Network Innovation Allowance Annual Summary

Progress and results from 2017/18

UK Power Networks
Delivering your electricity

ukpowernetworks.co.uk

Contents

Foreword

Innovating to make things better for our customers is part of our DNA. Every day, the team at UK Power Networks is innovating, collaborating and finding new and better ways of doing things. We are driven by making our network safer, more cost-efficient and more reliable through smart interventions.

In the last year we once again demonstrated our market leading performance. In ED1 we have saved our customers a market leading £149m through innovation. We pride ourselves on the highest volume of innovative solutions deployed into business as usual, as reported to Ofgem in our most recent Regulatory Reporting Pack table E6 in July 2017.

We continued to maintain our 100% success rate in bidding for Network Innovation Competition and LCNF T2 funding as a result of our interactive innovation process and stringent idea challenge process.

The purpose of this report is to give you an insight into the work the Innovation team has undertaken and our key achievements over the last regulatory year spanning 1 April 2017 to 31 March 2018.

The way energy is generated, managed and consumed continues to change at an unprecedented pace. The volume of distributed energy resources connected to our network continues to grow. Distributed electricity generation has more than doubled since 2010, with renewables taking the leading role. Last year was the greenest year since records began in terms of renewable energy generation. We now have more than 8.5GW and over 200,000 generators of all sizes connected to our three distribution networks.

Consumer interest in electric vehicles continues to rise, with more than 55,000 connected to our three networks as of March 2018, well ahead of our ED1 forecasts and continuing to grow year on year. The growth of electric vehicles and distributed energy brings wide-ranging challenges and opportunities to our business.

The change associated with the dynamic evolution of our industry will have an impact on every department at UK Power Networks from planning to operations, and everything in between. To remain abreast with this transformation, we are committed to ensuring we have the right people, processes, products and systems in place to continue to run the network safely, reliably and efficiently.

> “In ED1 we have saved our customers a market leading £149m through innovation.”

We place a high value on seeking out the best ideas to improve our performance for our customers, from start-ups to established industry leaders. We actively support Small and Medium Enterprises (SMEs) to develop and demonstrate their solutions through the Energy Innovation Centre. This continued initiative has also developed the highest volume of cross-network collaboration of any year to date, with the inclusion of gas network partners and cross vector projects now being developed as a norm. A key metric to delivering our corporate vision is to be a respected corporate citizen; this drives our energy to collaborate with research and demonstration centres such as Power Networks Demonstration Centre, focussing their research towards overcoming our key industry challenges.

To ensure we are able to evidence the value of the RIIO Innovation stimulus and share the great innovations which networks are delivering, we believe networks should engage with industry and wider stakeholders at key events. In the last year we undertook more than 25 external speaking engagements to connect with industry, helping to learn from and share our work to optimise the network with key stakeholders, as well as raising our profile among potential project partners and collaborators. We also continue to promote innovation internally by including innovation content such as presentations and information stands at internal events, working with colleagues to develop ideas, and engaging early with the end users of each innovation solution.

Our vision remains to be the best performing DNO Group between 2015/16 and 2018/19. A key objective in achieving our vision is to be the most Innovative, which means focusing on three key areas:

- **Efficient & Effective** – The top DNO Group in delivering value to network customers through Innovation and the benchmark for best practice
- **Low Carbon Ready** – Consistently credited as an active facilitator of, and not an obstacle to, the low carbon transition
- **Future-Ready** – A future-ready distribution business providing new services, which meet the needs of tomorrow's customers

Innovation is playing a crucial role in making our network safer, more reliable and more efficient. The Network Innovation Allowance has played a vital role in enabling us to create and embed innovative solutions into business as usual processes and to deliver great smart savings for customers. This is achieved via our mantra of "learning through doing".

Ian Cameron, Head of Innovation

> "Innovation is playing a crucial role in making our network safer, more reliable and most efficient."

If you have an idea or would like to put forward a potential innovation project, please get in touch with us at: innovation@ukpowernetworks.co.uk

Innovation facts and figures

28
Number of NIA projects in delivery

31
Total number of projects in delivery

54,164,039
£ value of all projects currently in the pipeline

2.5MVA of capacity
Released by timed connections 17/18

20,687,909
£ value of NIA portfolio in delivery

12
Transformers with RTTR deployed on them

Most granular EV uptake forecast

90
Joint shells used on our equipment

1,284

LV re-energising devices were deployed

This led to a saving of 1.38 CMLs (= 62,720 hours of 'loss of suppply') and 0.86 CIs (= 23,842 power cuts in total)

Innovation at UK Power Networks

How and Why we Innovate

The energy industry is undergoing unprecedented change. We are moving away from a simple but carbon-intensive model of delivering electricity generated by large coal and gas-fired power stations, to a much more dynamic and complex network with large volumes of distributed energy resources connected at distribution level. We are seeing the advent of producer/consumers (or 'prosumers') and local energy markets. The rise of electric vehicles, renewable energy, storage and, in time, decarbonisation of heating are all contributing to the low carbon and better air quality agendas being promoted by government at all levels. At the same time we have the responsibility to continue keeping the lights on at the lowest possible cost to our customers. We are committed to playing a key facilitation role in the UK's low carbon economy. Innovation, and specifically the Network Innovation Allowance, has and continues to be fundamental in enabling us to develop new ideas, fresh approaches and better processes using the network as a living testbed.

In 2017/18 we continued to focus on working collaboratively with the wider energy industry; one of the projects initiated last year is the first of its kind cross-vector project, led by the Energy Innovation Centre (EIC) and featuring Cadent, National Grid Gas Transmission, Northern Gas Networks, Northern Powergrid, Scottish & Southern Electricity Networks, Wales & West Utilities and UK Power Networks. The project, Eye in the Sky, is working with the Civil Aviation Authority to explore unmanned aerial vehicles to undertake the aerial inspection of network infrastructure.

Our door is always open to new ideas. To be the most innovative DNO group we need to have a rich and robust pipeline of ideas and to make sure we select the best solutions. That is why we have made it easier for innovators to engage with us over the last 12 months. We have updated our innovation processes so that innovation ideas can now be submitted through our website[1] for review by the Bid & Opportunities Manager. Our company-wide Problem Statements are available to view on our website[2] to help potential solution providers clearly demonstrate how their ideas can help us overcome our challenges or develop new opportunities.

