NORTHERN POWERGRID

Maximising the value of electric vehicles for our customers

September 2019


NORTHERN POWERGRID
Powering our Lives
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Northern Powergrid is responsible for the network that takes electricity from power stations and smaller generators to eight million customers and businesses across the North East, Yorkshire and northern Lincolnshire.
We are here 24 hours a day, seven days a week, 365 days a year to make sure that the electricity you need gets to you safely, whenever and wherever you need it. If, for any reason, your power gets interrupted, it will be us who come to fix it and we will respond night or day.

Our business

We have 2,700 employees looking after more than 63,000 substations and over 96,000km of overhead power lines and underground cables, spanning almost 25,000 square km.

The amount of revenue that we recover from our customers is defined by Ofgem through a process that takes place every eight years and our performance is monitored on a yearly basis, from 1 April to 31 March.

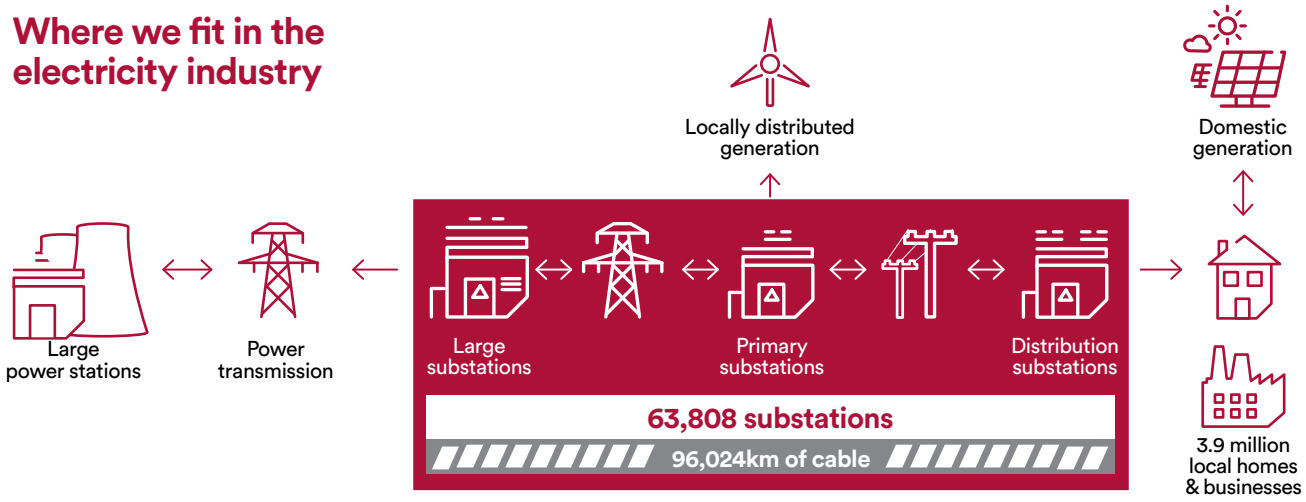
The current eight-year period is called RIIO-ED1 and lasts from 2015 to 2023[1]. A typical domestic customer currently pays roughly £85 per year for our services.

Our commitment to operational excellence and customer service means that we are constantly looking to do things better, at a lesser cost for our customers. We provide the electrical infrastructure for the future. As the UK energy landscape changes to meet its carbon reduction targets, renewable electricity, electric vehicles and heat pumps place new demand on our network. We are adapting how we manage our customers' changing use of the network so it continues to provide a secure supply of electricity, at least cost.

We are committed to supporting the electrification of transport in a way that minimises the need for new network infrastructure, and maximises the value for all of our customers, also supporting the national decarbonisation agenda.

Our regional structure enables our teams to best serve the local needs of our customers.

Where we fit in the electricity industry



[1]For more information, please refer to: ofgem.gov.uk/network-regulation-riio-model/current-network-price-controls-riio-1/riio-ed1-network-price-control

Executive summary

Electric vehicles (EVs) are set to become the dominant form of personal motorised transport over the next 20–30 years, driven by technology advancement, electrification policies, and economics. The growth in EVs has started with adoption doubling annually. We are working to enable the electrification of transport and to ensure it is for the benefit of all of our customers.

In 2018, the UK Government announced its plans to reduce emissions from transport in its Road to Zero Strategy[2]. Most importantly, it outlined the ambition to ban new petrol and diesel car sales by 2040 and specific actions for improving air quality and decarbonising the transport sector.

We acknowledge that the issues surrounding air quality and decarbonisation of transport can be tackled by avoiding travel altogether or by strategically promoting walking, cycling, the use of public transport, and carpooling. However, there is no doubt now that EVs will be a significant part of the transport future in the UK.

In this document, we are setting out what we are doing to accommodate the charging of EVs. It acts as a reference guide to inform stakeholders on what we are doing now, what we have planned, and what we believe are the wider energy system development actions needed in the future. We have used case studies to illustrate the range of different EV charging solutions available for our customers. We are interested in views on what more we could do or what we should be doing differently.

[2] HM Government, 2018. Road to Zero. Next steps towards cleaner road transport and delivering our Industrial Strategy.
See also: Department for Environment, Food and Rural Affairs & Department for Transport, 2017. Clean Air Zone Framework.

The actions we are taking to enable the electric transport future are being informed by our local stakeholders where our events and direct engagement with over 20 local authorities are guiding our work. Nationally, we are also working with the industry through the Energy Networks Association (ENA) and with Government and Ofgem.

It is widely understood that the evolution of EV charging infrastructure will drive increased demand in electrical energy and higher peak loads in the electricity systems, perhaps adding to the network costs. And yet, the benefits associated with utilising flexible load and the storage inherent in EVs may reduce the network costs by entirely offsetting their increase. We are continuously updating our localised, scenario-based forecasting to inform our network infrastructure planning.

We believe the roll-out of EVs and their charging infrastructure can be, and should be, for the benefit of all electricity customers. As we transition to the role of distribution system operator (DSO)[3], we are seeking to unlock the full potential of distributed energy resources, including EVs.

Innovation trials of new commercial and technical solutions are being used to see how smart charging and vehicle-to-grid (V2G) technology could be a source of customer flexibility[4] that may help us to manage the system. Early innovation trials have already proved useful – we have updated our network planning standards to reflect observations from the network impact of customers' charging behaviours. Now, the focus is on collaboratively developing and demonstrating how EVs can be part of the solution for the overall energy system of tomorrow – providing a benefit to electricity customers, as opposed to being the problem.

Industry leader for electric vehicle solutions

Partnership with Nissan – a leader in EV manufacturing

Silent Power – electric vans restoring electricity supply

First DNO to start a V2G innovation project

[3] For more information, please refer to https://www.northernpowergrid.com/DSO
[4] Please refer to the *Glossary*.

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Listening to our customers

There is a significant interest in EV charging infrastructure, which peaked after the Government's announcement to ban fossil-fuel powered new car and van sales by 2040.

Recognising this interest, regionally and nationally, we have created this document outlining the many actions we are taking or considering for electric vehicles. We would be interested in views on what more we could do or should be considering.

We host a number of events for our stakeholders throughout the year. We have discussed our current EV-related activities in the following events:

Unlocking the energy future
(November 2017, January 2018)

Minimising our environmental impact
roundtable discussion
(23 March 2018)

Unlocking a smart energy future
roundtable discussion
(23 April 2018)

Clean air zones and low emission vehicles: challenges, opportunities and future thinking
roundtable discussion
(7 May 2019)

We also hold monthly Connections Surgeries for our customers[5], where they can sit down with our engineers to discuss any current or planned installations. On 10 October 2018 in York, we hosted a dedicated EV connections workshop. Recognising the high levels of interest and appetite for this type of engagement, we have plans to run further events in 2019 and 2020.

Our activities relevant to this topic, including this document, have been reviewed by an external stakeholder panel, which provides us with suggestions and quality assurance of our engagement activities.

Electrification of transport continues to be a significant topic for numerous stakeholders in our area:

- To date, we have spoken to over 20 Local Authorities about their EV plans:
  - Our Design Team have held more than 10 working meetings with Local Authorities to align the plans for the future needs of EV infrastructure.
  - We invited a number of Local Authorities from across our region to review our new self-service LV budget estimating tool for connections (see case study for more detail). Feedback from these stakeholders will be used to inform the development of this new tool that could play an important role in helping Local Authorities to meet decarbonisation targets.
- In 2018, BEIS awarded Local Enterprise Partnerships (LEPs) with funding to develop their Energy Strategies. We have since held meetings and contributed to the development of the Energy Strategies of LEPs in our region.

