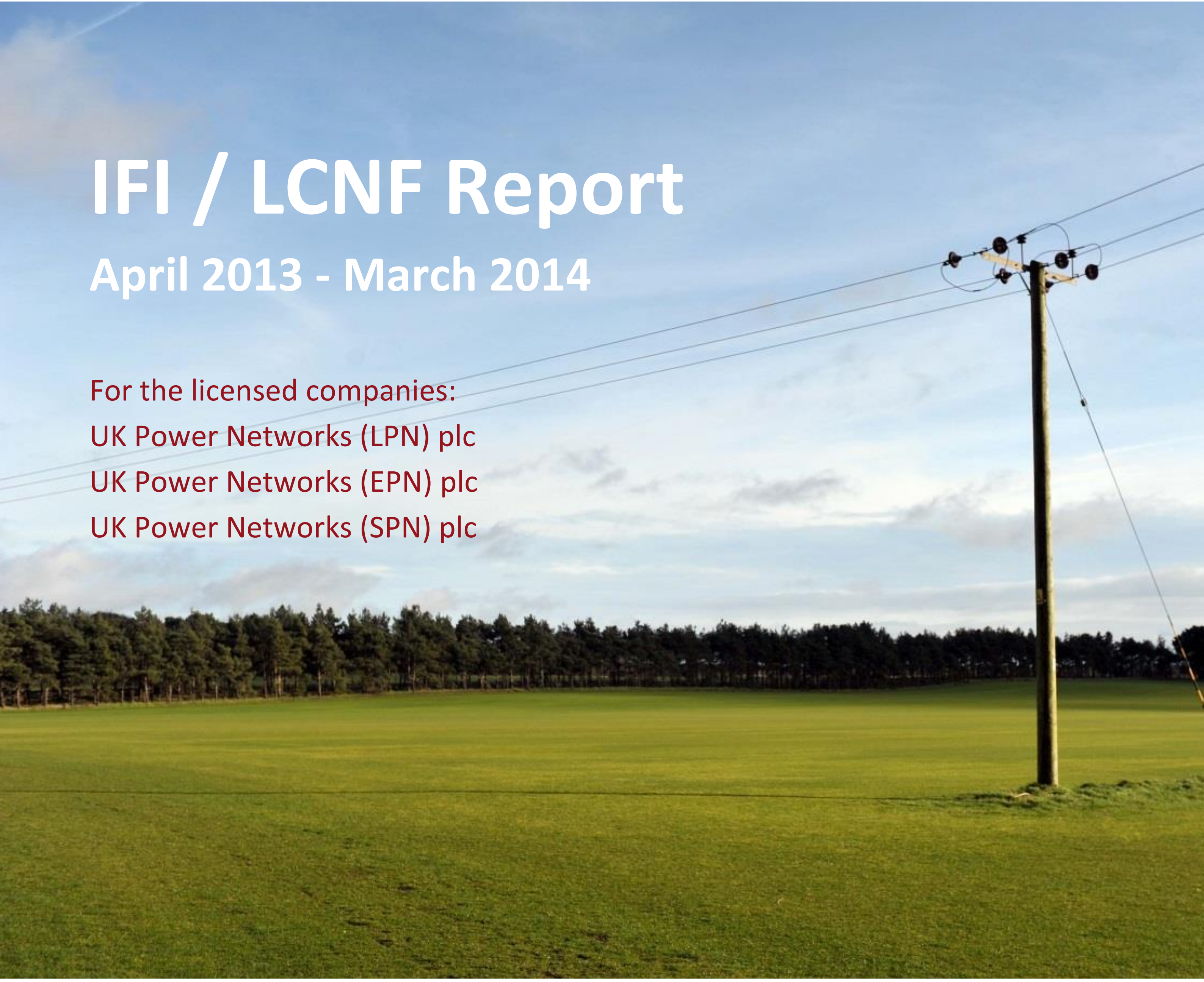
IFI / LCNF Report

April 2013 - March 2014

For the licensed companies:
UK Power Networks (LPN) plc
UK Power Networks (EPN) plc
UK Power Networks (SPN) plc



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UK Power Networks
Delivering your electricity

Contents

Introduction

UK Power Networks operates the three licensed electricity distribution networks serving London, the East of England and the South-East of England. These networks serve more than eight million homes and businesses and support critical national infrastructure.

We are the lowest price, most reliable and most innovative DNO group. Our obligations are to invest wisely and cost-effectively in infrastructure, offer timely and affordable connections to our network and maintain high standards of security of supply. In parallel, we have a core challenge to support the transition to a low-carbon economy. The UK Government's Carbon Plan[1] outlines how the Government proposes to manage the UK's transition to a low carbon economy; it contains ambitious proposals for generating electricity from low-carbon and renewable sources, and for electrification of heat and transport.

Wide-scale adoption of electric vehicles (the batteries of which will be charged from the electricity distribution network) and electric heating (which will be supplied by the electricity distribution network) will be fundamental to achieving these targets. UK Power Networks' challenge is to understand how future electricity demand will change, and to then develop new tools and design options to add to our armoury in order that this increased level of electricity demand can be met efficiently and economically. Innovation is central to this challenge.

This annual report is our summary of innovation activities that have been funded by the Innovation Funding Incentive (IFI). We are aware that a number of other important stakeholders will be reading this report in order to understand our activities. For this reason, we provide some initial context by introducing the company, our approach to innovation and the background to the IFI.

Our activities funded by the IFI form only part of our overall innovation portfolio. We have been awarded a total of £51m of funding from the Low Carbon Networks Fund (LCNF) Tier 2, the largest amongst the DNO groups. Throughout the report we refer to other innovation activities, including LCNF Tier 1 and Tier 2 projects. You can keep up to date with developments on our larger-scale LCNF Tier 2 Smart Grid trials: 'Smarter Network Storage', 'Low Carbon London', 'Flexible Plug and Play', 'Flexible Urban Networks – Low Voltage', and 'Vulnerable Customers and Energy Efficiency' through their regular progress reports published on the Ofgem website[2].

Further information relating to these projects can be found on the projects' dedicated website: www.ukpowernetworks.co.uk/internet/en/innovation/

Company Structure

UK Power Networks owns and operates the licensed electricity distribution networks serving the East of England, London and the South-East of England. The licensees managed by UK Power Networks are:

- Eastern Power Networks plc for the East of England, referred to as 'EPN' in the rest of this report
- London Power Networks plc for London, referred to as 'LPN' in the rest of this report
- South Eastern Power Networks plc for the South East of England, referred to as 'SPN' in the rest of this report

These licence areas are shown in the map in Figure 1 on the following page.

[1] http://www.decc.gov.uk/assets/decc/11/tackling-climate-change/carbon-plan/3702-the-carbon-plan-delivering-our-low-carbon-future.pdf

[2] http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/stlcnp/Pages/stp.aspx

