Bath	Clean air zone for commercial vehicles is live.
Birmingham	Clean air zone.
Bradford	Clean air zone expected in summer 2022.
Brighton	Ban for all passenger vehicles in 2023.
Bristol	Clean air zone is expected to go live from summer of 2022.
Cambridge	Clean air zone under consideration.
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 HGV's, buses, coaches and taxis in July 2020.
Leicester	Clean air zone has been scrapped.
London	Ultra low emission zone expansion from 25/10/21.
Manchester	Clean air zone expected in spring 2022.
Newcastle	Clean air zone for HGV's, buses, coaches and taxis in July 2021.
Oxford	Zero emissions zone introduced summer 2021.
Portsmouth	Clean air zone introduced in November 2021.
Reading	Potential clean air zone or low emission zone at a date to be confirmed.
Saint Albans	Clean air zone under consideration.
Sefton	Clean air zone under consideration.
Sheffield	Clean air zone are on hold.
Slough	Potential clean air zone or low emission zone at a date to be confirmed.
Southampton	Have a Clean air zone running already free of charge.
Warrington	Clean air zone under consideration.
Wokingham	Clean air zone under consideration.
York	Clean air zone for buses introduced January 2021.

Local authorities required by the national government to produce a local action plan: -

- Bolton Borough Council.
- Bury Borough Council.
- Fareham Borough Council.
- Gateshead Borough Council.
- Guildford Borough Council.
- Middlesbrough Borough Council.
- North Tyneside Council.
- Rochford Borough Council.
- Rotherham Borough Council.
- Rushmoor Borough Council.
- Salford Borough Council.
- Stockport Borough Council.
- Surrey Heath Borough Council.
- Tameside Borough Council.
- Trafford Borough Council.

Despite the current barriers, the FES 2020 presents a much higher growth projection for electric vehicles than FES 2018, reflecting the UK government's proposed ban on new hybrid diesel and petrol vehicles in 2035[8].

The two highest scenarios in FES 2020 (Leading the Way and Customer Transformation) 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.

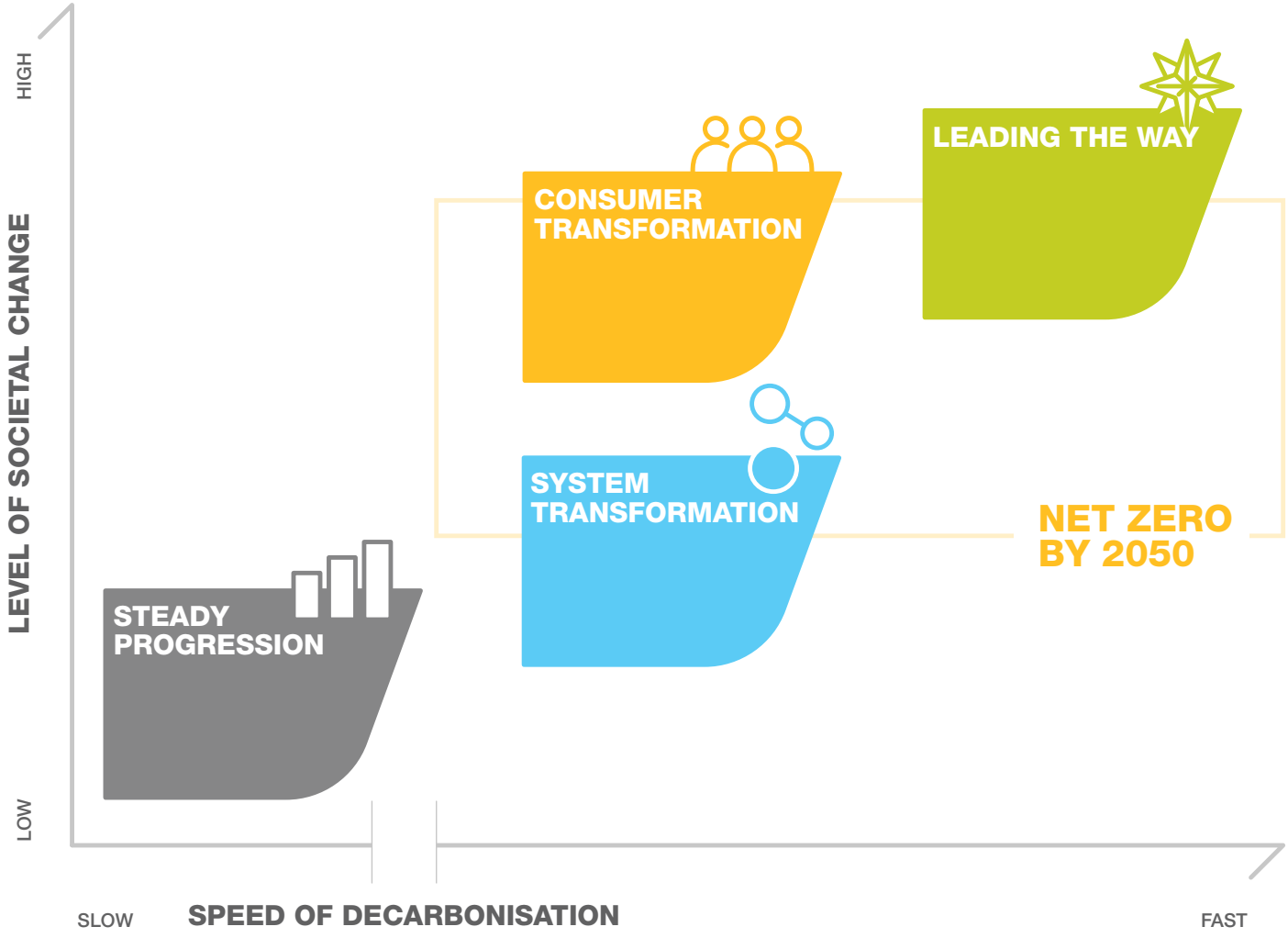
To provide a wider profile for network analysis in this study WPD have amended the Leading the Way scenario to show a more explosive growth profile which sees growth accelerating ahead of the FES 2020 and then levelling by 2050.

WPD would also assume that EV uptake in the licence area stays ahead of the national average uptake of EV's 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.

4 Forecasting and data

4.4 Developing Distribution Future Energy Scenarios (DFES)

In the latest report WPD have aligned the four scenarios with National Grid's 2020 FES, which has the following four scenarios: -



4 Forecasting and data

4.5 Investment allocated within ED1

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

4.6 Forecasting local growth and pinpointing upgrades

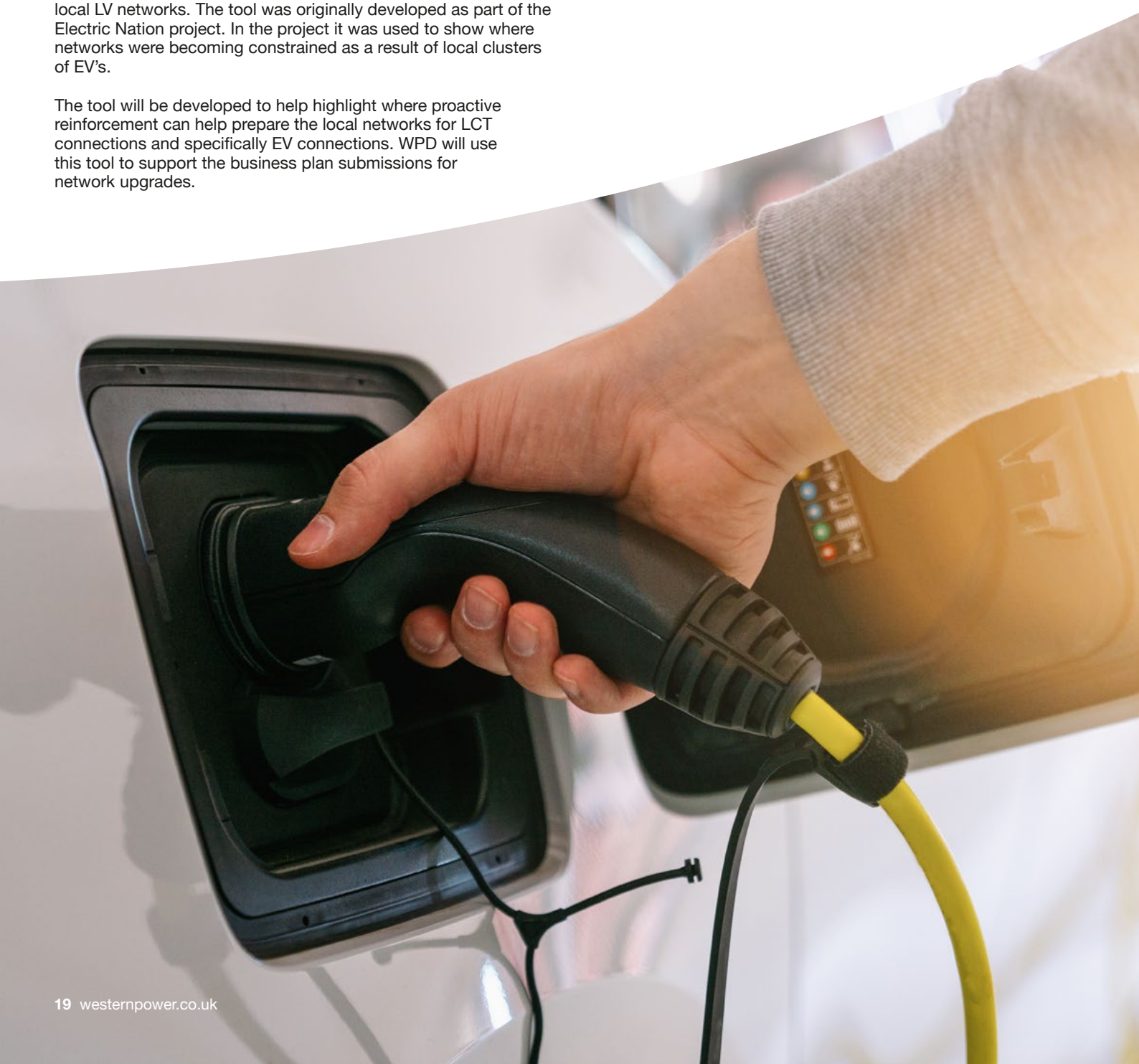
In addition to the high level DFES work, WPD are working with EA technology to deliver a tool which will assess the impact on the local LV networks. The tool was originally developed as part of the Electric Nation project. In the project it was used to show where networks were becoming constrained as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

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.

4.7 Forecasting ED2 and informing specific ED1 plans

WPD's DFES are being used to target flexible solutions where they offer alternatives to 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.



5 Planning and capacity availability

5.1 WPD's expectation of EV charger installations

Since becoming more mainstream over the past decade or so, BEV technology has undergone rapid development. With most BEV's still somewhat limited in range, automobile manufacturers have developed ever-faster charging vehicles over the years to improve practicality. This has come through improvements to batteries, controller hardware, and software. Charging technology has evolved to the point where the latest BEV's can now add hundreds of kilometres of range in under 20 minutes.

However, charging BEV's at this pace requires large amounts of power. Thus, automobile manufacturers and industry groups have worked to develop new charging standards that can deliver high current to top vehicle batteries off as quickly as possible.

Modern EV charge ports can carry anywhere from 2 kW up to 350 kW in some cases, and require highly specialized connectors to do so. Various standards have come about over the years as automobile manufacturers look to pump more electricity into a vehicle at greater speed. 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 at locations where of vehicles require a quick turnaround charge such as taxis ranks.

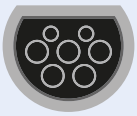
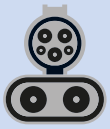
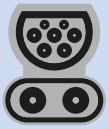
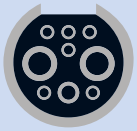
Chargers of 7kW are likely to be accommodated on existing house services but larger charger installations will often require a three phase service or other upgrades.