[5] Full list of events available on our website: northernpowergrid.com/customer-events-and-surgeries

Our stakeholders

Taking a collaborative approach for joined-up solutions

Alongside engagement with our customers and local stakeholders, we are taking an active part in a number of industry working groups and collaborations that are seeking to facilitate an increased EV uptake, share knowledge and improve the services we provide to our customers.

— We are contributing to the ongoing work undertaken by the ENA Low Carbon Technology (LCT) working group to co-ordinate our efforts for facilitating EV uptake in the UK. Via this group, we are working with the Office for Low Emission Vehicles (OLEV) on improving the notification process for EV chargers, so that we know where they are being installed and to ensure that the design checks are made where there is uncertainty in the level of domestic demand.

— We supported ENA in organising and running the first ever EV forums in London and Glasgow in Q1 2019. The objective of these events was to provide a platform for EV stakeholders and DNOs to discuss the steps that are being taken to facilitate the roll-out of EVs.

— We chair the national ENA earthing group and are leading the work with the Institute of Engineering and Technology (IET) to ensure the EV Code of Practice and IET Wiring regulations provide adequate guidance on EV charging point connection and earthing arrangements, which are critical to the safety of users. We also work with the IET to improve the guidance for electrical installers on maximum demand and diversity calculations to ensure the safe and reliable operation of the customer's supply and their EV charging points.

— Through the Electric Vehicle Energy Taskforce, we are working with a wide group of industry stakeholders such as OLEV, Ofgem, BEAMA, Energy UK and the Automotive Council to make suggestions to the Government and ensure that the energy system is ready to facilitate and exploit the mass EV uptake.

— We are also running a collaborative project to assess the impact of EVs on the UK's electricity networks under various uptake scenarios and to identify the optimal network development pathway using a combination of smart solutions and traditional reinforcement. The project will develop a bottom-up empirical model which will enable electricity networks to understand how existing capacity can be optimised at a minimum cost using a combination of network and market solutions while maintaining network resilience.

— The linkage between the car manufacturing industry and the energy industry is crucial to develop opportunities and mitigate the impact of EVs. We have formed a strategic partnership with Nissan that enables us to carry out a number of projects relating to smart charging, resilience and second life uses of vehicle batteries.

— We have been working with Scottish & Southern Electricity Networks and EA Technology on their Smart EV project[6], a follow-on phase from My Electric Avenue[7], reviewing and researching charging solutions. Most recently, this project has been consulting on a managed charging 'back stop' solution to accommodate a rapid increase in clustered charging of EVs.

— Northern Powergrid is part of the wider Berkshire Hathaway Energy group. All our network companies are experiencing increasing customer interest in EVs. Each of the platforms within the larger corporate group is investigating the impact through trials or innovation projects. To capitalise on the benefit of being part of a multi-national energy company, we work together with our colleagues to share knowledge and develop a common understanding of the impacts and possibilities of EVs, also reflected in this document.

[6] SSEN. Smart EV project. Available from: eatechnology.com/engineering-projects/smart-ev/
[7] SSEN. My Electric Avenue. Available from: myelectricavenue.info/

Current actions	Next steps
✓ Stakeholder events	✓ Dedicated Local Authority forums to explore current and emerging topics
✓ Stakeholder panel meetings	✓ Working collaboratively with Local Authorities
✓ Connections Surgeries	✓ Continued engagement with stakeholders to inform them about the steps we are taking to prepare our network for the uptake in EVs
✓ Meetings with individual Local Authorities	✓ Continue to work collaboratively with ENA and other industry groups
✓ Providing inputs to LEP Energy Strategies	✓ RIIO-ED2 business planning and dialogue with our Customer Engagement Group
✓ Participating in ENA LCT working group	
✓ Working with IET	
✓ Participating in EV Energy Taskforce	
✓ Consortium with Nissan	
✓ Energy network innovation projects	
✓ Knowledge sharing within the Berkshire Hathaway Energy group	

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Current EV uptake in our region

At the end of 2018 Q4, there were 186,402 plug-in vehicles[8,9] registered in the UK. Out of these, 2% were registered in the North East and 6% in Yorkshire and the Humber.

There are currently more than 3,000 charging points installed in our region.

186,402

plug-in vehicles in the UK

8%

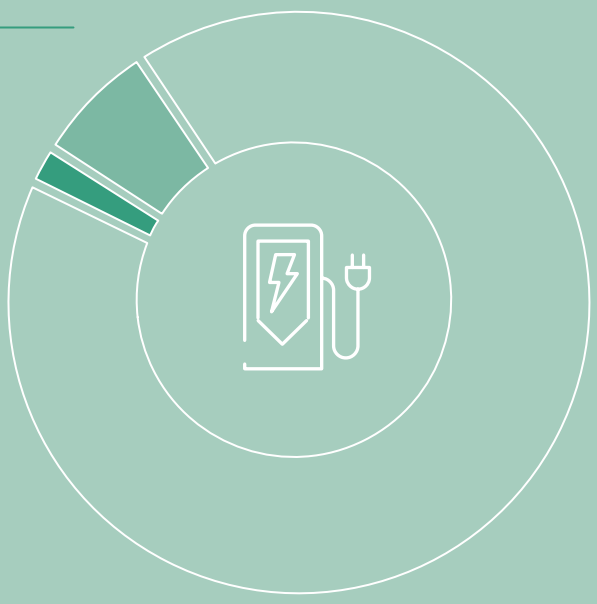
of UK plug-in vehicles are in our region

12,051

plug-in vehicles in Yorkshire and the Humber

3,384

plug-in vehicles in the North East



[8] Electric and hybrid cars, light goods vehicles and quadricycles.
[9] Department for Transport statistics, 2018. Vehicle Licensing Statistics. Table VEH0131. Plug-in cars, LGVs and quadricycles licensed at the end of quarter by upper and lower tier local authority, United Kingdom from 2011 Q4.
Note: Although this data gives a good indication of the number of plug-in vehicles using our network, some deviation is to be expected as North East and Yorkshire and the Humber regions, as defined by Office for National Statistics, do not correspond to the exact borders of our DNO licence areas.

Forecasting potential EV uptake and increases in network use

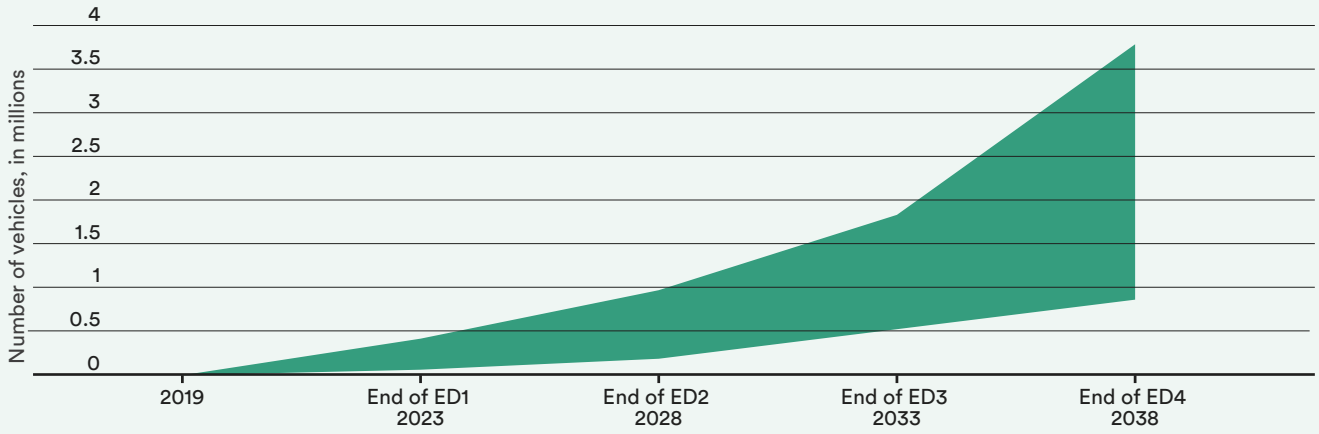
We use forecasts to inform our network infrastructure planning. We forecast a range of EVs in our region to be between 150 thousand and 1 million in the next 10 years (Figure 1). That's up to 65 times the number on the road today.

The forecasts used in our RIIO-ED1 (2015-23) Business Plan were based on the 2012 DECC scenarios[10]. Since then, we have been developing our own scenario modelling capability which includes the earlier DECC scenarios for comparison purposes, the National Grid Future Energy Scenarios, as well as scenarios developed for us by Element Energy.

The uncertainty[11] associated with future volumes of EVs (Figure 1) significantly impacts the load-related forecasts (Figure 2) which, in turn, are used to inform the decisions made on future procurement of customer flexibility services and expenditure on network reinforcement.