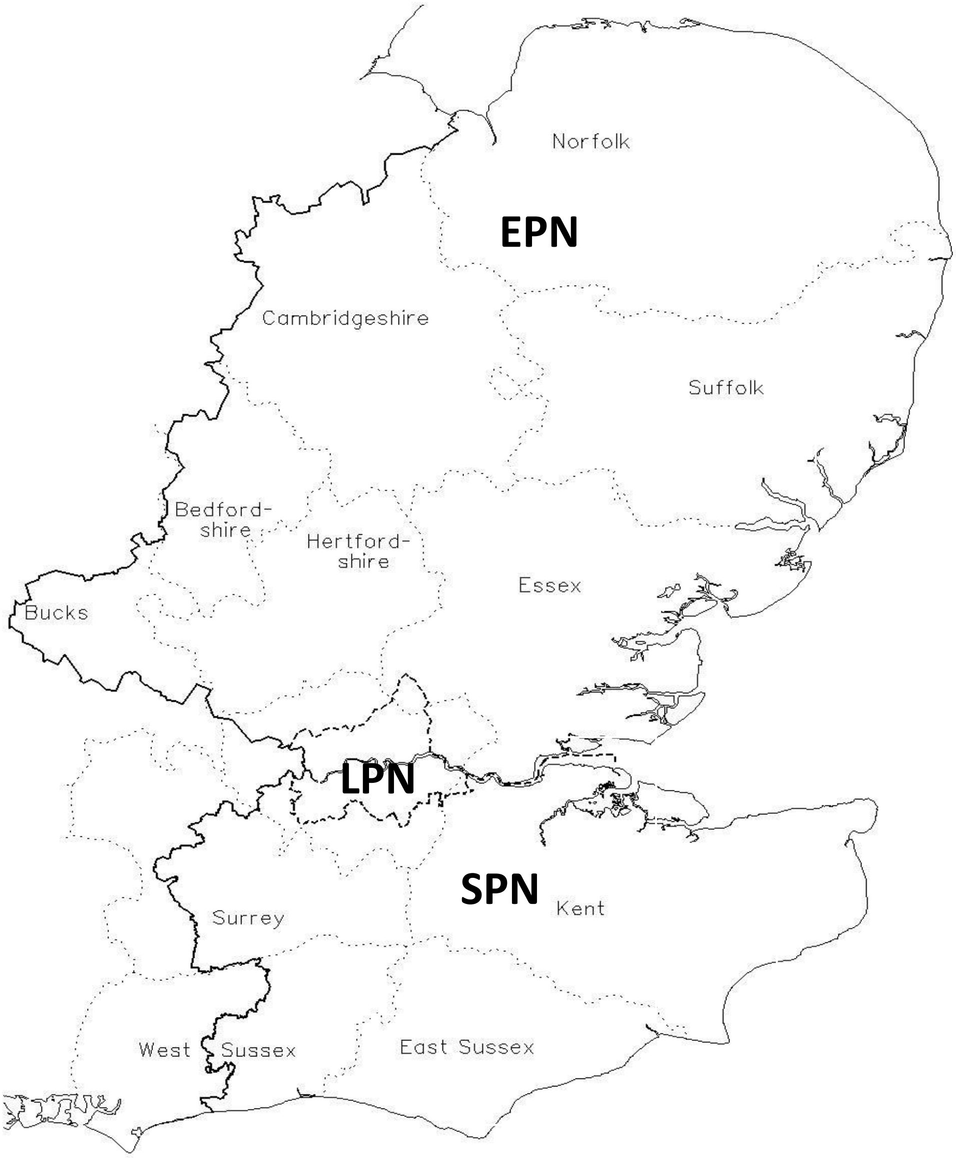


Figure 1: The areas served by UK Power Networks

Innovation activities across the EPN, LPN and SPN licensed electricity distribution areas are conducted by UK Power Networks. For each project, we allocate expenditure across the three license areas in proportion to the major assets within those license areas that are expected to benefit from the innovation activity, or according to the number of customers in each licensed area who will benefit. For example, our innovation projects associated with overhead line networks are largely funded from the IFI allowance allocated to the EPN and SPN license areas, where the vast majority of our overhead line network is found.

Our innovation activities typically fall into a number of categories: to understand a future issue and build a timeline for action; to inform engineering decisions; or to develop new solutions such as test equipment, sensors, devices which can make decisions and control the network, network management software and desktop design tools.

UK Power Networks operates a balanced portfolio of innovation, with projects ranging from early-stage research through to trials on our network. Whilst the IFI has been a significant source of funding for our innovation activities, we seek to leverage other sources of funding where possible. In parallel with the activities reported here, UK Power Networks is strongly involved with Ofgem's LCNF[3]. As

[3] http://www.ofgem.gov.uk/Networks/ElecDist/lcnf/Pages/lcnf.aspx

well as the LCNF Tier 2 projects, six smaller LCNF Tier 1 smart grid projects are also registered covering areas ranging from remote control of the Low Voltage (LV) network, greater network monitoring and the impact of photovoltaic (PV) generation. Details of these projects can be found on the Ofgem website.

Background to the Innovation Funding Incentive

The primary aim of the IFI is to encourage distribution network operators to apply innovation in the technical development of their networks. Ofgem recognises that innovation has a different risk/reward balance compared to a network operator's core business. The incentives provided by the IFI mechanism are designed to create a risk/reward balance that is consistent with research, development, demonstration and deployment.

The IFI is intended to provide funding for projects primarily focused on the technical development of networks in order to deliver value (e.g. financial, quality of supply, environmental, safety) to consumers.

The IFI activities described in this report are governed by Standard Licence Condition 46 and Charge Restriction Condition 10 in the Electricity Distribution Licence. Their requirements can be summarised as follows:

- A network operator is allowed to spend up to 0.5% of its combined distribution network revenue on eligible IFI projects
- Internal expenditure incurred by the network operator in running and implementing IFI projects can be considered as part of the total IFI expenditure accrued by the network operator
- The network operator is allowed to recover 80% of its eligible project expenditure via the IFI mechanism within the network operator's licence
- Ofgem does not approve IFI projects, but network operators have to openly report their IFI activities on an annual basis
- Ofgem reserves the right to audit IFI activities if this is judged to be necessary in the interests of customers

In April 2015, both the IFI and LCNF (Tier 1) will be replaced by the Network Innovation Allowance (NIA). UK Power Networks has requested, via the RIIO-ED1 process, an allowance of 0.5% of revenues to continue work similar to that reported, and will continue to participate in the competitive funding rounds under the Network Innovation Competition.

Eligibility for IFI Funding

Projects will be judged as eligible within the IFI, provided that:

- The project satisfies the eligibility criteria described in Engineering Recommendation G85, Issue 2, 'Innovation Good Practice Guide for Energy Networks', published by the Energy Networks Association (ENA);
- The project has been well managed as defined in Engineering Recommendation G85; and
- The reporting requirements have been met.

This report fulfils our reporting requirements for the regulatory year 2013/14 and demonstrates that our projects are being well managed. Each individual project report presented later in this report includes a project 'score' which summarises how the project meets the eligibility criteria laid down in Engineering Recommendation G85.

Work that has been approved within an industry recognised or national/governmental programme (such as a Technology Strategy Board Programme or European Commission Programme) and whose terms of reference clearly address innovation in the networks may be considered eligible within IFI if it meets the defined criteria. Co-operation between network operators and other organisations to pursue

IFI projects is encouraged, and there are several examples of such co-operation in this report. UK Power Networks is an active member of the Energy Innovation Centre and the Energy Networks Association Research & Development (R&D) working group. In such cases the overall project would be expected to meet the IFI eligibility criteria and it would be acceptable for each participating network operator to use the eligibility case for the overall project. IFI projects that secure additional funding from outside agencies, such as the Technology Strategy Board or the European Commission, will not trigger any claw-back of IFI funding by Ofgem. Engagement with industry engineering committees is not considered eligible as this does not constitute a project with a specific target or delivery.

In the event that a network operator provides resources to contribute to an eligible IFI project that is led or managed by a third party, those costs incurred by the network operator that are not recovered from the third party will be considered eligible IFI expenditure. Where supporting such projects with a net cost to the network operator, the network operator should demonstrate that the expected benefits to the network operator exceed the costs involved.

IFI projects, by their nature, involve risk. It is understood, therefore, that not all IFI projects will meet their aims and objectives and deliver net benefits. However, it is expected that the benefits from those that do succeed will significantly outweigh those which do not, and exceed the overall costs of a network operator's IFI programme.

New Projects over the Coming Year

You can read about new projects as they are added on the Energy Networks Association (ENA) Smarter Network Portal (http://www.ena-eng.org/smarter-networks/). The portal (Figure 2) allows users to search our project portfolio, and those of other DNOs, for topics of interest.

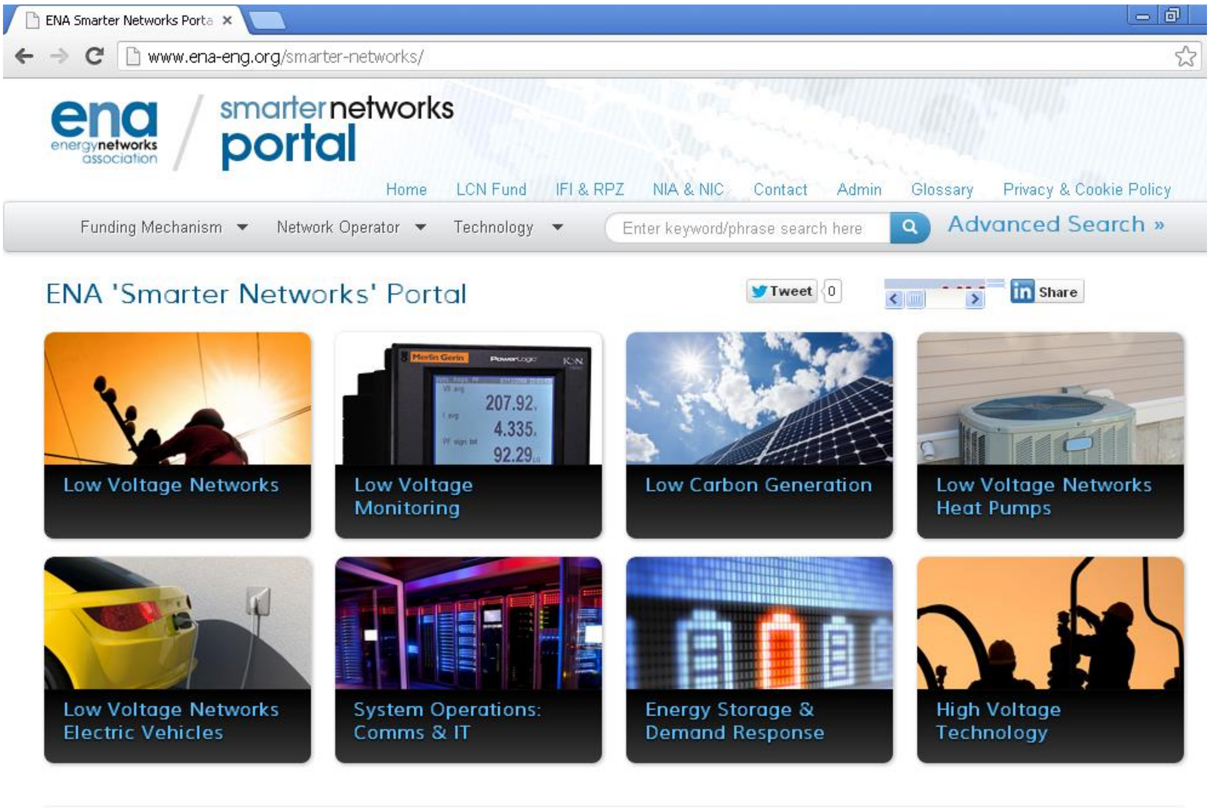


Figure 2: Smarter Network Portal

Summary of Expenditure

Figure 3 and Tables 1 and 2 below show UK Power Networks' usage of the Innovation Funding Incentive since its inception:

