Network Innovation Allowance Annual Summary

Progress and results from 2015/16

UK Power Networks
Delivering your electricity

ukpowernetworks.co.uk

Foreword

The electricity sector continues to evolve – over the weekend of 9-10 April 2016, solar generators provided more electricity than coal for the first time in the UK; a symbolic milestone that highlights the major changes occurring in our electricity system. National Grid estimates that the system now has 10-11GW of solar generation and 10-14GW of wind capacity - sufficient to exceed consumer demand at certain times in summer. The distribution networks are at the forefront of enabling these changes; 90% of the solar energy alone connects directly to the distribution system.

UK Power Networks has connected 7.6GW of DG to its three networks, representing nearly 28% of the installed DG across the UK. We are proud to have enabled these changes with an 86% customer approval rating and at the same time delivering a step change in network reliability for our customers over the last five years.

The pace and scale of change in our industry is increasing. We are starting to see electric vehicle sales picking up: a total of 47,000 have been sold in the UK to date alone. In the global market, China is expecting to set a target of c.5 million electric vehicles by 2020, up from 400,000 in 2015. The drop in the cost of storage technology driven by scale on a global level will no doubt impact the growth of the electric vehicle market in the UK.

In the last six months, grid-scale storage has emerged into a topic of major commercial interest to developers, manufacturers, construction partners, regulators and government. At the time of writing, UK Power Networks alone had received over 500 applications to connect battery storage for a total capacity of 11GW.

At the same time we are seeing less uptake in other areas: the activity around heat pump connections is less than we foresaw when we published our last innovation strategy in 2014. We have now begun a review of our innovation strategy and will be publishing our updated version later this year.

As we finish our first year in the RIIO-ED1 period, we continue to demonstrate how innovation has played an important role in preparing for the new energy landscape, as well as enabling strong business performance to date. Our focus will continue to be using innovation in order to improve our service by making it better, cheaper, easier, greener, or safer. Once we have researched and tested new ideas, we must bring them into the business and run with them.

As you read this annual summary of our network innovation allowance portfolio, you will see that the Network Innovation Allowance (NIA) has been a vital element to explore how we continue to improve in our fundamental role of keeping the lights on, managing safety, and investing efficiently in new equipment.

We have put together this report to give you an overview of our innovation projects and have selected some projects to highlight. I encourage you to provide us feedback, give us your ideas and continue to challenge us. We have explicitly given ourselves the challenge of going from #GoodToGreat – hold us to it!

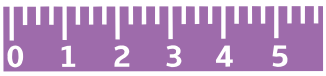
Suleman Alli

Suleman Alli
Director of Safety,
Strategy and Support Services

Innovation in numbers

2,715

The number of joints we have inspected for hidden defects using the innovative PD Hawk tool



The length of redundant cable extracted from the ground using an innovative cable replacement technology, without the need for disruptive excavations

500 metres

2,390

The number of homes that can be powered with the improved capacity rating on just one of our real-time ratings sites

12,400/year

The estimated number of excavations that could be re-instated faster and for lower cost, using our RoadMender solution

The number of load profile assumptions from our Low Carbon London trials that have informed the commercially available Windebut software

The confidence with which we can now predict the number of faults that will occur on our network based on weather forecasts

90%

24

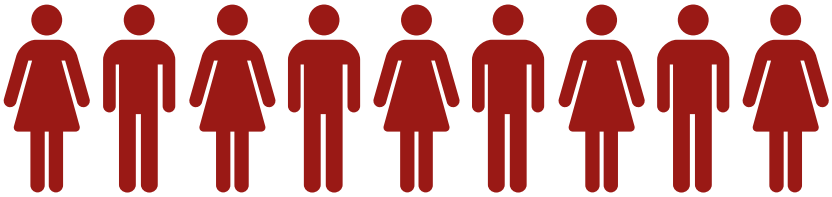
The number of collaborative, industry wide NIA projects we are involved in

£14.8 million

The lifetime budget of the currently registered portfolio

The number of customers already benefitting from our pipeline of innovative solutions for increased resilience and faster fault response

68,394



Meet the innovators

Innovation is a key element of our vision for UK Power Networks and we constantly work with our colleagues to deliver our projects.