We are continuously developing our scenario-based forecasting approach to manage the aforementioned uncertainty. Our enhanced load forecasting capability is enabling us to consider a range of electric vehicle forecasts and the potential impact on the network, which is a combination of all customers' energy practices. This enables us to choose our best view from the scenario building blocks, enveloped by high and low sensitivities.

Figure 1: EV growth projections in the Northern Powergrid area



In the last 10 years, we have observed a reduction in overall net peak load on our network. We believe this is due to an increased amount of distributed generation, improvements in energy efficiency, changing patterns of electricity usage, and general economic activity in the region. So far, the reduction of net peak load has offset the increase in load from EV charging.

Our updated forecasting model indicates that:

— **Until the end of the RIIO ED1 period (in the next four years),** we expect very little impact on our network due to the growth of electric vehicles.

— **In 10 years' time,** depending on which EV growth scenario materialises, we expect the growing number of electric vehicles connected to the network could result in a small number (less than 3%) of our secondary and primary distribution substations requiring reinforcement, however, we are committed to using flexibility wherever we can (potentially from EVs) to avoid or defer investment wherever that is feasible and economic (see the section *EVs as a key part of our customer flexibility strategy*).

[10] The full range of Department of Energy & Climate Change (DECC) scenarios at that time showed that this figure could be anywhere between 337,425 to 1,071,864 EVs by 2031.

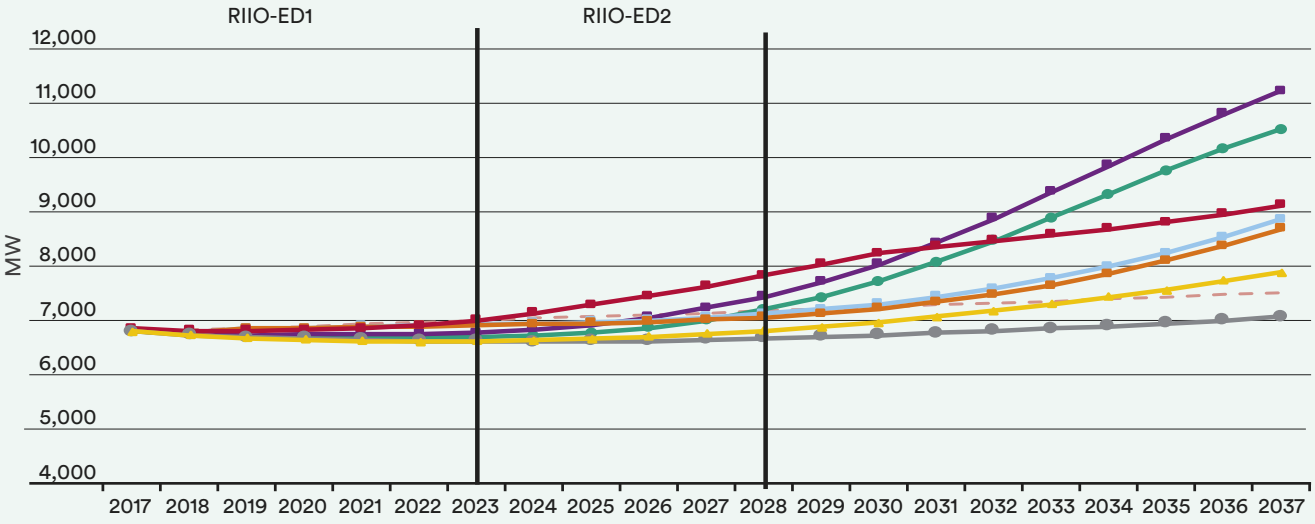
[11] A potential range for the electric vehicle growth projections of between 48,988 and 376,758 by 2023 and 237,708 and 1,277,517 by 2030.

— **In 20 years' time,** a significant increase in the number of EVs is expected. This will have a varied impact on the peak loading of substations due to differences in regional demographics. There is a high uncertainty about effects on our network:

- Under the high-deployment scenario, it could contribute to a maximum of 4.4 GW increase in peak demand, and 5.7 GW increase by 2050. The number of overloaded substations projected could be in the hundreds for primary substations and in the thousands for secondary substations, excluding the impact of customer flexibility, domestic time-of-use (ToU) tariffs, and smart charging. To put this in context, these represent 44% of the primary substation and 12% of the secondary distribution substation population.
- However, sources of customer flexibility could have the potential to reduce the impact of EV charging on system peak demand significantly. Then, as little as 8% (ca. 45) of our primary substations and less than 3% (ca. 1,700) of our secondary distribution substations could become overloaded under the high-deployment scenario, provided that the load is being shifted away from the time peak at the other sites. We discuss EV flexibility in greater detail in the next sections of this document.

To help manage the clusters of EV chargers that we believe will appear in future on our network, we are presently rolling out LV monitoring equipment at some of our distribution substations. This equipment allows us to make a more informed decision on initiating flexibility solutions or network upgrades. The equipment will also provide the basis for emergency management of EV infrastructure in future to ensure a reliable network for all customers.

Figure 2: There are a number of scenarios of gross peak demand forecast on Northern Powergrid network.



Delivering Smart Grid technology

A key pillar of our ED1 business plan, our £83m Smart Grid Enablers programme is preparing our network for rapid growth of electric vehicles, domestic heat pumps and renewable power. As part of it, we are rolling out monitoring and control units in our substations.

This investment will give us greater ability to control and analyse how our network is operating in real time to respond to the uptake in low-carbon technologies.

The programme provides a foundation to build smart solutions in response to emerging customer needs – in particular at scale should a higher EV uptake scenario become a reality. This upgrade and extension of our visibility and control capability ensures that we may manage the higher EV roll-out scenarios in the 2020s.

It will also enable a better understanding of capacity available on the network currently – thus we may be able to facilitate a moderate increase in demand (potentially driven by EVs) simply through a better use and monitoring of existing assets, enabling the additional headroom requirement on certain assets to be minimised. Ultimately, the programme introduces network flexibility, by allowing us to operate it with smarter, more efficient and cost-effective practices and technologies.

Smart Grid practices and technologies

Primary network	Local network
✓ Self-healing networks	✓ Time-of-use demand data
✓ Real time capacity management	✓ Remote monitoring of LV circuit power flow
✓ Two-way power flow monitoring	✓ Automated control of voltage
✓ Advanced substation control devices	✓ Fault prediction and smart “fuses”
✓ Narrowband flexible communications (IP-based)	✓ Narrowband communications
	✓ Harvesting network data from existing HV devices

Current actions	Next steps
✓ A forecast model based on National Grid Future Energy Scenarios & Element Energy scenarios utilising our own data	✓ Refined forecasting model
✓ Working to improve our understanding of EV ownership in our region and where the EV charging points are connected	✓ Regular engagement with stakeholders to verify our forecasting assumptions

EVs as a key part of our customer flexibility strategy

In a world of intermittent and time dependent generation, flexible load has the potential to increase the overall value for customers, providing flexibility for all network users.

We believe that Government policy, such as tax incentives for workplace charging, and commercial incentives for customers, such as ToU tariffs, should be the primary routes to enable this flexible load. Technology also has an important part to play – in both the development of smart charging systems and the use of network technology to maximise the capacity available from existing assets.

We have a variety of smart network flexibility tools to address constraints depending on the extent of the problem. These include smart voltage controllers at primary substations, the use of bespoke asset thermal ratings, the use of HV regulators for clusters of problems with distribution substations, and on-load tap changers on distribution substations.

We have already published data of where we consider that customer flexibility solutions may provide a suitable alternative to traditional reinforcement[12]. This 'flexibility first' approach will not be limited to accommodating growth in demand for EV charging; but we consider that it could be a key driver. Initially, we are most interested in using flexible demand or generation to defer the need for network reinforcement, adding value through managing construction risk differently and providing support during times when points of the system require restoration.

Our innovation work is looking at longer term potential use cases and solutions. Whole system innovation projects are exploring how network services and energy markets work together for customers. Activating Community Engagement and GenDrive projects are (see section *Innovating to deliver more value for customers* for more detail) where gamification is being trialled to see if it can drive behaviour change of domestic customers.

Properly implemented, a combination of ToU tariffs and flexibility payments will be key tools to manage the loading on network infrastructure. It is important that whatever market model is adopted gives the DSO first call and/or a co-ordinating role for flexibility on its network so it can manage within the physical constraints of the assets.

Figure 3: Cases for use of customer flexibility

Traditional reinforcement	To defer spending on traditional reinforcement.
Planned maintenance	To manage the risk of power cuts during long duration construction periods.
Emergency support	To provide emergency support during unplanned power cuts.

