UK Power Networks
Delivering your electricity

Network Innovation Allowance Annual Summary

Progress and results from 2021/22

July 2022

Contents

Foreword

A culture of innovation that has been developed over the seven years of RIIO-ED1 reaches to the very heart of UK Power Networks. Innovation is not confined to a single department or to a handful of passionate individuals, but to our teams across the business. From tree cutting to customer service, field engineers to telecoms specialists, an innovative approach to how we approach challenges is delivering benefits for our customers today and for the future.

It is this innovative culture that has seen us achieve an industry leading position of deploying innovative solutions into our business-as-usual (BAU). In a time of unprecedented change, a culture of innovation is critical to ensure we have a network capable of delivering the lowest cost, safest and most reliable possible service.

The 2020s is the decade of change, where Net Zero will become a reality for many of our customers. For this to happen, we have a responsibility to ensure our offering and the network is ready for Electric Vehicles (EVs) to connect and charge. There is still a long way to go to ensure a Net Zero transition is inclusive for all. Our collaborative approach with industry leaders and working closely with local authorities has helped us lead from the front in our industry.

By 2025 there will be over 300,000 EVs in our network areas alone, in addition to more and more people switching to electricity for their heating. With all these low carbon technologies (LCTs) connecting to the grid, we have a vital role to play in facilitating the transition to Net Zero.

We are already seeing an increase in LCT adoption, and it is only going to increase as we move into RIIO-ED2 from 2023 - 2028. It is essential we make sure our network is ready. From Connections to the Call Centre, everyone in our business will have a role to play.

The challenge of reaching the UK's legally binding Net Zero targets is too great for any one organisation or sector to achieve alone. That is why collaboration is key, and not just in the energy sector but by reaching out far and wide to seek out new partners with new insights. The success of Network Innovation Allowance (NIA) project Communiheat, our heat decarbonisation project with Community Energy South and Buro Happold, demonstrates the value new partnerships with high-quality data and insights can bring.

Given the pressures on our customers' finances and increasing energy bills, the climate change challenge, and the opportunity to innovate to support our customers in vulnerable circumstances, there has never been a greater need for innovators to tackle these macro challenges.

As we transition towards ED2 our focus will widen to deliver greater impact through innovation by evolving the pillars of our innovation strategy:

- Facilitating Net Zero
- Expanding Flexibility and Commercial Evolution
- Expanding to Whole Energy Systems
- Innovating to reduce Consumer Vulnerability
- Opening Data and maximising Digitisation

To make the most of the opportunities ahead we need creative thinking and long-term scalable solutions. If you have an idea or want to collaborate with us, we would be delighted to hear from you. Get in touch at innovation@ukpowernetworks.co.uk

Ian Cameron
Head of Customer Services and Innovation

Partnerships

As a company we collaborate with many organisations to identify opportunities and maximise outcomes for our stakeholders and customers. It also allows us to scale the impact of our service. For innovation, collaborating ensures that we have a diverse portfolio and get the best ideas from across the industry to solve pressing challenges.

Energy Innovation Charter

Last year, as part of the Energy Innovation Centre (EIC) partnership we formed a charter to commit to continuously improve the way we as Licensed Network Operators (LNOs) collaborate with each other and third parties while progressing how we work with innovators. The purpose of the charter is to join forces with gas, electricity, and water utilities to respond effectively to insights from the annual Energy Innovation Centre Innovation Innovator Insights report. These recommendations include providing better feedback on proposals submitted, rather than go/no-go outcomes; promoting a BAU adoption roadmap for each idea to help drive early engagement; and improving our procurement process.

Going forward we will continue to focus on making it easier for innovators to understand the problems we need solutions to, simplifying our procurement processes and ensuring the ideas we take on have a long-term roll out vision set for them. This doesn't mean that we will always get it right, but it gives us focus to continually improve the way we work with our innovation community.

Collaboration is key to successful innovation and has underpinned our success in this space over RIIO-ED1. Throughout this time, we have worked with traditional technology vendors, software start-ups, energy suppliers, vehicle and fleet operators, local public bodies, and Government to name a few. Since 2015, 75% of our NIA funding has been funnelled to third parties, with 38% of projects happening in direct collaboration with other LNOs

Third party access

The need to work closer with third parties continues to increase as we aim to unlock innovation and benefits across our communities and energy sectors. We continue to open access to innovation funding for innovators, at each stage of our innovation process, we will continue to strive to improve access for third parties:

Idea Review

This year we proved that our Innovation Council deliver great value. We will ensure our council continues to hold us to account for the ideas we choose to deliver and review the ideas that we have not taken forward.

Idea proposal

We will continue to engage with our innovation community including Small- and Medium-sized Enterprises (SMEs) through the EIC and co-create project proposals that benefit our customers.

Post idea approval

We will open the doors of our business operation and allow SMEs to have direct access to the challenge that they are trying to resolve with the aim of coming up with effective products and solutions.

Delivery

We will ensure that more third parties access our innovation funding, and that we collectively come up with solutions to guarantee wider benefits to our customers and stakeholders.

Our Innovation Strategy evolves

2021/22 has been an interesting year as we worked with stakeholders to inform our RIIO-ED2 business plan submitted in December 2021. Throughout that process innovation was a reoccurring theme. For that purpose, we updated our Innovation Strategy to reflect all the insights from engaging across the whole energy system.

One of the key findings from discussing the future with our innovation stakeholders is that everyone recognises that the challenges we face span the entire industry – and beyond – and require greater collaboration between parties to tackle them. As a result, our Innovation Strategy has made a shift. Our role going forward will be less focused on driving benefits solely within the network, for the benefit of consumers, to focus on being an enabler of innovation across the industry.

The path to decarbonise transport and heat is not fully clear, and the impact that this transition will have on customers' cost of living is a great concern for all. Coupled with that, the impacts of Covid-19 have highlighted that innovation needs to remain agile and open to understand customers' changing needs. Our Innovation Strategy must provide agility to face future uncertainties, leverage other sources of funding and remain open to disruptors. It must maximise the opportunities of seizing benefits across the energy value chain and provide a venue to collectively determine solutions that will unlock and deliver benefits to society.

Finally, these shifts will have significant implications for customers, therefore we recognise the importance of focusing our innovation efforts on ensuring no one is left behind in the energy transition.

As we transition towards RIIO-ED2 we will start to focus our innovation efforts on our wider role. This will see us going from our three pillars of Efficient & Effective, Net Zero ready and Future ready to adopting industry-wide focus areas of Net Zero, Flexibility and Commercial Evolution, Whole Energy System, and Consumer Vulnerability as key areas of focus. Additionally, our stakeholders have guided us to add Data and Digitisation as an enabler of these focus areas.

Our Innovation Strategy will continue to focus on maintaining the highest level of investment whilst leveraging our innovation culture, processes, frameworks, and experience of deploying innovation into BAU to fund more innovation ourselves where it will deliver benefits to our network and customers.

What our stakeholders are telling us

This year we have engaged on multiple occasions with our wide range of stakeholders. This engagement has helped us understand customer and stakeholder priorities. As a result, we have defined seven 'Keys to Success' to ensure we remain the best performing Distribution Network Operator (DNO) enabling the Net Zero transition for all. These keys to success relate to our focus on innovation, while we search for innovation partners and ideas, we will aim to find alternatives that enable us to:

- Deliver a brilliant service for all by staying in tune with customers' needs and expectations to deliver a responsive and high-quality service
- Facilitate decarbonisation at the lowest cost by maximising the use of the existing network with smart technologies and better data
- Invest to maintain a safe, reliable, and resilient network
- Deliver the lowest possible bills whilst enabling Net Zero by driving efficiency and innovation in everything that we do
- Be a force for good in the communities we serve by going beyond delivering a safe and reliable service at an affordable price and doing more to protect the environment and improve our communities
- Continue to be an employer of choice by attracting, developing, and retaining a skilled and motivated team
- Be a company that is worthy of the trust of our customers by acting with the highest standards of conduct and transparency in their interests

In previous versions of our Innovation Strategy we broke our focus areas into three pillars based on our stakeholders' priorities and they were:

1 **Net Zero ready**, an enabler of the low carbon transition, connecting electric transport, heat, generation and storage at the lowest cost, as well as ensuring sustainability of our operations to tackle the Net Zero challenge.

2 **Future Ready**, a future-ready distribution system providing new services, to meet our customers' evolving needs, whilst at the same time ensuring no one is left behind as a result of the energy system transition.

3 **Efficient and effective**, delivering value to customers and the business through innovation by enhancing network performance and reliability at the lowest possible cost.

Our RIIO-ED2 innovation themes

CONSUMER VULNERABILITY | NET ZERO & THE ENERGY SYSTEM TRANSITION | PROACTIVE OPTIMISED ASSETS & PRACTICES | FLEXIBILITY & COMMERCIAL EVOLUTION | DATA & DIGITALISATION | WHOLE ENERGY SYSTEM

Strategic Project Highlights

Strategic Project Highlights

Net Zero Ready

We are operating in uncertain times. Economies have reopened as we have emerged from the pandemic and alongside geopolitical turmoil the global demand for energy has surged. Volatility in international markets and rising global energy prices have been a consequence.

As one of the primary users of gas in Europe, the UK relies on this fossil fuel to generate around 40% of our electricity and heat 86% of our homes. Low gas inventories and storage leave us heavily dependent on European gas price volatility. The wholesale price of gas in the UK has risen sharply throughout 2021. Prices remain volatile and energy suppliers that are still in business are seeking to recoup losses resulting from their rising wholesale costs and the cost of taking on new customers from failed suppliers.

Drivers of petrol and diesel vehicles have been hit by increased oil prices, and electric vehicles (EV) drivers have not escaped either. While the cost of charging their EV increased less than for petrol and diesel vehicles, the worldwide shortage of raw materials such as lithium and silicon has increased EV prices and reduced availability.

A cost-of-living crisis has emerged, fuelled by the energy crisis. In response, the UK government released their Energy Security Strategy in April 2022 focusing on low carbon generation and the acceleration of nuclear and off-shore wind. Ofgem has responded to the rising gas prices by increasing the price cap to a historic high with further rises expected in 2022.

Against this backdrop, it is easy to lose sight of our Net Zero targets but arguably our reliance on fossil fuels is at the root of the energy crisis and the transition away from them is more important than ever. Local authorities, businesses and homes are taking action to protect themselves and their communities from rising energy costs. Whether customers are exploring distributed generation and storage options, seeking revenue opportunities, or looking at ways to optimise their energy use, DNOs remain a key facilitator in this transition.

The market share of EVs in the UK grew steadily throughout 2021 and with the 12-month rolling average increasing from 14% in March 2021, to over 21% in March 2022[1]. Charging infrastructure provision has not kept up with EV registrations but it remains on a strong upward curve as the number of charge point installations doubled from 2020 to 2021[2]. Heat pumps, heat networks and hydrogen are now widely considered the collective solution needed for decarbonising homes whilst the government has pledged to upgrade buildings to Energy Performance Certificate (EPC) Band C by 2035 where practical.

Innovation plays an important and necessary role in the transition. Exploring new business models, incentivising behaviours, testing new technologies, supporting, and enabling vulnerable consumers, improving processes and procedures underpinned by digitisation, and providing all customers with the tools and data they need to make informed choices.

Our innovation portfolio is as diverse as the challenges we collectively face. The Net Zero Ready highlights we have selected demonstrate this diversity:

Optimise Prime is the world's biggest trial of commercial EVs. It seeks to understand and minimise the impact that the electrification of commercial vehicles will have on distribution networks. Working with British Gas, Royal Mail and Uber, we are studying charging behaviour and investigating flexibility opportunities for return to home, depot based and mixed charging fleets respectively. We are also testing alternative network connection options and the provision of tools and data to support fleet managers in the EV transition.

White Van Plan is a research project aiming to support SMEs in their electric transport journey. With more than two million small businesses operating in our network we recognise that these businesses are more diverse and harder to reach than the larger corporate fleets. Through extensive engagement we are learning how they use transport and exploring potential technical and commercial solutions that will help facilitate the EV transition and reduce the impact on our network infrastructure.

1 UK Power Networks Market Intelligence Analysis - Apr 2022
2 UK Power Networks Market Intelligence EV Infographic - Nov 2021

Strategic Project Highlights

Net Zero Ready

Enable is undertaking research to gain a better understanding of the needs of EV drivers with disabilities. We estimate that nearly half a million drivers with disabilities will be partially or wholly reliant on public charging infrastructure within our areas of London, the South East and East of England. To help them make the switch to EVs and ensure no one is left behind in the transition to Net Zero we are working with Motability to identify actions that we can take to meet their specific parking and charging requirements.

Right to Heat seeks to develop a best practice template for decarbonising homes. Taking a whole system approach, we will explore a hybrid solution that sees an electric heat pump working alongside a traditional gas boiler. Focusing on high-density, smaller dwellings such as those in urban social housing settings, we are undertaking social research to assess the impact on consumers in vulnerable situations. Offering a level playing field to social housing tenants such that they can participate in the energy transition and future energy markets.

Transpower is investigating the network impact and potential for flexibility services for vehicle-to-grid (V2G) from domestic, commercial, and public charging through demonstrator trials and collaborative research and development. We have also been re-engineering our internal processes, introducing data-driven digital solutions, and testing new technologies to introduce an automated assessment approach that reduces customers' time and cost to connect and serves as a foundation for future innovation as the volume of LCTs connecting to our networks increases.

Strategic Project Highlights

Net Zero Ready

Optimise Prime

Background

For the UK to meet its Net Zero target, the EV share of new car and van sales must increase from today's 25% to up to 100% by 2030. Commercial vehicles will likely determine the speed of the UK's transition to low carbon transport with businesses buying 57% of new vehicles.

This creates a significant challenge for network operators as there has been limited study to understand or minimise network impacts of commercial vehicles going electric. Compared to vehicles used for domestic purposes, commercial EVs are expected to have a much greater impact on the electricity network due to higher energy requirements resulting from higher daily mileage and payloads as well as co-location of multiple EVs at a single site such as a depot.

Optimise Prime is the world's largest trial of commercial EVs. It seeks to understand and minimise the impact of the electrification of commercial vehicles on distribution networks. The project brings together partners from leading technology, energy, transport, and financing organisations to collaboratively design and trial technical and commercial solutions. These solutions aim to reduce customer costs and enable a faster transition to electric for commercial fleets and private hire vehicle operators.

As illustrated in Figure 1, Optimise Prime is built around three workstreams with three fleets. Each of these fleets has specific charging requirements: home charging for British Gas, depot charging for Royal Mail, and mixed charging, a combination of charging at home and on public charging infrastructure, for Uber's Plug-in Hybrid Electric Vehicles (PHEVs). Each charging model has its own unique challenges that also translate into specific network challenges. The project is gathering data from over 6,000 EVs driven for commercial purposes through these three trials.

Experience to date

Optimise Prime started in 2019, with the mixed charging trials starting in 2020 and the home and depot trials beginning on 1 July 2021. Since then, the project has been collecting journey and charging data from thousands of commercial EVs across the UK to build up a clear picture of the potential impact of EV growth on distribution networks. Alongside this, the project is trialling the effectiveness of new connection and flexibility services that could reduce the need for network reinforcement because of the EV transition.

We recently released the Site Planning Tool[1], making it quicker and easier for depot-based fleets to make the switch to EVs. A simple online system, it has been designed for any fleet manager to assess how to go electric at the lowest cost. The tool has been demonstrated to other DNOs and fleet operators, to capture feedback and ensure it is as easy to use as possible. We also presented it at a joint webinar hosted by Scottish and Southern Electricity Networks (SSEN) and Scottish Power Energy Networks SPEN), and at our Competition in Connections forum.

The output of the tool can also be used as a basis to obtain a profiled connection, which is an alternative connection type where the applicable maximum power requirement varies according to the time of day (up to 48 half-hourly time slots per day). Connection can be quicker and cheaper with the profiled connection, avoiding costly network reinforcement by consuming less electricity at times of the day when the network is constrained.

Key insights of these trials so far are summarised below.