Members of our Connections team running an advisory day for fleet operators looking to convert to electric vehicles

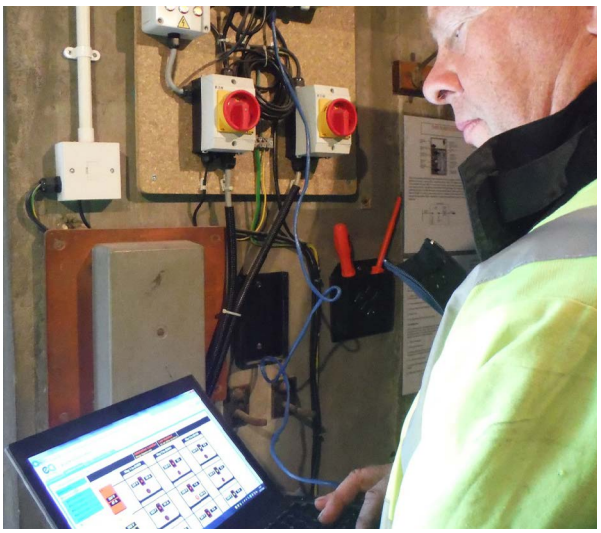
Members of our Connections and Network planning teams who have been instrumental in introducing new approaches delivering faster, cheaper connections for renewable generators

Members of our Connections and Innovation teams showing customers and supply chain partners how we can help low carbon projects

Members of our Capital Programme and Innovation teams, our Alliance partner Morrisons Utility Services and S&C Electric proud of delivering the UK's first grid-scale energy storage facility

Members of our core innovation team, who facilitate the inventive ideas in the business and run our largest innovation projects

One of our London fault response team members checking out our new power electronics circuit breakers which will help us find faults faster and restore supply to customers quicker



Member of our field team who has been installing new remote-switching capability into the last mile of the network in trial areas

Members of our control room systems team, who have been instrumental in ensuring that we have the necessary communications and monitoring in the control room for new equipment

1
Introduction

Introduction

At UK Power Networks, we recognise the key role that innovation plays in preparing us for the low carbon future while helping us both to ensure that security of supply is delivered cost efficiently and that our service to customers continues to improve. We live in a time of significant change in our industry and we as a distribution network operator, must continue to evolve to meet increased customer expectations.

We have a central innovation team accountable for both the way in which we create and authorise new projects, and for delivering the benefits expected from them. Additionally, we work hard to spread a culture of innovation throughout the organisation. As shown on the previous section of this report, our innovation team interacts with the business across our portfolio of projects.

This document is designed to help our customers and stakeholders understand the wide programme of innovation projects we are undertaking. It provides an insight into the key focus areas that the projects cover, and it also summarises the outputs achieved throughout this regulatory year, which runs from 1 April 2015 to 31 March 2016. It does not include our larger projects funded through the Low Carbon Networks Fund or the Network Innovation Competition. However, you can read more about these showpiece smart grid demonstrations on our website.

This report is therefore designed to allow you to gain more insight into the programme of typically smaller projects that span the full gamut of challenges which utilities face, such as improving security of supply or extending asset lives. We develop project concepts within the business and with suppliers, and then register these projects on the Smarter Networks Portal.

This report summarises the progress of our projects funded through the NIA during the regulatory year. It illustrates how these relate to our innovation strategy, and provides case studies of new learning. At the end of this report we have provided a full list of all the projects and links to where more information can be found on each of them.

UK Power Networks was awarded the Smartest Utility award at the Utility Awards ceremony in December, 2015

2

Putting it in context – our innovation strategy

Context

Our Innovation Strategy sets out seven key themes or challenges around which we have organised our innovation activities, as shown in Figure 1. The themes cover the critical activities we undertake to provide our day-to-day service to customers and also consider our relationship with them, as we move from a passive Distribution Network Operator (DNO) towards a Distribution System Operator (DSO).

These themes are:

1. Managing the risk of our assets and improving fault performance. This corresponds to our central function of keeping the lights on, restoring outages and managing any risks to the public associated with our electrical equipment
2. Understanding current and future performance of the 11kV and LV networks which are currently least visible to us in real-time
3. Identifying new options to release capacity at 11kV, 33kV and 132kV where commercial buildings and renewables connect and where we interface with the transmission network
4. Developing commercial solutions and products that will enable the uptake of new technologies
5. Understanding the condition of our assets to inform how long we can use them for and how to effectively refurbish them
6. Leveraging industrial and commercial Demand Side Response (DSR) and dispatchable generation to enable assets connected to our networks to support and help us avoid building unnecessary new assets; and
7. Managing residential and small and medium size enterprise consumer demand and addressing the biggest changes in demand on our network