Current actions	Next steps
✓ Flexibility expression of interest in DSO v1.0	✓ DSO v1.0 plan update
✓ Smart network flexibility tools	✓ Flexibility tenders
	✓ Flexibility services

[12] For more information, please refer to https://www.northernpowergrid.com/DSO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Selecting the EV charging solution that meets your needs

Where you are planning to charge your vehicle will likely affect the type and size of the charger you need. There are a number of things to consider before picking the solution that meets your requirements.

EV batteries are typically sized between 5 and 100kWh – plug-in hybrid batteries are smaller in size, while the pure electric vehicle batteries are normally in the 25–100kWh range. Battery size has grown over recent years, however the cost in efficiency terms of carrying the weight of a large battery in the car means that battery size growth may slow down – or their size may even decrease in future.

While much charging is likely to be at low charging speeds at places where people have parked for a number of hours (home, work, shops, cinemas, stations), fast chargers will be needed to power longer journeys and potentially, as distribution fleets move to EV, also larger vehicles. Therefore, the different EV charger types described in Table 1 below should be seen as complementary – i.e. all will be needed in different circumstances. Additionally, Table 2 gives an indicative overview of new connections for different EV charger types.

Table 1: Charger types – illustrative example

	Slow	Fast	Rapid
Power rating[13]	3.5–7kW	7–22kW	43–50kW or more[14]
Electrical supply type	AC	AC and DC	AC and DC
Time to charge (empty to full)[15]	6–11h	2–6h	48–56min or less
Time to charge (typical daily use of 10kWh)[15]	1.5–3h	0.5–1.5h	Less than 15min
Range added in 15min[15]	3–7 miles	7–23 miles	45–53+ miles

Example

If you have 50kW of spare network capacity at your site, you can add either **14 slow, 7 fast, or 1 rapid** charger. This affects how many vehicles can be charged at the same time.

Also consider how long people are likely to be parked for; at an office site people may be parked for 4-8 hours at a time, therefore a slow charger may meet their needs – and may be better for some EV batteries. Consider several solutions – with solar PV, storage (e.g. onsite batteries), or a flexibility arrangement you might be able to offset the increase in electricity demand. If you require assistance with your connection or weighing up the options, you can contact one of our local engineers or book a surgery[16].

Things you may want to consider:

— **What is the minimum requirement to fulfil your needs?** Specifically, thinking of:
  – Number of charging points needed
  – Number of cars using the charging points at the same time
  – Amount of time EV drivers will spend at your premises and the likely hours of charging
  – Transport alternatives
— Available (existing) connection at your premises
— Whether the charging can be matched or offset by other LCTs
— Battery degradation/heating
— Flexible/smart charging arrangements
— The need or the potential for shared ownership (see *Community-owned EV infrastructure* case study for more information).

[13] For comparison, the power rating of an electric kettle is between 2-3kW.
[14] Ultra-fast EV charging points have the power rating of 120-350kW.
[15] Based on assumed battery capacity of 40kWh.
[16] For contact details, please see northernpowergrid.com/contact-our-connections-engineers. For a list of upcoming Customer Surgeries, please see northernpowergrid.com/customer-events-and-surgeries

How to get your charger connected

We have introduced a new process and a single form to simplify the connection process for EVs. The dedicated section on our Connections webpage[17] provides additional information on the new connection process.

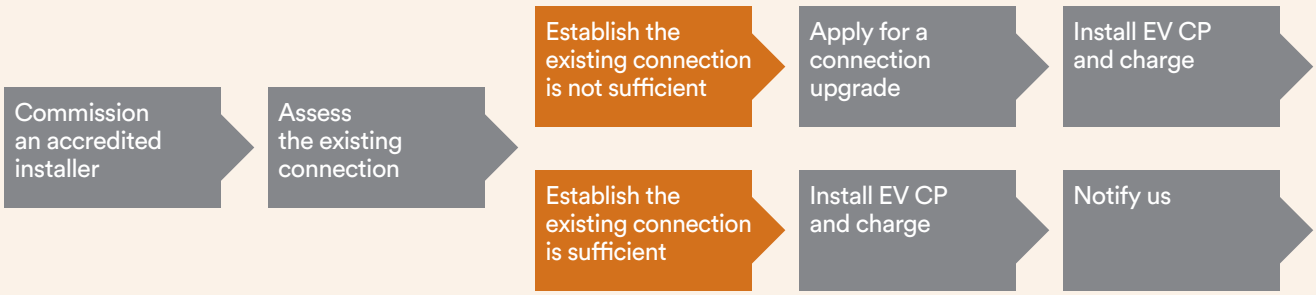
To install a charging point, the first thing to do is to commission an accredited installer who can assess whether the existing electricity supply can support the new charging point(s).

For new installations
the installer will need to visit our Connections Services webpage and 'Apply for a connection service'[18].

For existing connections
the size, type and location of the installation will need to be assessed. To ensure the safety and security of the network, you may need to apply for a connection prior to the installation. However, under certain conditions, you may be able to connect and notify[19] us within 28 days of the installation.

For bigger connections
the demand availability map[20] is a useful tool to determine if the connection could be accommodated by the existing grid infrastructure if you are considering a charger with a higher power rating or a large volume of chargers e.g. for a car park.

Figure 4: Step-by-step process for adding an EV charging point to an existing connection



Current actions	Next steps
✓ An ENA-standardised notification form is available online	✓ We are continuing to work with other DNOs in ENA LCT group to further improve the notification process for EV chargers
✓ Connection process turnaround for an existing connection in domestic property takes less than 10 days	✓ We are working to develop self-service tools on our website (see the *LV budget estimating tool* case study)

[17]Available from: northernpowergrid.com/get-connected/
[18] For Connections Services website, please follow: myservices.northernpowergrid.com/connections/index.cfm
[19]Available from: northernpowergrid.com/asset/0/document/3849.pdf
[20]Available from: northernpowergrid.com/demand-availability-map

Table 2. Overview of new connections (indicative)[21]

	Unmetered	Small	Medium	Large	Very large
Typical for...	Street lighting	Domestic property single phase connection	Small commercial property, e.g. petrol station, multi-storey car park three-phase connection	Medium commercial, e.g. motorway services, future petrol stations and car parks low voltage current transformer metered connection	Industrial, e.g. factories and future motorway services high voltage current transformer metered connection
Capacity sought	≤1.4kW*	≤18kW	≤55kW	≤276kW (fuse) OR ≤1.1MW (air circuit breaker)	≤8MW
Typical charger power rating	1.4kW*	up to 7kW	up to 43kW	120-350kW	350kW
Average time to quotation	≤20 working days	5 to 17 working days	17 working days	24 to 54 working days	24 to 54 working days
Average time to connect following payment	5 weeks	10 weeks	19 weeks	19 to 29 weeks	29 weeks
Average price	c. £600 to £3,000	c. £600 to £1,500	c. £11,000	£11,000 - £95,000	£95,000+**
Time to charge (for typical daily use of 10kWh)***	7¼ hours	1½ hours	15min	2-5min	2min

*More capacity may be released following a site specific assessment to determine whether the street light cut-out can safely accommodate the new load under this operating cycle

**More expensive if the location of the sought connection is far from primary substation

***Based on assumed battery capacity of 40kWh.

[21]For more information, please refer to: https://www.northernpowergrid.com/guide-prices-and-timescales/standard-connection

If you are a Local Authority...

You might want to consider discussing your future plans for EV charging with Northern Powergrid at the early stages of any project.

This can include the EV charging infrastructure for new or retrofit solutions for car parks, buildings, on-street charging solutions, and rapid charging stations on major roads. Once the LV budget estimating self-service tool is launched (see case study for more detail) you'll be able to explore the connection options in an area you are considering.