Interim learnings from the home trials:

- When unmanaged, the peak charging demand from return-to-home vehicles is likely to occur between 17:00 and 20:00, coinciding with peak demand on the distribution network
- Smart charging has been modelled to significantly reduce peak demand from return-to-home vehicles if the load is balanced over a longer period and not just shifted to later in the day, as illustrated in Figure 2

1 Site Planning Tool Introduction — Optimise Prime (optimise-prime.com)

Strategic Project Highlights

Net Zero Ready

Optimise Prime

Interim learnings from the depot trials:

- Smart charging should deliver a reduction of peak demand for the networks as well as energy and connection cost savings for the depot operator
- Initial trials and modelling of profiled connections, illustrated in Figure 3, have shown that it should be possible to control EV charging to keep sites within an agreed profile
- Flexibility trials have shown an ability to control charging in response to flexibility requests from the DNO.

Interim learnings from the mixed trials:

- Charge demand from PHEVs is likely to peak in the evening as some drivers return home and others need to top up
- There is a significant number of locations in Greater London where drivers need to travel far during their shift (e.g. over two miles) due to limited availability of rapid chargers
- There is sufficient network capacity to support additional charging infrastructure to meet on shift Uber EV demand in Central London.

We continuously seek opportunities to disseminate findings from Optimise Prime. We presented project updates at the Cenex Low Carbon Vehicle conference jointly with SPEN's Charge project in September 2021, at the 2021 ENIC conference, and at COP26 to name a few.

Future developments

Trials are ongoing and planned to conclude in summer 2022. Data capture, analysis and trialling activities will continue over the coming months to build on our initial insights. The project is due to publish a dataset from the trials later this year, with final insights and results expected to be released in winter 2022/23.

UK Power Networks has developed a Site Planning Tool making it quicker and easier than ever before for fleets to make the switch to EVs. A simple online system, it has been designed for any fleet manager to assess how to go electric at lowest cost in a matter of minutes.

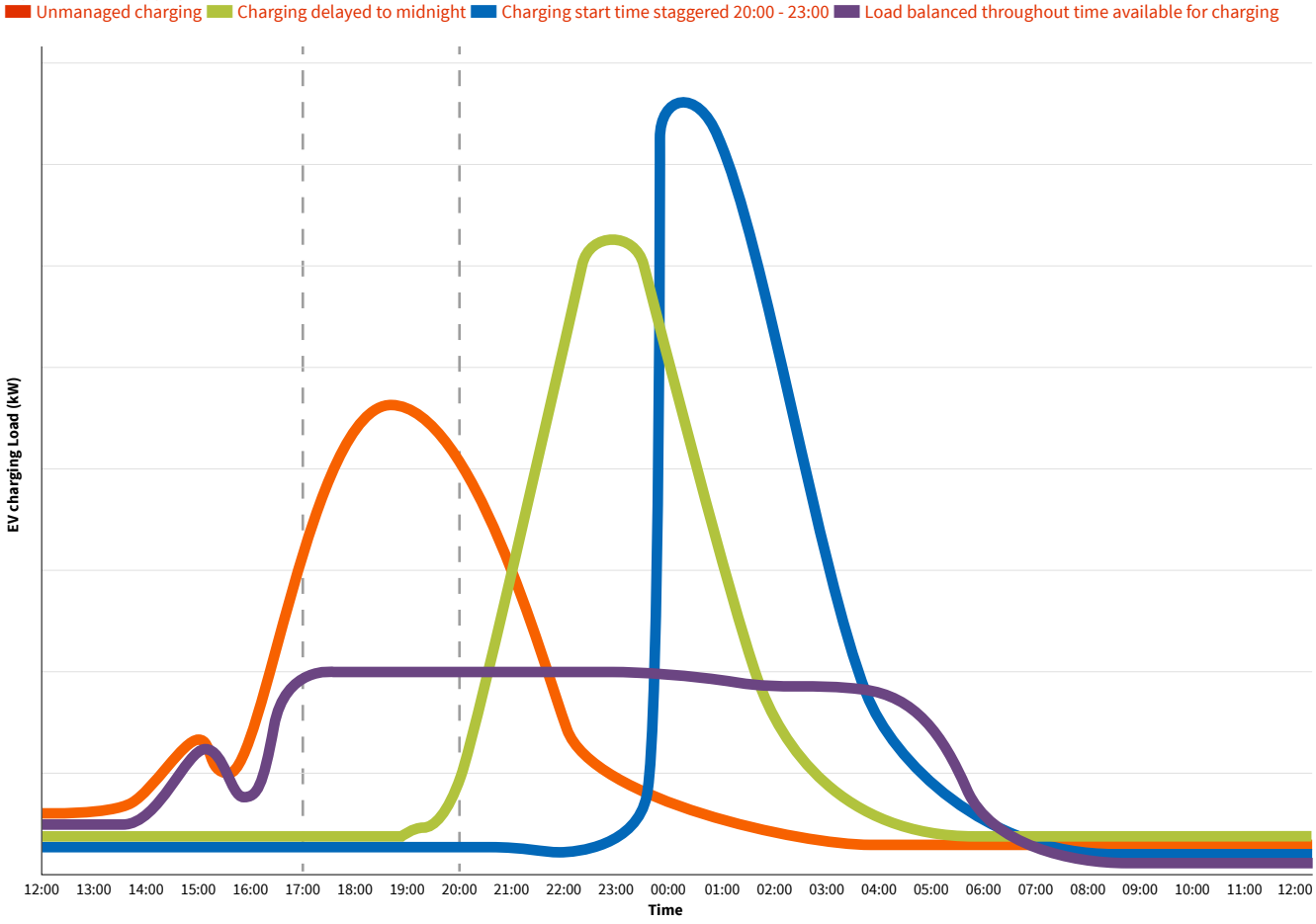
Figure 1 The Optimise Prime trials

Strategic Project Highlights

Net Zero Ready

Optimise Prime

Figure 2: Four charging scenarios, real power (in kW)



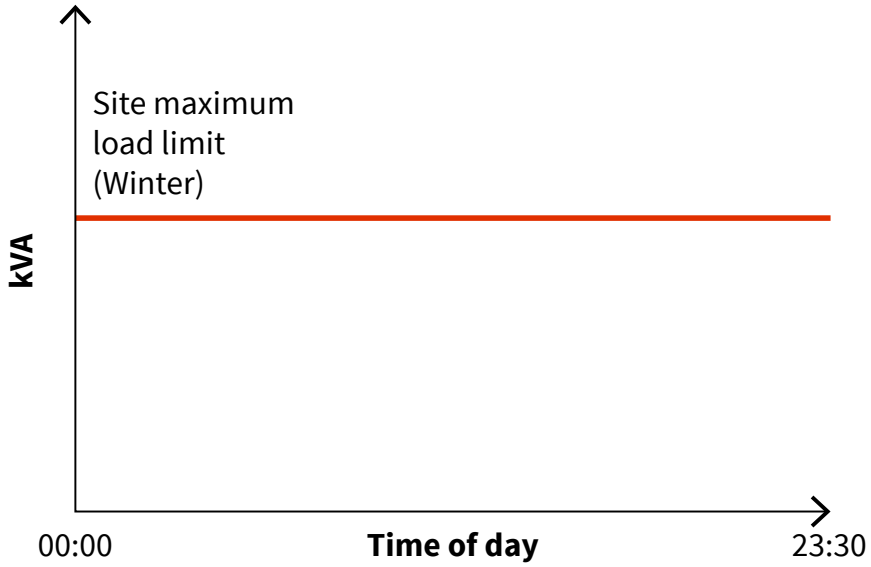
Strategic Project Highlights

Net Zero Ready

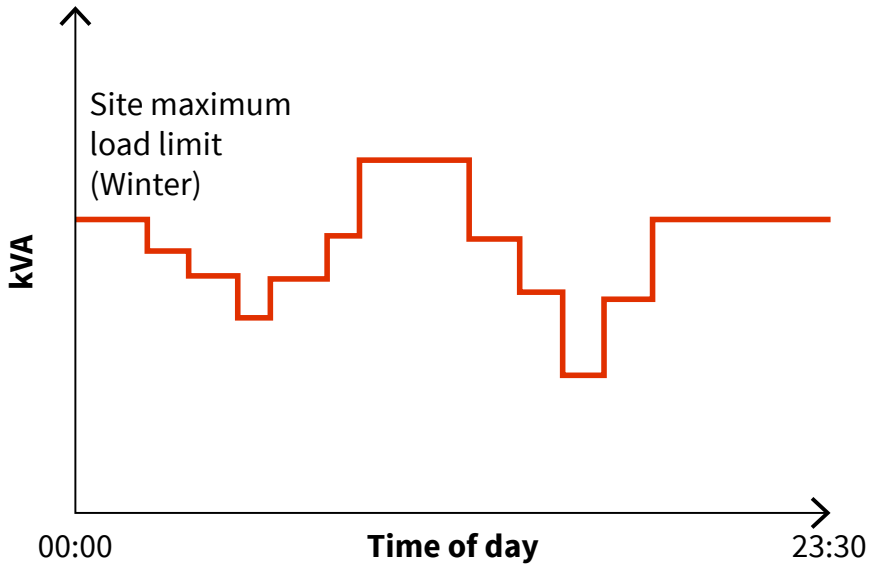
Optimise Prime

Figure 3: Illustration of connection types
A connection agreement where the applicable **maximum power requirement** (in KVA) **varies according to the time of day** and the season, up to 48 half-hourly time slots per day, with adherence to the profile **actively managed through smart systems by the customer** and monitored by the Distribution Network Operator.

Illustrative **standard** connection agreement



Illustrative **profiled** connection agreement



Strategic Project Highlights

Net Zero Ready

White Van Plan

Background

The transition to electric vehicles for SMEs is critical for the UK to achieve Net Zero targets. In recent years, DNOs have developed technical and commercial solutions that enable EV uptake. However, the UK's nearly six million SMEs have very different needs to the widely studied domestic and large commercial customers.

Network operators' limited understanding of their SME customers and their specific needs creates a significant challenge in facilitating Net Zero. UK Power Networks recognised the need to engage with these customers to better understand the barriers they face in the EV transition, particularly those who may be left behind without adequate support.

To meet this challenge, UK Power Networks launched an ambitious research project, White Van Plan, focused on developing a comprehensive understanding of SME customers by:

1. Delivering a first-of-kind segmentation of SME customers.
2. Investigating the specific needs of SMEs and their vehicle usage.
3. Identifying the barriers SMEs face in transitioning to electric mobility; and
4. Outlining initiatives that tailor support to SMEs in the transition to a low carbon economy.

Experience to date

White Van Plan has carried out extensive research since launching in 2020. Over the past two years, the project has utilised both primary and secondary research techniques to develop quantitative and qualitative datasets to develop key findings. This research included:

1. A literature review of over 80 publicly available documents.
2. Analysis of over 27,000 SMEs through a fleet dataset.
3. More than 1,200 SMEs surveyed; and
4. Engagement with over eighty key SME representatives and stakeholders.

Key insights of the research are summarised below.

Learnings from preliminary research

- There are 2.3 million SMEs within UK Power Networks' licence areas, 95% of which are the smallest SMEs with up to four employees.
- Two million vehicles belong to SMEs in UK Power Networks' licence areas, the majority of which are estimated to be vans (1.2 million), followed by cars (0.6 million), and trucks (0.2 million)
- SME vehicles are most frequently parked at work premises when not in use

Learnings from first-of-kind segmentation of SME customers

The segmentation created SME segments that classified specific customer archetype based transport use and behaviour (fleet size, fleet composition, primary parking location, and vehicle mileage) producing seven segments and key findings shown in Figures 4 and 5.

These segments enable manageable and effective assessments of SMEs' needs and how UK Power Networks can prioritise resources to support them. The first-of-kind segmentation revealed the following:

- Most SMEs are car free, with almost half of all vehicles being predominantly parked at home
- Smaller SMEs are more likely to be car free (Segment A) or home parkers (Segment B) with over 90% of these segments comprising of the smallest SMEs (0 - 9 employees)
- Larger SMEs are more likely to be workplace parkers with larger businesses typically more likely to be based in commercial premises
- SMEs who operate small fleets (1 - 4 vehicles), mainly park their vehicles at work premises and are more likely to be composed of cars and vans

Learnings from analysing the barriers faced by SMEs and supported needed

A full analysis of barriers facing the individual SME customer segments was undertaken to identify which were prominent. The findings from the analysis can be found in the Final Customer Research Report, published in October 2021. The barriers listed in Figure 6 represent the primary barriers faced by SMEs.

This analysis highlighted key differences between SMEs depending on their sector, business size, and vehicle fleet characteristics, enabling the identification of key areas for UK Power Networks to support SMEs. These are described in the Final Project Report, published in January 2022, and are summarised below:

1. Establish an SME EV information hub on UK Power Networks' website
2. Raise awareness of potential network solutions suitable to SME customer segments
3. Create easy-to-follow connections guidance for each SME customer segment
4. Develop case studies of successful SME EV transition and charger installations
5. Promote the role DNOs in SME fleet electrification via active engagement with the representative organisations of SMEs
6. Explore development of UK Power Networks services that may be of interest to third parties; service propositions or service packages that increase the number of ways that SMEs can take part in the flexibility market through third parties

Strategic Project Highlights

Net Zero Ready

White Van Plan

Future developments

White Van Plan is now in its final stages and is actively building on the learnings developed throughout the research by implementing the following to ensure UK Power Networks is well-positioned to support SMEs in their EV transition:

Built an EV Business Hub on the UK Power Networks website

A centralised information hub was developed to support SMEs and help them to learn about the potential network solutions available to them, provide them with easy-to-follow connections guidance, and share case studies. This hub addresses 50% of the key initiatives identified in the research and can accessed by here.

Network impact modelling analysis

A key area to support SMEs is investigating new commercial options and technical network solutions and services that could reduce the cost and time to connect EVs. White Van Plan is supporting this by using the extensive datasets gathered on SME vehicle usage behaviour to understand the potential network impacts from SME transport electrification.

SME EV journey research

White Van Plan aims to enhance the EV transition for SMEs by understanding their journey when procuring EVs and charge points by mapping the steps that SMEs take and the organisations they interact with. This research can help inform partnerships with organisations identify the appropriate point to intervene in the connection process and streamline where possible.

The project will help to achieve quicker, easier, and cheaper access to the network for SMEs wishing to transition to electric vehicles and help save our customers' money by avoiding infrastructure upgrades.