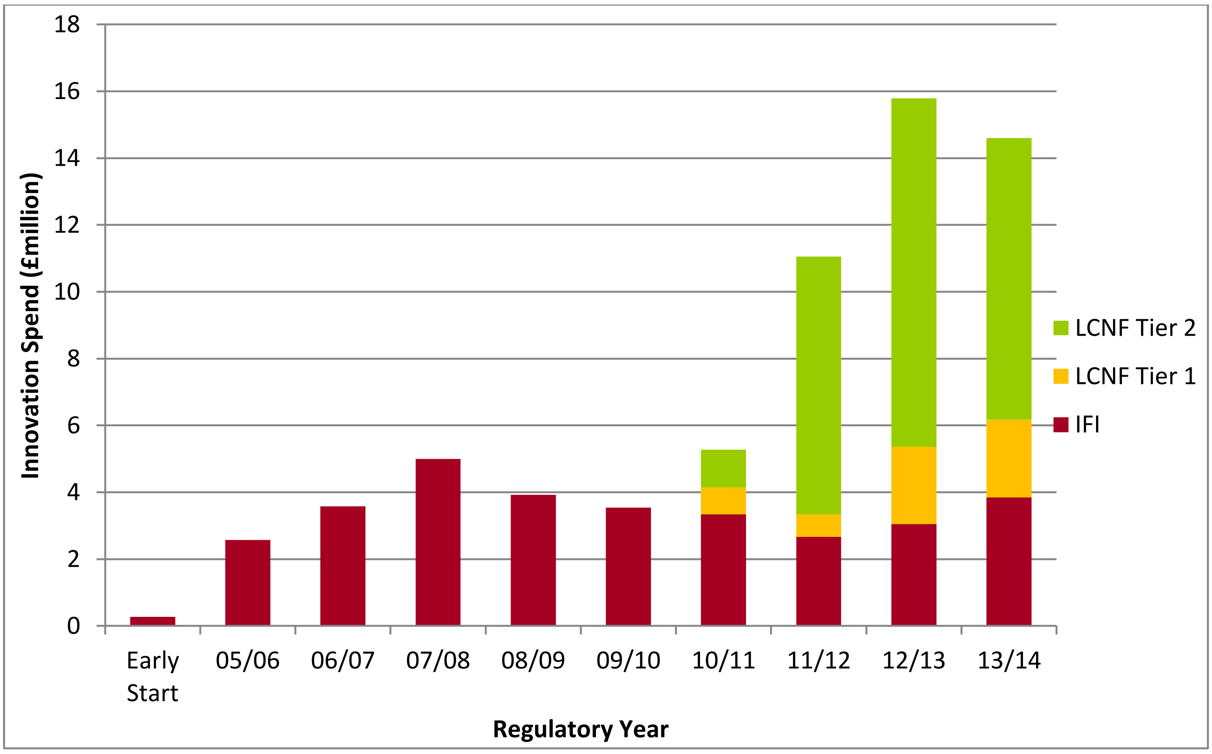


Figure 3: Trend of innovation spend

Regulatory Year	Total IFI Expenditure	IFI Allowance
This regulatory year 13/14	£3,859,8k	£6,731.0k
Regulatory year 12/13	£3,053.8k	£6,260.0k
Regulatory year 11/12	£2,668.9k	£5,392.3k
Regulatory year 10/11	£3,339.5k	£4,793.3k
Regulatory year 09/10	£3,545.2k	£4,460.6k
Regulatory year 08/09	£3,922.6k	£4,425.5k
Regulatory year 07/08	£4,993.5k	£4,326.3k
Regulatory year 06/07	£3,575.8k	£3,938.3k
Regulatory year 05/06	£2,570.9k	£3,664.7k
Early start report 04/05	£275.8k	N/A
Total	**£27,946.0k**	**£37,261.0k**

Table 1: IFI expenditure and allowance

Details of the expenditure in the current regulatory year are shown below:

	EPN	LPN	SPN	**TOTAL**
IFI carry forward from 12/13 (£k)	£1,274.7k	£804.4k	£844.0k	**£2,923.2k**
Combined distribution network revenue (£m)	£518.6m	£451.9m	£375.7m	**£1,346.2m**
Allowance 13/14 (Including carry forward) (£k)	£3,867.8k	£3,063.7k	£2,722.7k	**£9,654.2k**
Eligible IFI expenditure 13/14(£k)	£1,146.1k	£1,583,1k	£830k	**£3,859.8k**
Of which internal expenditure 13/14(£k)	£106.1k	£135.3k	£61.1k	**£302.6k**
The IFI carry forward to 14/15 (£k)	£1,146.9k	£676.0k	£939.3k	**£2,762.4k**

Table 2: IFI spend/allowance/carry forward per licence area

Expenditure from IFI Projects

Table 3 below details individual project expenditures from April 2013 to March 2014. Investment is apportioned across UK Power Networks' three licence areas according to the number of customers or assets in each area most likely to benefit from the research outcomes. The basis of the allocation is specified in each project report.

	EPN	LPN	SPN	Total
Managing Asset Risk and Improving Fault Performance				
Tree Growth Regulator (Completed)	£25,803	£0	£9,414	£35,217
Earthing Information Systems (Completed)	£7,783	£4,991	£4,940	£17,714
Developing Long-Term Asset Risk Replacement Modelling (Completed)	£43,114	£23,815	£27,346	£94,275
Satellite Imagery and Lidar (Completed)	£91,772	£59	£33,506	£125,338
Overhead Lines Incipient Fault Detection	£3,123	£0	£1,141	£4,264
Development of Technologies to Extend the Life of Link Boxes and Mitigate the Impact of Cable Pit Disruptive Failures	£89,834	£365,779	£71,251	£526,864
Detection of Broken and Low -hanging Conductors	£2,330	£0	£850	£3,180
Earthing Design Tool	£6,829	£4,380	£4,335	£15,544
Directional Earth Fault Passage Indicator (DEFPI)	£0	£2,559	£0	£2,559
Fringe Fuses Monitoring	£0	£1,721	£0	£1,721
Smart Heat	£3,109	£3,124	£2,711	£8,944

	EPN	LPN	SPN	Total
Trial of Arc-Flash-Based Busbar Protection at Primary Sites	£2,967	£1,024	£2,335	£6,326
Leveraging Industrial and Commercial Demand Response and Dispatchable Generation				
Freight Electric Vehicles in Urban Europe	£0	£5,867	£0	£5,867
Managing Residential and Small and Medium-Sized Enterprise (SME) Consumer Demand				
Supergen 3 – HiDEF Highly Distributed Energy Futures (Completed)	£0	£0	£0	£0
Home-Based Flexible Demand Management (Completed)	£4,271	£2,739	£2,711	£9,721
Vehicle to Grid (V2G)	£785	£434	£498	£1,716
New Options to Release Capacity at 11kV, 33kV and 132kV				
Urban Transformer Substation (Completed)	£829	£458	£526	£1,814
Increased Capacity from Existing Overhead Line Routes	£144,141	£93	£52,626	£196,860
Strategic Technology Programme (STP) Module 2 – Overhead Networks	£29,870	£19,156	£18,959	£67,985
Strategic Technology Programme (STP) Module 5 – Networks for Distributed Energy Resources	£23,879	£15,313	£15,156	£54,349
Fault Level Management Study	£0	£10,796	£0	£10,796
Understand Current and Future Performance of the 11kV and LV Network				
Distribution Network Visibility (Completed)	£0	£635,851	£0	£635,851
Technical Losses Review (completed)	£47,978	£30,769	£30,453	£109,200
LV Remote Control and Automation / Smart Urban LV Network	£413,332	£234,920	£270,069	£918,321
Strategic Technology Programme (STP) Module 3 – Cable networks	£36,194	£23,211	£22,973	£82,379
Strategic Technology Programme (STP) Module 4 – Substations	£26,084	£16,728	£16,556	£59,368
Rogowski Coil and Voltage connection Fuse Carrier	£249	£138	£158	£544