Assume that the battery electric vehicle has a 55kWh battery, which the on-board capabilities are limited to 11kW maximum AC charging, plus the car is capable of accepting a maximum 170kW DC rapid charge.				
Charge Point type and power output	**Likely installation location**	**Specific connection requirements**	**Network considerations**	**Likely charge time for 0% to 100%**
Slow up to 2.3kW	Domestic	None – connects via household 13A plug/ socket	None	25 hours 45 minutes
Slow 3.7kW	Domestic or street side	Dedicated household circuit or on street equivalent	In some cases limited local reinforcement is required	16 hours
Fast 7kW	Domestic or street side	Dedicated household circuit or on street equivalent	Likely upgrade to cut-out and/or LV service cable and LV local mains	8 hours
Fast 22kW (the car limits this to 11kW)	Street side or public charging location	Three phase dedicated supply point	Requirement for three phase connection and likely local mains upgrade	5 hours 30 minutes
Rapid 50kW	Public charging location	Three phase dedicated supply point	Requirement for three phase connection and likely local mains and transformer upgrade	53 minutes
Rapid 150kW or multiple rapid chargers	Public charging location	Supply point from dedicated transformer	In most cases a new transformer will be established	26 minutes

Rapid AC chargers provide power at 43kW (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.

The typical standards that are currently in use around the world are shown overleaf.

5 Planning and capacity availability

Area	United States	Europe	China	Japan	Worldwide
Standard	SAE	IEC	GB/T	CHAdeMO	Tesla
AC	 J1772	 62196-2	 20234.2	 J1772	
DC	 J1772	 62196-3	 20234.3	 CHAdeMO	

The various main stream designs of charger that are currently available in the UK are shown below with the maximum power output that are available at certain charge point operators sites. It should be noted for completeness the Tesla connector has been shown as the early generations of Model S and X use the Tesla type 2, all new 2022 models of European/UK Tesla's are now CCS 2 equipped.

CHAdeMO
62.5kW DC

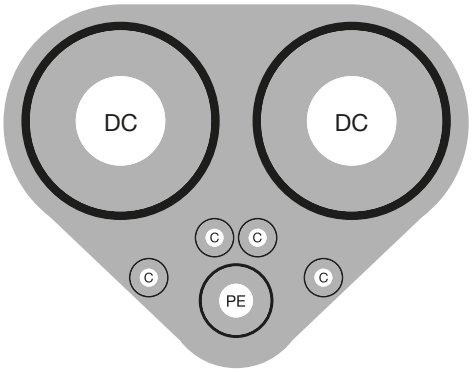
CCS
350kW DC

Type 2
43kW AC

Tesla Type 2
120kW DC

The new megawatt charging system MCS plug arrangement for HGV's is shown below: -

The proposed layout



The actual plug photograph

Speculative v3.2 MCS connector; there are two primary power (DC) pins, four communications/detection (C) pins, and one protective earth (PE) pin.

5 Planning and capacity availability

5.2 WPD's expectation of EV charger installations

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, and Jaguar I-Pace. 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.

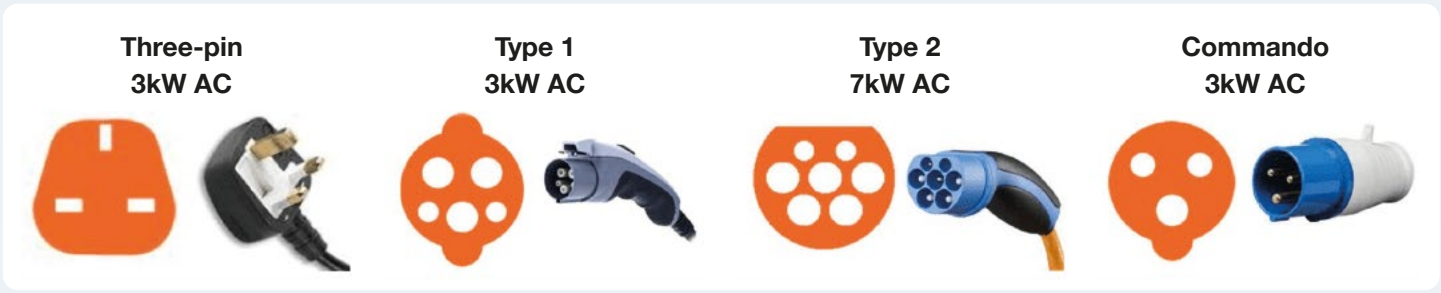
The only BEV model able to make maximum use of Rapid 43kW AC charging is the Renault Zoe. Currently CHAdeMO is the only connector type which supports V2G, this is changing as CharIN, the organisation which created CCS 2 and MCS, have now generated a time line for these connectors to be type tested for 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 3kW with some lamppost chargers being rated at 5kW.

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 3kW 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 three-pin socket, because of the higher current demands of EV's 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.



5.3 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	Usually none
Fast 22kW	Street side or public charging location	8 to 12 weeks	Streetworks and permissions	£3,500 to £12,000
Rapid 50kW	Public charging location	8 to 12 weeks	Streetworks and permissions	£3,500 to £12,000
Rapid 150kW or multiple rapid chargers	Public charging location	16 weeks	Streetworks, permissions and cost of land for transformer	£70,000 to £120,000

5 Planning and capacity availability

5.4 Simplifying the application processes

WPD use the latest paper copy version of ENA application form for the notification of both EV and Heat Pump applications. Since 2021 WPD have introduced a "Traffic Light System" for the connection of LCT's, for example with heat pumps WPD currently have 268 heat pumps that qualify for connect and notify, however, we have 548 heat pumps that fall into the acceptable Green or Amber category.

During 2022 WPD will be introducing the new NIA funded iDentify App which has been developed by SPEN. This app will totally change the way applications will be made to WPD. The whole process will be electronic and should speed up the connection process for the customer. It is envisaged that all the DNO's within the UK will adopt the app as the primary method application.

Once signed into the app, the installer of any LCT infrastructure needs to follow the relevant application process for their particular LCT device which can be defined in two ways:

1 **Where the connection of the LCT is LESS than or equal to 32A; or**

With both of these connection procedures there should be no identified adequacy or safety concerns with the properties existing LV service equipment.

The app has built in the IET's methodology to determine the load of the property. The app through asking pertinent questions ascertains the possible load of the building, but there is a requirement on the electrician to ensure the building load is correct and has visited the property to determine whether the Distribution Network Operator needs to be informed before or after installation.

2 **Where the connection of the LCT is GREATER than 32A.**

It should be noted by owner and installers of heat pumps, be they new build or retro fit there is a legal obligation to inform the host DNO. This is covered by the National Conditions of Connections which all customers are signed up for.

It is the asset owner's responsibility to ensure that this notification has been undertaken by the installer.

5.5 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 LCT's. 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 and efficiency of the electric vehicle's motor, typically this provides a charged range of around 150 miles in many EV's 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 2000's.

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 1.3 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 37,000 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.

5 Planning and capacity availability

5.6 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 LCT's. To meet the demands of the EV charging and the installation of heat pumps WPD carried out a consultation with all interested parties. This all lead to WPD changing their policy documentation that for all new build and service alterations three phase service cables and three phase cut-outs are now installed as BAU.

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.

Connections which include PV, ES, HP and EV charging shall be designed with a network impedance that meets the WPD defined value at the point of common coupling (PCC), i.e. at the point where the customers system meets the WPD system.

Connections of PV, ES, HP and EV charging to existing houses with a looped LV service cable is not recommended, WPD's default position is we un-loop retrospectively so allowing the connection of LCT devices to connect to a looped cable initially for a period of up to 12 months while WPD remove the looped LV service cables to the LCT device.

Where a connection supplies more than one LCT, no diversity shall be allowed unless load control is provided and verified by the relevant LCT installer to prevent the service and cut-out from being overloaded.

5.7 Mitigation of local network constraints

There may be isolated locations where a cluster of new EV's will exceed the capacity of the local network. This is most likely to happen with domestic EV charging. It is envisaged 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 due to interruptions to supply.

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 of 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 i.e. it is only a short term fix to enable WPD to upgrade the network.

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 LCT's have created a specific problem.

5 Planning and capacity availability

5.8 Technical changes related to electric vehicles

To permit the connection of EV Chargers there are typically some technical aspects to overcome, including thermal capacity, power quality and harmonic emissions. All these issues are covered in WPD's Standard Technique documents in the SD5G suite.

These Standard Technique documents describe WPD policy for processing the ENA EV and HP approved application form from customers, or their nominated installer, for the installation and connection of individual or multiple LCT's (Electric Vehicle Charge Points and/or Heat Pumps), where any items that have a rating greater than 32A per phase, onto WPD's low voltage distribution system.

WPD use the information provided by the customer or installer to assess the suitability of the existing network to supply the Electric Vehicle charging or Heat Pump infrastructure. Suitability will be based upon the network's susceptibility to voltage fluctuations, flicker and harmonic voltage distortion, as well as ensuring it is kept within the designated thermal and voltage limits.

They are detailed below:

5.8.1 Thermal Capacity

To assist with thermal capacity, i.e. the ability to carry more load within the low voltage network, since the start of ED1 WPD have increased the minimum size of the low voltage mains cable to have a cross sectional area of 185mm², during ED2 this will change to a minimum cable 300mm², WPD have also increased the minimum size of low voltage service cables to 25mm² aluminium/copper or 35mm² aluminium concentric service cables.

The smallest rated ground mounted transformer has increased to 500kVA and the smallest rated pole mounted transformer to 25kVA single phase, during ED2 the smallest pole mounted transformer will be 50kVA.

5.8.2 Earthing

The current IET Code of Practice Ed 4 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.

5.8.3 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 EV's 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 190mΩ.

6 Providing information to customers

All guides produced by WPD are available to download from the WPD website, hyperlinks are provided below to make this easier for the user.

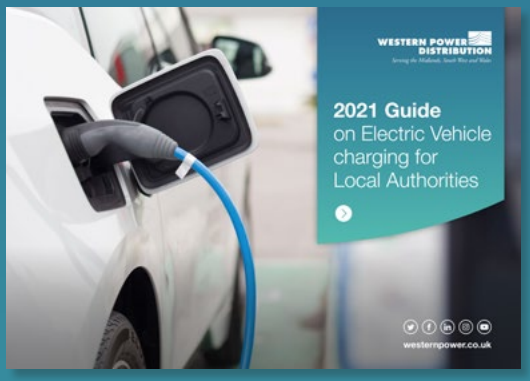
6.1 Guidance and advice documents published

WPD have for a number of years provided a guidance document for local authorities who are considering public and street side charging connections.