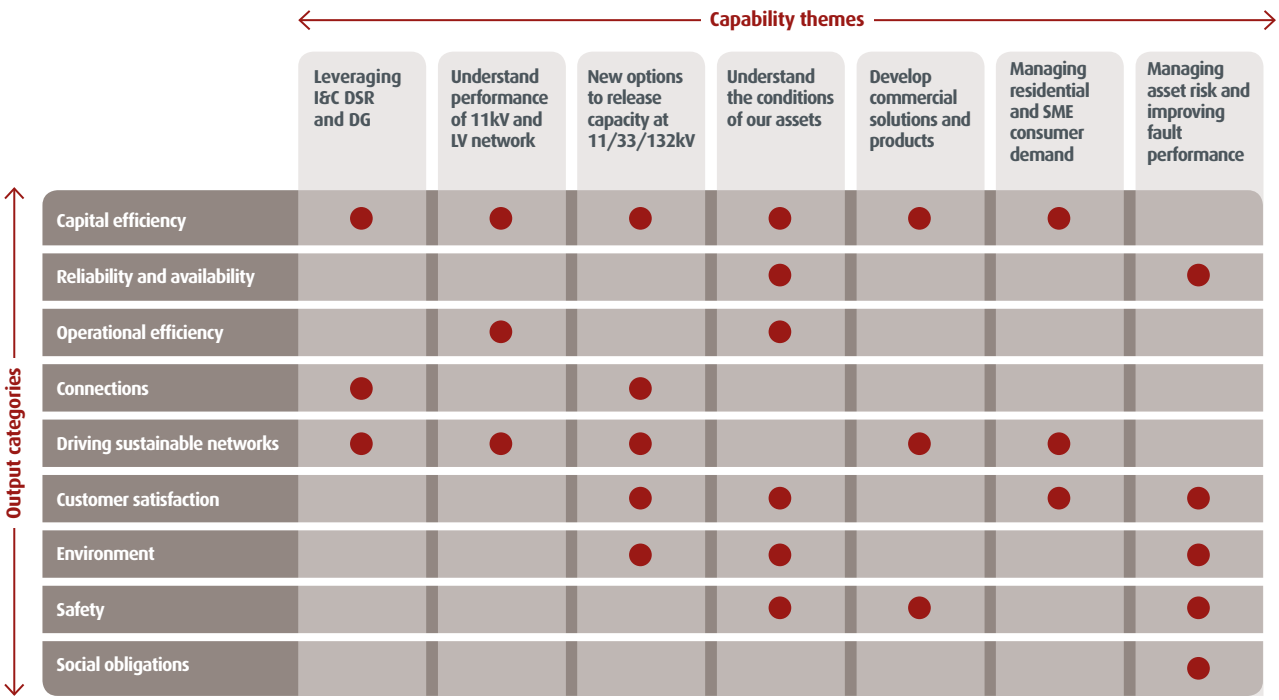
Figure 1. UK Power Networks' innovation themes

These themes encompass the main RIIO-ED1 outputs which incentivise us to deliver value for customers. The outputs are:

- **Capital efficiency** – replacing and upgrading equipment at the right time: not so early that it risks creating unused capacity nor too late so that it starts to be detrimental to service
- **Reliability and availability** – reducing the likelihood of supply interruptions and restoring supply to as many customers as we can, as fast as we can
- **Operational efficiency** – carrying out essential supply restoration activities and essential maintenance (such as cutting trees away from our overhead electricity lines) as cost-efficiently as possible. Meanwhile, running best-in-class support functions, such as Information Technology (IT) and customer call centre
- **Connections** – facilitating cost-effective, timely connections to the network
- **Driving sustainable networks** – supporting the government target to convert more of the UK's generating fleet to renewable sources e.g. solar and wind, achieving the benefits of electricity storage, and enabling domestic customers to generate their own electricity
- **Customer satisfaction** – exceeding customer expectations, whether in the event of an outage or as we carry out planned work to connect a customer or alter their connection
- **Environment** – minimising the impact of our operations on the environment, both from our equipment and our activities (such as driving to site)
- **Safety** – maintaining industry leading safety performance, with respect to both our employees and members of the public
- **Social obligations** – playing our part in the areas that matter to us, such as caring for vulnerable customers and the fuel poor.

Figure 2 outlines how our themes overlay with the expected outputs.

Figure 2. Relation between UK Power Networks' innovation themes and Ofgem RIIO outputs



As our innovation portfolio has evolved, we have addressed all of these categories and have built a wide-ranging selection of projects. In 2015/16 UK Power Networks spent a total of £11m on innovation activities. In total, we were involved in 31 innovation projects that spread across all output categories. As shown in Figure 3, the NIA enables us to innovate on topics which are not being covered by our larger smart grid trials.

Throughout this period, £8.2m was spent on larger innovation projects funded by the Low Carbon Network Fund Second Tier mechanism. A total of £2.7m was spent under the NIA. Figure 4 and 5 show how this expenditure was spread across both our innovation strategy themes and our core outputs to customers, demonstrating great coverage of all of our areas of importance.