	EPN	LPN	SPN	Total
Understand the Condition of our Assets				
Sustainable Asset Risk and Prioritisation Modelling (Completed)	£142,301	£78,602	£90,260	£311,163
Helicopter Mounted Partial Discharge Locator (Completed)	£652	£225	£513	£1,391
Micro-helicopters	£153,486	£99	£56,038	£209,623
Transformer Research Consortium	£19,931	£7,935	£11,365	£39,230
Underground HV Cable Research	£4,445	£2,675	£2,652	£9,772
Develop Commercial Solutions and Products				
Smart Power Distribution (completed)	£0	£7,737	£0	£7,737
Bankside Heat Transfer	£0	£0	£0	£0
Collaborative Programmes				
Energy Innovation Centre	£65,195	£46,170	£45,794	£157,158
Power Networks Research Academy	£9,878	£6,335	£6,270	£22,482
Collaborative ENA R&D Programme	£45,959	£29,474	£29,171	£104,604
TOTAL	**£1,446,123**	**£1,583,176**	**£830,579**	**£3,859,878**

Table 3: Allocation of expenditure per project and licence area

Please note that for readability, all the figures in the report have been rounded to the nearest £ or £k as appropriate.

The next section presents the highlights from our innovation programme, and some of the key projects carried out under the IFI and the LCNF.

Portfolio highlights

Our IFI and LCNF projects have again delivered a number of successful outcomes. The next few pages show innovations which:

- Can be considered as an alternative to traditional network reinforcement, and enable more load or generation to be connected to the distribution network
- Improve safety by carrying out aerial inspections to minimise the need for Working at Height and using vented street covers to prevent the build-up of flammable gas
- Enable the LV Network to be remotely managed and minimise the impact of LV intermittent faults
- Enable network data from more than 9,500 substations to be automatically analysed, and network issues such as high voltage and high utilisation to be proactively addressed.

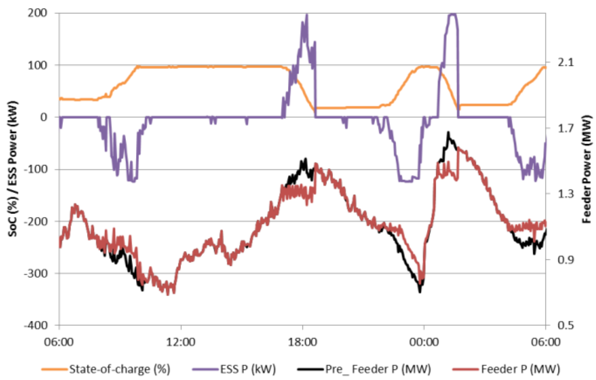
Highlights

We have achieved a wide range of technology successes over the last year

Short-term discharge energy storage (LCNF Tier 1):

The project has now closed and the close-down report is available on Ofgem's website.

The main project outcomes are:
- Autonomous voltage control was successfully demonstrated
- Automated peak shaving and feeder demand management was successfully demonstrated with algorithmic control of the Energy Storage System (ESS).
- Stability of both the ESS and communications network proved a major challenge



Impact of automated peak shaving algorithm (Without Storage: Black, With Storage: Red).

Micro-helicopters (IFI):

UK Power Networks is testing the benefits of using Micro-helicopters for aerial inspections of live power lines and equipment. The aim is to detect problems on the power network before they result in a power cut, and identify defects to restore power supplies more quickly when problems do occur.

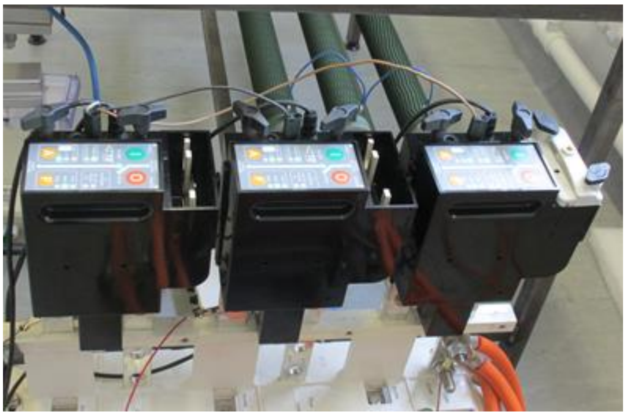
Benefits are expected to include: carrying out inspections while circuits are live, improving safety by reducing the need to climb, and speeding up inspections. For example, inspecting an electricity grid substation, a job which could take half a day, can be completed in ten minutes using a micro-helicopter.

Micro Helicopter inspection

Smart Urban Low Voltage Network (LCNF Tier 1 / IFI):

Following the original supplier's decision to sell the technology and a lengthy technology transfer process, UK Power Networks has secured the availability of the technology going forward.

In addition to the LCNF Tier 1 demonstration, Low Voltage Circuit breakers configured as "LV Reclosers" will also be trialled to reduce the impact of intermittent LV Faults.



Recloser test rig

Distribution Network Visibility (DNV)

Case Study – Automatic Voltage Control (AVC) Setting at Osborn Street Primary Substation

DNOs are required to maintain the voltage at the end users' meters within statutory limits (230V +10%/-6%). Voltage is set at primary substations with Automatic Voltage Control (AVC) schemes, and from here onwards it directly affects both the secondary substation voltage and customer voltage.

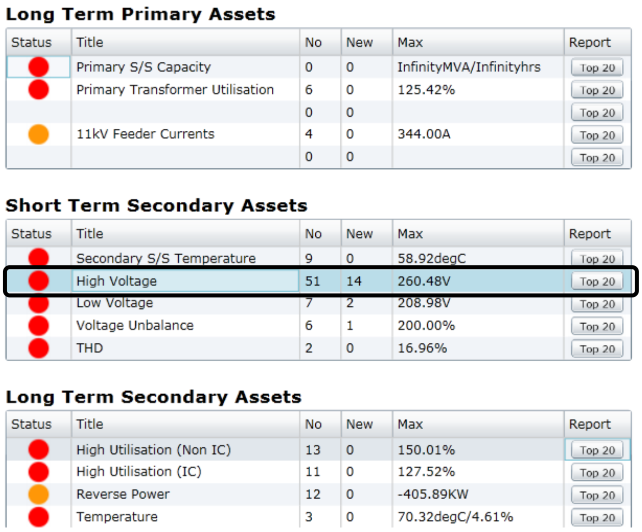
Analysis:
Using the DNV Dashboard and the Top 20 report option for High Voltage Short Term Secondary Assets (Figure 4), a number of secondary substations with high voltage levels were identified. Many of these secondary substations were supplied from Osborn Street Primary Substation, indicating that the high voltage levels may be associated with a problem at the primary substation level.

In order to obtain an overview of the voltage levels at the different secondary substations supplied by Osborn Street primary, the GIS Map was used to highlight (in red) any secondary transformers with voltage excursions above 253V (Figure 5).

Time-series analysis of voltages at both the primary (all Osborn Street primary transformers) and secondary levels (secondary substation transformers previously highlighted in red on the GIS Map) showed a step increase in voltages in January 2014 (Figure 6), which coincides with T4 primary transformer being switched back into service. The issue was reported to key personnel from our Network Operations department for further investigation.

Conclusions:
Voltage measurements taken on site at Osborn Street showed high values for all primary transformers, but mainly for transformers T1 and T4 (working in parallel). A revised setting was applied to all the Automatic Voltage Control (AVC) relays and the AVC relays responded to the new setting by tapping down to lower the target voltage.

Recent voltage profile graphs generated through the DNV tool demonstrate that the voltage-related issues identified for the secondary substations supplied by the Osborn Street primary substation have now been resolved (Figure 6).