6.1.1 WPD – 2021 EV charging guide for Local Authorities

This document was last updated during 2021 to reflect the current topics "WPD – 2021 EV Charging guide for Local Authorities" 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.

https://www.westernpower.co.uk/downloads/3220



6.1.2 WPD - 2021 Business Guide for EV Charging

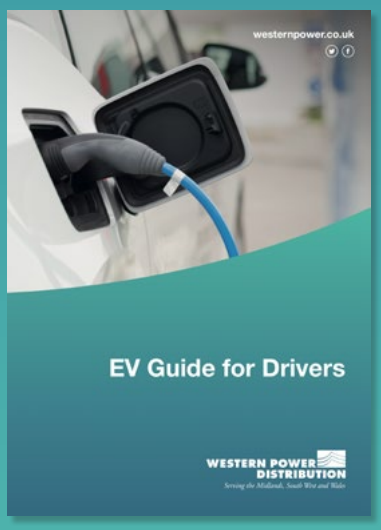
During 2020 WPD produced a new guide aimed specifically at business within the WPD area who were planning on converting the fossil fuel vehicles to BEV's. This document has now been updated for 2021, "WPD - 2021 Business Guide for EV Charging" the document provides information specifically tailored to local business customers who are wanting to convert their fleets to BEV. The guide covers some of the technical considerations related to installing EV charger connections as well as offering advice on how to make applications and discuss plans with WPD.

https://www.westernpower.co.uk/downloads/15766

6.1.3 WPD – 2021 Guide for Purchasing an EV

During 2020 WPD produced a new guide aimed specifically at the general public who were planning on converting their fossil fuel car to a BEV. This document has now been updated for 2021, to reflect the current matters, the guide is "WPD – 2021 Guide for Purchasing an EV" this document provides information specifically tailored to ordinary customers who are wanting to convert their fossil fuel car to a BEV, and covers some of the technical considerations related to purchasing a BEV as well as offering advice on how to make an EV charge point application and how to find and contact their host DNO.

https://www.westernpower.co.uk/downloads/117721



6 Providing information to customers

6.2 Guidance and advice documents planned

During 2022 WPD will produce a new guide aimed specifically for fleet conversion to BEV HGV's.

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.

6.3 Capacity indication for customers

WPD has consolidated the network capacity map into a single map with different layers so that a single source of visual data retrieval can be easily and readily achieved. This will further support customers being able to access our data to inform their new connection and operation decisions.

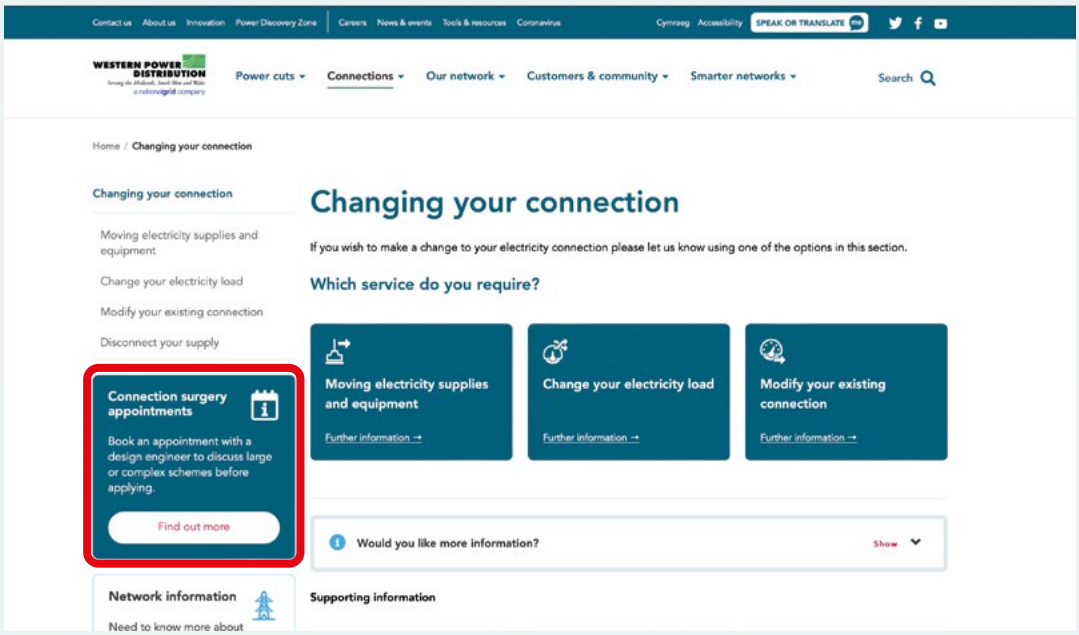
6.4 Connections surgeries

Local authority, Charge Point Operators, Bus Depots, Business and Fleet 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.

This can be achieved by going to the WPD website at:

https://www.westernpower.co.uk/connections-landing/changing-your-connection

This link will take you to page shown below, which you can then complete.



7 Stakeholder Engagement

7.1 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 it has been found a more informal engagement is the most efficient solution and complements the more formal strategic stakeholder event engagements.

The table below shows the stakeholder engagement that is undertaken by WPD on a regular basis during the course of a year:

Customer Panel	Quarterly
Customer Panel surgeries	Ad-hoc
CCSG	3 per annum
DGOOF	Quarterly
Stakeholder workshops	Annually
DFES	Annually
Local investment workshops	Annually
Connections conference	Annually
Social obligations conference	Annually
Online engagement hub	Ongoing
Vulnerable customers survey	Ongoing (reported monthly)
Major connections survey	Ongoing (reported monthly)
DG survey	Ongoing (reported monthly)
CEG/RIIO-ED2 Plan Delivery Challenge Group	Ad-hoc
Deliberative focus group (BP delivery/refinement)	Ad-hoc
Online panel	Post annual stakeholder workshops
Connection surgery appointments	Ongoing
Community energy workshops/surgeries	Ad-hoc
Power for Life newsletter	Annual
Local Authority Engagement For Strategic Forecasting	Annually
Connections Strategy Heat Pump event	Ad-hoc
Scenario Workshop: Accessible EV charging	Ad-hoc

7 Stakeholder Engagement

7.2 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.

7.3 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, recreational areas and park & ride sites.

In 2018 WPD developed an EV guide for local authorities to help them with their plans, this document has been getting yearly updates and will be updated for during 2022.

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 Local Authorities EV guide.

In local authority areas with large areas of high density housing without off-street parking the easiest way for the local authorities to provide charging facilities would be via local rapid charging hubs in car parks, recreational areas etc. With the demand for EV charging at hub locations, WPD in conjunction with manufacturers have developed equipment to allow the efficient connection of 10 off 150 kW rapid DC chargers in these hub locations.

7.4 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. For example during the past twelve months in South Wales a group of ten Local Authorities formed a larger group called Cardiff Capital Region (CCR) to make use of Welsh government funds for installing EV chargers and meet up with WPD, to 1) set up a single point of contact for all ten Local Authorities and 2) to install the chargers to meet CCR's installation time lines and needs at the various locations.

During 2021 WPD's normal programme of local based stakeholder engagement included specific sessions covering EV charging. These depot based engagement sessions took place remotely and covered all local authorities across the WPD area.

7.5 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 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 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 which will ultimately smooth the adoption by the public of electric vehicles. Visible and plentiful charge points will help reduce range anxiety from EV users.

7 Stakeholder Engagement

7.6 Engagement for fuel station operators

With motorway services WPD are part of the OZEV'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, of these sites the average power required would be of the order of 7 MVA, WPD have provided pricing for all the MSA site 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.

WPD has also engaged with the Welsh Department of Transport and is helping facilitate the connection of rapid chargers throughout the motorway and A road network of South Wales.

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 is currently engaged with a certain well known CPO who are wanting to build a 10 by 150kW bay rapid charging hub within the WPD area. WPD are currently working with equipment supplies and the CPO to ensure the needs of the CPO are meet.

WPD are working with Moto Services and Grid Serve/Electric Highway at their Exeter Motorway Services Area (MSA) on Take Charge an NIA project which will provide a module based approach at 33kV to supply large amounts of power to MSA's as and when they need the capacity to meet the forecasts set by OZEV with project Rapid.

The Take Charge project will supply the Exeter Services with 33kV power which will then be transformed down to 11kV via a reduced footprint containerised substation for use within the MSA by Moto.

The project is progressing well and it is envisaged the first tranche of rapid chargers will be available for connection for quarter two of 2022.

7.7 Engagement for housing design

WPD along with the other DNO's through the ENA LCT Group have been involved is developing the Future Homes Standard via Part S, Part L and Part F of the Building Regulations which has recently been out to Consultation in 2021.

In particular Part S which deals with the fitting of EV chargers to new buildings and retro-fitted buildings has now been published this approved document supports Part S of Schedule 1 to the Building Regulations 2010. The document takes effect on 15 June 2022 for use in England.

It does not apply to work subject to a building notice, full plans application or initial notice submitted before that date, provided the work is started on site before 15 June 2023. Full detail of the transitional arrangements can be found in Circular Letter 02/2021 published on gov.uk.

During 2020 WPD went out to give consultation to all interested parties about changing the current single phase LV Service cables to new build houses and service alterations, to three phase LV Service cables and a three phase cut-out.

The consultation showed support to convert to three phase therefore since Q4 of 2020 this has been BAU within WPD. This then gives the householder/developer the option to convert to three phase if they wanted to without having to pay retrofit prices for the installation thus future proofing the houses.

WPD have given a presentation on three phase LV services cables 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 WPD Superfast Electricity Parc Eirin project in Tonyrefail developed in conjunction with Pobl Housing Association and Sero is a new build estate of 235 homes, with each home fitted with the complete suite of LCT, smart white goods and all these devices will be controlled by a programme logic controller or Energy Management System, with a view to minimise fuel bills for the occupants, the houses will be supplied via three phase LV Service cables. WPD and Sero will be monitoring the estate to gain information on heat pumps, EV chargers and all the other LCT devices. Sero is an innovative Welsh based provider of energy positive homes and Pobl are a Housing Association based in South Wales.

7 Stakeholder Engagement

7.8 Engagement with vehicle manufacturers and transport operators

The WPD transport section provided introductions to various HGV manufacturers, which lead to WPD being invited to Stuttgart to provide a presentation on the Electric Boulevard project at the Daimler Trucks Utility seminar where Daimler Trucks 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.

This regulation requires CO_2 emissions from heavy-duty vehicles such as trucks, coaches and buses to be reduced by 30%, by 2030, with an intermediate reduction target of 15%, by 2025. This regulatory change is discussed in section 1.

The change will be significant for manufacturers of buses and HGV's. As an example of volumes, during 2021 Daimler Trucks saw trucks and buses sell 455,000 units worldwide, while demand stayed strong supply constraints slowed production.

Whilst commercial hydrogen based solutions are currently being developed, Daimler Trucks are using the HGV BEV 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 300 kms, large charger sizes and high charging speeds.

The Daimler Trucks aim was one of helping their customers achieve a quick and smooth transition from diesel to electric vehicles. The vision of Daimler Trucks was for understand electric trucking and how electric trucks charge.

Understanding the necessary information exchange between customers and DNO's 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.

To enable BEV HGV's to charge in as short a time as possible the Megawatt Charging Standard (MCS) is being developed by a task force within CharIN, the association advancing the Combined Charging System used for BEV HGV's shipping and planes.

CharIN actually announced its High Power Charging for Commercial Vehicles (HPCCV), rated at up to 1,250V and up to 3,000A in early 2019. The new charging standard for medium-duty and heavy-duty vehicles, equipped with really large battery packs, for which the CCS output (currently at 350kW) is not sufficient.

On September 23-24, 2020 another milestone in the development of compatible inlet and connector designs for medium-duty and heavy-duty electric vehicles was reached. At the facilities of National Renewable Energy Laboratory (NREL) cross-industry representatives tested, provided feedback and evaluated the compatibility of inlet and connectors for megawatt chargers.

Among them were leading OEM's, utilities, equipment manufacturers and suppliers.

This event enabled seven vehicle inlets and eleven charger connectors to test their designs together. NREL's facilities offered a convening location to compare components across the seven different manufacturers represented with prototypes in the hardware evaluations with another six manufacturers participating virtually.

Features like the fit, the ergonomics, the easy connection and disconnection and the thermal performance of the connectors and inlets were tested and evaluated by the participants.

These are valuable results for optimizing, further developing the standard and to ensure consistent performance across connector and inlet designs. The event was followed by a virtual CharIN task force meeting to review the evaluations.

The common goal of this event was to support the creation of a global megawatt charging system (MCS) standard to ensure the compatibility of connectors and inlet hardware from different manufacturers.