Strategic Project Highlights

Net Zero Ready

White Van Plan

Figure 4: First-of-kind segmentation of SME customers

7
SME customer segments developed

66%
of SMEs do not operate a business vehicle

3%
of SMEs operate a fleet comprising more than 25% HGVs

7%
of SMEs with business vehicles drive over 60 miles per day

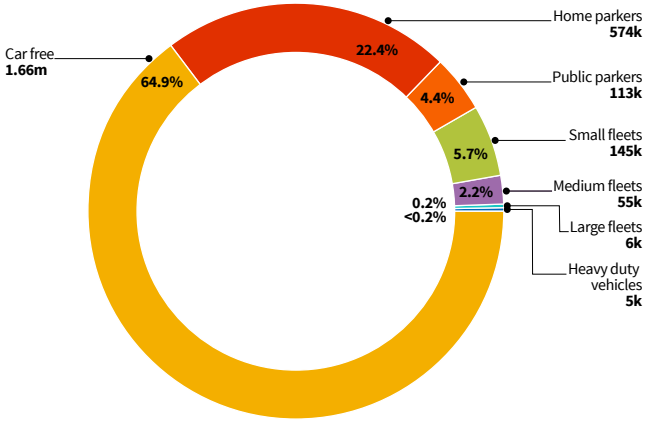
63% domestic
25% work
12% public
Primary parking locations of SMEs who operate a business vehicle

6%
of SMEs with business vehicles operate a fleet with more than five vehicles

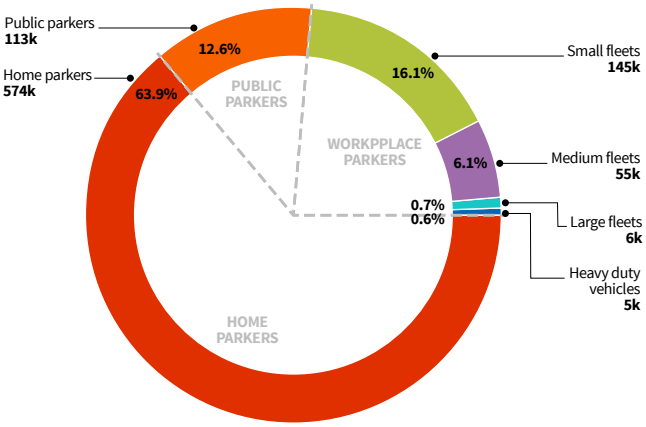
Figure 5: Proportions of SMEs and their vehicles in each SME customer segment within UK Power Networks licence areas

Customer segment	A	B	C	D	E	F	G
SME vehicle criteria	Car free	Home parkers	Public parkers	Small fleets	Medium fleets	Large fleets	Heavy duty vehicles

Proportion of **SMEs** in each segment in UK Power Networks area (local units)



Proportion of **vehicles** in UK Power Networks area



Strategic Project Highlights

Net Zero Ready

White Van Plan

Figure 6: Top 5 barriers faced by SMEs

	BARRIERS	DRIVERS	SEGMENTS
1	**Cost of EVs** versus internal combustion engine vehicles (ICEVs)	SMEs are driven by short term benefits rather than long term cost-savings	All SMEs
		SMEs are very cost-conscious	Smaller SMEs are particularly cost-conscious (Segments B, C and D)
		SMEs see investing in EVs as risky and not cost-effective	
2	**Challenging economic and financial climate for SMEs**	As a lasting impact of the COVID-19 pandemic, SMEs are more focused on business survival than investing in new technology	All SMEs
		SMEs are resource-constrained and do not prioritse exploration of new technologies if these are not business critical or do not produce tangible benefits to those experienced in the short term	Smaller SMEs (Segments B, C and D) are especially vulnerable to the distruptions due to Covid-19 and have a lower ability to invest in non-business critical initiatives
3	**Limited understanding of charging requirements** (installation process, charger location, charger suitability, and network constraints)	SMEs do nto have time to research new technologies	All SMEs experience varying levels of confusion wiht respect to understanding of charging requirements
		SMEs frequently percieve network capacity to be limited, which can contribute to an overall negative perception of EVs	
4	**Lack of access to clear, useable tailored guidance** to assist full fleet EV transition	SMEs value information that is tailored to their needs	All SMEs value guidance and and case studies for successful transition
		Some SMEs are unaware of the stakeholders involved in transitioning their fleets	Especially prevalent with smaller SMEs such as Segments B and D
5	**Cost of workplace or depot charging** (infrastructure and connections perspective)	SMEs are very cost-conscious and hesitant to invest in new technologies without the certainty that the technology or policy direction will not change	All SMEs are affected by charging costs
		SMEs do not fully understand the cost-saving options available to them for both infrastructure and connections	Costs increase as fleet size or vehicle size increases (Segments E, F and G)

Strategic Project Highlights

Net Zero Ready

Enable

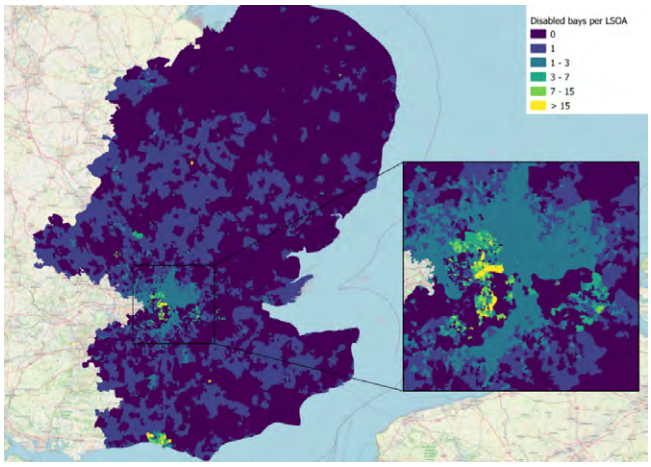
Background

Disabled motorists reliant on on-street parking will require electrification of disabled parking bays to transition to electric vehicles (EVs). This will have a possible impact on the UK Power Networks distribution network as an increasing number of disabled parking bays are electrified. The Enable project sought to understand the role of the distribution network operator in facilitating disabled motorists reliant on on-street parking in their transition to EVs, and to assess the impact of the electrification of disabled parking bays on our networks.

Prior research has shown that disabled motorists have specific needs and barriers when it comes to on-street charging infrastructure, and disabled motorists also have limited flexibility on where to park. Ricardo Energy & Environment, in a study commissioned by Motability estimated that 1.35 million UK-wide disabled drivers will be partially or wholly reliant on on-street or public charging infrastructure, with approximately 395,000 disabled drivers located in the UK Power Networks area falling into this category.

The results of the survey conducted as part of this project showed that 70% of disabled motorists who do not already use an EV plan to switch to one within the next 10 years. Whilst 76% of disabled motorists stated that they would expect their disabled parking bay to have an EV charge point installed beside it. This highlights the need to consider the accessibility of on-street charging for disabled motorists.

Figure 7: Estimated disabled bays per LSOA



Experience to date

UK Power Networks partnered with Motability on the Enable project. As a national charity that represents the needs of disabled people and ensures they are not disadvantaged due to poor access to transportation, they were the ideal partner.

The project consisted of:

- Qualitative and quantitative primary research engagement activities, including a survey of disabled motorists and engagement with local authorities, charge point operators, and national government, focused on barriers to on-street charging provision for disabled motorists and local authority policies and processes.
- A market sizing analysis of disabled motorists in the UK Power Networks area and identification of on-street residential disabled parking bay locations to the lower layer super output area (LSOA) level.
- A network impact analysis of electrification of on-street disabled parking bays in the UK Power Networks area.
- An analysis of UK Power Networks' role in assisting disabled motorists in their EV transition, and suggested further trials, synthesising all primary and secondary research undertaken.

The quantitative (survey) and qualitative (interviews) research investigated key barriers and challenges facing disabled motorists reliant on on-street parking. Although the majority (70%) of disabled motorists, disabled passengers and carers indicated that they plan to make the switch to an EV within the next 10 years, perception of low battery capacity and a lack of EV charging infrastructure were raised as key concerns.

The market sizing of disabled motorists and disabled parking bays in the UK Power Networks area found that out of approximately 745,000 disabled motorists, 395,000 disabled drivers or passengers (53%) may not have the ability to charge their EVs at home off-street in 2030. The scale of the challenge is expected to be greater in the UK Power Networks licence areas compared to the rest of the UK, where it is estimated that 35% of disabled drivers or passengers may struggle to charge their EVs at home off-street in 2030.

Due to the low number of disabled on-street parking bays and low power of chargers (likely 7kW) expected to be deployed in disabled parking bays, there were no major issues discovered regarding the impact on the network. One case study of a local authority with many disabled parking bays showed that, should 22kW chargers be installed in all bays within the local authority (analysed as a sensitivity analysis), this may require the replacement of a transformer (see Figure 7). However, this is an exceptional case.

Strategic Project Highlights

Net Zero Ready

Enable

Future developments

Taking our learnings together with quantitative research on market sizing and network impact analysis, we have developed an action plan to help make accessible low carbon transport a reality. We have identified six key roles that the distribution network operator can play in facilitating the uptake of EVs among disabled customers, along with two potential trials:

1. UK Power Networks can host the learnings of the project online on a dedicated accessibility portal, tailoring the content to different audiences including local authorities, charge point operators and disabled customers.
   This has been done and the hub (with link to the final report) can be found here: Accessible transport information hub | UK Power Networks

2. UK Power Networks can use its position as a trusted stakeholder to advocate for the on-street charging needs of disabled customers and ensure that the accessibility of charging is featured prominently within the EV industry stakeholder landscape.
   OZEV and Motability are co-sponsoring the development of an accessibility standard for public charging (PAS 1899), for which UK Power Networks is on the steering group as a result of this project.

3. UK Power Networks can proactively encourage third party service aggregators (such as smart charging providers) to consider the inclusion of disabled on-street charging bays in their flexibility services, and ensure that services that include disabled users are designed with their accessibility in mind.

4. UK Power Networks can undertake proactive data sharing and engagement with local authorities on the demand for on-street charging for disabled customers, potential network connection challenges, on-street charging needs of disabled customers, and the timelines for infrastructure provision.
   The results of the data analysis on estimated locations of Blue Badge holders and on-street disabled bays have been uploaded onto our Open Data Portal. *We hope that this data will help local authorities and charge point operators plan for accessible transport provision for customers.*

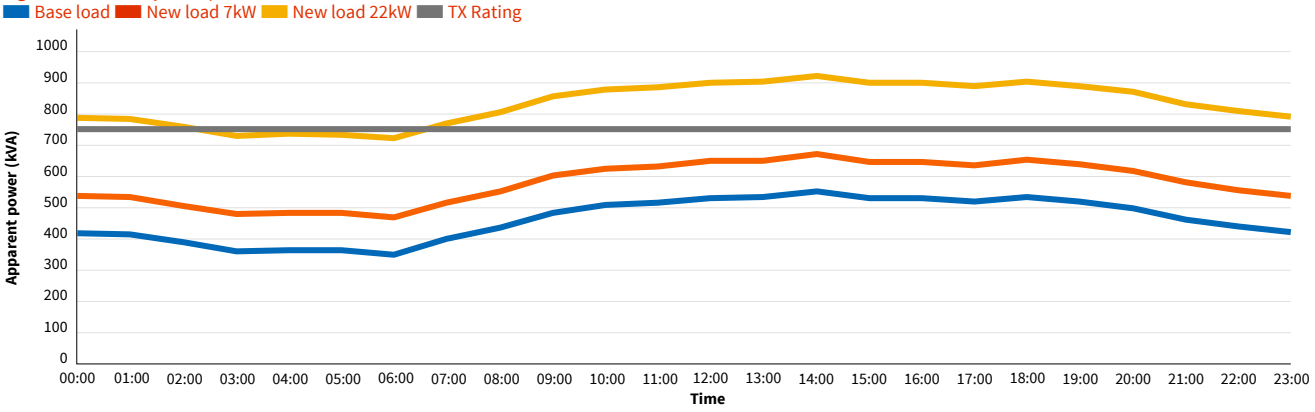
5. UK Power Networks can ensure that support teams are available to offer guidance to local authorities on issues related to on-street charging provision for disabled customers and consider the creation of a dedicated mailbox to offer a first point of contact.

6. UK Power Networks can seek to proactively understand different local authority plans and policies on on-street charging provision, including for disabled customers, to include in future demand modelling.

The project has now concluded, and these roles will be assessed and developed as business as usual, and the potential for subsequent trials investigated.

The findings from the project will be used to inform local authorities' Local Area Energy Plans, ensuring accessibility needs are considered when rolling-out public ChargePoints so that everyone can take part in the transition to EVs.

Figure 8: Case study example – thermal assessment at LV level in Camden area



Strategic Project Highlights

Net Zero Ready

Right to Heat

Background

The future of decarbonisation of domestic homes will result in a significant shift in electricity demand patterns that will impact both network planning and operations. If not given the right information, consumers will be faced with sub-optimal outcomes when it comes to comfort, convenience and ultimately, the price they pay for their energy usage in addition to any new technology required for the transition to Net Zero.

In addition, there is a growing risk that vulnerable customer groups will be marginalised and unable to maximise the benefits of this emerging technology and associated knowledge that will enable them to reduce the costs of their energy usage. The problem could also be worsened by physical constraints, such as lack of adequate space for new technology, especially in housing stock in more urban areas.

Previous projects have explored hybrid heating systems in larger, owner-occupied homes, but evidence is lacking for high-density, smaller dwellings, particularly from a whole system lens where electricity and gas can co-exist to offer a level playing field to social housing tenants such that they can participate in the energy transition and future energy markets. More understanding is required in the flexibility that these different assets working together can provide. Critical data on the ability of vulnerable customers to obtain the same benefits as others is also needed to inform policy, best practice, and technology requirements.

In combination, these factors could leave those least able to pay the costs of their energy with the prospect of more expensive bills and missing out on the benefits from the Net Zero transition.

Through our engagement with social housing providers, we found that there was a strong desire to decarbonise their housing portfolios but did not have a clear pathway to do so. Therefore, we saw a real need to find a way that works for both them and their tenants. As a result, the Right to Heat project seeks to develop a best practice template for decarbonising homes, particularly those in urban social housing settings, and understand the commercial value made available from low carbon technologies such as heat pumps. This template will work to address the risks decarbonisation could have on energy bills for those most vulnerable, offer commercial solutions for social housing providers, and inform utility networks of the impact of new LCTs connected to their networks and how best to support their roll-out.

Experience to date

Right to Heat is aiming to build on the success of the HyCompact project. The HyCompact project used recent advances in hybrid heating technology through the introduction of an integrated boiler or air source heat pump (ASHP) unit to explore options for deploying high volumes of grid-enabled hybrid heat pumps on the broader energy system. To do so, Right to Heat is focusing on more dense housing archetypes to determine how emerging assets such as heat pumps can be best operated in such archetypes to maximise the benefits to consumers; particularly those in vulnerable circumstances and at risk of fuel poverty. It will also enable networks to better plan and support the resulting demand profiles, whilst helping ensure those benefits are made available to all consumers.

The project is still in the early stages of delivery so outcomes from the project are still to be delivered. The project partner, Passiv UK, a home energy services company, is working with Stonewater, a leading social housing provider, with a mission to deliver good quality, affordable homes to people who need them most. Stonewater will help to identify suitable homes to take part in the trial. The initial phase will see the installation of an integrated solar Photovoltaic (PV), battery storage and single unit hybrid heating system in 10 homes. Throughout 2022 we will monitor and report on detailed activities conducted throughout the trial. Including successful installation of the units, system integration and the behaviour of the heating system, PV and batteries.

Strategic Project Highlights

Net Zero Ready

Right to Heat

Future developments

The project may expand the number of units installed from 10 to 25 depending on initial findings from the early phases from the trial and the ability of Stonewater to acquire additional funds. Ultimately, the project will be seeking to develop a best practice template for large-scale decarbonisation of heat in social housing that safeguards vulnerable consumers with an independent consumer research report that explores the social impact of integrated solar PV, battery storage and heat pump systems in social housing. This will take the form of a publicly available full operational data set, reporting on performance and gas and electricity network impacts and support project dissemination and promotion activities, from both UK Power Networks and project partners, including Stonewater. In addition, based on the outcomes, the project will provide consumers with advice on being safe and empowered consumers, including carbon monoxide (CO) awareness, Priority Service Register (PSR) registration, and energy advice and coaching. We will measure the impact this advice has before and after the trial.

Right to Heat will develop the best practices for decarbonising heating at the lowest cost for social housing and ensure no one is left behind in the transition to Net Zero, providing a valuable resource to help social housing managers.

Figure 9: A Hybrid Heat Pump unit as it would appear in a typical domestic property

Strategic Project Highlights

Net Zero Ready

TransPower

Background

The integration of renewable energy sources, and the forecasted growth of EVs, present capacity, voltage and power quality issues to the distribution networks. UK Power Networks' forecasts up to 3.6 million EVs connected to our network by 2030, a 30-fold increase on those connected today. As a DNO, we need to ensure that the distribution network is adequately sized for the expected future demand, while managing the uncertainty of when and where EVs will be adopted. Seen today, most parts of the distribution network would be able to accommodate the relatively low levels of EV penetration. However, as the projected EV uptake materialises, unmanaged EV charging would soon require significant additional network reinforcement.

When the project commenced in 2018, there had been limited demonstration of V2G in the UK. The scope for this project is focused on UK Power Networks' activities contributing to the following Innovate UK (IUK) V2G competition projects:

- Powerloop, Domestic, 2022
- Bus2Grid, Public Transport, 2022
- E4Future, Fleet, 2022
- V2Street, Public, 2020
- Sciurus, Domestic, 2021

This project explores V2G technology as one smart solution capable of reducing reinforcement costs due to EV uptake. UK Power Networks is evaluating the technical, commercial and customer proposition of V2G technology to the distribution network. This project aimed to investigate network impact and flexibility services for several different vehicle segments including domestic, commercial and public transport charging through demonstrator trials and collaborative research and development.

The innovative trials only evaluated the case for V2G equipment connected to our distribution networks and were not responsible for the connection of this equipment to the network. However, throughout the project a major challenge identified was the complexity of the V2G connections process which installers reported was complex and time-consuming.

Experience to date

Our involvement with Transpower has led to many improvements to our V2G application and overall connection process and remove the barriers to adopting green energy solutions.

The project has contributed to the development of best practice V2G connections processes through the development of a common industry connections form in collaboration with the Energy Networks Association (ENA) and the working groups undertaking review of Engineering Recommendation G99.