In addition to the highlights from our Network Innovation Allowance projects, this document includes our larger projects funded through the Network Innovation Competition and Low Carbon Networks Fund. This year's report also features a section on electric vehicle projects; a subject which is a significant area of focus for us and one that rose to national prominence in 2017/18. We recognise the importance of identifying innovative solutions to address the challenges associated with the uptake of electric vehicles while minimising costs and inconvenience to our customers. The Network Innovation Allowance has allowed us to undertake a number of important projects that are forming the bedrock of our company-wide electric vehicle readiness strategy that includes better forecasting, visibility and more deployment of smart solutions in response to the uptake. Projects such as Black Cab Green and Recharge the Future are developing our long-term forecasting ability, providing valuable insights for us and other network operators. The Innovate UK funded Smart Electric Urban Logistics (SEUL)[3] project is testing alternative solutions including smart charging that will enable the global logistics company UPS to electrify their depot in Kentish Town, and has been used as an exemplary case study at the launch of the Mayor of Londons' EV Taskforce launch event in 2018.

Our successful 2017 NIC bid, Active Response, will investigate a longer-term solution of re-allocating capacity around the network to facilitate the availability of capacity where it is required at different times of the day. We are collaborating on the project with the SP Energy Networks to ensure the benefits can be rolled out to other networks faster. For example, from office areas during the day to residential areas in the evening in order to follow the moving demand for electric vehicle charging.

[1] http://innovation.ukpowernetworks.co.uk/innovation/en/why-we-innovate/

[2] http://innovation.ukpowernetworks.co.uk/innovation/en/why-we-innovate/

[3] This project builds on a previous Crossriver Partnership project called FREVUE

While we are committed to enabling low carbon technologies like electric vehicles, we will never lose sight of the fact that our primary responsibility is to keep the lights on. We have highlighted a number of projects that are delivering benefits to our customers now, including reducing the time it takes to locate faults to keep more customers' lights on and reducing the number and duration of power outages. Projects like Mobile Field Control and Optimising Overhead Line Conductor Inspection & Condition Assessment are driving efficiencies in network operations by minimising customer supply restoration times and trialling new technologies to refine the overhead line inspection process. Our focus extends beyond technical projects, we are also exploring how we can deliver social benefits to our most vulnerable customers. Our energywise project has demonstrated how we can support people who may be struggling with their energy bills, changing the way they use electricity.

Data Sharing Policy

We recognise that innovation projects may produce network and consumption data, and that this data may be useful to others. This data may be shared with interested parties, whenever it is practicable and legal to do so, and it is in the interest of GB electricity customers. In accordance with our Innovation Data Sharing Policy published in 2017/18, we aim to make available all non-personal, non-confidential/non-sensitive data on request, in order for interested parties to benefit from this data.

You can find out what data we have collected by looking at:

- Project Progress Reports, which describe the data collected within the last year; and
- Project Closedown Reports, which describe the data collected over the project duration.

These datasets may be anonymised, redacted, and/or aggregated by us to protect commercial confidentiality and other sensitivities.

To request data, please email innovation@ukpowernetworks.co.uk, and provide the following information:

- What data you require (please be as specific as possible);
- Which organisations, and which people in those organisations, will have access to the data;
- What you want to use the data for; and
- How providing the data to you would be in the interest of GB electricity customers.

Non-confidential/non-sensitive datasets will typically be published or provided under the Open Government Licence v3 or one of the Creative Commons licences. For datasets containing confidential or sensitive information, the terms of use will depend on our obligations under any confidentiality agreements relating to it, the nature of the data and what you are planning to do with it.

We will aim to apply the least onerous terms required to protect commercial confidentiality and other sensitivities. These terms will require acceptance in writing before we provide the Data. To view the full Innovation Data Sharing Policy please visit our website at http://innovation.ukpowernetworks.co.uk/innovation/en/contact-us/

To find out more about our projects and their supporting documents, including project reports to our regulator Ofgem, visit our website at http://innovation.ukpowernetworks.co.uk/innovation/en/ or the Energy Networks Association's Smarter Networks Portal at http://www.smarternetworks.org/

Enabling the Electric Transport Revolution

Our Electric Vehicle Strategy

The pace and scale of electric vehicle numbers connecting to our networks continues to surpass even the most[4] optimistic expectations. **We want to enable our customers to make the most of the opportunities presented by emerging technology such as lower cost connections, smart charging and vehicle to grid services**. The Network Innovation Allowance has played a crucial role in allowing us to keep the electrification of transport moving at the lowest possible cost for our customers.

Our 2017 electric vehicle uptake forecast across the UK increased by 21% over our ED1 projections and the forecast for within our three network areas has increased by 25%. As of March 2018 we have more than 55,000 plug-in vehicles connected to our three licence areas, up 14,000 in the last year alone. By 2030 we estimate the number of electric vehicles in our region could be between 1.6 and 3.5m.

In readiness for this increasing demand, we are delivering our EV readiness strategy which includes a response toolbox of business as usual and smart solutions. These include solutions to reduce the time and cost of managing constraints resulting from more EVs connecting to our networks in the near and distant future.

> “Our electric vehicle strategy is to facilitate the uptake through proactive engagement, great customer experience and a future ready network.”

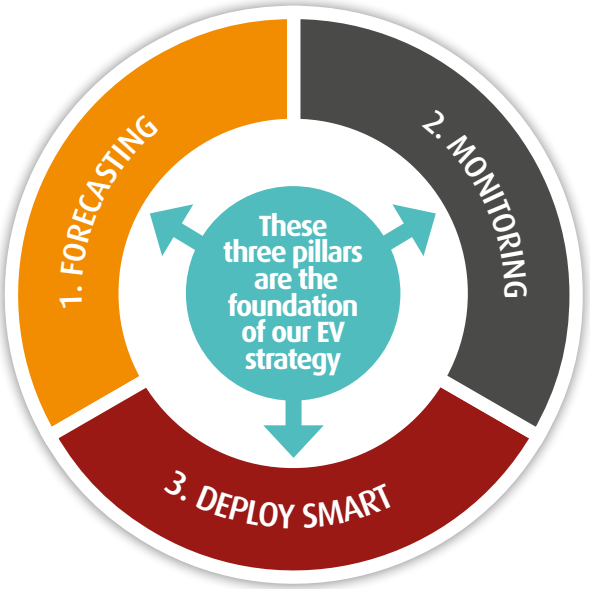

Figure 1 – Three pillars of our EV strategy

In addition to a response plan to address the most immediate challenges, we have designed an EV strategy to prepare our networks for the expected high electric vehicle uptake. This ensures that we are facilitating the electrification of transport and we continue to operate reliable networks while offering great customer service, this is achieved through our company-wide electric vehicle readiness programme. Our EV readiness approach has three key pillars:

- **Forecasting**: Granular understanding of the potential uptake. How, when and where it will affect our network in order to plan targeted monitoring and control solutions;
- **Monitoring**: Deploy control ready low voltage (LV) monitoring on 5,863 LV distribution sites to confirm the electric vehicle uptake model forecasts; and
- **Deploy Smart**: A toolbox of smart response solutions to enable us to optimise the use of the network in response to increased EV uptake ahead of building additional infrastructure.