Especially the American CharIN member community contributed with the organization of this event and the valuable feedback to further development of an industry standard for megawatt chargers. The new CCS based standard will streamline market introduction and encourage market stability.

The National Renewable Energy Laboratory (NREL) are currently several prototype connectors and inlet hardware were revealed and tested. Results from the tests will help inform the development of interoperable connector and inlet designs.

An industry standard for megawatt chargers will streamline the introduction of commercial electric vehicles by providing fleets with stability and certainty in accessing infrastructure globally.

WPD's fleet section 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.

7 Stakeholder Engagement

7.9 Engagement with depot based fleet operators

Fleet operators who return their vehicles to a depot overnight can offer DNO's specific benefits by charging their fleet at times which avoid the traditional early evening peak of demand. The majority of HGV's are idle for over 9 hours per day, presenting a clear opportunity for vehicle charging at lower power levels. So understanding where and how many is critical.

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 at the depot overnight a timed connection allowed this capacity to quickly connect.

7.10 Engagement with UK government

WPD and various other parties have been involved with OZEV and BEIS in their Stakeholder engagement, this engagement has seen the issue of the new The Building Regulations 2010 Part S1 amended in 2021 which takes effect on 15 June 2022 this amendment calls for the installation of 7.4kW fast chargers in all new homes and retro fitted homes going forward.

WPD along with all the other DNO's are involved with OZEV's Project Rapid. The project plans to install 130 rapid EV charger sites in England at the Motorway Service Areas (MSA's), 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 OZEV 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 BEV HGV's has not been considered by OZEV.

WPD will be supplying these MSA sites at 33kV and will be using the NIA Innovation fund at the Exeter MSA site to prove there is a smart solution to meet the OZEV capacity requirements. Bearing in mind that electrical plant has a service life of fifty years, it is essential 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 EV's specifically and the electricity network in general.

7.11 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.

WPD are also engaged with the Welsh Government DfT and their Consultant EVenergy in ensuring that the circa 400 BEV HGV buses that have been purchased to cover the various bus routes throughout Wales can be charged in the appropriate manner. This is currently an on-going project.

7 Stakeholder Engagement

7.12 Engagement with Local Enterprise Partnerships (LEP's)

Ensuring WPD's future network investment plans are aligned to developments being planned at a local level is a key priority for WPD 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 within 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 workshop led consultations 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.

7.13 Stakeholder engagement completed in 2021

WPD continue to engage with the UK Government through BEIS, OZEV and the DfT, and the Welsh Government and the Welsh DfT.

WPD have engaged extensively on our RIIO-ED2 Business Plan over the last year, which includes specific commitments to prepare the network for the mass adoption of EV's.

We held a bespoke 'Business Plan commitments' workshop for stakeholders to share their insights on the plan, and held in-depth consultations on BP1 and BP2, enabling stakeholders to respond to each individual proposal via our 'Your Power Future' engagement hub.

Our biannual stakeholder engagement workshops were conducted online, enabling wider participation from stakeholders with specific interests.

Topic-specific workshops on our Environmental Action Plan and DSO and Connections Strategy were led by the managers responsible for writing and delivering those strategies, giving stakeholders the opportunity to engage in greater detail and depth on EV's and other key areas of interest/expertise.

Our local Distribution Managers engaged with every local authority in our region to analyse their energy strategies and align our DFES planning with their ambitions and capabilities. They also invited all 130 local authorities within WPD's region to collaboratively build a joined-up energy plan to achieve net zero targets and sought feedback on our proposed investment and low carbon technology forecasts, including the local roll out of EV's.

In 2021, WPD conducted the annual local investment workshops online, with 206 stakeholders attending 11 regional workshops with local managers. The events gave stakeholders the opportunity to share local investment plans with their designated WPD teams and to learn about, and respond to, WPD's projected scenarios for each region.

7 Stakeholder Engagement

7.14 Stakeholder engagement plans for 2022

During 2022 Stakeholders will be able to discuss their local energy plans, including the likely take up of EV's, and review priorities identified for our RIIO-ED2 Business Plan.

WPD will continue to engage on EV's and our strategy throughout the year via a number of channels, including:

- Online/face-to-face workshops on WPD's Business Plan.
- Annual regional stakeholder engagement workshops.
- Topic-specific workshops including an EV theme.
- Interaction with all 130 local authorities in our region on WPD's DFES forecasting.
- Local Investment workshops, bringing together local authorities and local energy stakeholders with WPD managers to discuss local energy plans, including regional take up of EV's.

8 Plans to support electric vehicle charging

8.1 WPD's approach

Using data generated from the Electric Nation project, a typical 10k miles 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 take steps to mitigate this, using the ENA EV and HP notification system data is gathered and added to the WPD asset database, code has been written which then runs in the background to check if clusters are forming on the LV Mains and the local transformers.

If there is the database coding then create a work package for the local team 1) to verify the work package and 2) carry out the modifications required. WPD have already introduced an innovative solution to allow faster and efficient connections.

WPD are already planning for 2000 LCT application per working day and creating processes that will deal with this level of activity.

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

8.2 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 (GMT and PMT) 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 EV's 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.

With the changes carried out in 2021 with the capacity map, these changes will further support customers being able to access our data to inform their new connection and operation decisions.

This consolidation has now been carried out on WPD's website. The consolidated map has a capacity heat map which covers the whole company area and provides data at the Primary substation level or at the Distribution substation level showing the capacity available to support the connection of other Low Carbon Technologies from a Primary or Distribution transformer level.

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.

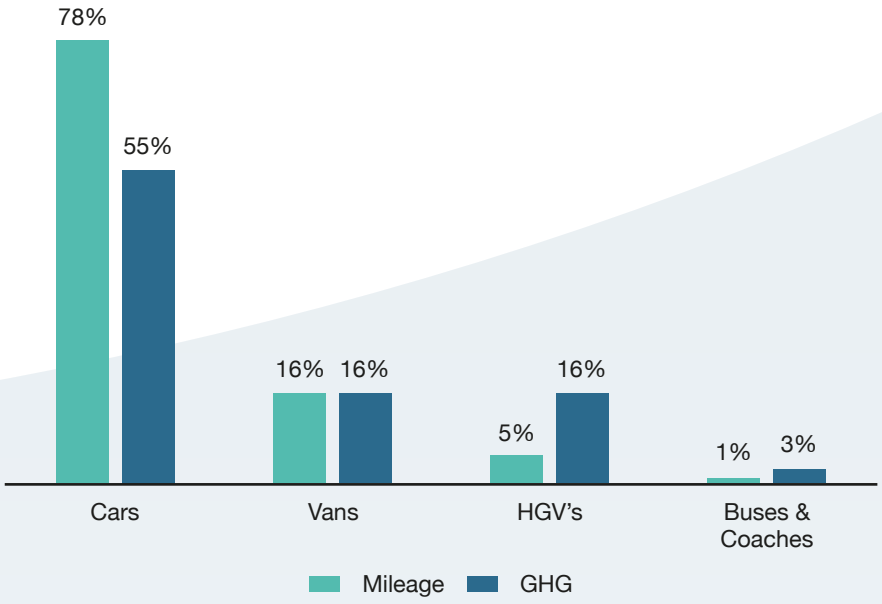
8 Plans to support electric vehicle charging

8.3 BEV HGV charging

The latest vehicle licensing statistics show that at the end of 2019 GB - registered HGV's range from a gross vehicle weight of 3.5 tonnes to 44 tonnes, with articulated vehicles - which tend to be longer, larger and heavier - carrying more freight compared to rigid HGV's. In 2019, articulated vehicles carried 62% of freight (897 million tonnes), whereas rigid vehicles only carried 38% of freight (542 million tonnes).

There were around 501,500 HGV's licensed in Great Britain, of which around 405,400 were taxed as 'good vehicles' (remaining vehicles would be exempt from tax or taxed as private HGV's), a small decrease from 2018. These vehicles "Goods moved" 136 billion tonne kilometres in the UK by GB-registered HGV's in the twelve months ending December 2020. In 2019, cars made up 79% of the road vehicle miles travelled within the UK, but produced 55% of transport emissions, while HGV's made up a much smaller proportion of the vehicle miles (5%) and their emissions were disproportionately greater (16%).

Emissions and mileage for cars, vans, HGV's and buses in 2019



8 Plans to support electric vehicle charging

Project Rapid is being developed by OZEV to install rapid chargers in motorway service areas for cars and light vans, if the scope could be increased to including ultra-rapid charging for long-haul HGV's this would have a greater effect on reducing the greenhouse gas emissions from UK transport.

The average length of haul (107 kilometres) for GB-registered HGV's in 2019 was similar to that in 2018 (108 kilometres).

The average length of haul for articulated HGV's (136 kilometres) continues to be longer than that of rigid HGV's (59 kilometres) In the EU the definition of long-haul trucking as freight movements on single vehicle trips longer than 400km.

Long-haul tractor-trailers will require a larger on-board battery for a minimum daily range of around 500 to 800km and in a few cases more than that. In the EU, 78% of the road freight activity (in tonne-kilometres) is performed on trip distances of up to 800km. As the EU is the UK's largest trading partner this data is relevant as BEV HGV's could well bring goods to the UK from the EU.

Data taken from the study of "Grid-Related challenges of high power and megawatt charging stations for battery electric long haul trucks 2021" on behalf of the Transport and Environment by Dr - Ing. Karsten Burges of RE-xpertise and Dr - Ing. Stefan Kippelt of ef.Ruhr GmbH states in this study, where they focused on public and semi-public charging and analysed three prototypes of charging infrastructure, covering and illustrating the range of requirements:

A. Highly frequented public charging station (MCS and CCS, prototype 1): a public charging station along the motorway network with intense BEV HGV traffic, representing the upper bound of public charging demands;

B. Remote, less frequented public charging station (MCS and CCS, prototype 2): a public charging station along the motorway network with minor BEV HGV traffic, representing the lower bound of public charging demands;

C. Commercial logistics hub (MCS and CCS, prototype 3): a medium-sized logistics hub with multiple haulage companies combining long and short-haul trucks.

The work done by Dr - Ing. Karsten Burges of RE-xpertise and Dr - Ing. Stefan Kippelt of ef.Ruhr GmbH shows that a strong distribution networks in the vicinity of motorway service areas for BEV HGV charging and BEV HGV logistics hubs will become an important factor for site development. The MCS charging system would be offered at special bays/stands at the MSA and that the use period will be for the duration of the charging process only.

While the overnight parking and charging at the MSA would be available at separate bays/stands. It should be noted that standing times for overnight charging would be determined by the mandatory rest period of the HGV driving regulations and not by the duration of the charging process.

For the two prototypes of public charging stations, Figure 4 indicates major parameters per scenario snapshot, such as the average distance between charging stations and the penetration rate of BEV HGV trucks in the truck fleet using the motorway service area.