The conclusion of the Powerloop trial, one of the world's first mass domestic Vehicle-to-Grid (V2G) projects bringing domestic V2G to over 130 customers, alongside Bus2Grid, a first of a kind large scale, multi-megawatt demonstration of V2G in electric buses, and E4Future's roll out of 58 chargers to fleet vehicles, has led to valuable learnings into the feasibility of V2G technology for future adoption.

Through Powerloop, and in collaboration with Octopus Energy, a specialised G100 export limiting device was developed to support the integration between solar PV and V2G, enabling customers to be rapidly connected to the grid, while accommodating export limitations. The project also contributed to the analysis and amendment of UK Power Network's existing voltage rise assessment, to account for variability across geographical regions and diversity of devices, to facilitate more connections without impact to the network.

UK Power Networks has also developed Smart Connect (Figure 10), the first self-service platform of its kind for an end-to-end digital journey to make the connections process more streamlined and transparent. The platform includes an automated assessment to reduce processing times and issue instant approval when criteria are met, incorporating into it a voltage rise assessment to assess the impact of export from a low carbon technology and automatic referrals to internal teams should further assessment or work need completing (Figure 11). Further, installers are now able to see all their applications and their status in one simple dashboard, and upload supporting documents as required. The usage of Smart Connect has grown considerably (Figure 12), with over 6,000 applications in its first year since launch across all LCTs. Of these, 52% of applications have received automatic approval notifications (connect and notify) which reduces the time to notification from 10 days to minutes.

Transpower has also been pivotal in the development of the V2G Hub, in collaboration with Everoze, EVConsult and IUK, to enhance knowledge sharing of global V2G innovation projects, their objectives, and the services they could provide.

Strategic Project Highlights

Net Zero Ready

TransPower

Future developments

All Innovate UK projects within Transpower ended in March 2022. However, the learnings and insights gained throughout the project will continue to be built upon and implemented. For example:

- The Smart Connect platform provides a basis for which future developments can be built upon to further streamline and enable the connection of V2G chargers, and other low carbon technologies.
- Data collected from the trials will be analysed for the impact on the network and capability to defer network reinforcement.
- Further opportunities for V2G to partake in current flexibility products, or develop new products specifically tailored for V2G, will be explored.
- The V2G hub will continue to incorporate new projects and findings to educate and disseminate learnings.

TransPower is investigating the network impact of V2G and developing vital learnings to share with stakeholders about how we can develop a market to harness this spare capacity.

Figure 11: Smart Connect process flow

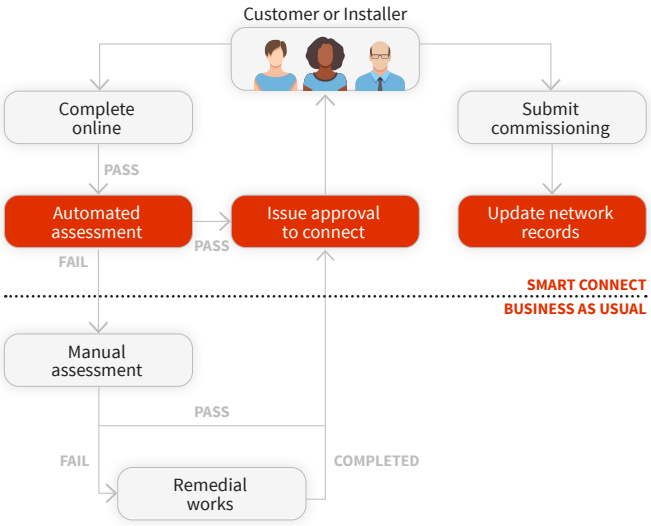


Figure 10: Smart Connect portal

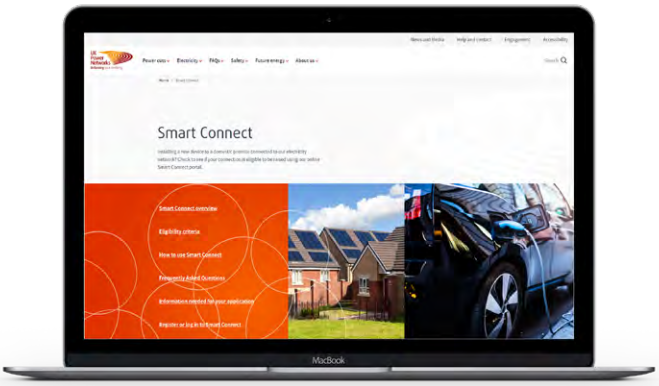
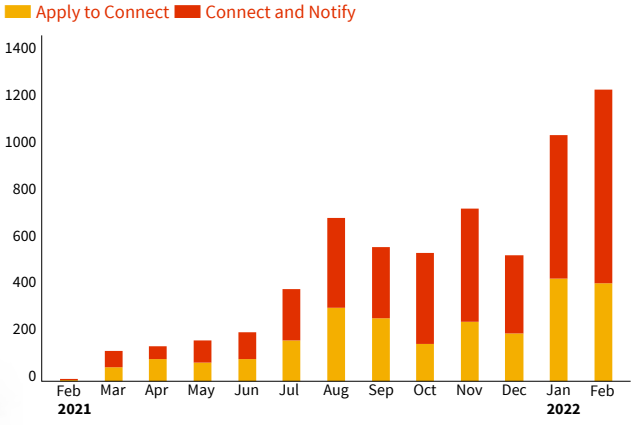


Figure 12: Number of applications submitted to smart connect and the outcome of their submission



Strategic Project Highlights

Future Ready

The second area of strategic focus for UK Power Networks innovation portfolio is to deliver projects which contribute to being a future-ready distribution business.

This means meeting the needs of tomorrow's customers as our customers are changing and their requirements from DNOs are evolving. Future Ready also covers ensuring that no one is left behind from the benefits of the energy transition towards Net Zero and covering the provision of new services involving Distributed Energy Resources (DERs). Our projects in this area include facilitating the reliable connection of increased DER on to power distribution networks as well as increasing the resilience of the low voltage (LV) network with greater visibility, monitoring and control.

Within this innovation summary report, we highlight a Network Innovation Competition (NIC) project and four NIA projects in our Future Ready portfolio.

Constellation is a world-first innovation initiative, which will demonstrate a novel approach to protection and control by introducing local intelligence in DNO substations. It is a customer-funded NIC project led by UK Power Networks and delivered in partnership with ABB, GE, University of Strathclyde's Power Network Demonstration Centre (PNDC), Siemens and Vodafone. In the future, DNOs will rely on services provided by DER to operate their networks optimally and reliably. Constellation will facilitate the reliable connection of increased DER on to power distribution networks. The project will also protect the use of smart services to reduce the risk of system-wide instability events by de-risking the likelihood of sudden and widespread DER curtailment and/or disconnection.

Line Search is reducing risks/improving safety for construction workers and reducing disruptions to customers caused by cable damage on the UK Power Networks distribution network by using crowdsourced data via Line Search Before You Dig (LSBUD) to improve asset data quality and, with access to the daily 3,000 UK Power Networks' maps enquires from LSBUD, improving UK Power Networks' education and engagement, targeting those that that are at greater risk of cables strikes.

Envision is exploring ways in which our own data can be used to model demand and enhance the visibility of our LV network. Using external data to enhance what we already know will allow us to build an even more detailed picture of what is happening on our network now and improve our service for customers. As more renewable energy sources connect to the network and more people switch to EVs and heating, having exact data means we can plan targeted investment in infrastructure across our network at the right time and in the right places.

Social Connect is helping to accelerate the identification of customers at risk of going into fuel poverty. The project is currently developing an innovative AI tool, modelled using the best available data, including Smart Meter System data to enhance our understanding of fuel poverty across our licence areas. Through this work, it will enable UK Power Networks to support more customers in vulnerable circumstances and provide further opportunities to promote energy efficiency as a way to reduce energy bills.

Urban Energy Club was designed for lower-income groups who may not have the financial resources or capacity to engage with and benefit from a more flexible energy system. The trial explored possible societal benefits of increasing flexibility via community-owned, shared assets. It tested how customers living in blocks of flats could access financial benefits from the provision of flexibility and whether the virtual allocation of assets would support more inclusion.

Strategic Project Highlights

Future Ready

Constellation

Background

Constellation is a customer-funded NIC project led by UK Power Networks and delivered in partnership with ABB, GE, University of Strathclyde's PNDC, Siemens and Vodafone. The project aims to demonstrate how novel protection and control solutions located locally within DNO substations can be used to:

- Facilitate the connection of more DER to power distribution networks; and
- Protect smart services by de-risking the likelihood of sudden and widespread DER curtailment and/or disconnection.

This world first innovation initiative will enhance the core of the distribution network – substations. It will introduce a first of its kind local intelligence and local intelligent operation at the substation level that complements existing functionality, in a sustainably cost-efficient manner for our customers.

The problems it is exploring

Network resilience As we increase our reliance on smart services provided by DER, there is a significant future risk to the network resilience. Previously the loss of distribution generation was of little consequence to the network operation, as it did not provide services in significant volumes to the distribution network. However, as we increase our reliance on DER to provide smart services, the loss of a high proportion of generation at the distribution level will reduce system stability and lead to an increase in disconnection events and potential blackouts. More specifically, smart services are at risk of being impacted by a loss of communication with our central systems or by unnecessary disconnection of DER.

Network capacity The expected increase in DER required to achieve Net Zero will require a significant amount of network capacity to be available in specific areas. However, our existing protection systems can limit the available capacity in some instances. Specifically, the directional overcurrent (DOC) protection, designed to protect the network from back-feeding faults, limits the amount of distributed generation (DG) that can be connected. Our traditional solution (load blinding) allows the protection to use a pre-calculated power factor to differentiate between network faults and generation/load. In the future, this will result in parts of the network having spare capacity which is not utilised to connect more DER to support our transition to Net Zero due to static protection settings.

The solutions to solve the problems

To overcome the limitations of our existing capabilities and facilitate Net Zero we need to enhance our local substations by making them more intelligent, digital, interoperable and enable secure, scalable communication between them. Constellation achieves this through a flexible and future-proofed system for local intelligence working in partnership with central systems, which in turn, enables two distinct methods:

Method 1

Local Active Network Management (ANM) Local network control at the substation level to provide resilience to DER operation against loss of communication with the central ANM system. Whenever the central system is unable to communicate with our local network assets, the local intelligence will take over optimisation for that specific DER, substation or area.

Method 2

Wide area and adaptive protection Provide resilience to DG operation against transient instability events triggering the conventional generator protection. Dynamically assessed protection settings to enable more capacity for DER connections.

Strategic Project Highlights

Future Ready

Constellation

Experience to date

The first phase of the project was between May 2021 and March 2022 and it was focused on the design of the Constellation solutions. We have successfully completed this phase and published our learnings (https://innovation.ukpowernetworks.co.uk/projects/constellation/).

Our approach to the design

The Constellation partners are global leaders in protection, control and telecommunication and have demonstrated they are at the cutting edge of development in their fields. In bringing this consortium together, we genuinely believe that the outcomes of the project will demonstrate transformational approaches for the industry that can readily be rolled out by DNOs both in GB and globally. To achieve that, we established a productive and open communication between all partners.

We began by researching and incorporating the learnings generated from a variety of previous and current ongoing relevant projects, such as FITNESS, SIARA, Open LV and Unified Protection. Additionally, to complement the learning from other projects, we launched two research streams, led by University of Strathclyde, looking into protection, communication and data architecture.

These activities provided the foundation to the high-level requirements for all Constellation solutions. We then carried out a series of collaborative workshops to bring more details into the requirements and the architecture development. Finally, we used all the learnings generated through the project so far to develop the detailed designs for each Constellation solution.

The Constellation architecture

The overarching architecture for the Constellation project is shown in the figure below. Within the substations, Constellation will include new 5G communications between sites within the same area, the transition of protection and control (PAC) functions to a virtual platform, development of new PAC functions and deployment of a software (virtualised) platform.

Furthermore, these new Constellation systems and sub-systems will interface with existing UK Power Networks' systems, such as central ANM Distributed Energy Resources Management System (DERMS) and Advanced Distribution Management Systems (ADMS). Together, all the elements in the architecture, will work together to achieve the Constellation aims.

Future developments

In 2022, the project team will develop all the Constellation solutions and in parallel prepare the trial locations. The trials are planned to begin in early 2023, with the first testing in the Power Networks Demonstration Centre. Following that, the project will transition to testing on the electricity network until 2025.

Constellation will deliver detailed technical insights on how world-first smart substations can revolutionise the way our networks are run.

Strategic Project Highlights

Future Ready

Constellation

Figure 13 Constellation summary diagram (with key partners for each Project element)

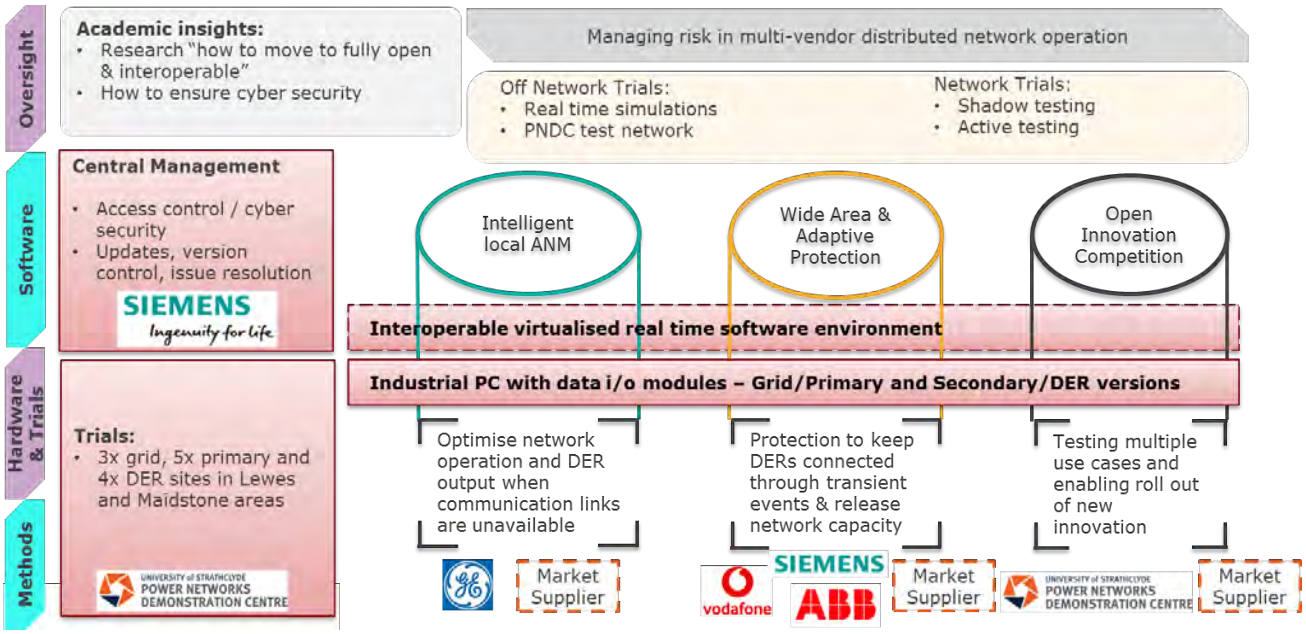
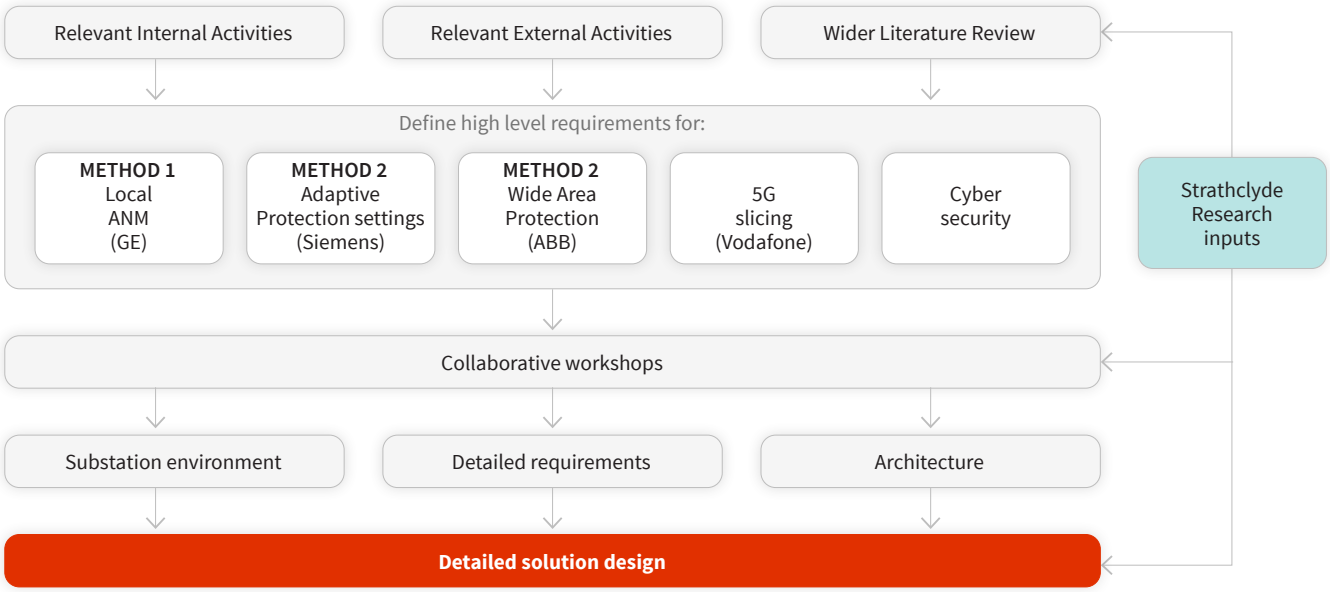