Figure 3. Number of innovation projects per output category

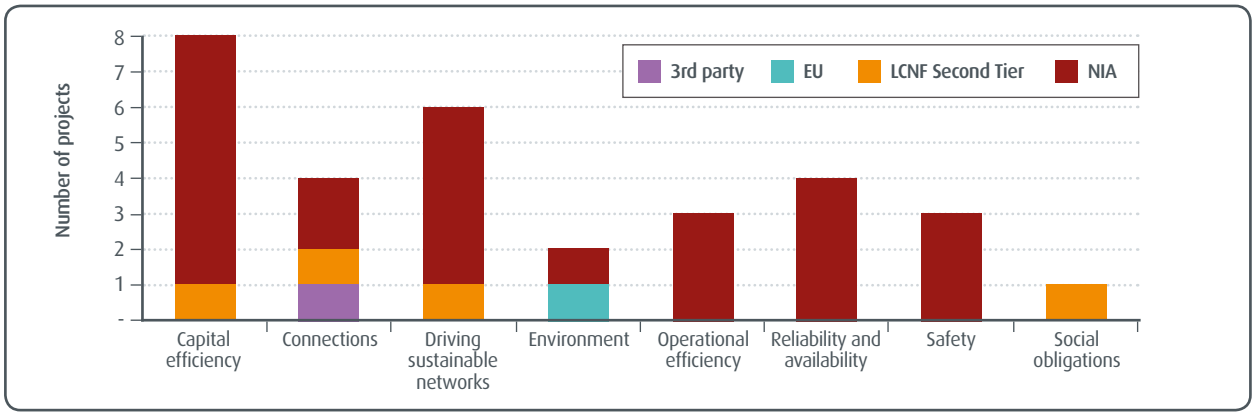


Figure 4. NIA spend by innovation categories

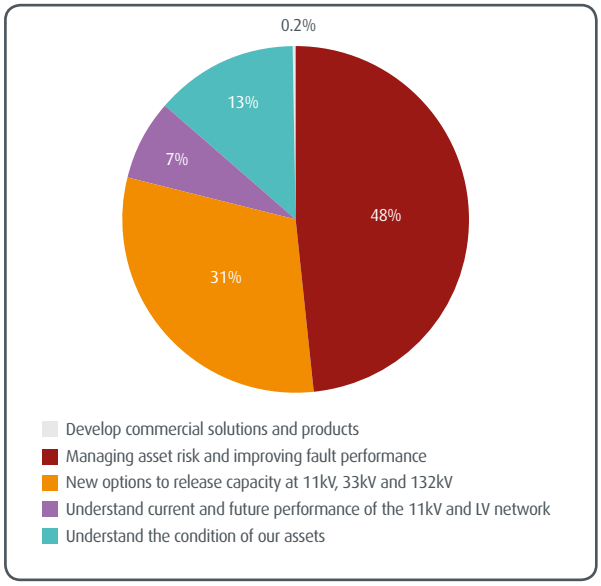
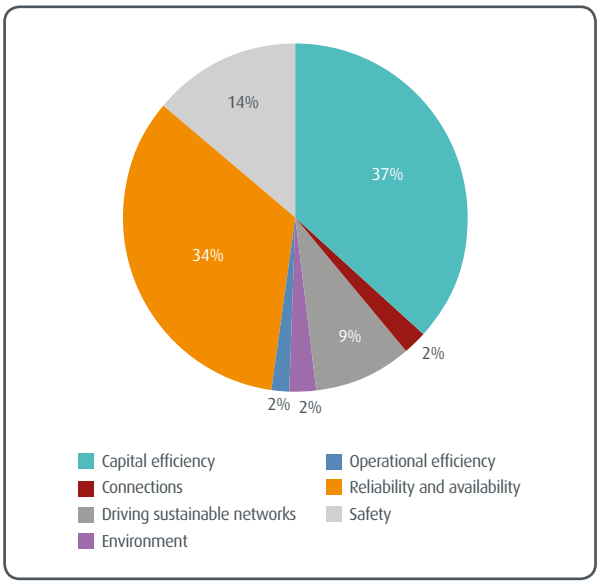


Figure 5. NIA spend by output categories



In Section 4 of this report, we provide links to each of our individual projects and reports, categorised by output. 2015/16 has been an exciting year as we continue to deliver value and learn lessons from our innovation trials. We have chosen five projects to present in more detail in order to explain the types of tests and research we are developing and how they will help us improve performance, deliver greater value and continue our journey from #GoodToGreat.