Our low voltage network covers many thousands of assets across a vast geographic area. We need to make sure that we undertake least regret investment on the network to cater for any additional load created by electric vehicles in the right place at the right time. That is why we are analysing data on where, when and how electric vehicles are being charged. NIA projects such as Recharge the Future and Black Cab Green, will enable us to forecast this information with greater granularity and certainty, so that we can plan future investments with more certainty than ever.

Current EV uptake forecast by 2025 is that 40% of vehicle sales in our network areas will be plug-in electric. In general distribution networks are robust and contain ample capacity to accommodate this 40% uptake using Smart solutions[5]. The challenge networks face is not as much the size or timing of such uptake, but rather where and what form this uptake will take. In the interest of wider network customers, investment in the right parts of the network is key.

Our Electric Vehicle Strategy: Facilitate the EV uptake through the top engagement, great customer experience and a future ready network.

Figure 2 - Our Electric Vehicle Strategy

[4] Source: Leading indicators model, figures presented in market intelligence report (not publically available)
[5] Source: SSE The Electric Nation

Benefits of Smart Charging

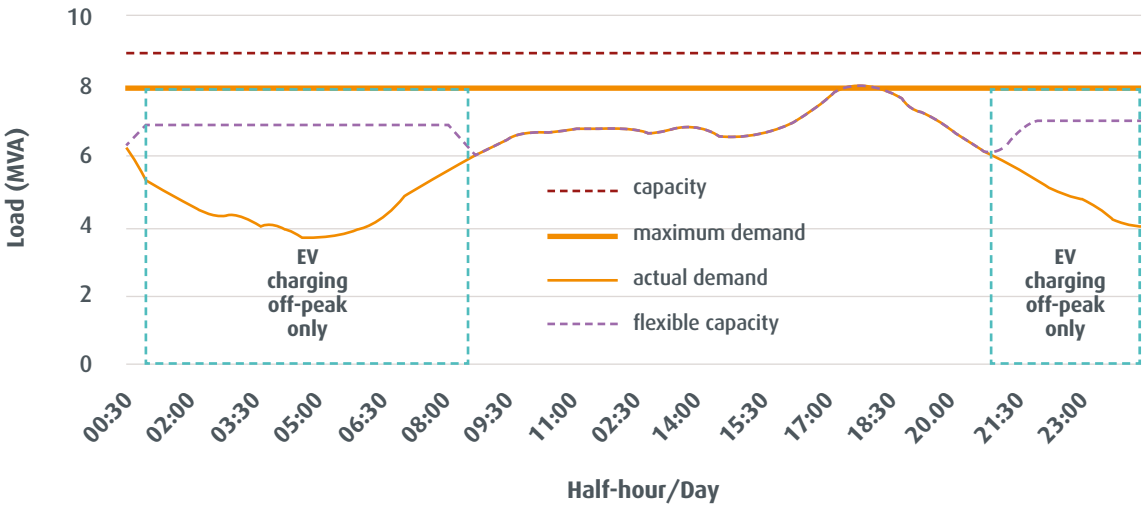

Figure 3 – An example of the potential headroom to deploy smart charging to support the uptake of electric vehicles

There are many opportunities to optimise the network infrastructure by using smart solutions ahead of requiring additional infrastructure build. The graph above shows an example of the potential headroom to deploy smart charging to support the uptake of electric vehicles. Off-peak charging is optimising the existing assets by utilising available capacity in the network.

EV Project Highlights

Black Cab Green

- **Challenge**: By 2023 all new taxis and private hire vehicles in London must be zero-emission capable to support the Mayor of London's plan for all taxis and minicabs to be zero-emission capable by 2033. As these clusters of drivers transition to EVs, this may result in upgrades to the local network.
- **Scope**: Establish what is required to change on London's electricity network, to prepare for a future when all of the 140,000 taxi and private hire vehicle drivers switch to zero-emission vehicles.
- **Action**: Analyse data of driving patterns and interview drivers to produce a robust forecast of the uptake and network impact of plug-in taxis and private hire vehicles in London.
- **Learning**: Projected potential cost avoidance of over 70% off upgrading the network to enable zero-emission taxis through optimised smart charging solutions.

Recharge the Future

- **Challenge**: Load growth from EVs is expected to contribute a large proportion of the UK's total load growth over the coming decades. It is therefore important that the accuracy of load forecasts are enhanced.
- **Scope**: Recharge the Future aims to greatly increase the accuracy and location of increased peak load caused by EVs by enhancing the Element Energy Load Forecasting model.
- **Action**: Undertake a Charger Use Study and significantly enhance the model we currently use to forecast EV load growth.
- **Learning**: The project aims to enable more efficient planning of networks and help ensure there is best in class forecast of EV load growth.

Active Response

- **Challenge**: Increased load growth from Low Carbon Technologies including EVs will create localised pinch points on the network. Active Response seeks a way of managing existing capacity in the most cost-efficient way for our customers.
- **Scope**: The project will trial a revolutionary way of managing spare electricity network capacity by using power electronics to move capacity from heavily loaded substations to nearby substations with spare capacity several times a day, season or year in a proactive manner in response to moveable energy assets.
- **Action**: It will research and demonstrate a responsive, automated electricity network that reconfigures itself constantly, moving spare capacity to where the demand is expected.
- **Learning**: Active Response builds on the findings of previous projects such as Flexible Urban Networks – Low Voltage, which delivered pioneering results by proving that an entirely new use for power electronics could be deployed on the electricity network. It could save customers £271 million by 2030 and cut more than 448,000 tonnes of carbon emissions by 2030.