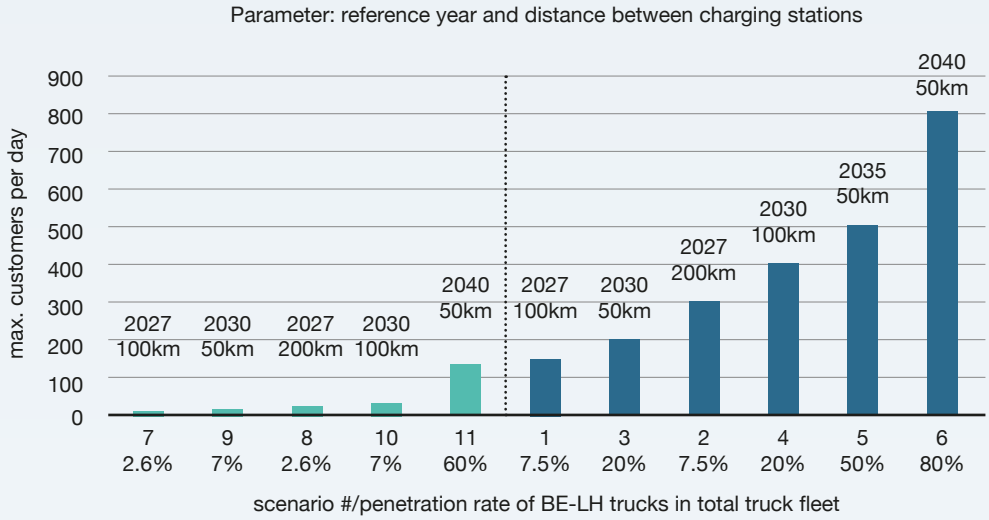


Figure 2: Maximum daily MCS customer volume and underlying assumptions for the various scenario snapshots

8 Plans to support electric vehicle charging

The simulations show that, as a rule of thumb, one MCS charger per 50 to 60 customers per day has to be installed. The MCS chargers require a grid connection capacity at the level of the installed capacity. If more than 100 MCS customers per day have to be served, with the given assumptions, the number of CCS overnight chargers grows proportional with the number of MCS chargers (ratio about 15 to 1).

As a prototype for a logistics hub, Burges & Kippelt considered a mixed business area with a size of about 125 hectare (ha) net. The traffic profile combines long-haul transportation with urban and regional distribution. BEV HGV short-haul (BEV-SH) trucks will be introduced earlier than BEV HGV long-haul (BEV HGV-LH) trucks. Initially, they will determine the charging needs. For that reason, the analysis for this prototype is restricted to a high penetration (2040) scenario. Traffic intensities are 23.9 BEV HGV-SH trucks and 8.6 BEV HGV-LH trucks per business day and hectare.

A large portion of the BEV HGV's leave the hub one or two hours after arrival, after loading and unloading goods. In case of BEV HGV-SH and BEF HGV-LH trucks, these periods dictate the time windows for charging. This, together with the traffic intensity and its distribution over the day, determines the required number and capacity of the high power MCS chargers.

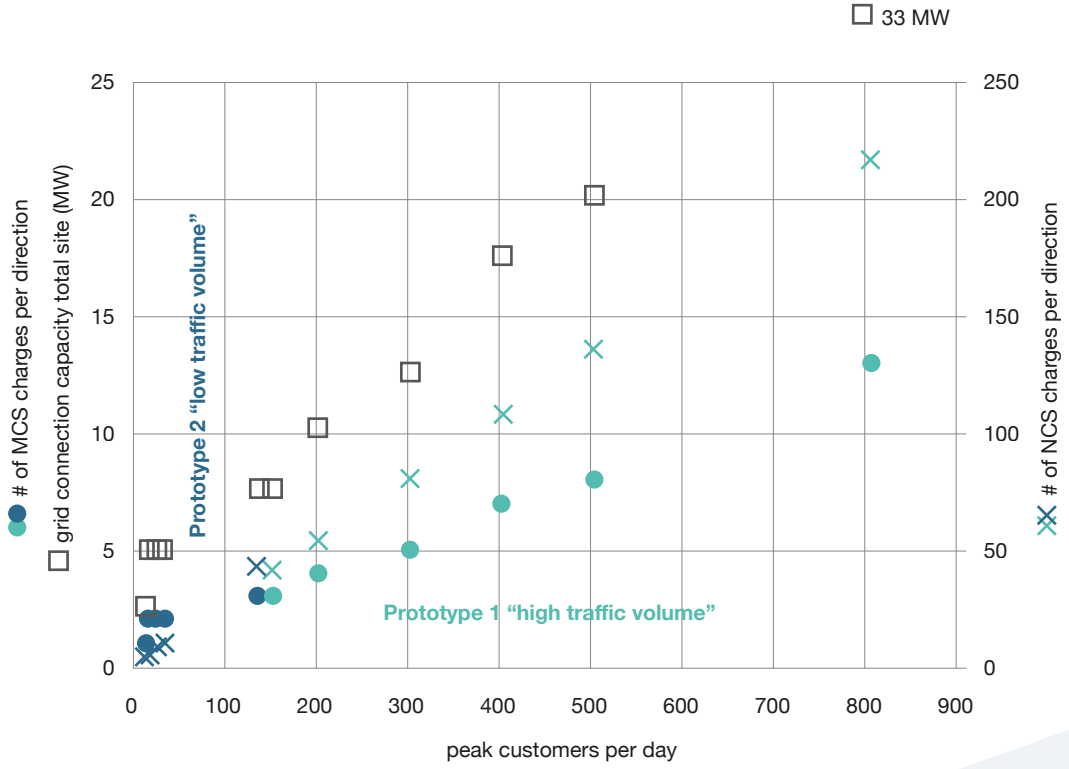


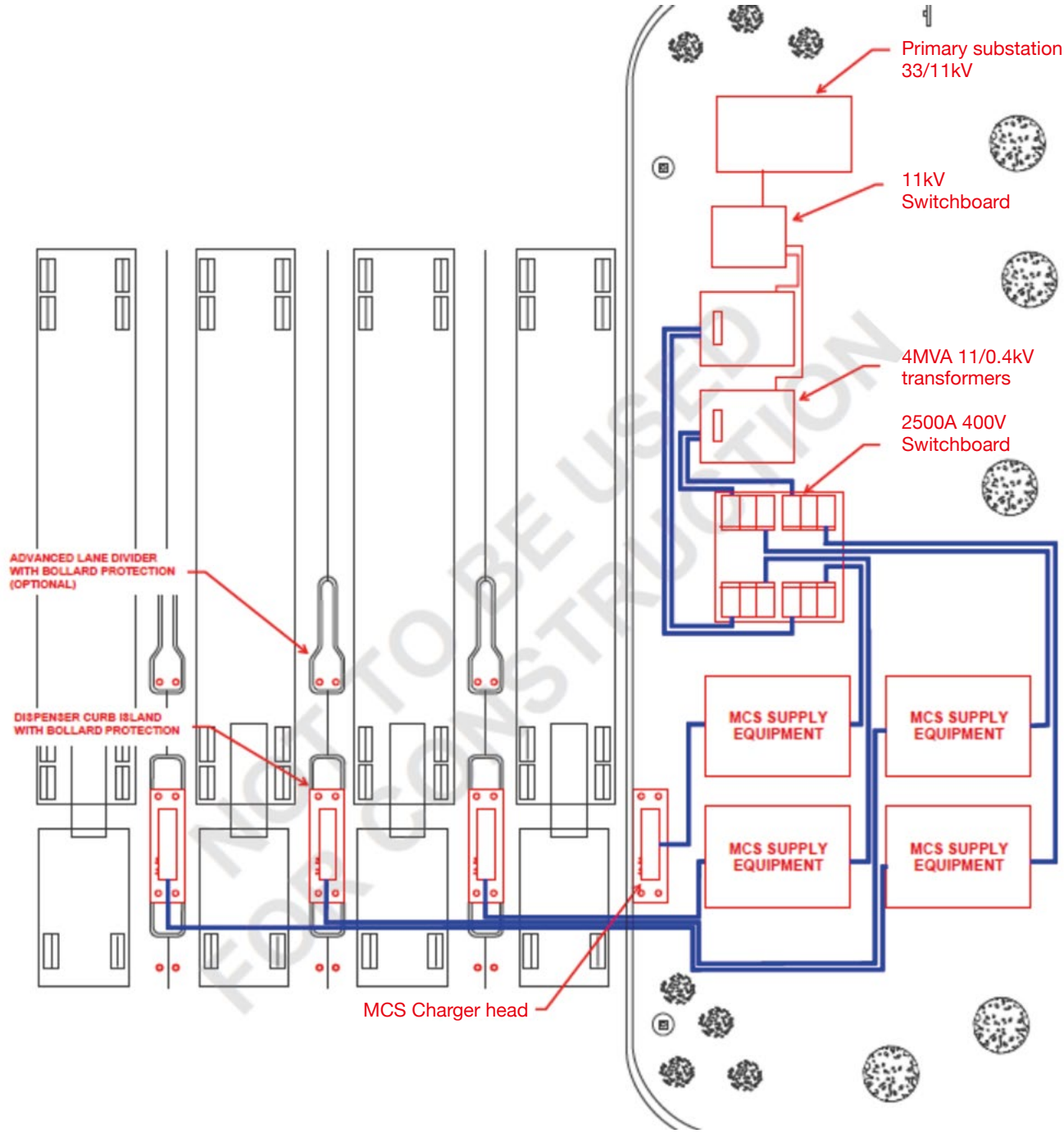
Figure 5: Required number of MCS and CCS chargers per driving direction and total grid connection capacity for both directions related to the maximum number of MCS customers, teal: "high traffic volume" (prototype 1), blue "low traffic volume" (prototype 2).

Using the Traffic intensities of 23.9 BEV HGV-SH trucks and 8.6 BEV HGV-LH trucks per business day and hectare, Then the energy required for charging both, BEV HGV-SH and BEV HGV-LH trucks, is about 6.7MWh per ha per day. For BEV HGV-LH trucks, it is estimated that, during the peak hour, up to 15% of the daily vehicle fleet stays at the area. Due to the generally short stay of BEV HGV-LH trucks, this figure translates directly into their peak load. The rest period of BEV HGV-SH trucks is distributed over a much larger range and longer periods regularly occur. The peak load caused by the total truck fleet is estimated at about 500kW/ha net business area.

For the considered prototype, the demand can be satisfied by 150 public HPC (@ 0.45MW) plus 500 public CCS (@ 0.1MW), connected to the grid via more than 100 compact distribution substations. This on-site infrastructure requires a total grid capacity of about 60MW and, hence, a connection to a Primary substation. Larger logistics hubs will need even larger connections.

Because HGV's are large vehicles it was necessary for CharIN to define the location of the charging port to the left hand side behind the front wheel of all BEV HGV's, the figure shown below shows the CharIN proposed layout of four bay high power MCS charging station complete with ancillary equipment. Sufficient room is required to allow the HGV to be able to ingress and egress the charging facility without access issues.

8 Plans to support electric vehicle charging



Drawing 1 The CharIN proposed layout of a four bay mega watt charging network complete with ancillary equipment.

8 Plans to support electric vehicle charging

8.4 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 OZEV are undertaking Project Rapid, which will supply capacity for cars and light vans to rapid charge at some 130 motorway service area's in England. Of these 130 MSA sites WPD have about 40 sites which are situated within the WPD area, the average power assigned to each of the sites in WPD's area as 7MVA. To meet this load, WPD expect to supply the MSA sites at 33kV and have developed an NIA project at Exeter MSA to provide a novel solution. In most cases these installations are currently supplied by bespoke 11kV connections but it is likely that these will not offer the level of capacity predicted. Because Project Rapid does not include the load of BEV HGV's, this will be additional load a 33kV solution offers flexibility for demands to increase without creating redundant networks.

Major Road Filling Stations are usually located in more urban locations. Engagement with the CPO's and the rapid growth of BEV vehicle uptake has shown that visible and plentiful charge points will help reduce range anxiety from BEV users. Charge point operators tell us that they want to provide EV charging availability similar to that of a traditional fuel forecourt, therefore providing the some 40% of drivers who don't have Off Street parking some place to charge their BEV's quickly and conveniently. Working with BP Pulse and Schneider Electric, WPD have co-created a new solution to meet the need for a forecourt of multiple rapid electric charging points which can be used in an urban situation. In a WPD first, we are providing a 1.5MVA rapid charging hub, enabling 10-12 off 150kW chargers to be connected.