Long Term Primary Assets

Status	Title	No	New	Max	Report
	Primary S/S Capacity	0	0	InfinityMVA/Infinityhrs	Top 20
	Primary Transformer Utilisation	6	0	125.42%	Top 20
		0	0		Top 20
	11kV Feeder Currents	4	0	344.00A	Top 20
		0	0		Top 20

Short Term Secondary Assets

Status	Title	No	New	Max	Report
	Secondary S/S Temperature	9	0	58.92degC	Top 20
	High Voltage	51	14	260.48V	Top 20
	Low Voltage	7	2	208.98V	Top 20
	Voltage Unbalance	6	1	200.00%	Top 20
	THD	2	0	16.96%	Top 20

Long Term Secondary Assets

Status	Title	No	New	Max	Report
	High Utilisation (Non IC)	13	0	150.01%	Top 20
	High Utilisation (IC)	11	0	127.52%	Top 20
	Reverse Power	12	0	-405.89KW	Top 20
	Temperature	3	0	70.32degC/4.61%	Top 20

Figure 4: Dashboard Tab
Short term issues on secondary assets

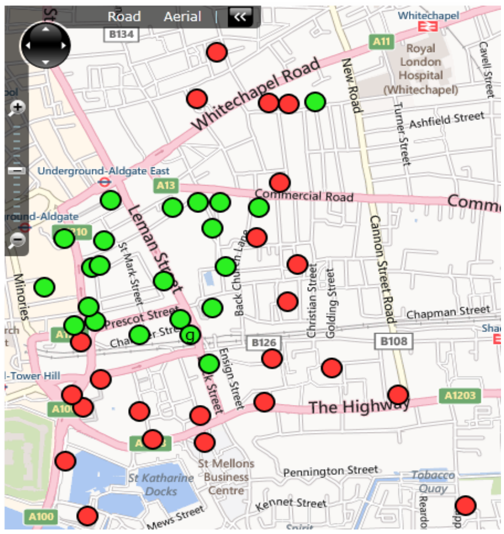


Figure 5: GIS Map
Red pins for Voltage > 253V
Green pins for V ≤ 253V

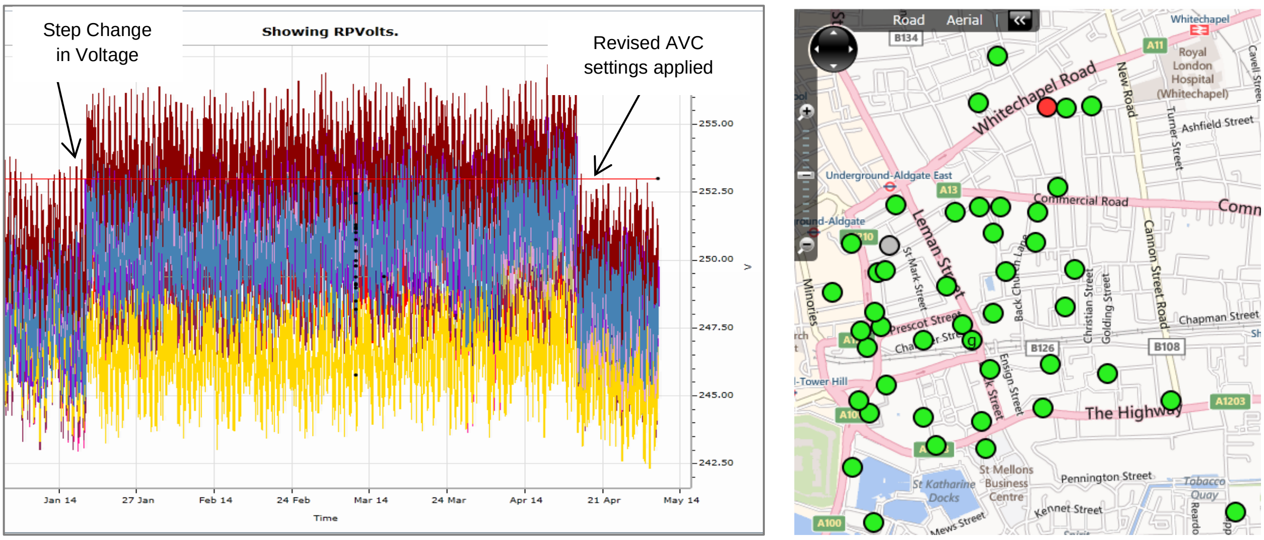


Figure 6: Time Series graph and GIS Map
Left – Voltage at secondary substations before and after revised AVC relays settings applied
Right – Voltage at secondary substations within limits following corrective action

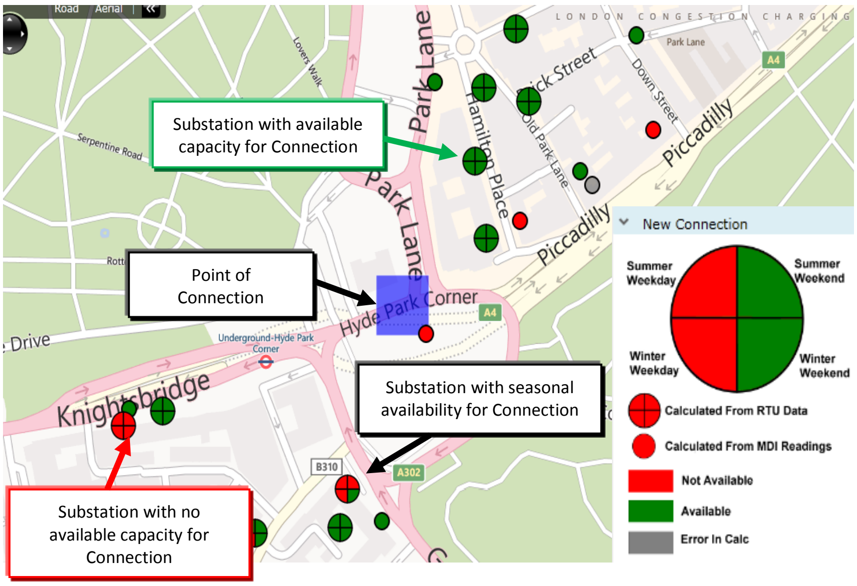
<u>Business Benefits</u>
Use of the DNV tool will enable UK Power Networks to act proactively to keep LV voltages within statutory limits, improving customer service and also avoiding the need for fitting voltage measuring equipment in response to enquiries.

Other DNV Advanced Functionalities – New Connections/Spare Capacity Tool

The New Connections/Spare Capacity tool, available through the GIS Map tab, assesses the availability of spare capacity at all secondary substations within a specified radius from the selected location. This will enable UK Power Networks to improve its connections process by being able to carry out more accurate assessments of the available spare capacity.

The assessment is based on maximum demand at each secondary substation, the requested size of connection, and the existing transformer and expected new connection load profile type (e.g. industrial, commercial, etc.). Existing referrals affecting the specified area and the reduction to transformer rating for interconnected areas are also taken into account.

The spare capacity is determined over four periods (winter weekday, winter weekend, summer weekday and summer weekend) where RTU data is available (quadrant pins), or a year round approach in cases where the calculations are made using Maximum Demand Indicator (MDI) readings (single pins). Colour feedback is given based on the availability of each substation for new connections as shown in Figure 7.



For additional information on spare capacity, the planning and connections engineers can also refer to a network-wide spare capacity report.

Figure 7: New Connections/Spare capacity GIS Map colour feedback pins/ quadrants for available capacity at substations near the point of connection

Development of Technologies to Extend the Life of Link Boxes and Mitigate the Impact of Cable Pit Disruptive Failures

UK Power Networks collaborated with Structural Science Composites (SSC) to develop an innovative new vented composite cover, specifically designed to reduce significantly the risk of injuries in pedestrian areas. The design was based on the ‘S’ cover that SSC previously developed for Con Edison New York. The new FFP10 (Footway Fault Protection) vented composite cover measures 860x860mm, and has over a thousand 10mm diameter holes in its surface, providing a vent area of about 12%.

Figure 8: Composite vented Cover (Left) and non-vented cover (Right)

Whilst the current priority is to mitigate cable pits in pedestrian areas, we are also working on solutions for cable pits in roadways (composite covers are not strong enough to withstand vehicular traffic). UK Power Networks has identified that hinged roadway covers – originally developed to reduce manual handling injuries – could potentially also be used to safely relieve pressure caused by an incident, if the hinged covers could be modified to automatically close after an incident.

This work formed part of a wider strategy to manage the risk of disruptive cable pit incidents, which can potentially cause injury and property damage. The strategy was developed in collaboration with Black & Veatch Ltd (BVL) and followed a structured approach to:

1. Prioritise cable pits by risk rating
2. Develop mitigation measures
3. Validate mitigation measures
4. Implement mitigation measures

Risk assessment

The first step in the strategy was to prioritise the inspection and mitigation of cable pits. We risk-assessed cable pits in our network based on information including:

- The number of cable joints known to exist inside the pit – which affects the likelihood of an incident; and
- The amount of pedestrian traffic near the pit – which affects the consequence of an incident.

Each pit was given a risk rating of very high, high, medium, or low risk.

We then started inspecting cable pits – highest-risk first – to accurately record their condition, especially any defects, and used this information to confirm or update the pit’s risk rating. We are using several innovative techniques to ensure the effectiveness of our inspections, including:

- Partial discharge measurement
- Bespoke high-resolution pole-mounted cameras – to minimise the need for staff to enter pits

Development of mitigation measures

The research found that cable pit incidents typically occur when a build-up of flammable gas is ignited by a cable fault, and that injury is most likely to occur when the pit cover is ejected. We developed a suite of mitigation measures based on the hierarchy of controls – i.e. elimination, substitution, engineering and isolation, administration and training, and PPE.