Project Highlights

NIA Projects

Eye in the Sky

Background

Aerial inspections of network infrastructure are expensive, and the use of drones is now becoming recognised as a viable and cheaper alternative. The main issue is that all current drone inspection tasks are operated 'Within Line of Sight' (500m horizontally, 122m vertically) due to Civil Aviation Authority (CAA) regulations. To fully realise the benefits that drones can bring to traditional inspections tasks, there is a requirement to fly 'Beyond Visual Line of Sight' (BVLOS).

This project plans to go beyond the scope of a desktop exercise and physically extend the operational capability to BVLOS for specific inspections relating to the requirements of the energy networks (e.g. inspections over lengths of 10s of km), with an innovative approach to engaging with the Unmanned Air Systems (UAS) industry and the CAA.

This project is supported by the Department for Transport, CAA and Transport Systems Catapult as it falls within the government's Drone Pathfinder Programme. The project is being funded by seven network operators, across gas, electricity, distribution and transmission. At £1.4m, it is a first-of-its-kind collaboration across the energy utility industry.

Experience to date

Legal negotiations have been successfully completed and all seven network operators, plus four key project partners have signed an agreement. The current ongoing tasks involve planning, site selection and safety case development for the trial flights in segregated airspace. These are scheduled to begin in Q3 2018.

Future Developments

Once plans have been developed and sites have been selected, the project will be requesting segregated airspace permits from the CAA to complete test flights starting from Q3 2018. Once flights have been completed, there will be a separate activity to analyse the collected data.

Figure 4 – Project participants from seven network operators, Energy Innovation Centre and Transport Systems Catapult meet for project kick-off meeting

Efficient Network Constraint Management through the use of Market Signals

Background

The significant rise in distributed generation (DG) has resulted in power flow constraints in areas of the distribution network. Under the conventional approach to connections, any DG customer wishing to connect to the network is offered a connection that gives them full access. Where a network is constrained, however, a condition of connection is that the network is reinforced to accommodate the additional generation capacity, and that the connecting party must pay for a proportion of the costs.

The delay and cost associated with these reinforcement works has in some cases been prohibitive. As an alternative to reinforcing the network, the concept of Flexible Connections was developed and implemented by UK Power Networks. This concept allows DG to avoid some of the reinforcement costs and instead accept a degree of curtailment during periods of network constraints.

The 'principles of access' that have been implemented for Flexible Connections that define how curtailment is designated have tended to have three key limitations: they show potential inefficiencies in curtailment decisions, do not consider alternatives to curtailment, and lack a trigger and funding mechanism for future reinforcement.

The project investigated a novel approach to address these issues. Using market-based arrangements, which take into account the sensitivity of a DG to a constraint and the opportunity cost of curtailing a DG, the technical and economic efficiency of allocating network capacity in constrained zones can be improved. This in turn should lead to the connection of more flexible resources more cheaply and quickly, whilst avoiding unnecessary reinforcement, ultimately leading to cost savings for end consumers.

Experience to date

A study was conducted by Baringa investigating different market designs, which was published in a final report[6]. The designs considered how the schemes would be funded and how reinforcement would be triggered. The proposed designs are also compatible with existing rules and regulations. The report highlighted areas for further development using feedback gathered from UK Power Networks' DG customers, who were generally interested in the principle.

Future Developments

UK Power Networks intend to carry out further work to quantify the benefit of market based arrangements to allow DG customers with a flexible connection to trade their curtailment obligations. If considered feasible, a small trial will be conducted to test this new approach in real-world conditions.

[6] A market-based approach to delivering efficient network constraint management", November 2017, Baringa on behalf of UK Power Networks.

Mobile Field Control

Background

This is a first of a kind solution which will set out a framework for using Mobile Field Control to improve customer service and operational efficiency. Mobile Field Control allows control engineers to delegate authority of specific network areas to field engineers on their mobile device reducing the number of phone calls between the field engineer and control and providing greater visibility of progress.

It is anticipated that the trials will demonstrate improved performance in Customer Minutes Lost when using Mobile Field Control rather than existing field control and mobile solutions, which currently cannot be aligned due to technical limitations.

The project will also design and gain approval for the relevant changes to existing business processes and policies which will enable smooth transition of these solutions into business as usual.

Experience to date

The project was registered in March 2018, thus is still in the early mobilisation phase. The project has completed its procurement activities with the proposed supplier.

Future Developments

The project will design, build, test and trial the Mobile Field Control solution. In the initial phase of the project, the focus will be on capturing detailed solution requirements through a range of stakeholder workshops. The trials which will begin in 2019 and run until the end of 2020 will demonstrate the benefits of using the tools. The trials will involve a number of control and field engineers and will be closely aligned with our safety practises, to ensure no increase of risk is incurred.

Figure 5 – UK Power Network's control room

Harmonic Effect on Network Assets (HENA)

Background

The project aims to determine whether there are long-term detrimental effects on a DNO's network equipment when harmonic order (multiple of fundamental frequency) levels are allowed to exceed the planning limits stated in Engineering Recommendation G5/4. The initial focus of the assessment has been provided through a literature review. Affected assets will be modelled by National Physical Laboratory (NPL) and the actual impact on equipment measured at the Power Networks Demonstration Centre (PNDC). The measurements taken at PNDC will be used to validate the modelled results, refining the accuracy of the model and enabling further assets to be modelled with an improvement in accuracy. The findings will be summarised in a report at the end of the project and shared with the wider DNO community.

Experience to date

The literature review suggested that protection relays, electricity meters and transformers are affected by harmonics more than any other equipment types. The expectation was always that transformers would feature within the scope of this project; the addition of protection relays and electricity meters will add a useful further dimension to the project.

Future Developments

Following the successful delivery of the literature study focusing on the deleterious effects of harmonics on various network assets and their contributions to losses, the project team has commenced working on the following deliverables:

- Estimation of cost benefit of harmonic management/ reinforcement versus harmonic levels;
- Testing of a selection of network assets, such as distribution transformers, to observe performance issues identified in the literature review at various levels of harmonics. This will be done through injection of harmonics in the LV and 11kV networks of the PNDC;
- Reconciling the observed results against the above modelling;
- A guidance document on harmonic effects on various assets/equipment will be published; and
- Utilisation of asset design documentation to model/ estimate heating, life-cycle effects of power quality and power loss.

All the challenges and opportunities will be recorded in line with the UK Power Networks Innovation Strategy and all the learnings such as an improved understanding of harmonics effect on network assets and the economic benefits derived from an advanced management of the harmonic levels will be available and shared with the wider community.