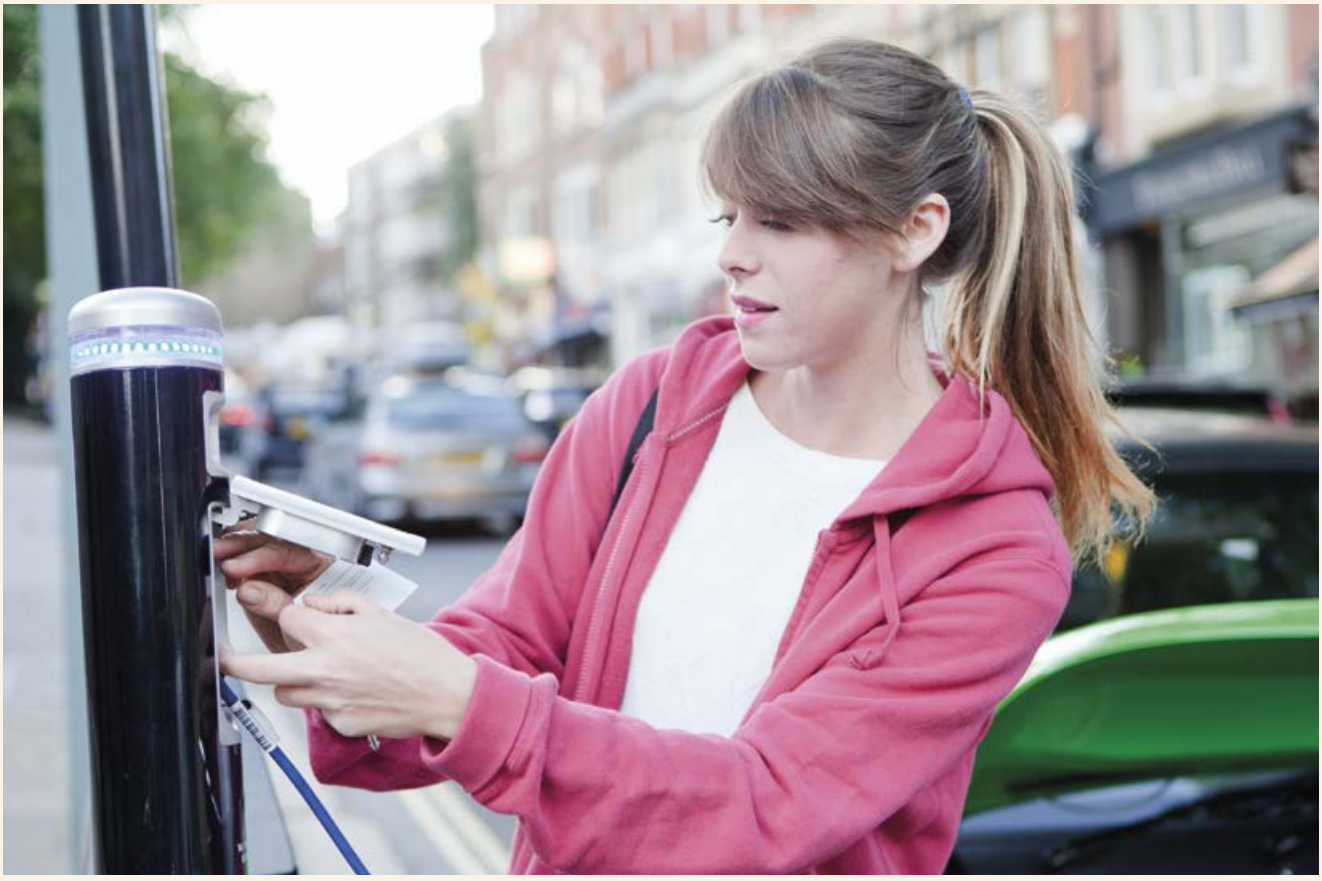
Once you have an initial proposal, our design and/or commercial engineers can engage with you to optimise the location, size and quantity of EV chargers to provide your community with a cost-effective charging network.

When a number of connections' applications are considered, this approach would ensure you are only charged connection offer expenses once, saving public money and in a time-efficient manner.

Where your plans exceed the capacity of the local electricity network, we can explain how a flexible connection could help to reduce any reinforcement costs and associated timescales.

This can be discussed with your local design team manager[22] or by attending one of our surgeries[23].

SafeDig[24] is a tool you might find useful in the process, as well as our demand availability map[25]. Please also refer to the *Innovating to deliver more value for customers* section for an overview of local (and national) challenges and opportunities we are working to address.



[22]For contact details, please see northernpowergrid.com/contact-our-connections-engineers
[23]For a list of upcoming Customer Surgeries, please see northernpowergrid.com/customer-events-and-surgeries
[24]For more information, please see northernpowergrid.com/get-connected/safedig
[25]Available from: northernpowergrid.com/demand-availability-map

If you are a Local Authority...

If you are a Fleet Manager...

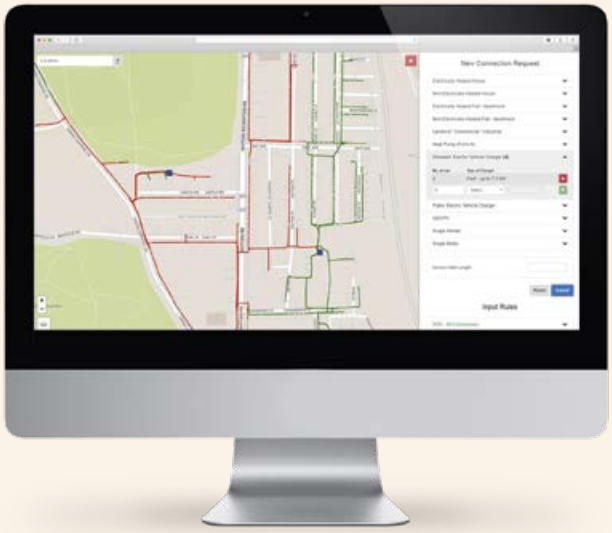
Case study:
LV budget estimating tool

This Network Innovation Allowance-funded project aims to develop a customer-friendly online self-service connections tool.

The interactive platform will assist the user in specifying the capacity required by guiding them through connections options. The tool will allow considering both single and multiple connections and include most of the common technology options, such as EV charging, home energy storage, and solar PV.

Once deployed, this new tool will enable customers to self-serve and assess the viability of their proposed connection ahead of making a formal application. Using the capacity requirement details, it will display the desired location and show existing network assets and indicate their ability to service the proposed connection. In this way, the tool will guide them towards the most cost-effective and viable connection option, potentially within minutes.

It is planned that, by 2020, the tool will enable customers to produce their own budget estimates as a guide and, in most cases, avoid the costs of requesting this work from us.



If you are a Fleet Manager...

To get the best value out of electrifying your fleet, you might want to start planning the project early.

As the number of EVs on our roads is increasing, you might be planning to install EV charging points at your company site(s) to allow employees or visitors to make use of workplace charging facilities. Likewise, you might be introducing EVs into your fleet and want to examine and better understand the infrastructure needed to support their charging.

In order to determine the spare capacity available for EV charging, you will need to check the authorised supply capacity of your site(s), as well as the maximum existing demand. If the spare capacity is sufficient for the number of charging points you are planning to install, you will be able to proceed and subsequently notify Northern Powergrid when you have connected the charging points, as outlined in the section *How to get your charger connected*.

Where your plans exceed the spare capacity available, you might want to have a conversation with Northern Powergrid at the early stages of your project. We will be able to advise you on increasing the size of your connection and to explain how a flexible connection could help to reduce any reinforcement costs and associated timescales. This can be discussed with your local Commercial Engineer[26] or by attending one of our surgeries[27].

There are various reasons companies quote for electrifying their fleets: to reduce CO_2 and NO_x emissions from their vehicles, to reduce fuel costs, and to avoid the cost of Ultra-low Emission Zone or Clean Air Zone charges. However, it still is not *business-as-usual* and requires a number of company-wide changes and careful planning. We have summarised the key learning points from our conversations with organisations who have commenced utilising EVs in their fleets and our own experience in this area (see case study *Electrifying an electricity company* for more detail).

These learning points are:
- Appoint a dedicated project manager
- Have your installer conduct site visits to assess the installation feasibility
- Have an early conversation with your DNO
- Factor in the vehicle delivery timelines – they can sometimes be several months due to manufacturing demands
- Expect the infrastructure installation to take longer than you initially planned and to potentially cost more than estimated
- Identify all internal and external policies and planning procedures that will need to change
- Depending on where the vehicle is parked during the day and overnight, make a decision about where and how you would like to manage the charging.

[26]For contact details, please see https://www.northernpowergrid.com/contact-our-connections-engineers
[27]For a list of upcoming Customer Surgeries, please see https://www.northernpowergrid.com/customer-events-and-surgeries

If you are a Local Authority...

If you are a Fleet Manager...

Case study:
Exploring vehicle-to-grid opportunities

Innovate UK funded e4Future[28] consortium project aims to assess the technical and commercial viability of aggregating electric vehicle fleets to provide flexibility services to the UK power system.

The project intends to understand best practices and determine the benefits for stakeholders in the V2G value chain – with a focus on automotive manufacturers, utilities, electricity network companies and electric vehicle owners.

Participants sought at this time are typically EV fleet operators. Among other things, the e4Future project hopes to quantify whole system benefits of V2G, test the impact of V2G on the electricity network, and provide V2G policy recommendations.