3
Project highlights

Power Transformer Real Time Thermal Rating

Background

Transformers are one of the most vital elements in the chain supplying each customer. Transformers are limited to a safe rating, which depends on being able to dissipate heat from the transformer. A number of standard design equations or design assumptions are used to create a "fail-safe" loading on the transformer, which can be used in all realistic circumstances. However, since these are designed to be "fail-safe", they may lead to cautious network reinforcement decisions.
By monitoring conditions on site, we may be able to run transformers for longer periods of time before upgrading them.

Experience to date

Since commencing, the project has trialled Power Transformer Real Time Thermal Rating (RTTR) techniques for six primary transformers across two primary substations. This work has included:

- Conducting extended heat run tests to clarify the variance between rating assumptions
- Measuring transformer top oil temperature
- Modelling winding hot spot (WHS) temperature
- Installing Transformer Management System (TMS) equipment to gain access to key parameters in real-time as well as supplementary cooling systems
- Proposing summer/winter ratings with and without supplementary cooling systems

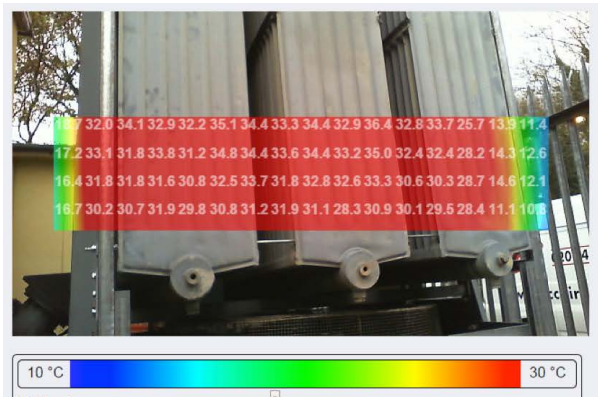
The application of RTTR on these trial sites alone has deferred expenditure on reinforcement schemes for both substations – schemes with a combined traditional reinforcement cost of over £15m.

Future developments

RTTR techniques for network assets challenge the old assumptions on transformer capacity ratings and have used new but simple data sets to identify up to a 20% increase in transformer capacity by installing dynamic ratings systems. The project is now focusing on the development of approved policies to facilitate the wide spread adoption of Power Transformer RTTR techniques.

Dynamic Ratings E3 Transformer Management System (TMS), Weybridge Primary Substation

Additional Transformer Cooling Fans, Weybridge Primary Substation



EkkoCam Thermal Profile of Transformer Radiators, Weybridge Primary Substation

Installed Load Banks for Heat Rise Tests

Smart Urban Low Voltage Network

Background

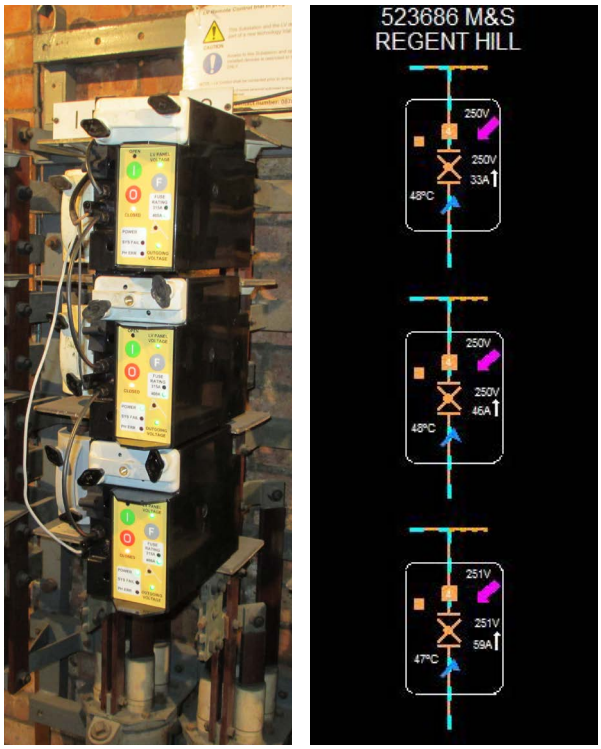
UK Power Networks has worked over several years to industrialise a single phase circuit breaker (CB) and link box switch that allows remote control and reconfiguration of low voltage (LV) networks. The vast majority of our LV networks are connected and configured by links mounted in link boxes within the pavement, and are protected by fuses in the substation. Both of these require personnel to visit the site to make changes to the way customer supply is routed, or to restore supply after a power outage. We are now carrying out a larger demonstration of the equipment and staff are now beginning to use the system more widely.