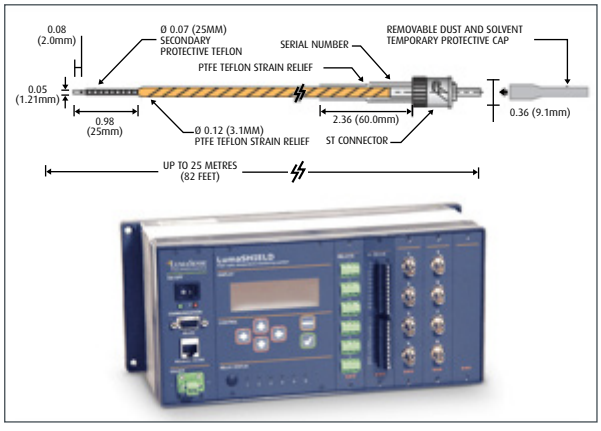

Figure 6 – Fibre optic sensor for transformer temperature monitoring

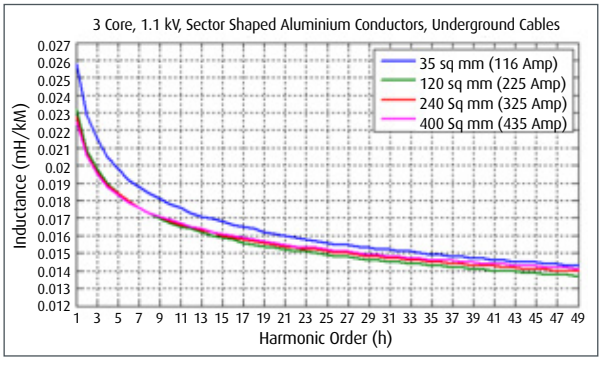

Figure 7 – Reduction in inductance depending on the harmonic orders

Real Time Thermal Ratings - Transformers

Background

Transformers are limited to a safe rating, which depends on being able to dissipate heat from the transformer. A number of standard design equations are used to create a fail-safe loading on the transformer (IEC 60076). Real-Time Thermal Rating (RTTR) challenges the current assumptions on transformer capacity ratings. It enables consideration of environmental-specific, accurate thermal data on transformers and the effect it has on windings in real time.

RTTR is a two-part solution:

1. Addition of real-time monitoring to transformers; and
2. Implementation of a software solution and thermal model (optimising algorithm), which uses real-time data to calculate ratings more accurately.

RTTR has benefits for a variety of users. It will allow:

1. Infrastructure planners to plan load estimations using different scenarios based on historical data;
2. Outage Planners to plan with greater understanding of specific site transformer limits;
3. Control Engineers to permit, as informed by real-time data, temporary reallocation of load on to other transformers in an emergency. Also, real-time data will allow for more advanced alarms to give warning of any potential issues with the transformers; and
4. Deferment of reinforcement of some sites, leading to cost reductions for our customers.

Experience to date

RTTR has been trialled at UK Power Networks on two primary substations (Lithos Road & Weybridge) involving extensive monitoring. The project was successful, with increased transformer ratings realised following the analysis of real time data captured from both substations (9% at Weybridge). The NIA budget and timeline was extended to allow completion of a second round of trialling due to the success of the first phase.

The data collected from the monitored transformers was also used to develop a thermal model (algorithm) that was optimised through a Particle Swarm Optimisation method and reached an accuracy within 1˚C of top oil temperature predictions.

Furthermore, in 2018 new monitoring equipment was fitted on 16 transformers, which once commissioned and enough data is collected, will be used to validate the accuracy of this thermal model and calculate real time ratings to be used to defer replacements of the transformers on these sites (subject to the asset conditions and network arrangements for each site).

Figure 8 – Dissolved Gas Analyser Installation in Wickford Primary Substation

Future Developments

The next phase of the project will complete the following:

- Verify the thermal model developed to predict top oil temperatures and calculate ratings;
- Develop a software tool to collate the data received with the implemented algorithm to perform what if analysis for planning purposes and calculate real time ratings for control and monitoring of the transformers; and
- Complete the commissioning of the installed equipment on all 16 transformers and linking them to SCADA through on-site RTUs.

UK Power Networks is also in the process of commencing a project to develop a thermal model for underground and tunnel cables using a similar approach to the RTTR Transformer project by creating a thermal model for underground and tunnel cables utilising the current Distributed Temperature Sensing (DTS) systems available. This will allow monitoring of cables understand and analyse the cables behaviour and hot spots with the aim of reducing the overall capex (cable costs) and opex costs (DTS & ventilation costs). This will be trialled in two schemes in London and is expected to be completed by 2020.

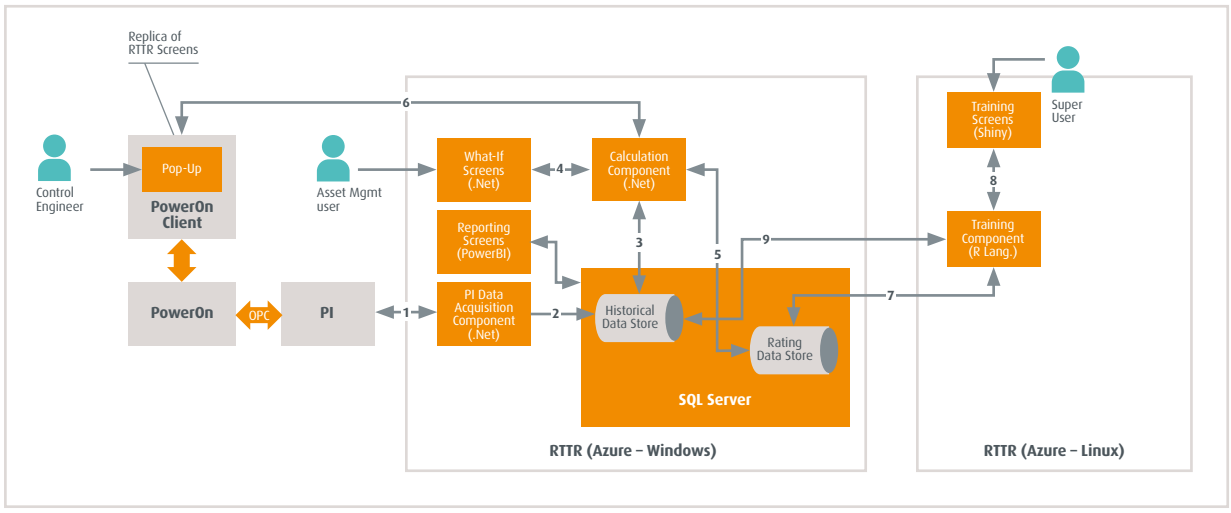

Figure 9 – Transformers Real Time Thermal Ratings Software Platform Architecture

Optimising Overhead Line Conductor Inspection & Condition Assessment

Background

UK Power Networks has approximately 9,000 broad-based towers on its networks. Of these, approximately 6,000 are strung with Aluminium Conductor Steel Reinforced (ACSR), 1,200 with All-Aluminium Alloy Conductor (AAAC), and the rest are made up of a mixture of conductors. The majority of ACSR were installed in the 1950s and 1960s and is also currently being installed.