Type of control	Mitigation measure	Effect
Elimination	Fill the cable pit with sand, or covert to a buried cable pit	Eliminates the possibility of a flammable gas build-up
Substitution / Engineering	Install vented / hinged pit covers	Reduce the likelihood and severity of a flammable gas build-up / Safely relieve pressure caused by an incident, and hence reduce the likelihood that the pit cover will be ejected
Engineering	Tether the cover to the pit	If the pit cover is ejected, reduce the likelihood that it will travel far enough to injure anyone

Validation of mitigation measures

UK Power Networks collaborated with BVL to develop and undertake a programme of type tests to demonstrate that the proposed mitigation strategies would work. The tests verified that the pit covers remained in place when HV and LV cable faults were simulated inside the pit, using typical prospective short-circuit current levels:

- Sand infill: No cover movement or displacement was observed during either LV or HV faults.
- Vented cover: No cover movement or displacement was observed during either LV or HV faults. The cover successfully vented the arcing fault and gases.
- Hinged cover (Saint-Gobain Opt-Emax carriageway cover): The cover successfully lifted, vented and returned to position during both the LV & HV faults.

Implementation

Our innovative cable pit risk management strategy has been implemented in business as usual and is already making our cable pits safer. We have successfully visited every cable pit in our LPN licence area that was rated very-high or high risk, and have applied mitigation measures to 1,700 of these, and expect to complete a further 5,000 cable pits by March 2015.

Future Innovation Work

The next steps are to develop and validate a similar risk management strategy and mitigation measures for link boxes, and hinged covers that can safely vent cable pit incidents on roadways.

Smart Heat

The fluid-filled cable network is approximately 2,315 km in length and provides the backbone to the EHV network across the three licence areas. All cable fluid losses are proactively reported each month to the Environment Agency. One of UK Power Networks' objectives is to keep the network robust, and one of the ways to achieve this is by having minimal cable outages at any one time or by keeping them to as short a duration as possible.

Following the introduction of the Perfluorocarbon tracer (PFT) leak location technique (see 2009/10 IFI report), UK Power Networks is looking to further improve the process of locating cable leaks. Not all of our fluid-filled cable network has been tagged with PFT and this process will take many years to complete given the logistical issues involved and size of network. In the areas where the cables have not been tagged, a freezing technique is still used to locate the fault. Cable freezing has been the traditional method of finding cable leaks but it has several drawbacks such as the hazards of handling liquid nitrogen, potential damage to the cable and the long outage times required.

This new method will enable UK Power Networks to minimise the safety risks and costs associated with undertaking cable freezes, and reduce outage time by being able to locate leaks faster.

Prototype system

The method uses a heating element to elevate the temperature of short length of fluid-filled cable. The temperature of the cable is then logged at either side of the heated section; the side where the temperature becomes elevated is toward the leak. This is due to the thermal convection and conduction from the heated cable fluid migrating towards the leak.

Figure 9: Leak direction (Left: Theory, Right: Measurements)

Figure 10: Prototype system set up in a controlled indoor environment.

The initial trials were carried out using a three-core 400mm² 33kV fluid-filled cable (Figure 10). A variety of leak rates and cable elevations were used, which conclusively proved that the method works under a variety of conditions. Figure 10 clearly shows that the temperature on the left hand side of the heating jacket (TC3 and TC4) is higher than that on the right (TC1 and TC2).

Field Trials

Following on from successful testing in a controlled environment, field trials were carried out in Hornsey, on a leak with a rate of 840 litres per month (Figure 11). The results were conclusive, and the leak direction could be determined using temperature display unit and the thermal imaging camera.

Figure 11: Field trials in Hornsey

Business Benefits and next steps

The trials have conclusively proved that the method works in controlled conditions. Further controlled indoor trials and field trials need to be carried out to validate these results. Once the parameters for use have been conclusively decided, the solution will be rolled out to the rest of the EHV leak detection team, with training and implementation taking place towards the end of 2014.

Strategy

Our guiding principles

Innovation has many different definitions and interpretations depending of the context in which it is used. UK Power Networks views innovation as introducing something new to our business processes or distribution network so we can provide a better, cheaper or quicker service than before. Innovation does not always have to be ground-breaking; many improvements are achieved by smaller step-by-step improvements.

In UK Power Networks we often think of innovation as either:

- Incremental innovation: continuous evaluation to achieve gradual improvements of our business efficiency, for example by using small remote controlled helicopters to carry out overhead line inspections
- Disruptive or transformational innovation: redefining the way we run our business or network, embodied in our Low Carbon Network Fund (LCNF) projects to trial Smart Grid technologies

Why Do We Innovate?

In UK Power Networks we innovate to identify opportunities for developing new or more efficient services, processes or solutions. This rationale for innovation contains two vital elements that are at the heart of our approach to innovation:

- Value to our stakeholders – if we cannot identify how a proposed innovation will deliver value to our stakeholders then we do not proceed with it. We are clear on our duties to serve customers; support the economic recovery; and facilitate the government’s carbon reduction targets. Our innovations deliver across all of these goals
- Continuous improvement – we are committed to deliver continuous improvement of our services, processes and solutions. This commitment covers the entirety of UK Power Networks, including customer relations, new connections, management of our substation assets, the remote workforce, health, safety and sustainability, our construction programme and back office functions, rather than being focused only on specific areas

How Do We Innovate?

We undertake innovation by a variety of approaches that are tailored to achieving effective outcomes and value for money. Our innovation projects draw on internal and external resources so that we take advantage of best advice and experience, we adopt the best techniques, and we build new in-house knowledge for the future. This leads us to work with large and small manufacturers, academia, specialist advisers, community organisations and other stakeholder representatives.

In order to deliver innovation of the scale that we believe is required, we access funding from a variety of sources over and above our own financial support. We will naturally seek to optimise our use of available income from the IFI, LCNF, NIA, NIC or third-party funding agencies. As we identify new innovation ideas, they are scoped to the extent that is required in order to understand the associated costs, benefits and risks. We then evaluate if the potential project will deliver appropriate new value on a self-funding basis and decide whether or not to proceed. Where the benefits are not immediately quantifiable or available, but could be substantial, we will seek to deliver the project using the other available innovation funding mechanisms.

There will also be circumstances where we identify technology development activities that we regard as worthwhile but may not be eligible for funding; in these scenarios we will determine on a case-by-case basis if the potential value is sufficiently high for us to self-fund. An example of this was the Green Rhino filtration bag, which was developed with a manufacturer and offers a means to remove water from an excavation by ensuring that any contaminants are held in the bag and disposed of whilst the remaining water is released.

We actively engage in the ENA Research and Development (R&D) working group and we collaborate with other DNOs on specific projects. Participating in collaborative projects is a good way of delivering value for money for customers and sharing information and results across our industry.

Innovation activities or projects that are selected for delivery are actively monitored to clearly identify the business case for innovation throughout their delivery lifecycle. This will help us ensure that the expected value to be delivered remains on target, and enables us to monitor its realisation after delivery. This is formalised in a set of ‘stage gates’ including an after-the-event post-investment appraisal, in line with project management best practice.

The Future Networks Team is responsible for maintaining balance within the overall portfolio of innovation projects. Our balanced portfolio contains a mix of:

- Projects addressing short, medium and long-term issues from across our innovation themes;
- Projects that are high and low risk
- Projects to inform decision making or that are a step further and are likely to result in practical changes to our internal engineering policies
- Projects that are further developed and are full-scale trials of new technology solutions (e.g. LCNF Tier 2 projects)
- Projects that are addressing both technical and commercial challenges
- Projects being funded collaboratively and those that are contracted directly to UK Power Networks
- Projects that involve external partners and suppliers, so that the portfolio is neither too diverse in its relationships nor too dependent on a few critical relationships.

How Do We Make Innovations Business As Usual?

Our innovation projects will only be successful if we embed the new knowledge into our ‘Business as Usual’ (BaU) practices to improve the way we work and serve our customers.

The integration of innovation sponsors at a senior level within the directorates in the company is an important part of this process. Their senior roles allow them to be fully aware of the working practices and day-to-day challenges; therefore, they are best placed to drive the company through change.

We have developed a systematic approach that is integrated into our company policies and procedures. This includes management oversight through project sponsorship and tracking mechanisms to ensure closed-loop governance. These governance mechanisms ensure that network innovation project outputs are consistently embedded into BaU solutions and become part of our toolkit for planning and operational activities at all stages in the asset life cycle.

An important requirement at this stage is to adopt the knowledge and skills to deliver the outcomes of demonstration projects and make solutions suitable for full-scale deployment. To assist the transition to BaU for our network innovations, we have developed and implemented an approach we call the Smart Network Plan (SNP). The SNP is a comprehensive transitioning plan and governance process that gives confidence that the outputs of network innovation projects are migrated smoothly into BaU solutions that can be adopted on a large scale throughout the RIIO-ED1 period and beyond.