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e·on

Imperial College London

nationalgrid

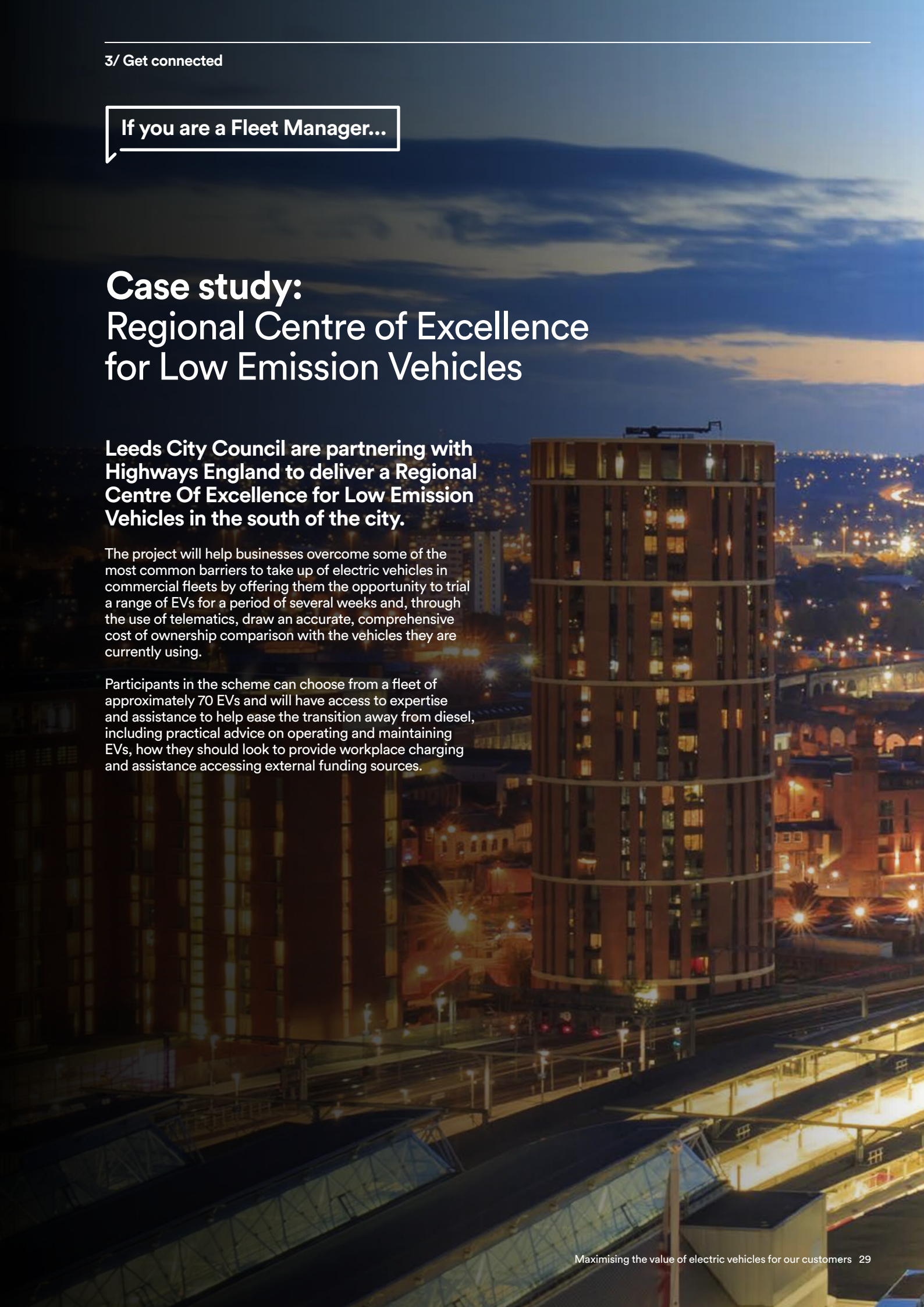
Newcastle University

UK Power Networks
Delivering your electricity

[28] UKRI. e4Future. Available from: https://gtr.ukri.org/projects?ref=104227
See also: Northern Powergrid, 2018. 1000 vehicle-to-grid chargers to put UK at forefront of electric vehicle revolution.
Available from: https://cms.npproductionadmin.net/innovation/news/1-000-vehicle-to-grid-chargers-to-put-uk-at-forefront-of-electric-vehicle-revolution

If you are a Fleet Manager...

Case study:
Regional Centre of Excellence for Low Emission Vehicles



Leeds City Council are partnering with Highways England to deliver a Regional Centre Of Excellence for Low Emission Vehicles in the south of the city.

The project will help businesses overcome some of the most common barriers to take up of electric vehicles in commercial fleets by offering them the opportunity to trial a range of EVs for a period of several weeks and, through the use of telematics, draw an accurate, comprehensive cost of ownership comparison with the vehicles they are currently using.

Participants in the scheme can choose from a fleet of approximately 70 EVs and will have access to expertise and assistance to help ease the transition away from diesel, including practical advice on operating and maintaining EVs, how they should look to provide workplace charging and assistance accessing external funding sources.

If you are a Fleet Manager...

Case study:
First of a kind: Fast charging station in Sunderland

In April 2019, Fastned opened its first fast charging station in the UK. The station in Sunderland has four 50kW fast chargers and two 175kW fast chargers that are already enabled for 350kW charging. The station canopy is covered with solar panels, and all electricity supplied to drivers comes from the sun and wind.

We worked with Fastned to extend our HV network and add a new loop-in substation which meets Fastned's import and export requirements.

"We are very proud of having opened the UK's first 350kW fast charge station here in Sunderland. The Northern Powergrid Connections team worked flexibly and proactively with us to get our HV infrastructure delivered quickly and on budget. We are building another six facilities in the North East this year and continue to receive a good service as we ready the next grid connections. We know our new stations will support the increasing number of EV owners in the region."

Thomas Hurst
UK Network Development Manager at Fastned

Photo credit
Fastned, Go Ultra Low North East


Fastned
KR19 OGX
Wearside

If you are a Local Authority...

If you are a Fleet Manager...

Case study:
Community-owned EV infrastructure

Community-owned EVs and community-owned EV charging points[29] are another option for delivering value in situations where parking space is shared and/or where costs of the infrastructure are a barrier. They can also be a good fit for existing community energy schemes looking to maximise the value from their renewable generation.

Most community energy schemes in the UK supply renewable energy, energy efficiency, and carbon emission reduction to the local communities via projects wholly owned and/or controlled by them. Community Energy England believe that we could see more of EV-related community schemes in the future.

"In 2018, 29 community energy organisations were actively involved in low-carbon transport projects, 8 of which were installing charging infrastructure.

Not only does this provide access to a means of low-emission transport supported by renewable energy, but it also provides new revenue streams for community energy organisations, as well as a learning opportunity for the wider community. We are seeing an increasing interest in EVs amongst our members and expect to see the growth of similar schemes in the future."

Emma Bridge
CEO of Community Energy England

[29]For more information, visit Community Energy England website http://communityenergyengland.org/
See also: Community Energy England State of the Sector Report 2019 communityenergyengland.org/pages/state-of-the-sector-report-2019

Technical design policy updated to ensure clarity on connections

We continuously update and improve our policies to provide clear guidance to our customers.

We have updated a number of our design policies to provide clear guidance on the assessment process of EVs to both our staff and third parties such as independent DNOs and independent connection providers to accelerate their connection.
To date, we have:

Updated the diversity figures used for 16A and 32A charging points installed at domestic premises[30] as well as our design demand calculator to reflect these changes[32]. This is to ensure that we make less conservative assumptions when we build new infrastructure.

Reviewed the standard sizes[30] across the whole of our asset suite to ensure that the selection of circuit conductors and transformers is based on the development of an efficient, coordinated and economic system that allows for an annual load growth and ensures distribution losses are as low as reasonably practicable. The economically efficient sizing of assets combined with the network interconnectivity increases the available capacity and improves power quality.

Published clear guidance on how to assess larger EV charging facilities installed at domestic and non-domestic premises, as well as public locations, and provided guidance to allow the installation of unmetered EV charging points in street lighting columns under certain circumstances[30].

Provided further clarity on earthing arrangements for EV charging points[31].

Updated our Standard Design Rules[33] to accelerate the connection of EVs by providing quick and easy assessment rules for internal members of staff and third parties.

Current actions	Next steps
✓ Updated diversity figures for 16A and 32A chargers	✓ Continue to develop our policy by including learning from innovation projects
✓ Provided guidance on EV charging facility access	✓ Continue to monitor national activity and update policies accordingly
✓ Facilitating installation of charging points in street lighting columns	✓ Continue to participate in ENA technical working groups
✓ Further clarity on earthing arrangements	
✓ Updated Standard Design Rules	

[30] Codes of Practices for the Economic Development of the LV, HV and EHV systems, all accessible from: northernpowergrid.com/document-library/
[31] Code of Practice for Earthing LV Networks and HV Distribution Substations accessible from: www.northernpowergrid.com/document-library/
[32] NPg Design Demand Calculator V2.0 accessible from: northernpowergrid.com/document-library/
[33] Code of Practice for the Point of Connection assessment using Standard Design Rules for Low Voltage Connections up to 60kVA, accessible from: northernpowergrid.com/document-library/

4 / Future developments

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Innovating to deliver more value for customers

We have a number of innovation projects exploring the potential benefits EVs could bring for our customers and the energy system.