Failure of ACSR conductors may occur when the supporting steel core deteriorates either through corrosion or is annealed through over-heating of the conductor. The steel core is protected from corrosion by high temperature grease and some earlier conductors had a bitumen paste layer. Corrosion can occur where there has been incorrect application of the grease during the manufacturing either by applying too little or applying too much. It can also occur where grease has migrated to a lower point of the conductor because of excess heat.

The device currently used to measure the condition of ACSR conductor, the Cormon device, has been used since the 1980s and has reached the end of its life. The objective of the project is to evaluate what devices that have not been used by GB DNOs before are available globally for assessing conductor condition. The project also aims to work with willing suppliers to adapt devices to the GB electricity network, if needed, and to trial them on the network.

Experience to date

A literature review has been carried out by EPRI on devices currently available globally for conductor assessment. Following a desktop assessment three devices were chosen for the trial. The trial consisted of three parts:

- A network trial to check ease of use and performance;
- A laboratory assessment where the devices where tested on a known bit of conductor. This conductor was then stripped and had the condition checked to validate what the devices found; and
- A commercial assessment looking at future use options as well as overall costs and what support would be available.

All three suppliers that were trialled were also given the option to work with UK Power Networks to improve their device to be better suited to the UK. This option was chosen by one supplier.

Future Developments

The project has demonstrated that there are devices on the market for testing the condition of overhead line conductor. The laboratory tests validated their results and proved that they can accurately record the condition of the conductor tested. UK Power Networks is currently looking at ways to integrate one of the devices into business as usual so that the condition information can be used to justify conductor replacement projects in the remainder of ED1 as well as assisting in planning for ED2.

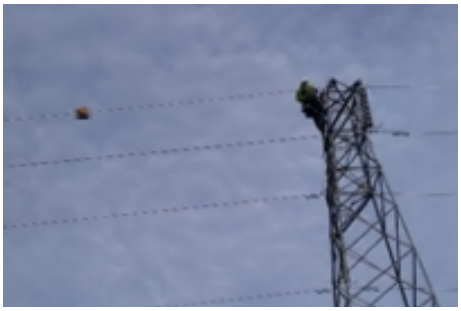

Figure 10 – Device being trialled on network

Figure 11 – Conductor tested in Lab

Project Highlights

NIC Projects

Active Response

Background

Distribution networks are experiencing a quicker than expected uptake in Low Carbon Technologies (LCTs). A significant uptake in Electric Vehicles (EVs) is expected in the early years of the next decade, as indicated by the number of EVs registered in our licence areas currently exceeding our RIIO-ED1 business planning forecasts by 25%. National Grid's Future Energy Scenarios 2017 expect this to materialise as 3.5GW additional peak demand across GB to 2030. This will require significant reinforcement with costs largely borne by customers.

We are proposing to demonstrate two methods:

1. **Network Optimise** – Optimisation and Automatic reconfiguration of HV & LV networks in combination, using remote control switches and Soft Open Points (SOPs).
2. **Primary Connect** – Controlled transfers between primary substations using a Soft Power Bridge (SPB) to share loads and optimise capacity.

We estimate that by 2030 Active Response solutions could save customers £271m in reinforcement costs. This is equivalent to approximately £9.34 from every electricity customer's bill by 2030. The project methods also enable Carbon Savings of 19,592 tCO2 eq. and Capacity Benefits of 4.2 Gigavolt Ampre by 2030.

Figure 12 – Electric vehicle and charge point

Experience to date

The project started in January 2018 and is in the mobilisation phase. The project is finalising contracts with Project Partners, which include; Turbo Power Systems, CGI, Scottish Power Energy Networks and Ricardo Energy and Environment.
In parallel, the project has focussed on gathering project requirements through a number of stakeholder workshops. These requirements will feed into the procurement of the optimisation and automation software.

Future Developments

The project will run until November 2021, during which we will design and build the relevant hardware and software to support the project trials. The first trial will begin in January 2019 and the final trial will finish in October 2021.

Over the next year, the project team will work with Turbo Power Systems to design and build the SOPs and SPBs. The designs are planned to be approved by October 2018 and March 2019 respectively. Furthermore, by August 2018 the team will have selected a vendor for the optimisation and automation platform. In August 2018 the project will also submit the first Ofgem deliverable which describes the high level design specification of the advanced automation solution.

Budget (NIC funding)	£13.8M
Start/End Dates	January 2018 to November 2021
Project Partners	Ricardo Energy and Environment, CGI, Turbo Power

Powerful-CB (Power Electronic Fault Limiting Circuit Breakers)

Background

Powerful-CB will use advanced power electronics technology to develop a new type of circuit breaker that is 20 times faster than existing units. This high speed operation provides extra protection for the electricity network, allowing many more highly efficient Combined Heat and Power (CHP) units to connect before the network needs to be upgraded.

Across London, many major offices and housing developments have their own CHP units, which capture the heat created as a by-product of electricity generation and circulate it round a building instead of having a separate boiler. They are up to 30% more efficient than having separate electricity generators and boilers and save energy users on average 20% off their energy bills.

Presently, most of London's power is generated in power stations outside of the capital, which also generate heat, which it is sent up the chimney into the atmosphere. The London Plan aims for a quarter of London's heat and power to be generated in the capital by 2025, which could save more than 2.5 million tonnes of carbon dioxide a year.

It is expected this will lead to a large increase in demand for the connection of CHP units, which are highly efficient in generating heat and power at the same time. This means they use less energy than conventional energy systems in meeting the same energy demand.

However this rapid change could cause constraints on the electricity distribution network that could make that target hard to achieve safely without prohibitively expensive infrastructure upgrades – or advances in technology.