Capability Themes Areas

Figure 12 below shows the seven themes into which we organise our innovation activities. These themes describe the actions that need to be carried out to deliver innovation in a cost effective and timely manner.

Figure 12: UK Power Networks' innovation themes

The five themes at the centre of the diagram (labelled 1-5) are critical success factors in the service that we offer to current and potential customers. The two themes shown in the outer ring (labelled 6 and 7) describe a more interactive relationship with our customers, whether directly or through energy suppliers, aggregators and other market entities.

1 Managing asset risk and improving fault performance

At the centre of the diagram is the most basic innovation theme. This will correspond to all activities or innovation that we need to carry out to fulfil our central function of serving existing customers and managing risks to our electrical assets. Examples of innovations that fall into this category are investigations into improved fault restoration techniques and methods that have the potential to improve reliability of customer supply.

2 Understand current and future performance of the 11kV and LV network

The change in demand and the introduction of micro-generation will bring new pressures to the parts of our network that are currently least visible to us in real time. This includes changes to the low voltage (LV) network and 11kV (or in some cases 6.6kV) feeders and the load cycle on our assets. It is important to understand, for example, their ability to dissipate heat and thereby cool down between peaks of high load. Understanding loading on the network is essential to the service improvements that we are seeking in time to connect and cost of connection.

3 New options to release capacity at 11kV, 33kV and 132kV

This theme is strongly targeted to facilitate the low-carbon economy. We are currently exploring the particular cases in which a commercial solution such as DSR may provide a way to avoid reinforcing the network. We are aware that the driver for these solutions is the greatly increased demand peaks which we might see as a result of the low-carbon uptake. There are immediate applications for DSR, such as managing the load transfers required to support a wider 132kV reinforcement scheme; but our research intensity is based on the wider challenges arising as a result of the low-carbon economy.

Similarly, we are exploring the use of dynamic line rating technologies as a means of releasing network capacity.

4 Develop commercial solutions and products

The alternatives that are explored throughout our innovation strategy are analysed in order to be implemented and therefore contracted. Therefore, in line with identifying the new options to release capacity at 11kV, 33kV and 132kV with our existing assets, it is critical to understand the commercial implications of the new technologies. This implies having a specific innovation theme related to developing commercial solutions and products to support the technological solutions.

5 Understand the condition of our assets

Just as understanding the current and future performance of the 11kV and LV network, it is important for UK Power Networks to understand the condition of our assets. This will be essential to meet the efficiency savings we have set for ourselves on our existing inspection and maintenance expenditure and asset replacement expenditure.

6 Leveraging I&C demand response and dispatchable generation

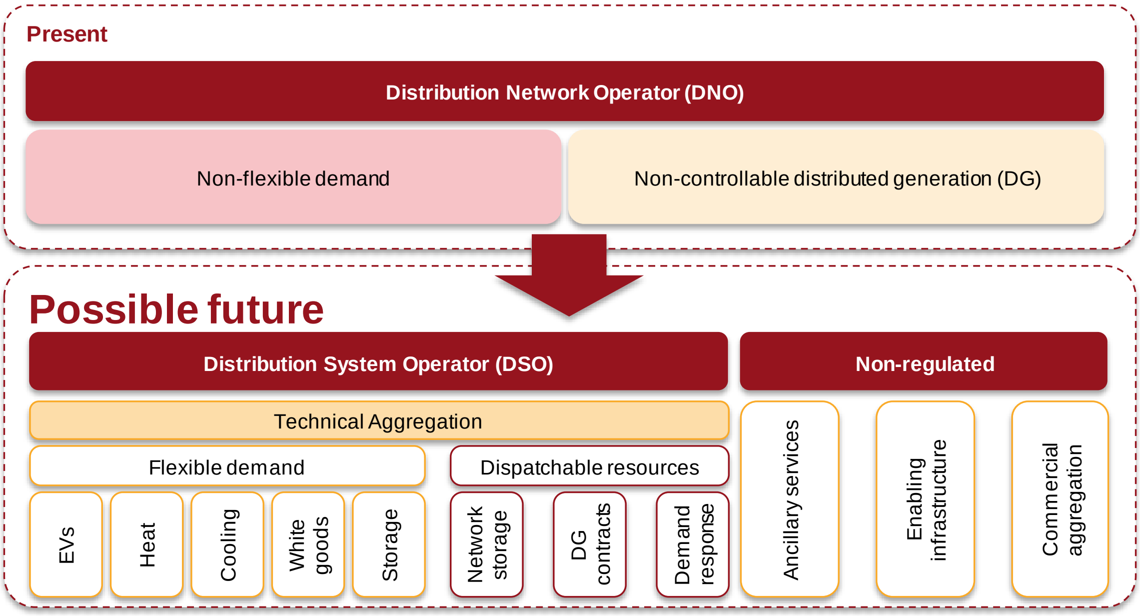
The theme ‘Leveraging I&C demand response and dispatchable generation’ expresses a series of actions which UK Power Networks needs to take and capabilities which it needs to develop, in order to capitalise on the opportunities offered by Industrial & Commercial (I&C) demand and generation. Historically, the distribution network has been a passive network with a one-way power flow towards end customers. This model will continue to change into a two-way network through the widespread adoption of distributed and backup generation, and Combined Heat and Power (CHP) schemes. A significant number of our I&C customers firmly view the distribution network as a two-way network in which they can make use of latent backup generation capacity in the system reserve market. This capability could equally be deployed by DNOs to support the network in critical periods. Our outlook, customer interactions and back-office systems need to adapt to this and capitalise on it.

7 Managing residential and Small and Medium-sized Enterprise (SME) consumer demand

The theme ‘Managing residential and SME consumer demand’ recognises the unprecedented opportunity represented by the rollout of smart meters to every residential and SME premises. Currently, a proportion of the population have their electric home heating controlled or timed by Radio Teleswitch Service (RTS) technology. Smart meters will provide an opportunity to expand this small set of directly controlled customers and to introduce tariff-based incentives or additional offers which are more visible and immediate to the consumer.

Transition to a Distribution System Operator

We strongly believe that the challenges we face require a radical change from the current business, and to a future in which DNOs become ‘Distribution System Operators (DSOs)’. This change is being strongly debated by government and the industry. It is clear that the DSO future defines a direction of travel for the DNOs which will take many years to navigate and with a great deal of uncertainty regarding timing, technologies and customer behaviour. The move from the present DNO to the possible future DSO, which innovation will play a key role in, is illustrated below.



What is a Distribution System Operator?

A Distribution Network Operator (DNO) continues to build in response to growth in maximum or peak demand. A DNO does not have the ability or desire to influence demand and generation, and tends to introduce flexibility only to the extent that it supports existing regulatory priorities (such as to reduce supply interruptions and the risk of catastrophic asset failure).

By contrast, a Distribution System Operator (DSO) has access to a portfolio of responsive demand, storage and controllable generation assets that can be used to actively contribute to both distribution network and wider system operation. A DSO builds and operates a flexible network with the ability to control load flows on its network. The combination of a highly flexible network and access to demand and generation response allows the DSO to contribute to the increasing challenge of encouraging demand to follow generation.

Individual Project Reports

Managing Asset Risk and Improving Fault Performance

Tree Growth Regulator (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">This project is investigating the effect of a tree growth regulator (TGR) on tree vitality and growth rates. Six field trial sites have been established, supported by thirteen observational sites throughout the UK to represent a diverse range of bioclimatic zones. There are two sites in each of the participating network operators' licence areas. Tree species selected for TGR evaluation were chosen to represent those that occur commonly near overhead networks, and where both the landowner and the DNO may find mutual benefit in using TGRs to manage growth and health of trees.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£24,975</td><td>£0</td><td>£9,112</td></tr>
<tr><td>Internal</td><td>£828</td><td>£0</td><td>£302</td></tr>
<tr><td>Total</td><td>£25,803</td><td>£0</td><td>£9,414</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of overhead lines in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£90,812</td></tr>
<tr><td>Internal</td><td colspan="3">£11,161</td></tr>
<tr><td>Total</td><td colspan="3">£101,971</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£715,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Ability of tree growth regulators to manage rate of vegetation growth and reduce maintenance costs, whilst improving vitality of vegetation.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>15.4</td><td>-2</td><td>17.4</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The expected outputs from the project will be data and information on the effect of paclobutrazol (PBZ) on tree growth rates across a range of species and bioclimatic areas. This data will be used to apply for a licence to use PBZ for utility vegetation management.

PBZ could then be used as part of utility vegetation programmes to reduce growth rates on restricted cut sites and reduce overall vegetation management costs. This would also reduce the disturbance to landowners and the high costs of returning each year to maintain clearances in locations where access to perform vegetation management is limited.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2014 / 2015</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
<tr><td>Probability of Success</td><td>75%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">>£1,000,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">All the project objectives have been achieved. UK Power Networks is currently reviewing the project conclusions, and the decision on whether to use PBZ will be subject to a licence being granted and a review of the financial business case.</td></tr>
</table>

<table>
<tr><td>Project Progress
March 2014</td><td>In 2013 (the final year of the project), the effects of PBZ on branch and root growth were less than in the previous year and for many tree species, there was no significant difference in growth rates between PBZ treated and non-PBZ treated controls.