Experience to date

In order to use the equipment, it is vital that our control room staff can monitor what the equipment is doing and see its effects as they re-route customer supplies. An LV single line network diagram with detailed three phase views has been created in our control system PowerOn Fusion. Control engineers are now able to act on incoming LV alarms by responding to faults and/or mobilising operational staff even before customers have called in reporting loss of supply.

In one example, high temperature alarms were received from a link box where waste water was being pumped from a building site which had submerged the link box. LV control engineers were able to remotely isolate the link box more quickly and safely utilising the trial equipment, and dispatched field staff to pump the water out of the link box prior to any failures or unplanned customer interruptions.

Finally, the equipment is designed to test the circuit before it attempts to close, preventing it from re-energising a fault hence minimising safety risk. In a variety of scenarios, the trial CBs have correctly tested the network and closed or prevented a close as designed.



Three power electronics circuit breakers in situ on the network and represented in the control system

Future developments

EA Technology Ltd who supply this equipment under licence are now developing a distance to fault application to further enhance the system capabilities, allowing operational staff to diagnose the fault location quicker and restore customer supply faster.

Detection of Broken/Low Hanging Overhead Line Conductors

Background

Overhead lines and the wood poles supporting them are exposed to the elements 24 hours a day, 7 days a week. The detection of broken and low hanging conductors has been a long standing issue for DNOs and their equivalent industry organisations across the globe. This issue can present an obvious safety hazard to the general public. Currently, there is no proven and commercially available technology for the reliable detection of this condition. For this reason, UK Power Networks partnered with Nexans to investigate whether a sensor could be developed which could detect an issue as it occurred, and which may be cost-effective enough to roll out. This would augment our existing safety controls through inspections, responding to unexpected readings from sensors on our network, and responding to issues reported by members of the public.

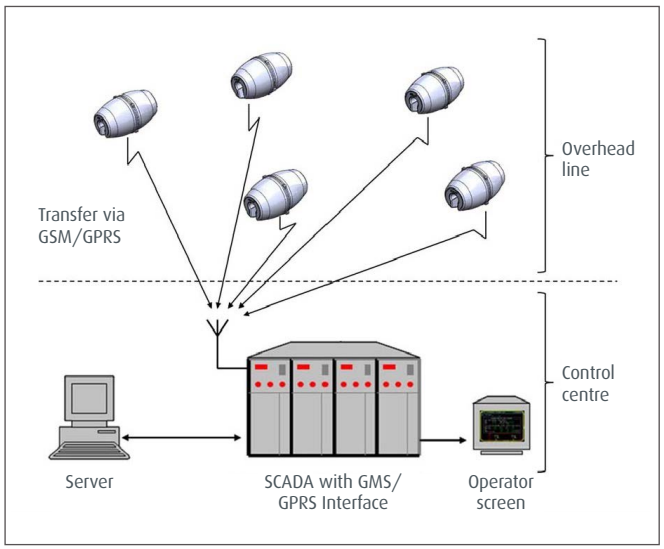


Diagram of how sensors communicate with control centre

Experience to date

The first phase of the project has successfully developed a proof-of-concept of device and a housing which is suited to mounting on the line. The picture below shows some of the early trial units being installed. A total of four trial units are planned to be installed over the next few months.

Early trial units for detecting broken or low hanging overhead line conductors being installed

Future developments

We are currently working with Nexans to develop an enhanced sensor that will potentially produce a lower cost product with improved functionality, which is easier to install under "Live Line" conditions.

Business Models Enhancement

Background

The increase in electric vehicles (EV), consumers generating their own electricity with photovoltaic (PV) panels and the installation of heat pumps in domestic and commercial properties will potentially continue to make significant changes to what we think of as the "average" home and business, and the amount of electricity which each uses. In 2012 UK Power Networks commissioned Imperial College London (ICL) to create a model which would help us understand the relationship between load growth and investment in our networks. This model informed our business plan submission, providing guidance on the amount of investment required to meet this growth in low carbon technology.

Table 1. Availability

	Load forecast model	Transform model	WinDEBUT	LRE
UK Power Networks	✓	✓	✓	✓
All DNOs		✓	✓	
Globally			✓	

Since then the Low Carbon London (LCL) project has concluded and contributed vital new learning by monitoring the energy use associated with domestic customers, EV users and charge points, heat pumps and PV installations. Accordingly we now have updated profiles and data to inform our business models and reflect the real impact of Low Carbon Technology (LCT) uptake.