London will become the first city in the world to host the Powerful-CB device, which could revolutionise the way energy is distributed, and could help keep down electricity connection costs for CHP customers.

Experience to date

Since the project has started we have spent time engaging with customers who have experienced fault level constraints when connecting new Distributed Generation (DG). We have engaged with a number of customers, other DNOs and stakeholders including the Greater London Authority and have published our learning in the Successful Delivery of Reward Criteria (SDRC) report 'Understanding Customers' Requirements' in October 2017.

These interactions with customers have helped us to select a trial site for Method 2. We have been working with internal stakeholders to ensure that installation works go ahead to time, and as part of this work we have also selected our trial substation site for Method 1.

The development of prototypes has been a focus for the team, working with our suppliers, ABB and Applied Materials, in order to be ready for the trial installations in summer 2019 – taking part in design, build and testing of components and test builds. We have developed a design standard for the device specifications and published a preliminary safety case document, compiled by Frazer Nash Consultancy, outlining the safety considerations for the trial devices and their applications after the project concludes.

Future Developments

In the next year we will continue our work to prepare for the trial installations in summer 2019, by liaising with the suppliers on prototype development and witness testing. We will also carry out enabling works at the selected trial sites. In addition to this, we will publish a learning report on the development of a Fault Limiting Circuit Breaker (FLCB) device for substations – based on our experience in developing the Method 1 device and preparing for its installation.

Project Highlights

LCNF Tier 2 Projects

Kent Active System Management (KASM)

Background

The last few years have seen a number of Grid Supply Points (GSPs) come under pressure from the level of embedded generation exporting power onto the electricity transmission network. In the most extreme form of the electricity network operating in the opposite way to which it was originally designed, whole sections of the network are not only supplying their own demand but are also exporting the surplus onto the transmission system. These conditions on the network can result in significant network constraints which can impact existing generators as well as new generators seeking to connect to the distribution network.

The KASM project ran from January 2015 to December 2017 and carried out a range of technical innovation trials to demonstrate more advanced operations and planning techniques for the 132kV and 33kV network in East Kent, located in the South Eastern Power Networks (SPN) licence area. The project delivered benefits spanning various areas, including the enablement of low carbon generation, the deferral of capital-intensive reinforcement associated with new generation connections, and improved reliability of the network.

Experience to date

We have designed, built and successfully trialled the use of state estimation, contingency analysis and forecasting tools. The project has demonstrated that using these tools, we can enable increased levels of renewable distributed generation to export onto the distribution network. During the project trials we have demonstrated that by using these advanced tools, we can allow 3,000MWh of additional renewable distributed generation to be exported onto the network. This is the equivalent amount of energy required to power 1,500 homes in Kent for six months.

The project has also developed advanced communications links between National Grid and UK Power Networks control centres, which allows for real-time data exchange. This allows engineers from both parties to have a more accurate view of network conditions and thus operate the network more efficiently.

Future Developments

Moving forward we will continue to embed and improve the solutions developed. In addition, we will monitor the benefits the solutions continue to provide.

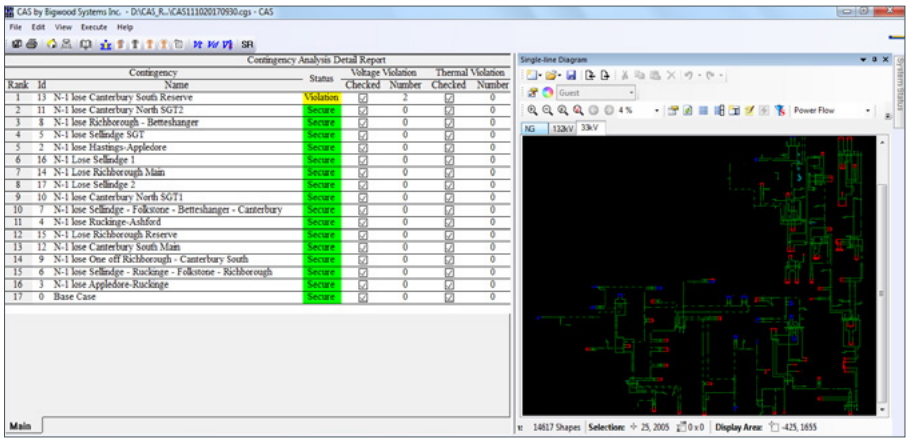

Figure 13 – Real-time contingency analysis tool

energywise

Background

energywise is exploring how DNOs can work collaboratively with energy suppliers and local trusted organisations to deliver appropriate services to communities of low income households who may be struggling with their energy bills. The project is doing this by undertaking a research study with hundreds of social tenants in Tower Hamlets (East London) and carrying out two trials: Trial 1, focusing on how they can participate in energy saving opportunities; and Trial 2 investigating both energy saving and Demand Side Response.

The project aims to understand:

- the extent to which this residential customer group is able and willing to engage in energy saving campaigns and Time of Use (ToU) tariffs;
- the benefits that they can realise from their change of behaviour in household energy management;
- the challenges and successful approaches to engaging with these groups of customers to achieve these aims, and
- whether their reduction in demand, and shifting demand away from network peak periods may benefit the electricity network by deferring or avoiding network reinforcement.

Experience to date

The two trials are now completed as shown in the timeline in Figure 14 and decommissioning of the temperature monitoring system from participants' properties is in progress. At the end of April 2018, the project hosted two thank-you events (one for credit and one for prepayment customers) to thank customers for their participation in the project and to disseminate key project learnings.

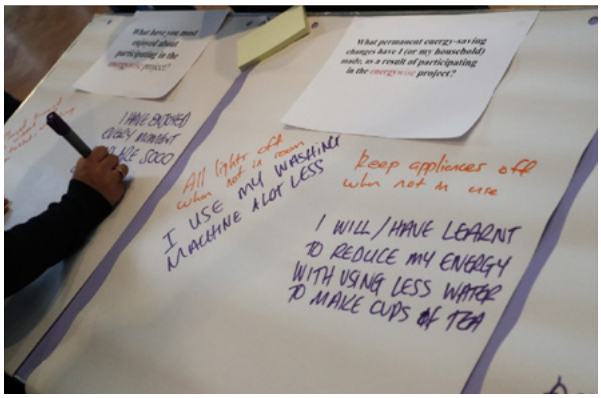

Figure 15 – energywise thank you event

Figure 14 – energywise project timeline

Key achievements to date

Recruitment and engagement:

- The project designed an engagement strategy tailored to the specific needs of the target population and the demographics of the area, with a dedicated customer field officer team established with local intelligence and language skills;
- 538 social tenants in Tower Hamlets living in less efficient properties were successfully recruited resulting in a 40% sign-up rate; and
- 86% of all active participants consented to new ToU tariff arrangements: Bonus Time for prepay customers (an innovative non-punitive ToU tariff that rewards them for using less electricity during peak events) and Home Energy Free Time for credit customers (offering free electricity from 9-5pm on Saturday or Sunday).