8.5 New homes

Since 2013 WPD has stopped using tapered networks 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 UK government's production of the new Future Homes Standard brings consultation on requirements for new homes. WPD have already seen an interest from some developers and local authorities to add a readiness or futureproofing for future charging requirements and heat pump installations.

WPD already design and install LV mains networks which include a level of diversity, which allows for the fact that all customers do not use all of their installed demand at the same time.

This means that our LV mains networks are able to flex to the demands placed on them and only require reinforcement when a proportion of customers have increased their demands. 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. During 2020 WPD held a consultation with interested parties on upgrading the standard single phase service cable to three phase thus preventing the need to dig up the gardens at some point in the future to upgrade the service cable because of increasing demand. The outcome of this consultation has seen WPD change their standard service cable design from single phase to three phase hybrid cable three phase cut-out for all new builds and service cable alterations.

8.6 Existing homes

Over the 100+ years of electricity supply there are sections of the existing networks which were designed for the varying standards and conditions of the day the network was built, in addition the electricity usage assumptions at the time of installation would have been lower than those currently applied.

Whilst most new homes connected from the mid-1990's will have a service provision which can accommodate a normal domestic demand and the new demand of an EV car charger, the older housing installations will most likely need to be assessed.

For example some LV services to houses in certain housing estates were still using looped LV services in the late 2000's. A house with a looped service cable needs to be de-looped for the fitting of LCT's. WPD have now changed their policy documents so that existing housing that does not have a suitable LV service i.e. there is a looped service cable, or the cut-out is not capable of supplying 80A then WPD will upgrade the service cable and or cut-out as a socialised cost.

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 when they choose an electric vehicle so WPD are working with all the other DNO's and the ENA to produce a common methodology and assessment process which will make the acceptance process 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 DNO's.

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.

8 Plans to support electric vehicle charging

8.7 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 streetlights, which have historically been sized and connected for the relatively low demand of a single lamp fitting. To prepare the infrastructure required for charging WPD are expecting to provide bespoke street lighting mains cables 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 streetlights 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.

8.8 Depot based fleet users

In 2020 WPD were the first DNO to produce a guide for businesses to convert their fleets to BEV vehicles, this document gets reviewed yearly, and the 2021 version is available on the WPD website. During 2022 – Guide for fleet conversion to battery electric heavy goods vehicles this will be available to download from the WPD website once completed.

After the 2020 document had been produced an electronic copy was sent to every business in WPD's four license areas. The document provides advice on the initial conversion of the business to BEV's and details the various steps that need to be taken to ensure that the needs of the company are meet.

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 a new supply taken at 11kV.

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 Timed or other Alternative Connections to these customers to make most efficient use of the network.

8.9 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 substation 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.

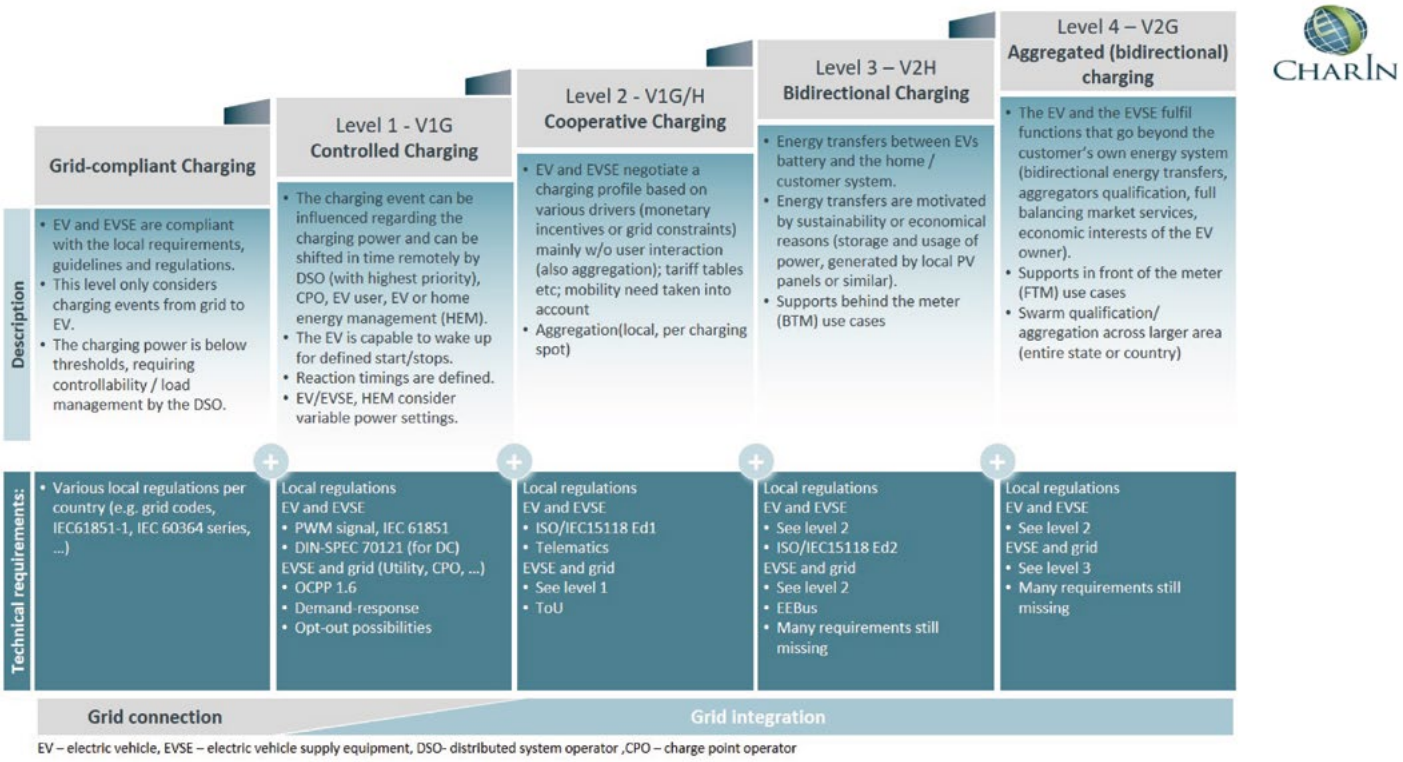
8 Plans to support electric vehicle charging

8.10 Vehicle to X (V2H = vehicle to home & V2G = vehicle to grid)

As part of WPD's Electric Nation project a mini V2G trial was conducted. WPD have also recently started Electric Nation Powered Up, in this project, up to 110 homes (minimum of 90) with existing EV users will be equipped with Vehicle to Grid (V2G) chargers to study and then manage the throughput of energy.

To replicate the likely future situation up to five energy service providers will be invited to provide unique energy flow strategies delivered via a Charge Point management platform (Crowd Charge). The flexibility that is potentially available is currently restricted to specific models of car/light van and also only tied into the CHAdeMO plug charging system at present. Currently only CHAdeMO is certified – to do this. In fact, CHAdeMO has long been touted as the only DC standard that does it as a marketing point of difference to CCS. Therefore – does the demise of CHAdeMO end the future for V2X?

The short answer is "no, but it may be delayed a little bit". CharIN (the consortium supporting CCS) actually has a roadmap for implementing V2H and then V2G into the CCS standard. (This is shown in figure 1).It should also be borne in mind that by using the cars/light van battery, one is actually reducing the life of that battery, as each car/light van battery only has a finite number of charge/discharge cycles in it, as the replacement cost of the battery on the current only car able to undertake V2G is significant, at approximately twenty-five to thirty-three percent of the cost of the new vehicle.



This roadmap for CCS to reach full V2G capability is expected to be completed by around 2025. As the graphic shows, there are many issues to overcome if level 4 (V2G) is to become truly ubiquitous.

CharIN says that CCS with ISO 15118 is the key enabler of grid integration and readiness for V2G. Even once the standard is finalised/published, it typically takes 4-5 years for products to come to the market, especially on the vehicle side, which has a longer planning/designing cycle. There are many issues to overcome to achieve V2G, including grid capacity to handle and control Vehicle to Grid or Home (V2X) in a safe and secure way. This means a number of international standards must be agreed, then built into the communications hardware and software in the cars, the chargers and the grid.

8 Plans to support electric vehicle charging

8.11 Vehicle to X (V2H = vehicle to home & V2G = vehicle to grid)

These include whether the ISO 15118 standard that enables V2G to work with CCS – which is expected to be adopted in Europe and globally – will be supported in the UK, or whether the UK may go in a different direction. For example, will smart metering be involved in the management of smart charging and V2G? And what about the level of control by Distribution Network Operators (DNO's)? Or will the EV's themselves control V2G?

So the slightly more nuanced answer to the question "what happens to V2X after CHAdeMO?" is V2H may be delayed by a year or two, but V2G capability is likely unaffected as it will take at least that long for the grid to be ready for it.

Given most EV's are already CCS – this means there is no change at all to current owners as they can't do V2G or V2H now anyway (and most likely never will unless they buy a new car when CCS V2X capabilities are introduced: after all, most car manufacturers – except Tesla – hate upgrading cars after they are built!).

Assuming that the technical challenges can be resolved, then it is possible that a whole-system analysis suggests V2G-related savings could be worth £3.5bn/year by 2040 ("Blueprint for a Post Carbon Society", Imperial College/OVO).

WPD were also involved in the V2GB Innovate UK project. WPD also helped connect the first domestic V2G charger in 2019 with Ovo following existing industry practices.

8.12 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.

The EV Chargers are three phase 22kW ac chargers, so provided the vehicle can accept the 22kW charging, the charge time is reduced, therefore along with the price signals and charging when demand is low, this will all help to smooth out daily electricity demand. This could help DNO's 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.

8.13 EV clustering

The low voltage networks rely on a level of diversity between connections. Where there is a cluster of EV's 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 EV's 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 EV's and other LCT's. The recent LCT detection project provided information of 20,000 LCT connections that had not been notified to WPD by the installers, WPD also received the locations of 7,500 un-notified LCT's when working with MCS. All these locations have been added into WPD's Crown database, where code has been created that then looks for clusters of LCT's on the LV Mains and Distribution transformers, once clusters are found a Crown task is raised on the particular local team to 1) investigate the clustering by monitoring the LV Mains feeders and transformer if the monitoring shows maximum levels are close to being reached then 2) the local team are then empowered to address the LV Main cable and transformer issues by overlaying the LV Main and or replacing the transformer to prevent customers going off supply. Therefore WPD are using this clustering information to direct our proactive reinforcement of networks.

9 Smart solutions and flexibility

9.1 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. This was recognised in the 2021 Utility Week Disrupter of the Year award for the Flexible Power Brand.

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 EV's 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 areas.

9.2 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 EV's. 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.

9.3 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 moves 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.

9.4 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.

10 Projects to demonstrate EV connections

10.1 Developing a balanced portfolio of projects

The WPD 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 the 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 stakeholder engagement sessions to ensure our projects are providing the right blend of technical and flexible solutions.

10.2 Completed projects

10.2.1 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 carparks 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 Benz, Smart, Tata, Jaguar and 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 DNO's are well equipped to install and connect electric car charging infrastructure in the public highway;
- That carpark charging of multiple vehicles simultaneously presents challenges for local electricity network infrastructure.

Learning from the project helped inform WPD's 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.

10.2.2 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.

10.2.3 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 an high-voltage connection. This solution means that charging infrastructure can be connected much cheaper and quicker than previously thought.

10 Projects to demonstrate EV connections

10.2.4 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 have been tested at scale in our Electric Nation project.

10.2.5 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.

10.2.6 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.

10.2.7 Electric Nation (2019)

From 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 35kWh). 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.

10.2.8 IET Code of Practice Ed 4 (2019)

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,

10 Projects to demonstrate EV connections

10.2.9 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.