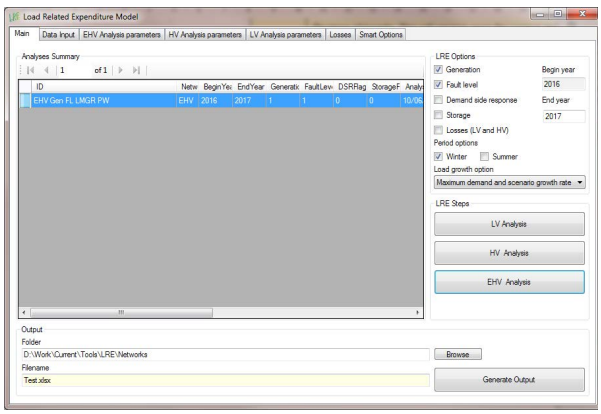
Experience to date

As a result, our business models for load forecasting, network design and load related expenditure have been updated with the profiles from the LCL project.

Additionally, the Load Related Expenditure (LRE) model has had a more extensive update to include multi-period demand modelling including summer minimums, more accurate demand diversity, application of revised LCT uptake profiles and various forms of DSR. We have developed a user friendly interface which will enable the implementation of the tool by the business. The benefit of these updates comes from the improved characterisation of the demand on the network, the ability to test the impact of a variety of scenarios and the cost of mitigating actions and/or reinforcement on the network.

Future developments

We are conscious that there is another new technology on the horizon, namely home energy storage most familiar as Tesla's Powerwall product. We are currently developing a trial which will capture the information we need to forecast the changes that this will create in demand.



User friendly interface - LRE model main screen

RoadMender Reinstatement Trial

Background

At present UK Power Networks has c.14,600 works per year that can be classified as involving small excavations (less than 2m^2). The activities include fault restoration, new customer connections, link box replacements, link box frame and cover replacements, pole replacements and public (street) lighting faults. Also, with the ever increasing pressure on people's time, more customer connection work is being requested to take place over the weekend and for fault work to be done as a continuous process (locate, dig, fix, reinstate). This is difficult when asphalt plants, required for reinstatement materials, typically close at 3pm each day and do not open at weekends.

The RoadMender device

The RoadMender device allows teams to mix the necessary material on site to finish the job there and then – but it is vitally important that the quality of the repair is maintained.

Experience to date

We have partnered with the Transport Research Laboratory (TRL) to help us verify that the quality of any repair will be maintained with the new asphalt mix. We were very pleased with the results, shown by the test certificate in Figure 6. This verified that we will be able to meet the Specification for Reinstatements of Openings in Highways (SROH), which is enforced by local authorities.

Future developments

We expect to put the first unit into trial with one of our teams in July with operation through to the end of 2016.

Figure 6. Test certificate for the RoadMender device

TRL Limited,
Crowthorne House,
Nine Mile Ride,
Wokingham.
RG40 3GA.
Tel: 01344 773131

UKAS TESTING 2721

Sample No.	160699 & 700
Site Ref.	See below
Project Code	11113894

Determination of Wheel Tracking Rate
BS EN 12697-22 Small Device Procedure B in Air

Client:	UK Power Network	**Sampled By:**	TRL
Scheme / Site:	Billian UK Roadmender Trial	**Sample Type:**	200mm core
Location:	HRA Patch at Alliance Utilities Cockridden Farm Estate Brentwood		
Material Type:	14mm HRA Surf plus 20mm Pre-coated chippings	**Date Sampled:**	27/04/2016
Material Specification:	BS EN 13108	**Date Received:**	29.04.2016
Source:	Roadmender Batched	**Date Made:**	25/01/2016
Mix Components:	Not known	**Date Tested:**	See below
Mix Proportions:	Not known		
Method of Manufacture:	Roadmender Equipment	**Number of Specimens:**	2
Age at Test:	106 days	**Test Temperature °C**	60
Storage Conditions (Laboratory prepared specimens): 20°C		**Mixer / Compaction:**	Site Core

Test Results

Sample Reference Number 16-	0699	0700			
Site Sample Reference Number	1A	1B			
Date Tested	10/06/2016	10/06/2016			
Specimen Thickness (mm)	66.8	68.6			
Specimen Density (Mg/m3)	2.245	2.238			
Wheel-Tracking Rate WTR_{Air} (microns/cycles)	0.17	0.34			
Mean Wheel-Tracking Rate WTS_{Air} (microns/cycles)	0.255				
Proportional Rut Depth @ 10000 Cycles (%)	5.76	8.18			
Mean Proportional Rut Depth @ 10000 cycles (%)	6.97				
Individual Max Rut Depth @ 10000 cyclesRD_{air} (mm)	3.85	5.61			
Mean Max Rut Depth @ 10000 cyclesRD_{air} (mm	4.73				

Remarks : 1:*Density Method: BS EN 12697-6 (Clause 9.2 Air & water)

Client Name UK Power Networks
F.A.O. Paul Dooley
Newington House
237 Southwark Bridge Road
London

Posteode SE1 6NP

Signed :
Date :

Digitally signed by Prime, John
DN: cn=Prime, John, ou=TRL Users, email=jprime@trl.co.uk
Date: 2016.06.21 15:19:13 +01'00'

Authorised Signatories:

D Blackman	Laboratory Manager	J Prime	Deputy Laboratory Manager
J Weeks	Senior Technician	P Hannah	Senior Technician

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4

A full list of our projects

Our Network Innovation Allowance Portfolio

The tables below provide a full list of the projects, which were funded within the regulatory year running from 1 April 2015 to 31 March 2016, and also projects which have commenced since then. You can find out more about each project and its progress by clicking the links in the tables below.