Figure 14 Summary of the approach for the Constellation design

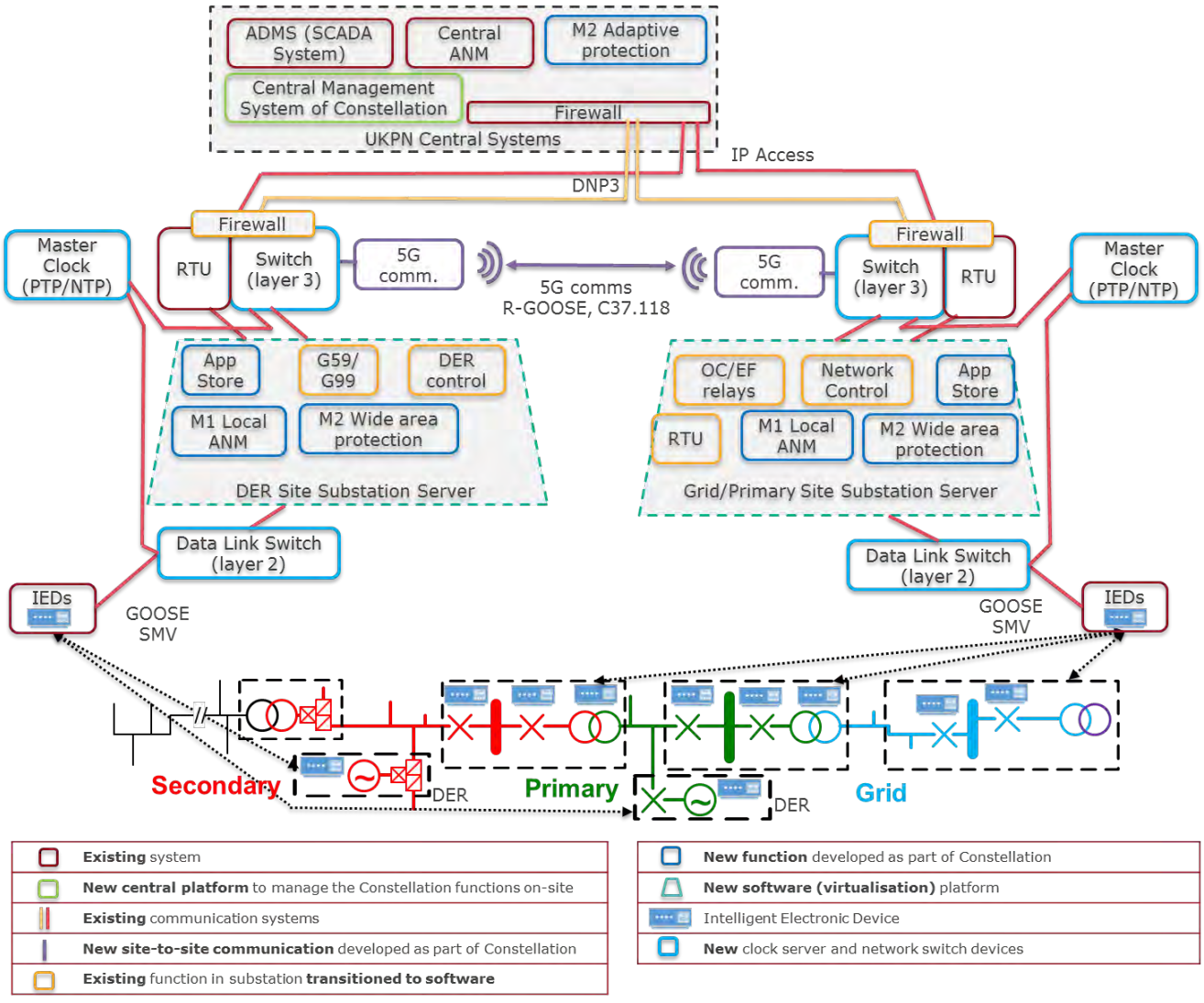


Strategic Project Highlights

Future Ready

Constellation

Figure 15 Constellation - concept architecture



Strategic Project Highlights

Future Ready

Line Search

Background

UK Power Networks provides network maps to a wide variety of third parties working near its network daily. These include utilities, contractors, developers, the general public and landowners. There is always a risk that these parties may accidentally strike a buried cable. This endangers lives, incurs costs, causes disruption and can result in reputational damage to the instigator and the asset owner.

Occasionally the data recording the asset location is inaccurate thus further increasing the risk of cable strikes. The root cause of the problem lies in the historical difficulties of capturing accurate asset locations in the days before technology made this a routine task.

Line search before you dig (LSBUD) is a free to use online search service that any individual can use to check their works against over 75 asset owners' utility assets.

Every day LSBUD receive over 3,000 enquires from users requesting UK Power Networks' maps. The data generated by this activity will tell us where, who, when, and what has been done near our network. Gathering feedback from the users can also be used to improve the quality of asset data.

The project was delivered in the following phases:

- Discovery, including a workshop to stablish user personas, user stories, and prioritised features.
- Develop an Application Programming Interface (API) to make LSBUD data available to UK Power Networks.
- Development, including Geospatial Analytics (GSA) data integration and user survey feedback gathering platform.
- End to end trial of the Line Search process on a selected part of the network.
- Assessment of feasibility of BAU integration including complete roll-out across UK Power Networks.

LSBUD was a project partner and provided location data of the users requesting the network maps.

Experience to date

To follow best practice and avoid data duplication, we decided to adopt the original user's reference number when linking the LSBUD Application Programming Interface (API) to the GSA application for future tracking and reporting purposes.

We found that third party contractors will typically consult the free LSBUD online search service to request utility maps. Although all necessary data is available from LSBUD we concluded that for greater flexibility and better control over the data, the feedback form should be hosted by the asset owner (UK Power Networks in this case).

The network map request data from LBSUD and survey results were embedded into our geographic information system (GIS) and is accessible from our geospatial analytics web application (GSA). A heat map representation shows all the third-party enquiries we have received about our network as well as the contents of the feedback form, see Figure 16.

LSBUD data is transferred to UK Power Networks' systems via an API and we launched a user survey feedback form in our South Eastern Power Networks (SPN) area in November 2020. Since then, UK Power Networks' top five contractors have used this feedback form to share their views and observations to help us improve data accuracy. This initiative has proven to be effective in increasing user engagement.

Over the course of the trial, we have seen an increase in feedback from users due to the implementation of a Quick Response (QR) code embedded on the network map. We previously found that recipients of our enquiry emails were not necessarily the field staff working on the ground but administrators hence the low feedback response. Introduction of a QR code on our network maps ensured field staff could quickly and easily open and complete the feedback form.

We had received over 700,000 network map requests in 10 months of the project, as shown in Figure 17. However the quality of the crowdsourced feedback received didn't give sufficient information to enable us to improve our legacy network records. Although LSBUD enquiry data that has now been made available will enable us to target contractors and educate them on the use of the network maps to improve the data that we receive.

Strategic Project Highlights

Future Ready

Line Search

Future developments

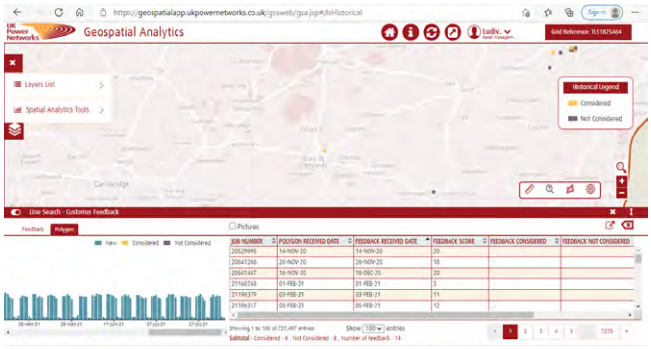
The project is now complete, however access to LSBUD enquiry data and integration into our GSA application can give insight into network map requests. By analysing cable strike trends will enable us to target contractors and educate them on the use of the network maps to improve the data that we receive.

This main benefit of this targeted education engagement will help reduce cable strikes, which will improve safety to operatives working close to UK Power Networks' electricity network, reduce the impact on customers and reduce associated costs.

Line search will give our engineers and third parties better information about the exact location of our electricity cables, enhancing safety, reducing damage to the network, and enabling engineers to locate faults more quickly.

Figure 16: GSA Heat map showing all third party LSBUD inquiries

Figure 17: Third party LSBUD inquiries



Strategic Project Highlights

Future Ready

Envision

Background

With the rise of renewables, decentralisation and the millions of connected devices on our network, it will take more than human intelligence to decarbonise the grid. To harness the benefits of the fourth industrial revolution, which centres on digital advancements, it is important we collaborate and experiment with stakeholders to solve emerging challenges using the latest technology.

Detailed 'visibility' of our network is critical as we plan to facilitate a low carbon, Net Zero future. In simple terms, 'visibility' means collecting data about what's happening on our network at any given time. The data can include anything from how power is flowing through the network to where demand for electricity is high and at what times of the day.

As more renewable energy sources connect to the network and more people switch to EVs and heating, having exact data means we can plan targeted investment in infrastructure across our network at the right time and in the right places.

We are exploring ways in which our data can be used to model demand and enhance the visibility of our LV network. In partnership with CK Delta Envision we are developing a software-based machine learning tool that will generate greater LV network insights faster and cheaper compared to traditional methods of physical monitoring.

By maximising utilisation of the existing network before approving asset-based solutions, we will ensure that we don't deploy solutions today that are inappropriate for meeting the problems of tomorrow. The project is a key step to widening the flexibility market and building a smart grid that enables cleaner, greener energy resources to connect quicker and at a lower cost.

Experience to date

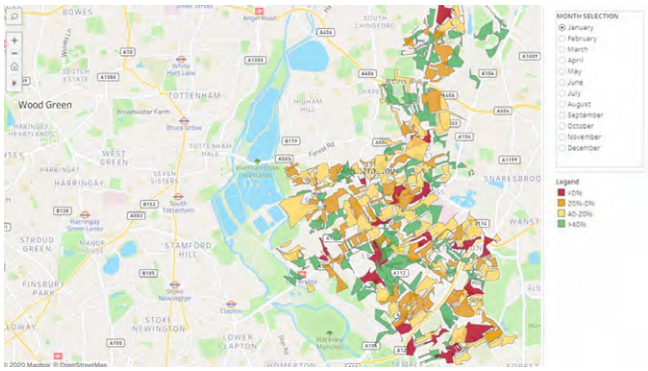
Of the circa 117,000 substations UK Power Networks operates, only 10% have remote terminal units (RTUs) which help monitor load information and relay information back to us. The remaining 90% require in-person visits to record data whenever this information is needed for network upgrades. Thus, there is a need to gain this insight into LV visibility in a more efficient and scalable manner.

Using a small subset of our network data we have proven that a machine learning model can be applied to gain estimates on maximum loads on substations in specific areas, as seen in Figure 19. The areas were selected based on the availability of historical RTU data to maximise accuracy for validation procedures. The results indicate which substations have a certain degree of available headroom[1] remaining.

Through extensive internal stakeholder engagement, we continue to assess our existing systems and their respective data sets and further develop the data models necessary to allow us to monitor the remaining substations, automate data handling and improve the accuracy of predictions.

We have recently completed our first enduring data model for ground-mounted transformers that uses a broader data set to provide yearly and monthly estimated load for all low voltage substations across our networks. A widely accepted and common industry standard 1-MAPE (Mean Absolute Percentage Error) method is being used to measure prediction accuracy. At present, the overall confidence accuracy for the model is approximately 75%, and we are exploring opportunities to improve this. With the help of subject matter experts, we will carry out detailed validation and take into consideration any feedback to further enhance prediction accuracy.

Figure 18: Estimated headroom on a set of distribution transformers in London (Low Voltage)



1 Headroom - a term to describe the difference between present Maximum Demand Indicator and Maximum load. As maximum demand indicator tends towards maximum load, there is a need to reinforce the network.

Strategic Project Highlights

Future Ready

Envision

Understanding and documenting the data sources has been a fundamental element of the development process. Whilst identification of input data quality issues is a key opportunity for prediction accuracy improvement. Over 50% of the 120 data quality issues identified to date have been resolved at the source system. This enriched data set benefits users of these systems and not just the project. We have also established an internal data management framework for all future projects to follow. This includes a data pipeline that alerts us of data quality issues and is used to share our network data with partners in a secure and automated way.

We are also exploring how much UK Power Networks would value visibility of connected DER[2] from owners and operators of those resources. In simple terms, how much are we willing to pay third parties for the information they have on DERs connected to our network and associated electricity flows? This external data could form part of the data models for our software-based LV visibility tool, but we are not ruling out other possible use cases. Thus far, we have concluded interviews with internal stakeholders, conducted 21 interviews with over 40 participants and pinpointed 23 potential use cases. Interviews with external stakeholders to determine available data and commercial models have also concluded and outputs are being mapped against the use cases to determine suitability. During the interviews, we identified the need for a simple and easy to understand reference model on which to base discussions, and the DER data pyramid was produced (see Figure 19).

Future developments

Whilst we improve our ground-mounted transformer model, we have started the development of our next model for pole-mounted transformers. We have also started work on a tool that will support our RTU implementation strategy by optimising device deployment and will lead to improved model predictions. We will then develop a graphical user interface and introduce half-hourly profiles for both load estimation models to get an even more granular view of our low voltage network and ensure our network planning and smart grid teams can answer the following questions:

- Where do we need to procure flexibility to alleviate capacity constraints?
- Where do we need to invest to ensure we are not a blocker to decarbonisation?
- How heavily utilised are our assets and how long we can ‘sweat’ them for?
- What’s the right size for a transformer when we’re replacing it?

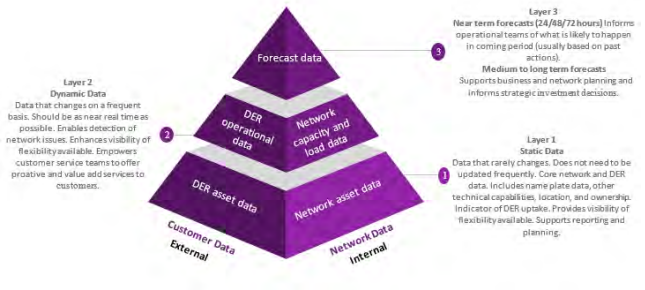
Meanwhile, we will wrap up our external data assessment with a report that sets out:

1. What data would be of use - in a practical sense - to UK Power Networks; why we may want it; what the counterfactuals are; what benefits it would bring and what it may be worth.
2. What data DER manufacturers and aggregators have/could make available; what condition it is in; how they could convey it to UK Power Networks and what it might cost to be able to do so.

If the data identified is available and the benefits can be proven, a real-world commercial software demonstration will follow. A common cloud-based “DER Data Gateway” will be developed, loading data streams from multiple sources. Analysis tools and techniques will then be used to turn data into useful products for UK Power Networks teams.