The evolution of an EV charging infrastructure will drive increased demand in electrical energy and higher peak loads in the electricity systems, perhaps adding 2-3% to total annual network costs[34].

Localised clusters of EV charging can lead to thermal or voltage issues on the LV network and at local distribution substations (20/11kV to 230V), for example, if clustering occurs on a single street. This can also result in a longer-term, wider impact at higher voltage level primary substations, amongst other infrastructure, as simulated in the models described in the section *Forecasting potential EV uptake,* and increases in network use.

— This impact has also been explored within innovation projects, such as Customer-Led Network Revolution (CLNR)[35] and My Electric Avenue[36]. In addition, Electric Nation[37] has carried out some work on power quality impact from clusters of EV chargers.

— We have built learning on domestic charging usage trials from CLNR and My Electric Avenue into our LV design policy to derive demand assumptions to be used in design studies. This is in addition to the updating of the national P5 planning standard where our observational learning on customer trials provided evidence.

— Consideration should also be given to the interaction electric vehicles might have with other LCTs (i.e., EVs in context of a low-carbon home). In particular, we know that some customers are benefitting from charging their EVs directly from their rooftop solar generation, minimising their costs and the impact on our network. In other places, EVs may interact with home heating and further add to the evening peak demand on the system and attention needs to be paid to network loading.

However, the spread of EVs will significantly increase the penetration and the embedding of storage at the lowest levels of our networks, an outcome that may allow for potential V2G services to our transmission and distribution grids.

There are areas of potential benefit associated with utilising flexible load and the storage inherent in EVs, and on potential impacts, particularly on demand diversity[38], if others choose to make use of those same features. These benefits may reduce network costs by entirely offsetting the increase. They may equally provide a greater benefit in reducing generation and storage costs and, to some extent, a choice may be needed between the areas of benefit.

[34] Vivid Economics, 2018. Accelerating the EV transition.
[35] CLNR, 2015. Electric Vehicles. Available from: http://www.networkrevolution.co.uk/customer-trials/domestic-customer-trials/electric-vehicles/
[36] SSEN. My Electric Avenue. Available from: http://myelectricavenue.info/
[37] WPD. Electric Nation. Available from: http://www.electricnation.org.uk/
[38] Diversity is understood as the variation of actual electrical demand. This variation occurs as every piece of the electrical equipment connected to the network is not used simultaneously.

We are exploring these opportunities through a number of innovation projects:

Enhancing resilience

Silent Power

We are working on an alternative to mobile diesel generation which we use to supply customers who would otherwise be off supply due to small local power cuts. Diesel generations are noisy, produce CO_2 and NO_x emissions and are incompatible with significant quantities of rooftop solar generation (where generation may outstrip domestic demand at times of day). They are not therefore the future of power restoration. A van carrying a payload of batteries and power electronics might be used as a mobile microgrid to give us that future solution and the Silent Power project is building three such vans for testing the concept.

Microresilience

Our Microresilience project will show how batteries and local generation can maintain electricity supplies to isolated communities and critical infrastructure in the event of a power cut. We are trialling solutions at four sites with different needs:

- two lifeboat stations, which are at greatest risk of losing power in storms when their services are needed most;
- a remote village supplied by a single 60km overhead line, which is vulnerable to high winds; and
- Newcastle Swing Bridge, which requires a dedicated power source when it is open.

The project will trial systems which can switch seamlessly from the National Grid to a microgrid without any interruption in supply.

Resilient Homes

Some of our customers are dependent on home electrical supplies for their medical needs and are therefore at greater risk if there is a power cut. This project is testing whether a simple battery and changeover switch can provide a crude (and therefore cheap) but effective solution to keep their lights and medical equipment on while we are working on restoring supplies from our network. In future, solutions such as this might provide an opportunity for re-purposing EV batteries.

Customers supporting the grid

Vehicle-to-grid
We are undertaking the installation of V2G EV chargers to explore technical standards and barriers to the adoption of this technology. This has much more potential to offer value to customers due to the scale of the demand side resource.

e4Future
We are working in an Innovate UK funded industry consortium to determine the benefits for stakeholders in the V2G value chain. Please see case study *Exploring vehicle-to-grid opportunities*.

Gendrive
Building on our successful Activating Community Engagement[39] project, GenDrive[40] is testing whether social media and gamification can significantly influence EV charging load and thereby provide a route to reducing reinforcement.

Improving customer service

LV budget estimating tool
We are developing an online connections self-service tool for connections. Please see case study *LV budget estimating tool*.

Impact assessment of LCTs on the design of LV network[41]
This is a modelling project that seeks to quantify and assess the technical impact that the significant integration of EV charging load causes on the thermal and voltage limits of the LV network and devise a simple and robust framework that designers can apply during their assessments.

Current actions

✓ 8 innovation projects focusing on EVs

Next steps

✓ Continue to develop our learning by investing in innovation projects

✓ Review of our Innovation Strategy

[39] For more information, please refer to: http://www.northernpowergrid.com/ACE
[40] For more information, please refer to: https://gtr.ukri.org/projects?ref=104225
[41] For more information, please refer to: https://www.smarternetworks.org/project/npg_nia_033

Case study:
Electrifying an electricity company

We are installing a total of more than 40 regular (uni-directional) and V2G charging points at our company sites as the first phase of charging infrastructure roll-out. These charging points not only allow charging of our fleet, colleagues' and visitors' vehicles, but also generate valuable knowledge about how we can respond to infrastructure requests from our customers.

We have started introducing EVs by adding five electric pool cars and three electric Silent Power[42] vans to our fleet. We are committed to developing a fleet that will comply with the UK decarbonisation and air quality targets.

We are planning to accelerate the introduction of zero emission electric vehicles into our fleet with the purchase of an additional 10 electric vans for use by urban rapid response teams and the substation inspectors.

Our fleet vehicles often operate in areas where no electricity is available, either being called out to reinstate supply after a power cut, replacing assets, or attending sites in rural areas. We therefore must carefully consider our options alongside our promise to provide a reliable network for our customers.

As more technological advancements are made for electrifying larger vehicles, we expect to be able to fulfil our ambition to gradually transition our fleet to incorporate an increasing amount of ultra-low-carbon vehicles.

40+

regular (uni-directional) and V2G charging points

We are committed to developing a fleet that would comply with the Low Emission Zones

[42] See section *Innovating to deliver more value for customers* for more detail on Silent Power project.

Industry developments supporting EVs

The ongoing work to enable accommodating more EVs on the system is not limited to activities carried out by DNOs only.

There are a wide range of energy system development actions that are required, many of which have been captured in the Government's Smart Systems and Flexibility Plan[43].

Retail market developments

To support smart charging, suitable market arrangements are needed to send the appropriate commercial signals to users, ultimately in the form of flexibility services, such as:

— the roll-out of **smart meters;**
— the introduction of **half-hourly settlement;**
— **ToU tariff** propositions. We believe any tariffs should be designed to be:
  – fair – in terms of the distributional impacts across society;
  – efficient – tariffs that suit and enable the use of smart appliances, including EV chargers, and are fit for the energy system of the future;
  – visible – under the existing arrangements, distribution use of system (UoS) charges[44] are levied on energy suppliers and are often not reflected to the end users.

Network charging

We see three areas of network charges that should be considered simultaneously to ensure that appropriate cost signals are sent once and only once:

— **Connection charges –** baseline connection charges should be offered with the option to participate in flexibility services should the network require them;
— **Flexibility contracting –** in areas where the connection or dispatch of demand or generation would be beneficial. Contracts could also allow the specification of duration and specific activation conditions. Costs would need to be based on a maximum willingness to pay based on present value of avoided network investment; and
— **UoS charges –** if locational cost signals are being sent by flexibility contracts, there is no need for UoS charges to send any overly complex signals, and UoS could focus on the recovery of efficiently incurred sunk costs. The framework for efficiently recovering network charges is currently being reviewed via Ofgem's Targeted Charging review – Significant Code Review[45].

DSO role at the heart of the smart, flexible system

From a DNO perspective, a combination of low voltage (LV) board monitoring and load flow-based analysis using smart meter data would need to be used to initiate a commercial response or, in the worst case, some form of managed charging to protect the network assets. In the future, network monitoring systems could be used by the DSO to initiate or inform smart charging regimes in local areas.