Capital Efficiency

Project Reference	Project Name	Research Area	Start-Ends	Budget
NIA_WWU_023	Lead Crystal Battery Assessment	Other	04/2015 - 10/2015	£20,511
NIA_UKPN0001	Power Transformer Real Time Thermal rating (RTTR)	High Voltage Networks	06/2014 - 01/2017	£1,382,000
NIA_UKPN0011	Small Bore Cable Replacement Technology	High Voltage Networks	09/2015 - 04/2017	£1,114,650
NIA_UKPN0014	Solid Cable Replacement Prioritisation	High Voltage Networks	09/2015 - 02/2017	£141,056
NIA_NGET0088	Transformer Research Consortium	Safety, Health and Environment	04/2013 - 10/2017	£1,050,000
NIA_SSEPD_0004	Ultrapole	Network Monitoring	04/2015 - 10/2016	£45,000
NIA_UKPN0013	Underground HV Cable Research	High Voltage Networks	09/2015 - 03/2017	£932,477

Connections

NIA_UKPN0004	Freight Electric Vehicles in Urban Europe (FREVUE)	Low Voltage and 11kV Networks	03/2013 - 09/2017	£74,310
NIA_ENWL003	Review of Engineering Recommendation P2/6	High Voltage Networks	01/2015 - 09/2016	£650,000

Driving Sustainable Networks

NIA_UKPN0008	Business Models Enhancement (BME)	Low Carbon Technologies	08/2015 - 04/2016	£208,340
NIA_WPD_008	Improved Statistical Ratings for Distribution Overhead Lines	Network Operations, Comms & IT	07/2015 - 01/2018	£747,554
NIA_NGET0100	Reactive Power Exchange Application Capability Transfer (REACT)	Low Carbon Generation & Connections	05/2013 - 05/2015	£315,998
NIA_NGET0154	Smart Grid Forum Work Stream 7 - DS2030	Various	07/2014 - 12/2015	£750,000

Environment

NIA_UKPN0012	Pressurised Cable Active Control and Monitoring	High Voltage Networks	09/2015 - 11/2017	£1,075,600

Operational Efficiency

NIA_SGN0035	Beyond Visual Line of Sight Aerial Inspection Vehicle	Network Monitoring	03/2014 - 09/2015	£567,111
NIA_UKPN0009	Composite Shell joint Retrofit Trial	Low Voltage and 11 kV Networks	09/2015 - 05/2017	£186,000
NIA_UKPN0016	RoadMender reinstatement trial	Low Voltage and 11 kV Networks	01/2016 - 01/2017	£493,106

Reliability and availability

NIA_UKPN0005	Better Spur Protection	Low Voltage and 11 kV Networks	04/2014 - 10/2016	£367,500
UKPNTI003	Smart Urban Low Voltage Network (SULVN)	Low Voltage and 11 kV Networks	07/2012 - 03/2015	£2,141,000
NIA_UKPN0006	The Prediction of Weather-Related Faults	Network Operations, Comms & IT	05/2015 - 08/2016	£128,310
NIA_UKPN0002	Directional Earth Fault Passage Indicator Trial	Low Voltage and 11 kV Networks	01/2014 - 12/2016	£483,764

Safety

NIA_UKPN0007	Detection of Broken/Low Hanging Overhead Line Conductors	Safety, Health and Environment	02/2014 - 12/2017	£737,900
NIA_UKPN0015	Tunnel Data Capture Enhancement	Various	11/2015 - 05/2017	£240,000
NIA_UKPN0010	Vertical Transition Straight Joints Innovative Inspection	Low Voltage and 11 kV Networks	09/2015 - 07/2017	£899,396

For more information on our projects and their findings please visit http://www.smarternetworks.org/site.aspx

#GoodToGreat

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

UK Power Networks Holdings Limited
Registered office: Newington House
237 Southwark Bridge Road
London SE1 6NP
Registered in England and Wales
Registered number: 7290590

UK Power Networks
Delivering your electricity