Envision will generate greater Low Voltage (LV) network insights faster and cheaper compared to traditional methods of physical monitoring. Better data will enable us to make better decisions about when and where to invest in the network, ultimately saving our customers money and getting more renewable energy onto the network at lower cost.

Figure 19: The DER data pyramid that shows the relationship and dependencies between different data types both vertically and horizontally.



2 DERs typically refer to generation that is closer to the consumer side of the network, such as solar panels, small wind turbines, combined heat and power units.

Strategic Project Highlights

Future Ready

Social Connect

Background

Fuel poverty in England is measured using the Low-Income Low Energy Efficiency (LILEE) indicator. Under the LILEE indicator, a household is fuel poor if:

- they are living in a property with a fuel poverty energy efficiency rating of band D or below; and
- when they spend the required amount to heat their home, they are left with a residual income below the official poverty line

Department for Business, Energy & Industrial Strategy (BEIS) state that there are three important elements in determining whether a household is fuel poor:

- Household income
- Household energy requirements
- Fuel prices

BEIS publishes fuel poverty statistics to the Regional and Sub-Regional (Lower Super Output Area Level). This data is used by practitioners as part of the process for identifying those in fuel poverty.

Tackling fuel poverty is one of the four strategic focus areas of our Social Sustainability programme. In the future we're expecting the number of customers we serve to grow, meaning identifying those who need extra support will be one of our key challenges.

Social connect is developing an innovative method for identifying customers who are in or at risk of fuel poverty. This will allow UK Power Networks to provide effective support to more vulnerable customers. Now, we work with local trusted organisations to reach roughly 800,000 vulnerable customers per year, of which 13,000 receive personalised support such as free information and advice on lowering fuel bills. With the new approach developed in Social Connect, we will increase the number of vulnerable customers who receive personalised support from 13,000 to 100,000 each year.

Social Connect is a collaborative project with the Energy Systems Catapult (ESC) and UrbanTide. The ESC have an existing deep understanding of vulnerability and fuel poverty, and their expertise will be invaluable in identifying and analysing data throughout the project. For more information about ESC's work in vulnerability, please see their recent report "How can innovation deliver a smart energy system that works for low income and vulnerable customers?"

Experience to Date

The data discovery phase undertaken in the last quarter of 2021 involved deep investigation into the datasets available for fuel poverty identification when integrated with or used for validation alongside the Data Communications Company Smart Meter System Metadata.

The evaluation confirmed the assumptions made during the proposal phase of this project in that the identification of fuel poverty in a different manner, that could potentially be better than the current status quo methods, is feasible. This has considered both the potential for machine learning techniques being applied to the Smart Meter System Metadata itself and the routes/ overlays which can be made with all other publicly available and paid for data sources available in the market.

As illustrated in the Work Package Breakdown (Figure 20 below) the Data Work Stream runs throughout the project. And whilst the findings of our Data Discovery Report supports feasibility at a point in time, it does not constrain future data exploration or extension of the key and supporting datasets illustrated here. Especially if new data is discovered or elements of the data researched already are given greater meaning.

Our work on consumer indicative fuel poverty behaviours highlights that identifying those in fuel poverty is not easy. Some people move in and out of fuel poverty, e.g. due to seasonality or changing circumstances. Others are more willing to disclose they are struggling, others are not (commonly associated with older people). The number of fuel poor paying by direct debit (1.8m) is twice that of those paying by prepayment meter (870,000). However, the rate of fuel poverty for prepayment meter consumers (29%) is three times that for Direct Debit consumers (10%). Most of the fuel poor prioritise paying for fuel - instead they cut back on other essentials, e.g. food, clothing, water bill, Council Tax. Further to this, fuel debt is often one of many debts and evidence of a serious problem. The challenge is to bring together behavioural and attitudinal data with housing and household data to identify groups of fuel poor households.

Strategic Project Highlights

Future Ready

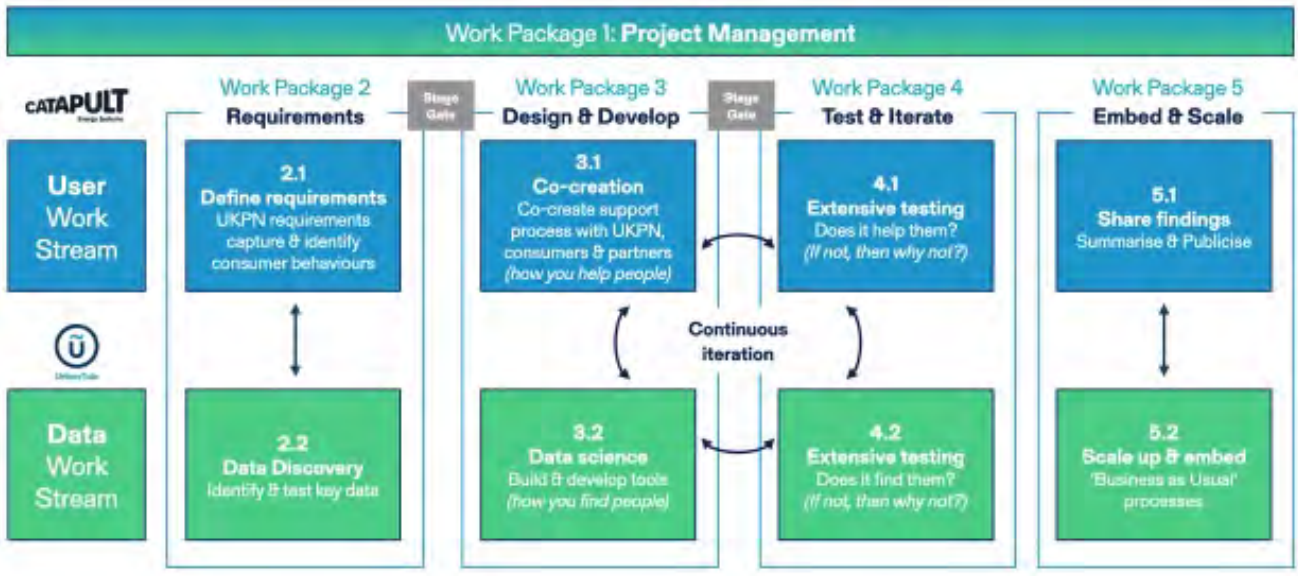
Social Connect

Future Developments

The project will run until December 2022. Its next steps will be to research and evaluate new data sources, before designing and developing the data science tools to build the dashboard.

Understanding the evolving needs of our customers so we can ensure targeted support that really makes a difference reaches those who need it most.

Figure 20: Project Workstreams Overview (User & Data)



Strategic Project Highlights

Future Ready

Urban Energy Club

Background

There is an increasing need for flexibility in the LV network. Decarbonising the energy sector requires the electrification of heating and transport and the integration of DER including more local renewable generation. A more flexible electricity system can accommodate these technical changes while avoiding costly upgrades.

The potential for a more flexible energy system to increase inequalities has been flagged. Those unable to take advantage of new flexibility products and services are at risk of only accessing higher-priced electricity or sacrificing comfort to manage costs. In addition, the commodity price increases of early 2022 have shown the impact on households as prices continue to fluctuate. Local energy markets and community flexibility schemes could potentially reduce exposure of participating households from these price increases.

Urban Energy Club (UEC) was designed for lower-income groups who may not have the financial resources or capacity to engage with and benefit from a more flexible energy system. The trial explored possible societal benefits of increasing flexibility via community-owned, shared assets. It tested how customers living in blocks of flats could access financial benefits from the provision of flexibility and whether the virtual allocation of assets would support more inclusion. The trial was awarded a regulatory sandbox and ran between 2019 – 2021, led by EDF with Repowering London, UK Power Networks and UCL.

Experience to date

Urban Energy Club (UEC) provided a 10kW/20kWh communal battery on the roof of a local authority-owned block of flats to deliver LV flexibility services and support collective self-consumption. The battery joined an existing community-owned 37kWp PV array on the building and was integrated into the building's peer-to-peer (P2P) local energy market trial, CommUNITY. A facilitating supplier (EDF) created the CommUNITY platform to virtually connect the assets behind the landlord's meter to residents. Through the P2P platform participating residents received equal allocations of the solar output and battery and the battery was optimised to deliver bill savings for residents. Participants could set preferences to impact the price they paid for their energy, but they did not have to adjust their consumption in order to gain profit. The battery was charged only with solar electricity, delivering flexibility to the LV network from a renewable energy source.

A battery control system was designed to receive signals from UK Power Networks for a scheduled flexibility window. The flexibility windows were scheduled in advance by UK Power Networks and shared with EDF. Two to three flexibility windows per week over the period of two months were taken into consideration. Flexibility was provided based on the data from the previous week which offered information on how many days are required to charge the battery.

The project is now completed. UEC demonstrated one of the first local solar/battery, commercial, peer to peer energy markets in the UK which also contributed significant financial savings to the participating households. There remain significant challenges to making this option widespread:

1. The requirement to switch suppliers to access UEC benefits limited the uptake amongst residents. Allowing local energy to be retailed alongside a household's main supply contract may increase the uptake or allow suppliers to automatically enrol their customers into non-punitive local energy markets.

2. The battery costs were not included as part of the trial. The value the UEC battery earnt through providing additional solar to a local P2P market and delivering flexibility would not currently cover the capital and operational costs within a feasible payback time. The battery revenues earned through the delivery of flexibility services and collective energy self-consumption would not currently cover the battery capital and operation costs within a feasible payback time.

3. The platform costs were not included in the trial and would likely reduce the amount of economic benefit households receive through such local energy markets.

This project will demonstrate the value of participating in flexibility markets to social housing providers.

Strategic Project Highlights

Future Ready

Urban Energy Club

Figure 21: CommUNITY & UEC - External platform architecture (Source: EDF)

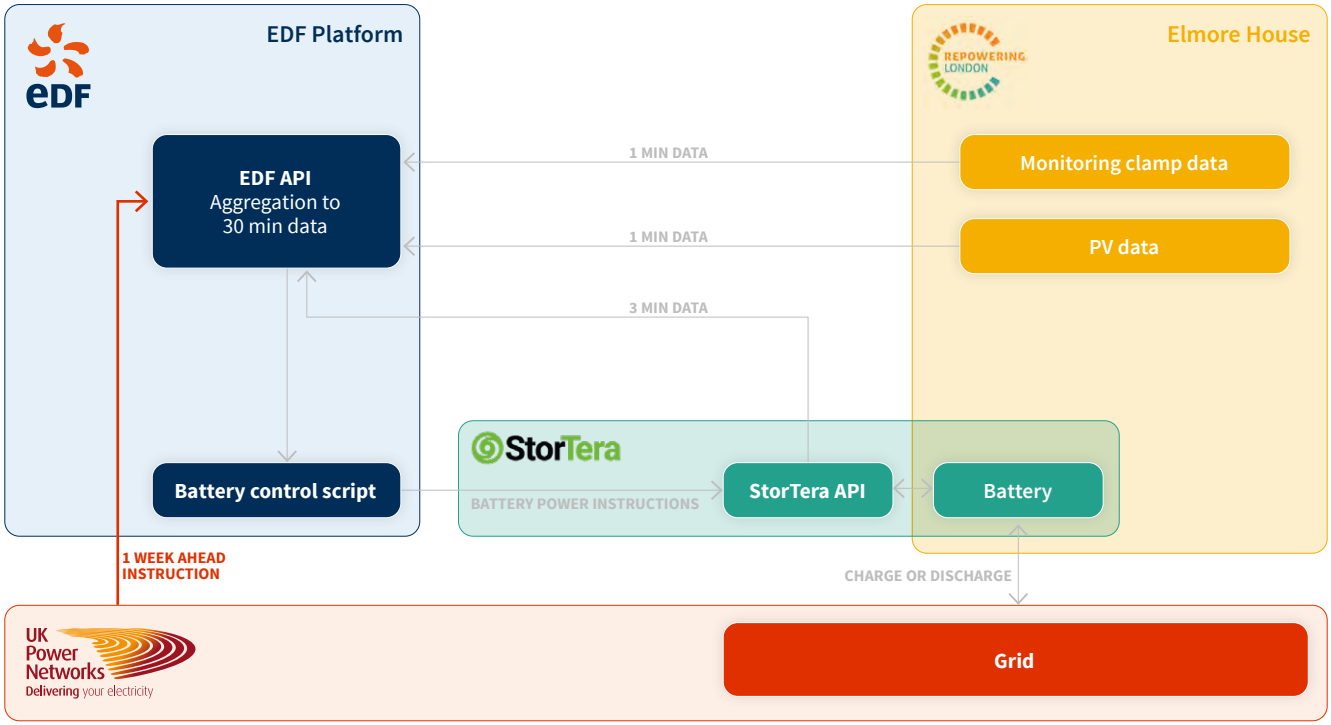
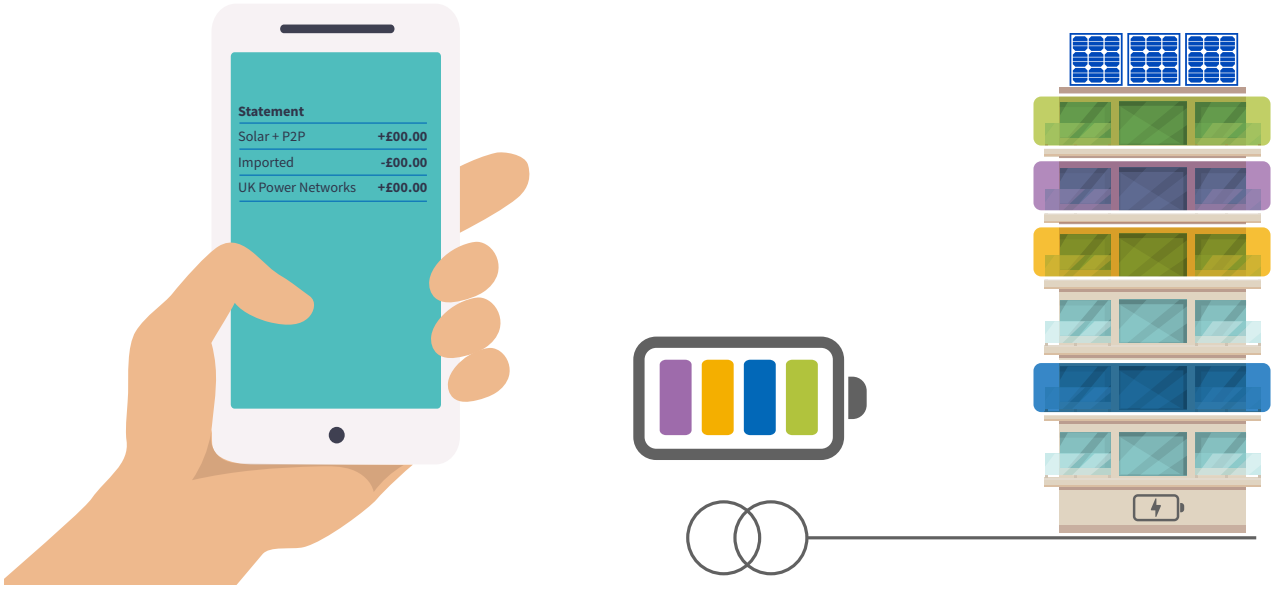


Figure 22: Illustration of shared storage and virtual allocation



Strategic Project Highlights

Efficient & Effective

Electricity distribution networks are evolving at an unprecedented pace. The national Net Zero target as well as a profound transformation of the energy landscape, led electricity customers to change the way they use electricity. A renewed focus on digitisation and decarbonisation of heat and transport, provides our customers the opportunity to make a positive impact on our environment and to address the climate change issue.

However, this great opportunity comes with key technical and commercial challenges to be resolved. UK Power Networks believes that distribution networks should be at the centre of the energy revolution and should be one the key protagonists, alongside our customers, of the decarbonisation journey of the country.

The 'Efficient & Effective' strategic focus area represents UK Power Networks' response to the decarbonisation challenge. The key objective of the focus area is to deliver smart solutions and distribution network improvements to guarantee a smooth low carbon transition at the lowest possible cost.

Numerous innovation projects are delivered by UK Power Networks' specialists and external Partners to explore new enhanced ways to design, operate and manage the network.

UK Power Networks strives to increase network performance by placing innovation at the heart of everyday activities.