Prior to LV Connect and Manage, technology for LV active network management (ANM), which extends communications and controls to customers' homes and is able to deal with bi-directional power flows, was still unproven and needed to be trialled by WPD in a low-risk way, to assess whether or not this option was a viable alternative to network reinforcement (for mitigating the rapid clustering effects of low carbon technologies).

A typical after diversity maximum demand for a domestic property is between 1.5 and 2.5kW. A typical electric vehicle will charge at 7kW. Whilst the domestic wiring network, and the individual network connections, will already be sized to accommodate loads of this magnitude, depending on the age of the housing estate, the upstream distribution network and substation might 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 was developed to provide a short term solution to provide emergency overload protection for the distribution network. This is a form of Active Network Management. The solution will be last resort measure deployed in areas with high concentrations of electric vehicles to prevent overload events on the network and to buy time while WPD upgrade the network.

WPD 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 WPD 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, Connect and Manage provides a short term solution which will mitigate constraint on the 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 has been trialled within Milton Keynes and Nottingham areas. In addition to the control of electric vehicles the domestic load controller can also be used to integrate with other low carbon technologies such as solar panels and home energy storage units.

The aims and objectives of the project were as follows:

- Develop the LV Connect and Manage solution architecture.
- Monitor LCT's and compare aggregated power flows with operational limits.
- Design, build and operate an active management system for LV LCT's.
- Demonstrate the effectiveness of broadband-over-powerline for the bi-directional power flow control of LCT's.
- Demonstrate the optimisation of real-time import and export patterns.
- Demonstrate how the solution can be used as a short term or long term intervention to avoid/defer network reinforcement.
- Develop new business processes for the deployment of DLC boxes into customers' homes.

The success criteria, by which the project was measured, were defined as follows:

- Demonstration of the active management of low carbon technologies (energy storage and electric vehicles) by controlling load profiles and alleviating electricity network constraints.
- Development of a replicable architecture for the LV ANM solution, which can be utilised by WPD in their other Licence Areas and by other DNO's, more generally.
- Development of novel business processes for deploying ANM technologies into LV networks. (This included the specification and development of an installation guide for the LV ANM technologies).

WPD met all of the projects objectives and delivered the success criteria on time.

10 Projects to demonstrate EV connections

10.2.10 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/householders to tell us where charge points have been fitted. This should reduce any mismatch.

The Low Carbon Technologies (LCT) Detection project has been managed and delivered by ElectraLink, the UK's Energy Market Data Hub, in partnership with IBM. It has been funded by Western Power Distribution's (WPD) Network Innovation Allowance.

The driver for the project was the need for WPD to gain better insight into where electric vehicles (EV's) and LCT's such as solar panels and heat pumps are connected to its Low Voltage network, at a domestic level.

Better visibility is essential in order for WPD, and other Distribution Network Operators, to manage their networks effectively as instances of such new demand and generation start to proliferate.

The project has combined over six years' worth of structured and freeform data from ElectraLink's Data Transfer Service dataset, with WPD's asset database and used machine learning and cognitive analysis to identify previously unknown instances of EV's and LCT's. An agile sprint process was used to manipulate the data, train and build the proof of concept model.

A 'design thinking workshop' at project outset engaged relevant personnel across WPD's business areas, to ensure that the project output was designed to meet WPD's business needs.

An additional business values report was delivered mid-way through the sprint process to ensure continuing alignment with WPD's business requirements.

The main project output is two proof of concept models that have successfully identified unregistered EV's and LCT's on the network – from both structured and unstructured data.

The models have found indications of 15,000 previously unknown EV's and solar panels connected to WPD's local electricity network. The data suggests that there could be 13% more households with electric vehicles and solar panels on WPD's network than was previously thought.

The project has also revealed valuable insights around energy consumption in general, including a 25% reduction in domestic electricity usage following solar panel installation, as well as a 5% increase in energy consumption where electric vehicle charge points are installed. The proportion of LCT's connected to the low voltage network is high in rural areas considering the density of the population.

The findings also show that EV's and solar panels are more prevalent in affluent areas while solar panels are also present in areas of high deprivation, likely due to leasing of social housing roof space for solar panels. The proof of concept model developed under this project has been based on consumption data only. It is clear from the static analyses carried out on the aggregated data that bringing in socio economic data will enhance the model.

Another key piece of learning centres on the need for more granular data and a negative dataset; the project developed its own negative data set which precluded use of, for example, socio economic data. The proof of concept model under the LCT Detection project is an essential stepping stone to development of an holistic virtual monitoring capability for WPD to underpin its transition to Distribution System Operator.

10.2.11 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 LCT's 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.

10.2.12 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, has built on the work completed and provides visualisation of smart meter data, consumption data and network conditions. The project has also investigated 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.

10 Projects to demonstrate EV connections

10.2.13 Smart Homes – EV's and Storage

With the Tonyrefail "superfast electricity" project as all the homes will have the complete suite of LCT's 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. This builds on our industrial and commercial storage project with Tesla which has demonstrated three new variants for the connection of batteries to the WPD system. These connection options rely on the operating mode of the battery being restricted to a defined purpose. These are self-sufficiency, supply resilience and flexibility market operation. Through this new project a further variant will be developed entailing the combination of energy storage with electric vehicle charging.

10.2.14 Self-Assessment

Customer electric connection priorities have evolved over time, this is being led by the UK's decarbonisation of heating and transport thus targeting the net zero emissions by 2050.

Low carbon technologies have a big part to play in this and whilst we have been harnessing these technologies for some years now the rate of adoption means that we constantly need to identify and adapt new processes for customers to apply and accept.

As some 60% of vehicles have off-street parking, charging at home has been a major consideration so WPD are looking at how we can help customers to install Low Carbon Technology (LCT) equipment. Our goal is to make it as easy as possible for customers to notify us of their intentions and reduce times to provide approval to install LCT equipment. We have adopted an automatic acceptance process for most domestic LCT's (EV & Heat Pump heating), but our intention is to evolve the process into an "Online application approach" for domestic LCT's. Our strategic plan leading into RIIO-ED2, we will evolve online application approach for many connection areas, including budget estimates, altering your supply, applying for small domestic customers (1 – 4 properties <69kVA).

10.2.15 Hub Charging Solutions

From previous engagement with the local authorities, they the 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 are proposed. It will be used to charge passing vehicles and also provide the facility to charge local terrace house owners' EV's. 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.

10.2.16 Temporary Event Charging (2021)

This feasibility study project aimed to design and assess Electric Vehicle (EV) charging solutions for temporary events, including music festivals and sporting events. This research was carried out in response to the increasing requirement for events to provide EV charging in line with the UK Government targets for phasing out internal combustion engine vehicles.

The project carried out two Work Packages (WPs). The first WP undertook background research on current practices and the need for EV charging at events, before collecting data on events carried out within our licence areas and selecting three for the later stages of the project. The case studies selected represented a range of event types, scales, locations, attendee numbers and durations.

Within Work Package two, solutions were then developed for each of the selected case studies, including base case network connections, and counterfactual tee'd connections, temporary connections, timed connections and Battery Energy Storage Systems (BESS). For each of these, implementation requirements were identified and capital and operating costs were outlined. Workshop sessions with our internal teams were used to generate practical ideas and to ensure implementation with our policy and design practices was considered in each design. The outputs of this work were then used within a Net Present Value (NPV) Cost Benefit Analysis (CBA).

Our research and CBA has led us to the conclusion that portable BESS are the optimal power solution to supply forecast EV charging demand at temporary events, therefore, the Distribution Network Operator (DNO) will not have any role in the provision of the EV charging infrastructure at the event site. It has therefore been found that there is no scope for a future NIA funded trial as any future work would need to be funded directly by the events industry in coordination with their EV charging delivery partners. The project has demonstrated a need for further development in this area, and it is recommended that EV charging delivery partners and event organisers look to build on the learning and findings presented during the course of this project.

10 Projects to demonstrate EV connections

10.2.17 Electric Nation – Powered Up

It is already known that the transition to electric vehicles will double the load per house where a car is being charged (Based on 10,000 miles per year). The addition of bi-directional charging that could be in use by 2040 in up to 15% of homes (ref National Grid Future Energy scenarios report 2019) brings a potential issue for low voltage networks with multiple cycles of charge and discharge greatly increasing the throughput of energy, higher than most stationary battery storage due to higher connection power (up to 7kW) and much larger battery capacity (up to 90kWh).

The energy flow for these batteries will be directed by various energy suppliers and other energy service providers who will give end users low cost electricity or even pay for use of the battery flexibility. Understanding the nature of this energy flow is essential to develop policies for connection and to allow for planning of network requirements to avoid voltages being over or under statutory voltage limits. In addition the opportunity to increase load or provide export to reduce load in a given network area is desirable but ascertaining the value of this service is essential to formulate appropriate incentives to electric vehicle battery owners.

In this project, up to 100 homes (minimum of 90) with existing EV users will be equipped with Vehicle to Grid (V2G) chargers to study and then manage the throughput of energy.

To replicate the likely future situation up to five energy service providers will be invited to provide unique energy flow strategies delivered via a Charge Point management platform (Crowd Charge). This should produce a wide range of use cases for which data will be gathered to produce charger use profiles.

These profiles will be served to a network modelling tool (EA Technology Network Assessment Tool) to model the effect on a range of networks at varying levels of EV penetration.

In turn this modelling will be used to provide “V2G use envelope parameters” that will describe any constraints that need to be applied to the use of these assets. The constraints will then be distributed across the whole population of V2G installations taking into account the requirements for vehicle use.

As part of this distribution any restrictions to delivery of energy service will be identified on an event by event basis and the cost of any non-delivery evaluated.

This should inform the value of incentives required for a commercial low voltage network demand/export response service to be offered by the Distribution System Operator (DSO).

10.2.18 Take Charge

Motorway Service Areas (MSA’s) have traditionally received an electricity supply from a local low voltage network or an 11kV network with a local distribution transformer. This arrangement has been suitable for the static loadings of the sites related to supplies for various retail/commercial units and other facilities.

EV chargers are now found at most MSA’s, however, the supplies will require significant upgrades to enable large scale rapid EV charging to take place when the population of EV’s dramatically increases in the near future.

Without understanding the ultimate level of demand expected from EV chargers, there is the possibility that planned upgrades do not offer the flexibility to meet future requirements. In the worst-case scenario, new assets installed to offer capacity at this moment in time, could quickly become redundant as a larger capacity or higher voltage supplies are required due to increasing EV charging requirements. Taking the Committee on Climate Change lead, we would plan to “touch once for 2050” when upgrading supplies at these locations.

The installation of a primary substation would typically be the traditional mechanism to facilitate the expected 10-20MVA EV charging capacity at MSA sites. This would involve a substantial installation including 33kV switchgear, two 33/11kV transformers and 11kV switchgear, along with protection and ancillary equipment housed within a large compound with associated brick building. This solution, whilst providing maximum security, is likely to be unacceptable to customers due to the costs and timescales associated with the install.

This project will design, build and trial a new technology solution to provide primary substation scale network capacity at MSA locations faster and cheaper than traditional methods, to support the increasing proliferation of EV’s and their charging needs.

Work during the last six months has focused primarily on:

1. Completing the build of the new 33/11 kV transformer and subsequent testing at the high voltage laboratory in Loughborough.
2. Completing the build of the switchgear container including the installation and testing of:
   - Siemens 33 kV switchgear.
   - Brush 11 kV switchgear.
   - Voltage control and protection panel.
   - Remote Telemetry Unit (RTU).
   - 110 V and 48 V battery systems.
   - Other ancillary low voltage systems.
3. Obtaining Planning Permission for the new substation site and the preparation of a Tree Protection Plan (TPP) and Arboriculture Method Statement to fulfil the requirements of a planning condition related to working around protected trees.
4. Commencing the 33 kV cable installation works between the new site and Sowton 132/33 kV substation.
5. Appointing the civil contractor for the construction of the new substation and commencing the site works at Exeter MSA.