Installation:

- The project completed 230 credit and 93 prepay smart meter installations and delivered almost 1,900 energy efficiency devices (LED lightbulbs, eco-kettles and standby shutdowns);
- Trial participants have also received energy efficiency tips and time shifting advice tailored to each tariff offer; and
- The UK's first end-to-end installation of residential smart meter sets operating across a Multiple Dwelling Unit building with difficult meter arrangements was successfully demonstrated.

In addition to extensive electricity consumption and network data captured over the two trials, the project gathered invaluable customer insights from a series of engagement activities including customer panels, interviews and research surveys.

Key project learnings include:

- Partnering with highly respected and trusted local community organisations was very effective in ensuring inclusive recruitment;
- There is no 'one-size-fits-all' approach so the engagement should be carefully designed according to the needs of the community involved;
- It is important to make sure that customers understand the offer and how they can benefit from it; and
- The analysis of the energy saving trial data showed that participants saved on average 3.3% off their annual electricity consumption (statistically significant at the level set out in the project bid), in line with the national average for households with smart meters. These savings correspond to a 5.2% reduction in average peak demand per household and they are expected to be seen in other DNO regions replicating the trial.

Future Developments

The project is analysing trial 2 data on energy shifting and the final results will be published in July 2018 in the SDRC 9.5 report. A series of dissemination activities including a final dissemination event are scheduled to share the key project learning outcomes with the other DNOs, the wider energy sector and policy makers. These will be reported in the SDRC 9.6 report in September 2018.

Budget	£5.49m (£3.32m LCNF Tier 2)
Start/End Dates	January 2014 – September 2018
Project Partners	British Gas, University College London, Bromley by Bow Centre, Tower Hamlets Homes, Poplar HARCA, CAG Consultants, Element Energy, National Energy Action

Complete NIA project portfolio

Our Network Innovation Allowance Portfolio

Customer and Stakeholder Focus

Project Reference	Project Name	Research Area	Start-Ends	Budget
NIA_UKPN0005	Better Spur Protection	Low Voltage and 11 kV Networks	04/2014 - 10/2017	£492,000
NIA_UKPN0032	Mobile Field Control	Comms & IT	03/2018 - 12/2020	£1,469,960

Network Improvements and System Operability

NIA_UKPN0001	Power Transformer Real Time Thermal Rating (RTTR)	High Voltage Networks	06/2014 - 12/2018	£1,820,853
NIA_UKPN0002	Directional Earth Fault Passage Indicator Trial	Low Voltage and 11 kV Networks	01/2014 - 01/2018	£483,764
NIA_WPD_008	Improved Statistical Ratings for Distribution Overhead Lines	Network Operations, Comms & IT	07/2015 - 01/2018	£747,554
NIA_UKPN0012	Pressurised Cable Active Control and Monitoring	High Voltage Networks	09/2015 - 11/2017	£1,075,600
NIA_UKPN0013	Underground HV Cable Research	High Voltage Networks	09/2015 - 06/2017	£932,477
NIA_UKPN0019	OHL Fault Location Concept & Directional Earth Fault Passage Indication	Low Voltage and 11 kV Networks	05/2016 - 09/2018	£2,585,000
NIA_UKPN0022	Global Earthing Systems (GES)	Fault Current	03/2017 - 03/2019	£483,000
NIA_UKPN0023	Harmonic Effects on Network Assets (HENA)	High Voltage Networks	03/2017 - 06/2018	£441,000
NIA_UKPN0025	Overhead Line Assessments Using Panoramic Images	Maintenance and Inspection	07/2017 - 01/2018	£165,550
NIA_UKPN0031	Link Alert	LV and 11kV Networks	02/2018 - 05/2020	£248,600

Safety, Health and Environment

NIA_UKPN0007	Detection of Broken/Low Hanging Overhead Line Conductors	Safety, Health and Environment	02/2014 - 09/2018	£737,900
NIA_UKPN0010	Vertical Transition Straight Joints Innovative Inspection	Low Voltage and 11 kV Networks	09/2015 - 07/2017	£899,396
NIA_UKPN0016	Roadmender Reinstatement Trial	Low Voltage and 11 kV Networks	01/2016 - 12/2017	£493,106
NIA_UKPN0020	Mobile Asset Assessment Vehicle (MAAV)	Safety, Health and Environment	07/2016 - 01/2018	£544,322
NIA_UKPN0024	Pole Current Indicator	Health & Safety	05/2017 - 01/2019	£282,685
NIA_UKPN0029	Assesment & Testing of Alternative cut-outs	LV and 11kV Networks	11/2017 - 01/2019	£765,080

New Technologies and Commercial Evolution

NIA_UKPN0017	Optimising Overhead Line Conductor Inspection and Condition	High Voltage Network	04/2016 - 01/2018	£1,520,432
NIA_UKPN0018	Efficent Network Constraint Management Through the Use of Market Signals	Various	06/2016 - 08/2017	£250,000
NIA_UKPN0030	Development of Oil-filled Cable Additive- Phase 2	Asset Management and Environmental	11/2017 - 12/2019	£1,988,128

Transition to Low Carbon Future

NIA_UKPN0004	Freight Electric Vehicles in Urban Europe (FREVUE)	Electric Vehicles; Low Voltage and 11 kV Networks	03/2013 - 09/2017	£74,310
NIA_UKPN0021	Domestic Energy Storage and Control (DESC)	Energy Storage and Demand Response	09/2016 - 06/2018	£625,000
NIA_UKPN0026	Black Cab Green	Electric Vehicles	08/2017 - 08/2018	£175,000
NIA_UKPN0027	Loadshare	Distributed Generation	09/2017 - 06/2019	£2,418,081
NIA_UKPN0028	Recharge the Future	Electric Vehicles	10/2017 - 01/2019	£239,750

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If you would like to get in touch or provide feedback, please email us innovation@ukpowernetworks.co.uk

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