We believe that DSO will be a simplifying force in the energy system and central to enabling customers' participation in both energy and network services markets[46]. The transition to the future role of DSO and what this would entail is being considered through ENA Open Networks project[47]. In parallel, work is ongoing to consider the future role of the electricity system operator (ESO). Flexible load (see section *EVs as a key part of our customer flexibility strategy* for more information) should provide a route to market for EV load to deliver services to the ESO and DSOs.

[43] HM Government, 2017. Upgrading Our Energy System. Smart Systems and Flexibility Plan.
[44] Please refer to the *Glossary*.
[45] Ofgem, 2018. Targeted Charging Review: Significant Code Review. For more information, please refer to https://www.ofgem.gov.uk/electricity/transmission-networks/charging/targeted-charging-review-significant-code-review
[46] For more information, please refer to https://www.northernpowergrid.com/DSO
[47] For more information, please refer to http://www.energynetworks.org/electricity/futures/open-networks-project/

Enhancing open data

We are building our data capability as per the Energy Data Taskforce recommendations. We already share some raw data sets and reporting on our website, but the concept of open data challenges us to do it in a way that creates more value for more stakeholders.

As set out in our DSO v1.0 thinking, the potential benefits for us are that we see data not only as a way to do our job better in managing an increasingly active network but also that we may support those parties delivering energy services to customers. Part of our vision for DSO is that if we publish more data, then parties delivering new products like innovative tariffs for electric vehicle charging may provide a better service (for example, cheaper charging of vehicles when networks are less congested).

In order to develop our capabilities on data and analytics, we have established partnerships with Peak Indicators, Newcastle University and Open Data Institute (ODI) in Leeds. These partnerships will help us deepen our skills and understanding of open data, and explore and realise the potential of data sharing.

Alongside smart metering and smart charging hardware, there will be a greater need to incentivise efficient use of existing assets in order to defer or avoid traditional reinforcement and a corresponding increase in costs. In particular, charging EVs is likely to require a strong price signal to incentivise users not to charge at the time of system peak. If a cost signal (e.g. to charge EVs away from peak periods) is to be given through ongoing usage charges, it should be unit charges that are used, as these can give an immediate benefit from a change in behaviour.

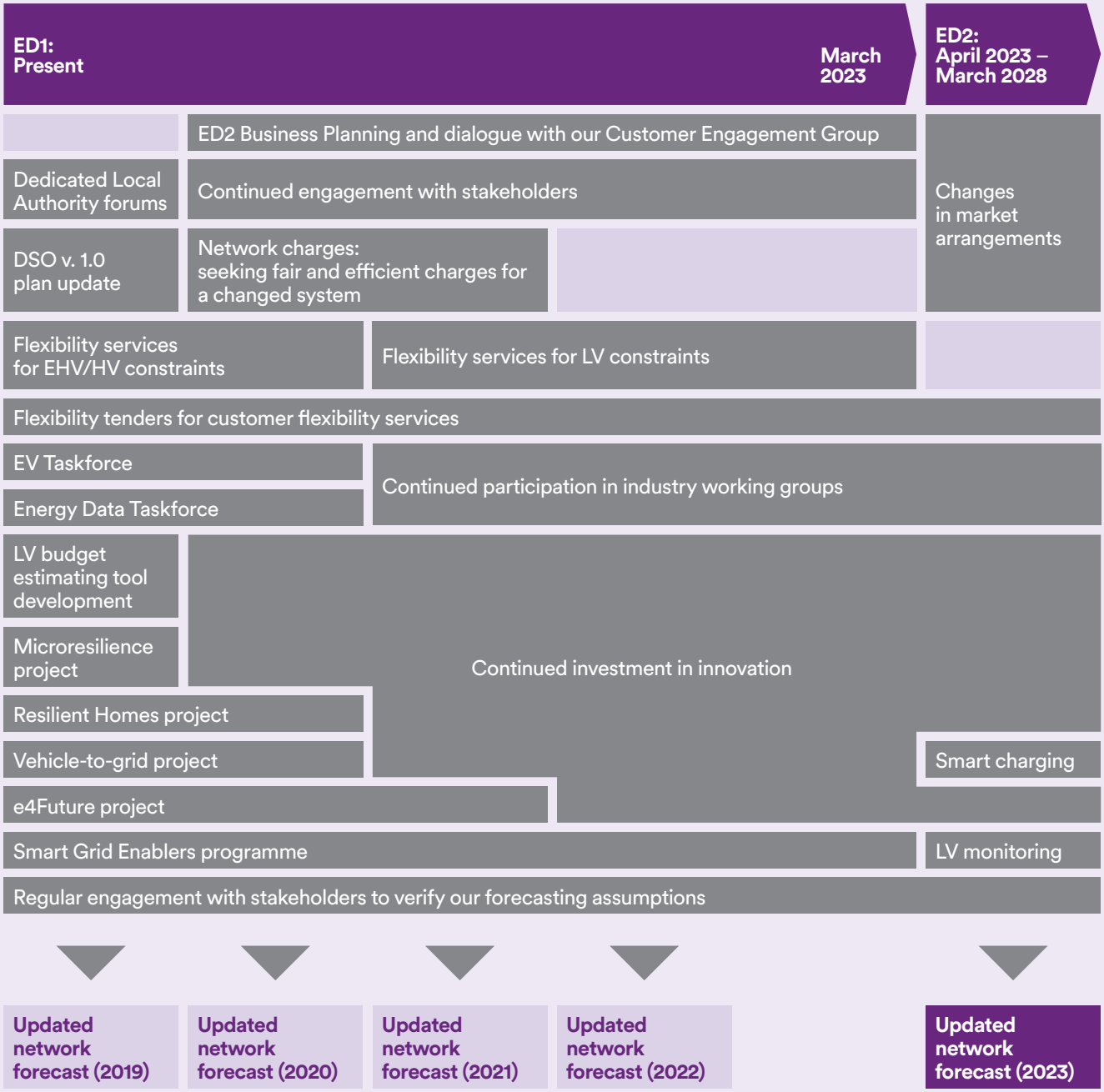
In addition, we believe there is more work to be done by the industry to ensure inter-operability of the charging infrastructure. This is especially important for managing the access to charging points where a multitude of solutions exist, dependent on the charging point manufacturer and/or operator.

Further, to enable the smart charging of EVs, users will need to have a smart charger, the specification of which will need to be provided by the Department for Business, Energy & Industrial Strategy or OLEV. Introduction of secondary legislation will be needed to specify the necessary functionality.

Current actions
✓ Smart Grid Enabler roll-out
✓ Energy Data Taskforce
✓ Participating in industry working groups

Next steps
✓ Changes in market arrangements
✓ Smart charging
✓ Flexibility services
✓ Outcome of the Targeted Charging Review
✓ Smart and inter-operable charging points
✓ Transition to DSO

Our next steps



Glossary

CP:
Charging point

DNO:
Distribution Network Operator

DSO:
Distribution System Operator

DUoS or UoS:
(distribution) use of system charges, charges that are levied for the use of a distribution network

EHV:
Extra high voltage (132 kV/66 kV/33kV)

ESO:
Electricity System Operator

EV:
Plug-in electric vehicle

Fast Charger:
For the purposes of this document, an EV charger with (usually) up to 22kW power rating

Flexibility:
One's ability to shift their demand or generation to a different time

HV:
High voltage (20 kV/11 kV/6.6 kV)

kW:
Kilowatt – one thousand watts of electrical power

kWh:
Kilowatt hour – a measure of electrical energy equivalent to a power consumption of one thousand watts for one hour

LCTs:
Low-carbon technologies. Technologies that have the ability to reduce the emissions associated with energy consumption (e.g. electric vehicles, heat pumps, solar panels)

LV:
Low voltage (<1000V)

Rapid Charger:
For the purposes of this document, an EV charger with (usually) a power rating above 22kW

RIIO ED1:
The current price control period for electricity distribution network operators which runs from 1 April 2015 to 31 March 2023

Slow Charger:
For the purposes of this document, an EV charger with (usually) up to 7kW power rating

Solar PV:
Solar photo-voltaics, solar panels

ToU:
Time-of-use tariffs. Tariffs that reflect the true cost of electricity based on the time, i.e. higher at peak times and lower at times when the demand is low.

V2G:
Vehicle-to-grid, a technology with capability of exporting the electricity stored in the vehicle battery back to the grid or a building, etc.

Contact us

We believe that our customers and stakeholders are the best judges of our performance. We always want to hear your views and opinions on the services we provide and your ideas for what we could be doing. If you would like to comment, you can contact us in a number of ways:

By email
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(for power cut information and advice)

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(for information about the company and the work we do in communities)

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