10 Projects to demonstrate EV connections

10.2.19 Dynamic Charging of Vehicles

The project was feasibility project looking at the impact that DWPT will have on the electricity network and what that means for the current infrastructure. Dynamic Wireless Power Transfer (DWPT) is not intended to be a replacement for conductive charging (static chargers such as hubs, workplace and public car park charging). This technology would be an additional means of charging vehicles alongside existing methodologies. One of the projects objectives is to understand if DWPT could provide sufficient on-route charging capabilities. EV's in theory should be able to travel longer distances between 'plug in' charges without the need for extra capacity and therefore weight.

The project consisted of five work packages, work package one included the project management activities with Coventry City Council driving the deliverables from all other partners with final approval and reports delivered by WPD. Work package two was a literature review carried out by Cenex where a report was completed detailing all past and current projects along with technology providers and their outcomes. It found there is only one provider worldwide who currently provides this technology. Work package three was to carry out modelling, this was integral to the project outcomes as WPD were able to determine a business case based on the utilisation of DWPT.

The selected case study area utilising modelling work had many parameters many factors such as, traffic flows, speeds and, wireless transfer potential etc. This work package was carried out by Coventry University. One of the main findings is that there may be increased demand on the network that coincides with increased traffic flows which aligns with the morning and tea time peaks on the network. Work package four was carried out by Cenex and detailed the business case for DWPT which was compared to traditional conductive charging methods.

The main findings of this business case was that the worst case scenario for DWPT was nearly ten times more expensive and delivers less electricity to vehicles than traditional charging methodologies. Work package five consisted of a final feasibility report which compiled all previous work packages and the main findings are detailed within that report.

It determined there was only one scenario where DWPT is anywhere close to price parity to traditional conductive charging, which is installation on motorways with 50% of HGV's utilising the technology and 50% of the motorways to have DWPT installed.

The main findings are that DWPT technology is not mature enough currently to be considered as a viable option for charging of EV's on the move as the technology and installation costs are very prohibitive. Only a small number of EV's that have been retro-fitted with the correct equipment (vehicle assemble, receiver coil) can utilise this technology. Traditional conductive charging methods are more than ten times less expensive and are EV agnostic, meaning that all EV's can utilise them.

There is also less civil works/disruption involved with installing conductive charging as opposed to excavating the highway to install the DWPT coils.

DWPT involves installing roadside management units and installing multiple grid connections. There may be specific cases where wireless power transfer is preferable, such as taxi ranks, disabled parking bays etc.

This does not alter the business case for DWPT as a solution to charge EV's whilst in motion but this may change as the technology matures and there is standardisation across technology providers, manufactures and government policies.

In conclusion the DWPT system is a promising solution in very limited areas but the high cost, low efficiency and disruptive nature of this technology remains a significant barrier for wide scale utilisation.

As battery technology matures, and the roll out of high powered chargers continues at its current pace, the need for DWPT remains highly unlikely except for very limited applications.

The cost of installing is extremely prohibitive and it is highly disruptive to road users. This technology becomes far more feasible if the technology reduces in purchasing and installation costs.

10.2.20 DC Share

WPD embarked on the DC Share project to determine whether LVDC meshed networks could help EV developers obtain HV/LV capacity with greater ease than existing approaches. As a result of learning captured during the design phase of DC Share, we decided to ask Ofgem to halt this project on the basis of evidence that LVDC meshes appear unlikely to deliver the expected benefits at scale. Some of the evidence that we captured include:

- The relative ease of increasing substation capacity when compared to the logistics involved with installing cables in urban environment.
- The resilience of LV mesh topology in comparison to the resilience of conventional AC radial connections.
- The availability of substations which can host AC to DC conversion systems.
- The strength of competing technology such as thermal monitoring systems.

10 Projects to demonstrate EV connections

10.2.21 Prime EV

Ofgem's significant code review is expected to socialise the costs of network reinforcement, which will remove economic barriers to connections for customers. As a result, queues for capacity are expected to grow as capacity on the 132 kV and 33kV system becomes oversubscribed. (Our RIIO ED2 business case submission expects that the impact of the significant code review will drive an additional £300M of capital reinforcement above our best view forecast of £419M worth of reinforcement on the primary system) .

We already have a capability to offer customers managed connections, but in networks that are full, these would result in pre-fault curtailment unless the customer invests in protection grade intertripping channels. Whilst large generators can often accept the cost of enhanced communications channels, these costs are too much for EV cluster developers to accept. This represents a barrier to the roll-out of rapid Electric Vehicle (EV) charging infrastructure that can be used by the public.

Prime EV proposes to overcome this by introducing a system of short term ratings into our management system. Short term ratings are approach to circuit ratings that allow a circuit to run at a higher than normal load for a defined period of time but only after an unplanned event.

After the use of the short term rating, the circuit must be returned to within a defined rating envelope, within a defined timescale. Short term ratings are commonly used on transmission systems, but to date, are not been commonly used on distribution networks.

By enabling use of short term ratings on 132 kV and 33 kV infrastructure and combining them with our existing suite of managed connection products, we believe that connection queues can be managed to the advantage of our customers. This will require co-ordination of WPD policy across Primary System Design, Connections Policy, Control Room Policy and Engineering Policy.

This project will be internally funded without the aid of external innovation funding and has the potential to create significant savings within ED2 for our DUoS customers in addition to accelerated roll out of rapid EV charging clusters.

The prime EV project is expected to cost £523k (including risk) and be delivered during spring 2022. No additional hardware or infrastructure will be required to deliver a short term ratings capability and the benefits accruing to customers are considered to be many times the project cost.

10.3 Future Projects

10.3.1 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.

10.3.2 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 streetlights.

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. This will also include work around the disabled driver and the mobility issues they face when trying to access EV charging.

10.3.3 EV charging mobility

In this project WPD will in partnership with mobility charities, community groups and local authorities explore the data and evidence to identify the needs of disabled motorists with respect to the various forms of EV charging on street EV charging, including the location of the disabled bays and the impact on the network.

11 Targeted commitments in 2022

11.1 Realising benefits

Stakeholder feedback and findings from projects undertaken becomes fully valuable once the findings become 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 details changes that are expected to be made in 2022 and beyond.

11.2 2022 - Eco home monitoring

Currently there are about 40 homes which are occupied in Parc Eirin, WPD using the smart meter data and correlating that data with the GridKey data we have slowly been getting, is giving WPD a better understanding of what is happening on the estate. Currently there are about 4 BEV's on the site. As the new homes get built and the new residents move in to their new homes WPD will continue to monitor the site and grow the learning.

11.3 2022 – 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, what with BEV HGV's becoming more prevalent on the UK's roads WPD are looking to develop and understanding of the different charging requirements which will be required for the HGV's to allow the HGV's to continue to work inside the HGV driving hour legislation.

It is highly likely that these values for the HGV charging will vary greatly depending on whether one looks at the overnight charging or the ultra-rapid MCS 45 minute break charging. Therefore it will be critical to understand the needs of HGV's especially as there are about three quarters of a million HGV's currently using UK roads.

Companies which have large fleets of HGV's like DHL, Royal Mail etc. once they start to convert to BEV HGV's WPD will need to already have the understanding to the requirements of BEV HGV's to be able to provide a suitable connection to meet their respective needs, because these depot sites will require a mixture overnight charging and also the ultra-rapid MCS charging to allow the quick turnaround of vehicles.

11.4 2022 – Public charging hub infrastructure

WPD, BP Pulse and Schneider Electric have developed a 1.5MVA hub charging solution to help the deployment of charging infrastructure in car parks and other public locations.

With the completion of this hub charging project we will have created a design specification for bespoke multiple rapid 150kW charging hubs.

If the CPO is working on lease from a third party, then there is a potential wayleave/lease issue around EV charging locations which WPD, all the other DNO's and Ofgem are trying to resolve, resolution of this issue will mean a far quicker turnaround in supplying connection agreements with all the DNO's, it is more than likely the issue will impact Project Rapid if not addressed early.

WPD are in the process of creating a "lawyer light" agreement between the CPO and WPD, this document will enable WPD to "back to back" with the CPO's lease and the agreement will only allow single supply to the CPO. This document will provide a rapid turnaround for the completion of supplies to the CPO.

11.5 2022 – EV charging with respect to Motability customers

In this project WPD will in partnership with mobility charities, community groups and local authorities explore the data and evidence to identify the needs of disabled motorists with respect to the various forms of EV charging on street EV charging, including the location of the disabled bays and the impact on the network.

Below are 11 actions to deliver alongside practical trials that will enhance WPD's EV and vulnerability strategies:

- Develop a resilience plan for power cuts to help support home and public charging for disabled and vulnerable customers.
- Share case studies and best practice examples of infrastructure and standards with relevant parties (e.g.: other DNO's, CPO's, etc.).
- Provide support for joint bids for government funding (e.g.: local authorities, CPO's, installers, etc.).
- WPD to contribute data to relevant schemes or programmes, such as Icebreaker One.
- Support CSR programmes for CPO's to help them show alignment with accessibility standards at the pilot stage.
- Identify future and current projects that WPD could influence and work on to better understand at what stage in the process they could intervene, or where accessibility standards would need to be considered.
- Respond to consultations as appropriate, using engagement and research to build WPD's opinion.
- Share results of pilot trials with stakeholders such as consumer bodies, other DNO's and government to prove benefits.
- Undertake research/schemes/partnerships/consultations with consumer bodies (e.g.: BSI, CSE, Motability, etc.)
- Engage with site owners, local authorities, or manufacturers to raise awareness on accessibility issues and ensure they are considering accessibility standards. This may also help WPD understand the internal processes of these bodies.
- Work with charge point installers to develop a Memorandum of Understanding/mutual agreement to share data across platforms and ensure that installed assets are registered with the DNO.

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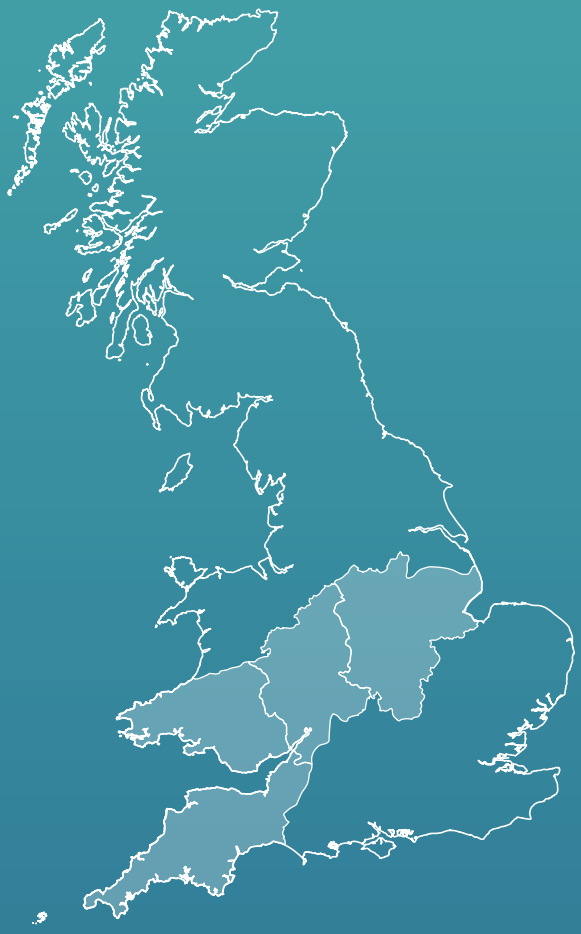

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