Delivering successful first-of-its-kind projects means delivering smart savings for customers, and some of our key project highlights are reported below.

Futurelink This project aims at delivering two phase link boxes required for two phase distribution networks (known as Scott Networks) effectively optimising asset management costs.

Underground fault predictive model and earthing assessments This project is delivering an innovative fault prediction methodology based on rainfall data and soil characteristics.

MILES Fault Location The project's aim is to deliver a fault predictive system which can give a precise location of a fault by using LV power quality sensors, voltage drop location algorithms and cloud computing to detect, locate and classify short and long-term faults.

LV Interconnected Pairs Network (LPN) The project is trialling a new way to share technology between our substations so we can automatically restore power without having to send engineers in-person to LV faults.

Storm Resilience The project developed an advanced tool that combines network data, historic fault data and live weather forecasts (lightning strikes locations) to predict the number of faults that could occur in an area to optimise the effectiveness of storm response activities.

Strategic Project Highlights

Efficient & Effective

Underground Fault Predictive Model and Earthing Assessments

Background

Previous studies by UK Power Networks revealed that there was some correlation between the amount of rainfall and underground cable faults; this was a conclusion from an innovation project "prediction of weather-related faults". However, it was suggested from the previous studies to carry out further analyses to determine if soil types also had an impact on underground cable faults. The hypothesis being that various soil types have different water retention properties which could contribute to moisture ingress in cable joints.

UK Power Networks has a desktop earthing assessment tool for distribution substations which requires soil resistivity values from each location in UK Power Networks operational areas. The soil resistivity values used in the earthing assessment tool were stored on a British Geological Survey (BGS) portal but was unsupported. To ensure uninterrupted use of the earthing assessment tool it was important to consider the implementation of updated soil resistivity maps in a UK Power Networks' Geospatial Analytics tool (GSA).

Experience to date

The project established that there is a weak correlation between the number of underground cable faults and soil types; hence soil types was not factored in the faults-rainfall formulae determined from a previous project. Analyses completed on the project also showed that wind speed has an impact on faults volumes, the main impact being on overhead line assets. The conclusion was that overall fault volumes was a function of the amount of rainfall and wind speed in each area. Based on these findings, faults forecast models were built in UK Power Networks' GSA tool. This included:

a. A faults forecast model based on the faults-wind and faults-rain formulae determined by the Met Office;
b. A faults forecast model based on a linear regression comparing faults and weather; and
c. A calls forecasts model based on linear regression between the number of customer calls we receive and faults on the network.

Whilst completing extensive testing to operationalise the above models, the project team determined that the weather forecasts for 2x2km grid squares, which the models rely on, were not always accurate. Based on further discussions with the Met Office, the project concluded that further developments will be required to improve the accuracy of forecasts for localized areas (e.g. 2x2km grid squares).

In contrast to the fault prediction model, a soil resistivity tool was successfully implemented in UK Power Networks' GSA tool. This tool is linked to UK Power Networks' earthing assessment tool and has enabled substation designers and planners to carry out desktop earthing assessments to determine the requirements for effective earthing of distribution substations. The use of the desktop assessment tool has reduced costs as onsite earthing assessments are avoided, potentially saving up to c.£660k per year across UK Power Networks.

Future developments

The learnings developed during the execution of the project showed that whilst weather forecasts for larger areas for e.g. London as a whole was accurate, it is a lot more difficult to provide accurate forecasts for localised areas (e.g. for 2x2km grid squares which was used on the project). The review of weather forecasts for each of these 2x2km grid squares vs actual observation data from weather stations in the vicinity showed that there were often significant variances. A review of these variances and further discussion with the Met Office concluded that further developments would be required to be able to provide accurate localised forecasts. Alternatively UK Power Networks would need to explore different levels of granularity e.g. 5 km² or 10 km² to determine which would be more practical to use for an operational weather and faults forecast model.

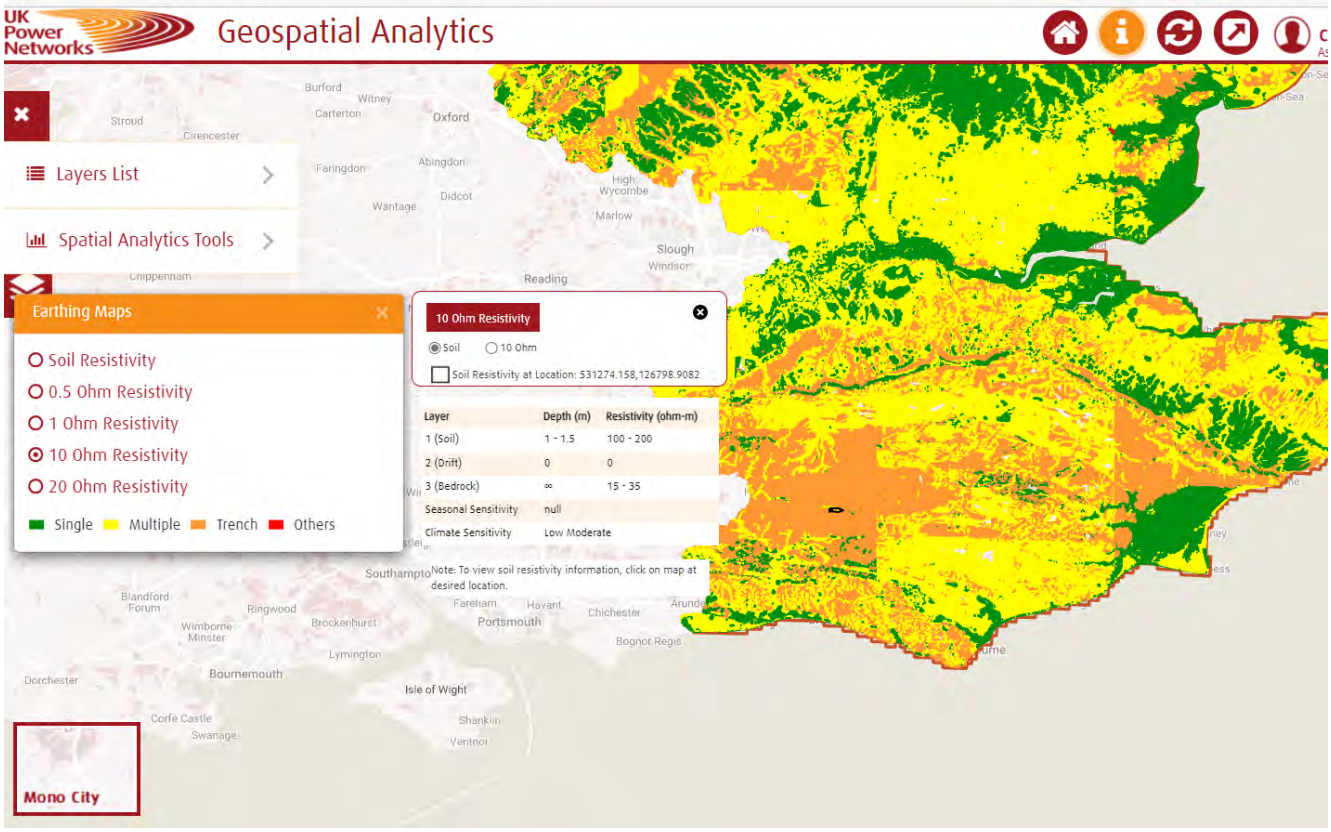
The project will improve our understanding of the relationship between soil types, rainfall, and underground cable faults, ultimately making improving network reliability for our customers.

Strategic Project Highlights

Efficient & Effective

Underground Fault Predictive Model and Earthing Assessments

Figure 23: Sample screenshot of soil resistivity tool in GSA



Strategic Project Highlights

Efficient & Effective

MILES Better Fault Location

Background

Power cuts are a common challenge for network operators and our customers. Their impact is measured by the number of Customer Interruptions (CI) and Customer Minutes Lost (CML).

To minimise CIs and CMLs, distribution network operators must find their cause and fix them quickly.

The innovation project MILES[1] has two primary objectives. To find the causes of:

- Permanent power cuts when they happen; and
- Transient power cuts before they become permanent.

The underlying premise of MILES is shown in Figure 24, where voltage sensors on the LV network measure and detect voltage waveforms as a fault occurs. The voltage waveforms are then uploaded to a server where they are analysed by the MILES algorithm, which combined with prior knowledge of the upstream high voltage (HV) feeders, is able to estimate a probable location of the fault. This technology was successfully developed and rolled out by Hydro-Quebec in Canada, and is now being industrialised in partnership with CGI. If proven successful from a technical and commercial perspective, UK Power Networks seek to deploy this at scale in order to reduce the CI and CML impact and improve the service to our customers.

Experience to date

Thus far, UK Power Networks have worked together with CGI to model six feeders and completed a desk study of the identified network trial sites. The potential levels of accuracy demonstrated by the desk study are promising, with about 87% of faults found within 200m. Sensitivity analysis has been performed to assess the impact of erroneous voltage measurements, as well as impedance values. CGI has also deployed their software-based platform within UK Power Networks' technology infrastructure.

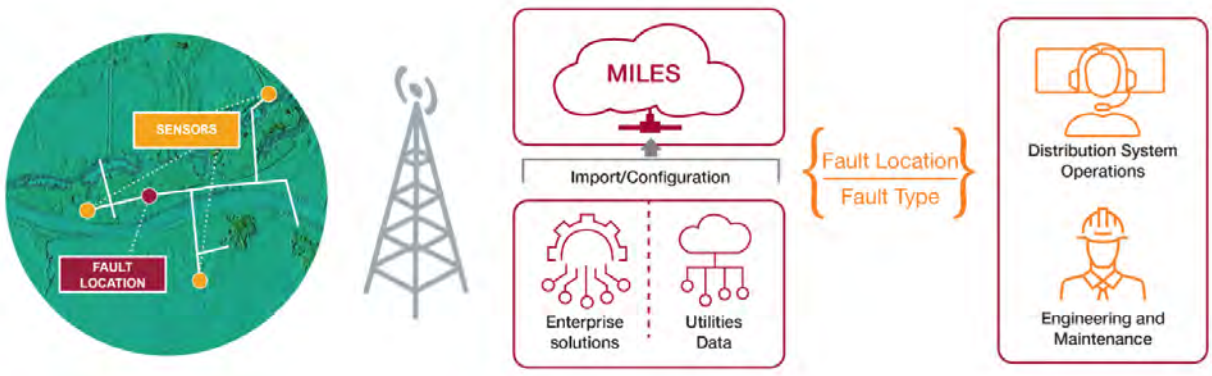
The Project team has also installed sensors on five feeders, and completed three months of trials on them, where faults data were gathered. It was determined that the average distance from the nearest MILES fault estimate to the real fault location is on the order of 500m (57% of faults were within 200m).

Future developments

Following the completion of the first set of trials, UK Power Networks would look to further assess the results in terms of the value and benefit it would add to our existing systems. In addition, the commercial and technical viability of the system integration and ongoing costs would be weighed up as part of a consideration to perform a wider integration as part of the project.

The system helps field engineers pinpoint the location of a fault down to a few metres so the network can be fixed faster, and our customers' power restored sooner.

Figure 24: A diagrammatic view of the system. In the field, voltage sensors are deployed on LV networks. These send the captured waveform data of voltage drops back to the MILES platform © CGI. Inc, which then provide an estimate of where the fault may be located.



1 A French acronym of Maintenance Intelligente des Lignes Électriques. When translated to English, it reads Intelligent Maintenance of Electric Lines.

Strategic Project Highlights

Efficient & Effective

MILES Better Fault Location

Figure 25: A view of the platform and the high-level summary of a month's worth of faults.

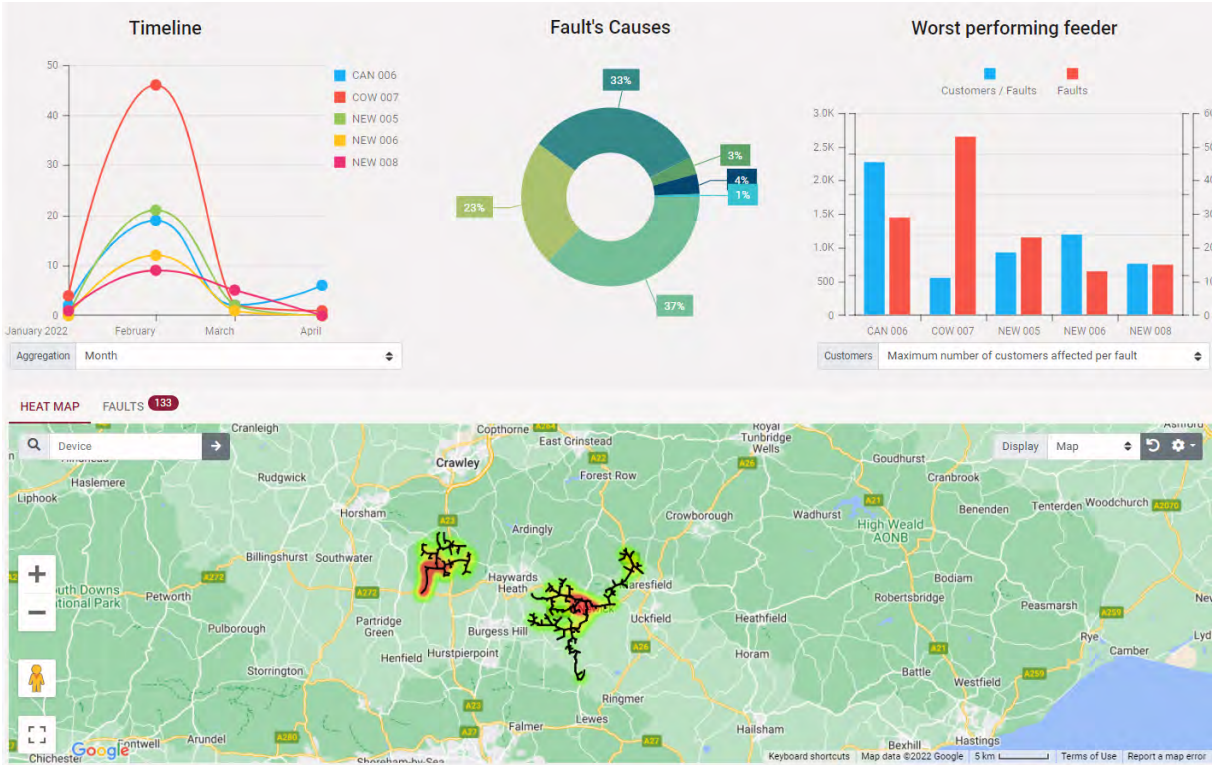


Figure 26: A fault found by MILES, with 4 possible locations on Newick 06 on the 7/8/21

Figure 27: A fault found by MILES, with 1 possible location on Newick 08 on the 8/9/21

Strategic Project Highlights

Efficient & Effective

LV Interconnected Pairs

Background

Current operation of the network means that when a HV fault occurs on the network to the supply of a non-remotely controlled substation, the LV network fed from the affected substation loses supply and therefore affects large amounts of customers. As a consequence, key network performance indicators such as CI and CML are negatively impacted.

When a fault occurs at a HV level, the LV network impacted by that fault would have to be restored prior to restoring the main fault. This is done with the aim to restore customers quickly and minimise the impact that fault has on them. In order to do so, field engineers are currently required to attend the site and restore supplies manually by the traditional method of Backfeeds (Linking & Fusing). The solution proposed by this project will still require site attendance to investigate the initial HV fault during the trial phase, however the use of this solution in restoring LV supplies to non-remotely controlled substations will result in customers experiencing less time off supply. Currently, the duration between a fault and restoring a non-remotely controlled substation is averaged at 90 minutes. By utilising this solution, the restoration process will drop to on average of 40 seconds. This value would be the time required for the automatic position reporting system (APRS) to acknowledge the fault at the receiving substation. Then, through a modified RTU, supply the affected network from the donor substation.

Although fully interconnected sites are already on the network, the application of this innovative solution will result in lower fault levels and will ensure the safest and most efficient operation of the network as possible. Through the successful implementation of this project, DNOs would be able to significantly reduce the number of CIs and CMLs, consequently reducing the number of customers who are affected by the faulty patch of the network.

Experience to date

The preliminary design and specification activities for this project have concluded successfully in collaboration with the designated suppliers of the tools used as part of this project. Following that, the detailed design phase was also a success. However, the latter had to go through a sequence of alterations to ensure compliance with distribution network standards. Therefore, the proposed proof of concept phase took more time to approve by the stakeholders. Prior to the commencing of the first installation trial, the kit had to undergo a series of testing to ensure further compliance with the proof of concept and to monitor the operation of this solution within a controlled environment. The last of which has been now concluded successfully.

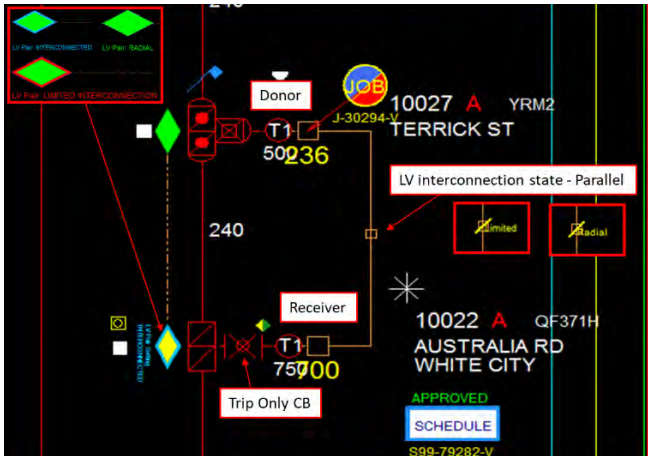
Future developments

An operational procedure document is currently being collated to provide a detailed breakdown of the process of operation. This document will also help set out the work division between the various departments especially after the solution is rolled out to BAU.

Following the conclusion of all the required testing, the team is now working together to commence the first trial installation as per the project plan. Once this trial is successful, the remaining trials will continue to take place. A list of suitable sites is being dynamically developed to eliminate any delays to future trials.

This technical project will help us restore power faster in urban areas.

Figure 28: Network View Representation of an Interconnected Pair



Strategic Project Highlights

Efficient & Effective

FutureLink

Background

The Croydon SPN LV Network uses a 2 phase -2 conductor system (known as Scott System) that requires a unique type of link box that is no longer available to buy. All the existing link boxes have been categorised as Health Index 5 (HI5) and currently, each link box has to be replaced by two standard four-way link boxes. This procedure is expensive, disruptive and requires a complex amount of planning/Jointing works. The existing population of 665 link boxes needs to be replaced in the remainder of RIIO-ED1 and into RIIO-ED2, once a suitable replacement can be found.

The use of DC networks is an area of ongoing research, and we believe, as the Scott Network in the Croydon area started off as one, it is appropriate to develop an enduring solution to replace the legacy Scott link boxes. This will provide UK Power Networks with the ability to run the Croydon LV network at Direct Current at some point in the future or even operate Alternating Current and Direct Current systems on the same piece of network.

The project will work with a manufacturer to complete the design and type testing of a modern 2-phase, 2-busbar LV link box that can be used to replace the ageing Scott Network link boxes. Prototypes will be type tested at an independent facility and if successful, two units will be trialled on the live LV network in the Croydon area to understand whether or not they are suitable for a wider rollout. On the back of the successful adoption of a 2-phase 2-busbar link box, the design can be modified to provide a 3-phase 3-busbar version, which could be used on the 3-phase LV networks as and when required. The current modern (3-phase) link boxes only have one busbar. An increased number of busbars will result in greater asset resilience, which will improve the quality of service.

Experience to date

The first success criterion (detail design) of the project has successfully concluded this year. The detailed design of the link box has been delivered by the supplier as planned. Following an extensive review and approval process, the design has been approved by UK Power Networks' stakeholders and the prototyping and testing phase is now underway. Once this current phase successfully concludes, the final stage of the project which is the network trail will take place.

Future developments

The project is currently in the prototyping and testing phase. As part of this process, prototypes of the approved designs are being tested to ensure compliance and operation of the link boxes. The tests will be carried out in parallel to minimise the overall time required for this phase. Once the prototypes successfully pass all of those tests, a full build will be established, and the final testing activities will take place.

The following phase of the project would be to start the network trial and monitor the link box performance outside of the controlled environment. A successful conclusion of that phase will lead to project closedown and migration to BAU.

Future Link is developing new equipment that will make the low voltage network more resilient for our customers.

Strategic Project Highlights

Efficient & Effective

Storm Resilience

Background

Severe weather events have an adverse effect on the distribution network because they result in high volumes of unplanned power outages. These faults are a consequence of the unpredictable and/or sudden changes in the weather. Such faults impose an immediate challenge on reconnecting customers following a lightning strike and the optimisation of resource allocation for successful fault management.

On the first challenge, if a circuit-breaker trip is caused by a suspected lightning strike, UK Power Networks' procedures allow a tele-close action after 30 minutes. In the case of lightning storms causing multiple faults, the Network Control Manager has the authority to waive the 30 minutes wait (this happens on average 5-10 times a year). This waiting period adversely affects the duration of customer supply interruptions caused by non-damage faults. At the same time, it has been found that if a lightning strike was the reason for circuit breaker operation (which is not always known), reclosing it before the 30-minute waiting period did not result in any adverse impact on the operation of the network or the assets. However, the lightning map used before this project was initiated did not give UK Power Networks' control engineers sufficient confidence to reliably link lightning strikes to affected circuits.

Moving onto the second challenge this project is trying to tackle, the emergency escalation process is invoked every time severe weather is forecast. Weather parameters from the Met Office are reviewed and a response plan is developed and put in place. This plan is re-evaluated and updated every few hours with up-to-date weather data. With that said, the currently available weather information is limited and not directly matched to the electricity network. Therefore, this makes resource estimation complex and, in some cases, suboptimal.

Project summary

UK Power Networks' 'Storm Resilience' project developed an advanced tool that combines network data, historic fault data and live weather forecasts to predict the number of faults that could occur in an area of our network. This is particularly helpful in times of stormy weather to ensure enough engineers are on standby. A separate part of the project trialled a lightning tracking software to help restore power supplies caused by lightning strikes up to 90% faster compared to current restoration processes.

This project supported the drive to be an even more reliable network operator by improving resilience during severe events. It was split into two separate initiatives:
Workstream 1 Lightning into PowerOn (see Figure 29)
Workstream 2 Resource Estimation Tool

Experience to date

Workstream 1

The project trialled a proof of concept where UK Power Networks' Distribution Management System (PowerOn) received lightning strike locations in real-time via an API developed by an international weather consultancy (See Figure 29). These locations were then linked to poles and the network diagram. After this mapping was established, a dedicated alarm was created in PowerOn to notify control engineers that the faulted circuit was likely struck by lightning in order to reduce the time customers don't have supply due to lightning strikes.

Workstream 2

The project gained access to advanced weather forecasting from stations across the UK Power Networks' licence areas. The project team trialled the concept of using predictive analytics to combine historic fault data and weather parameters. This built on and enhanced our existing capabilities to forecast the impact of severe weather. Using innovative technology, it was possible to develop the link between high frequency sampled weather data and the distribution network. Figure 30 gives a high-level representation of the back-end infrastructure used in this work stream. These forecasts are now helping UK Power Networks predict the impact of a storm and quantify the expected level of risk of each weather.

Strategic Project Highlights

Efficient & Effective

Storm Resilience

Key learnings

Lightning into PowerOn meant that, for the first time ever, real-time lightning data was available in our network management system. The system is now identifying when a fault is most likely caused by lightning. Using lightning data to this accuracy had never been trialled before. The project trialled Lightning into PowerOn and Storm Resource Forecasting throughout 2021.

The lightning trial captured 37 events. This was sufficient to prove the concept on the live system but was not sufficient to lead to a long-term business change. The functionality has now been built into our automatic power restoration system to enable us to restore a power cut due to lightning in less than three minutes. UK Power Networks has set a target of 200 faults to be recognised by the system before making the solution BAU. This will allow for a thorough verification to take place that the accuracy is as high as required for full deployment. This will not be part of the Storm Resilience project but will take place as part of a follow-on activity.

The Resource Estimation Tool combined network data, historic fault data, and advanced weather forecasts to predict the number of faults each region will experience during bad weather. This created a 'probabilistic fault forecast', which has never been trialled for a UK electricity network. The tool automatically predicts where and when to allocate resources and staff hours far more accurately than humans can. Machine learning will be used to help improve the tool over time. During the trial, the project team measured how well it predicted outages for different types of weather across our regions. The project found that for precipitation up to 20mm per day, the tool worked very well for all regions. For days with precipitation above 20mm per day, the tool slightly overestimated faults for South Eastern Power Networks and slightly underestimated faults for Eastern Power Networks. A comparison between the actual and the forecasted outages during rainfall events in all three licence areas is shown in Figure 31.

Helping restore power supplies caused by lightning strikes up to 90% faster, and ensuring we have engineers in the right places to reduce the time taken to repair faults caused by a storm.

Figure 29: Lightning data integration into PowerOn

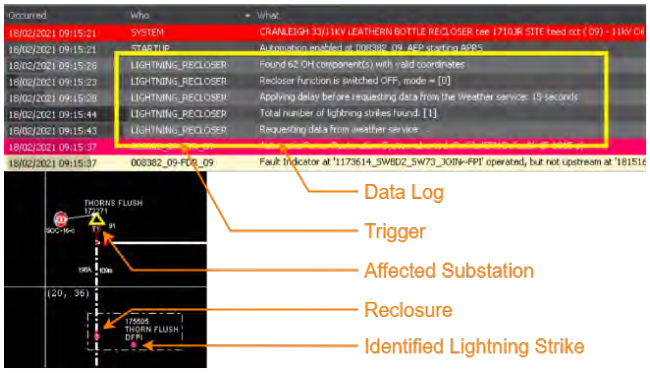


Figure 30: Fault Forecasting System back-end infrastructure

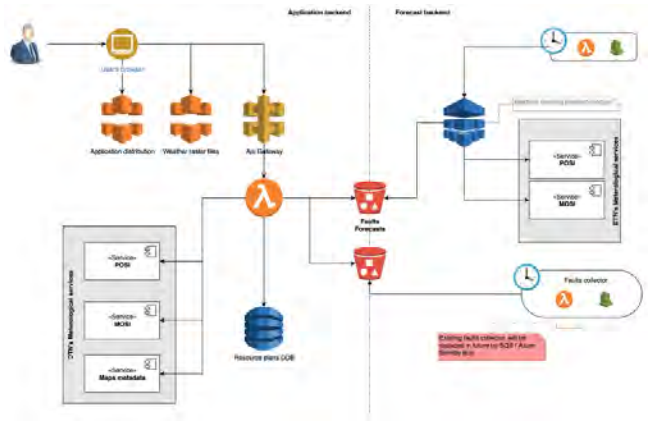
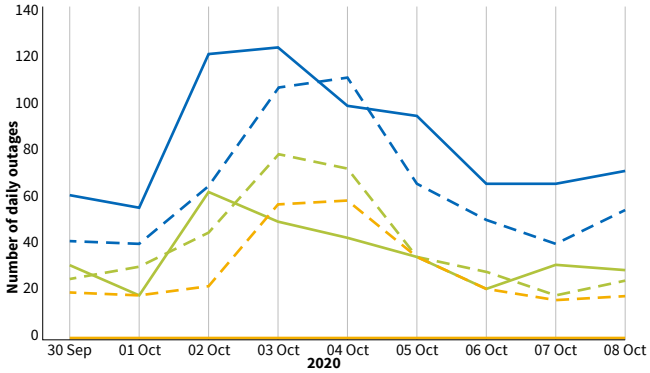


Figure 31: Network outages during rainfall events
Region: Eastern Power Networks London Power Networks South Eastern Power Networks
Type: Observed Forecast



Our Network Innovation Allowance Portfolio

Our Network Innovation Allowance Portfolio

Net Zero Ready

REFERENCE	PROJECT NAME	RESEARCH AREAS	DURATION	BUDGET
NIA_UKPN0032	Mobile Field Control	Customer and stakeholder focus Safety, health and environment	03/18 - 12/21	£1,539,960
NIA_UKPN0033	TransPower (V2G)	Transition to low carbon future	05/21 - 07/22	£2,143,717
NIA_UKPN0045	Shift	Transition to low carbon future New technologies and commercial evolution	02/20 - 10/21	£1,295,500
NIA_UKPN0049	Phase Switch System	Network improvements and system operability	02/19 - 03/23	£959,000
NIA_UKPN0060	White Van Plan	Customer and stakeholder focus	10/20 - 10/22	£604,000
NIA_UKPN0061	Heat Street	Transition to low carbon future	10/20 - 08/21	£318,652
NIA_UKPN0063	Charge Collective	Network improvements and system operability	11/20 - 04/22	£843,640
NIA_UKPN0065	Cleaner Engines	Network improvements and system operability	12/20 - 10/22	£433,000
NIA_UKPN0066	CommuniHeat	New technologies and commercial evolution	02/21 - 06/22	£919,688
NIA_UKPN0067	GIS Intelligent Fibre Optic Condition Monitoring	Transition to low carbon future	02/21 - 06/22	£327,000
NIA_UKPN0069	Socially Green	Network improvements and system operability	08/18 - 05/22	£925,000
NIA_UKPN0072	Voyage	Network improvements and system operability. New technologies and commercial evolution	04/19 - 06/22	£248,930
NIA_UKPN0073	Enable	Customer and stakeholder focus	05/19 - 03/22	£254,000
NIA_UKPN0077	Emerge	Transition to low carbon future	07/20 - 08/23	£730,733
NIA_UKPN0078	Right to Heat	Transition to low carbon future	03/21 - 07/23	£1,157,101
NIA_UKPN0079	Collaborative Local Energy Optimisation (CLEO)	Customer and stakeholder focus	03/22 - 07/24	£2,520,000

Future Ready

REFERENCE	PROJECT NAME	RESEARCH AREAS	DURATION	BUDGET
NIA_UKPN0048	Unified Protection	Transition to low carbon future	04/18 - 03/22	£765,254
NIA_UKPN0050	Urban Energy Club	Transition to low carbon future	06/19 - 02/22	£195,238
NIA_UKPN0052	Energy Exchange	Network improvements and system operability	01/20 - 08/22	£985,800
NIA_UKPN0058	Line Search	Transition to low carbon future	08/20 - 07/21	£209,000
NIA_UKPN0070	Envision	Transition to low carbon future. New technologies and commercial evolution	01/19 - 09/22	£1,971,000
NIA_UKPN0075	Social Connect (Empower)	Transition to low carbon future	02/20 - 02/23	£520,000

Our Network Innovation Allowance Portfolio

Efficient & Effective

REFERENCE	PROJECT NAME	RESEARCH AREAS	DURATION	BUDGET
NIA_UKPN0040	Transformer Care	Network improvements and system operability New technologies and commercial evolution Safety and health and environment	09/21 - 09/21	£218,393
NIA_UKPN0046	Underground fault predictive model and earthing assessments	Network improvements and system operability	02/20 - 08/21	£692,887
NIA_UKPN0047	HV Feeder Monitoring To Pre-empt Faults (EIC)	Network improvements and system operability	02/20 - 02/22	£1,915,101
NIA_UKPN0053	Storm Resilience	Safety, health and environment	02/20 - 12/21	£664,943
NIA_UKPN0054	EPRI Research Collaboration on Overhead Transmission (P35) and Network improvements and system operability Substations (P37)	Network improvements and system operability	02/20 - 07/23	£924,000
NIA_UKPN0055	Arc Aid	Network improvements and system operability	05/20 - 08/22	£571,000
NIA_UKPN0057	CircuitSee	New technologies and commercial evolution	08/20 - 04/22	£957,000
NIA_UKPN0059	MILES Fault Location	Safety, health and environment	09/20 - 05/23	£1,838,000
NIA_UKPN0062	VHF radios for teleprotection	Network improvements and system operability	11/20 - 08/23	£438,000
NIA_UKPN0064	3D printing of Network Assets - IUWG	Customer and stakeholder focus	11/20 - 04/22	£307,000
NIA_UKPN0068	Futurelink	Transition to low carbon future	06/19 - 09/22	£288,000
NIA_UKPN0071	Smart Cable Guard	Network improvements and system operability	02/19 - 02/23	£435,281
NIA_UKPN0074	LV Interconnected Pairs Network (LPN)	Network improvements and system operability	12/19 - 05/23	£661,000
NIA_UKPN0076	Neighbourhood Green	Safety, health and environment	05/20 - 02/24	£818,000

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