The key conclusions for the project are that:
• The effects of PBZ vary considerably between tree species
• The reduced shoot extension of sensitive species such as English oak and beech ranged between 40% and 70%
• The reduced shoot extension of less sensitive species such as poplar and willow ranged between 2% and 32%
• The reduced shoot extension with some species can last for up to 3 years, but with other species, the effects start to wear off after 2 years

The results will be used to obtain a license to use PBZ to control vegetation in the vicinity of electricity networks.</td></tr>
<tr><td>Collaborative Partners</td><td>Scottish and Southern Energy, Western Power Distribution, Northern Powergrid</td></tr>
<tr><td>R&D Provider</td><td>Bartlett Tree Experts, ADAS</td></tr>
</table>

Earthing Information System (Completed)

Description of Project	The Earthing Information System project will develop a Geographical Information System (GIS) to assist the installation of earthing systems for both ground- and pole-mounted secondary distribution substations. The system will provide a graphical presentation of ground conditions and predict the type and quantity of earthing required to achieve a particular earthing resistance. Earthing rural substations can be very labour intensive, with the need to drive earthing rods vertically into the ground to a depth of 12 metres, to achieve the necessary 10-ohm resistance. Rods are usually driven by pneumatic tools or by hand. Where hard ground restricts the depth of installation, an array of rods may be installed at shallower depth, or an earthing system is extended some distance from the substation to achieve the required resistance. This project aims to improve the prediction of earthing costs before on-site work commences by providing a desktop indication of the earthing requirements.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	£7,104	£4,556	£4,509
	Internal	£679	£435	£431
	Total	£7,783	£4,991	£4,940
	The costs have been allocated in proportion to the number of customers connected in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£519,448		
	Internal	£56,809		
	Total	£576,257		
Total Project Costs (Collaborative + External + UK Power Networks)	£593,971	Projected 2014/15 costs for UK Power Networks	Project completed	
Technological Area and / or Issue Addressed by Project	A network-wide geographical information system that will help network planners to improve planning and costing of new and replacement earthing installations.			
Type(s) of Innovation Involved	Significant	Project Benefits Rating	Project Residual Risk	Overall Project Score
		9.4	0	9.4
Expected Benefits of Project	The expected benefits are: • Accurate estimation of installation costs of rural ground earthing systems • Advice on the number of rods and techniques required for earthing installations • Improved employee safety			
Expected Timescale to Adoption	2014/15	Duration of benefit once achieved	20 Years	
Probability of Success	70%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000	
Potential for Achieving	The potential for achieving the expected benefits remains high and the			

Expected Benefits	outputs from the project are already being used for other earthing-related design work. Further work is expected to be carried out as part of UK Power Networks' business-as-usual support arrangements to make the data available via the NetMAP GIS system. This will maximise the benefits delivered to the company.
Project Progress March 2014	The earthing map data is mainly used to provide the soil resistivity information required by the substation earthing design tool, which is used to design the earthing systems for secondary (11kV) substations. Phase 2 of the project, which has been completed, included the ability to identify soil/geology types that are sensitive to seasonal change and/or climate change. The data can be used to identify assets that may be at risk from variable ground moisture conditions and take appropriate action. As well as planning at new sites, this can also be used to undertake a retrospective review of existing sites that may have been installed during optimum seasonal conditions (winter/spring) and that require a maintenance check in sub-optimal seasonal conditions (summer/autumn). The earthing maps project is now closed and UK Power Networks has a fully updated set of soil resistivity, earthing prognosis and climate change data. However, due to other on-going business initiatives, the new data is not currently available within the GIS but is accessible via an interactive web service from the British Geological Survey. A follow-up project is being considered to provide better integration and use of the map data within the earthing design tool. Plans for the integration of the new data into the GIS system are already in place.
Collaborative Partner	Western Power Distribution
R&D Providers	British Geological Survey and Cranfield University

Developing Long Term Asset Risk Replacement Modelling (Completed)

<table>
<tr><td rowspan="1">Description of Project</td><td colspan="5">The aim of this project is to redefine and expand currently-limited statistical models, to create a wider and more-accepted standard for use with higher-volume and lesser-data-populated asset categories.

Complex risk-modelling programmes require extensive amounts of data to work. The asset groups selected in this project (e.g. civil assets) are in the stages of having their data completeness, accuracy and timeliness improved. The aim is also to provide a capable platform for calculating Health and Criticality Indices for low-value high-volume assets such as cable pits based on a limited amount of data, and planned interventions.

The model methodology produced will be used as the first line approach for modelling new asset categories, before progressing them to more complex modelling tools.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td colspan="2">LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£41,873</td><td colspan="2">£23,129</td><td>£26,559</td></tr>
<tr><td>Internal</td><td>£1,241</td><td colspan="2">£685</td><td>£787</td></tr>
<tr><td>Total</td><td>£43,114</td><td colspan="2">£23,815</td><td>£27,346</td></tr>
<tr><td colspan="5">The costs have been allocated in proportion to the number of substations in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="4">£54,302</td></tr>
<tr><td>Internal</td><td colspan="4">£2,013</td></tr>
<tr><td>Total</td><td colspan="4">£56,315</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£152,000</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="5">• Modelling of future condition of assets and recommend replace/refurbish/maintain decisions on individual components
• Inconsistency in asset modelling and information gathering
• Preparation for an optimisation using parameters including plant loading in distribution assets or child asset aggregation in civil assets</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td colspan="2">Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10.2</td><td colspan="2">-6</td><td>16.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Benefits are expected to include:
• Greater consistency of asset health data and forecasts
• Enhanced trending capability
• Improved confidence of long-term asset planning
• Integration of a risk-based approach to asset management</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2013</td><td colspan="2">Duration of benefit once achieved</td><td colspan="2">5 years</td></tr>
<tr><td>Probability of Success</td><td>100%</td><td colspan="2">Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£200,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="5">This project was completed in July 2013 and the benefits have been realised.</td></tr>
</table>

Project Progress March 2014	The LV switchgear, link boxes, distribution transformer, cable pits and civil asset models have been migrated to a "production environment" since project completion. The LV switchgear, link boxes and HV transformer models informed the RIIO-ED1 submission. They were used alongside sensitivity analyses to understand the effect of modelled deterioration on the three networks and produce a balanced investment plan for the period of 2015 to 2023, optimising risk against cost to the customer. Decision Lab's reports were supplied as appendices to our RIIO-ED1 plan. Understanding the completeness, accuracy and timeliness of our data has enabled us to make better-informed and more consistent investment planning decisions. The improved models are facilitating our moves towards risk-based asset management, and reporting health and criticality indices for individual assets. The new civil assets model will help us better understand and manage our civil assets, and will allow us to report health and criticality indices for civil assets before it becomes a regulatory requirement.
Collaborative Partners	N/A
R&D Provider	Decision Lab

Satellite Imagery and LiDAR (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">The aim of the project was to establish whether a combination of high-definition satellite and Light Detection and Ranging (LiDAR) imagery could be used to survey vegetation on high-voltage overhead line networks accurately enough to enable a risk-based approach to tree cutting.

The trial was carried out on two areas within EPN, representing about 1% of UK Power Networks' HV network length.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£89,131</td><td>£59</td><td>£32,542</td></tr>
<tr><td>Internal</td><td>£2,641</td><td>£0</td><td>£964</td></tr>
<tr><td>Total</td><td>£91,772</td><td>£59</td><td>£33,506</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of overhead lines in each licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£125,338</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td>Project completed</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="4">Vegetation management around overhead lines</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>-2</td><td>14.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">• Reduce the need for on-foot surveys by about 80%, resulting in cost savings, reduced risk of safety incidents, and reduced impact on landowners
• Identify low-hanging conductors
• More accurately and objectively assess which trees require cutting, which will reduce tree-cutting workload and costs</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2014 / 2015</td><td colspan="2">Duration of benefit once achieved</td><td>9 years</td></tr>
<tr><td>Probability of Success</td><td>90%</td><td colspan="2">Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>>£10,000,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The trial results indicate that the method works, and will allow us to reduce our tree-cutting workload and costs by at least 20% in the trial area</td></tr>
<tr><td>Project Progress
March 2014</td><td colspan="4">Two areas were assessed as part of the trial, Aylesbury and Clacton. Satellite data was acquired, vegetation feature extraction algorithms were then run, and UK Power Networks' line data was overlaid. The blue lines below represent two 33kV lines in Figure 13 (from the Aylesbury area) and the yellow areas show where vegetation may impact the worst-case clearance envelope.</td></tr>
</table>

	 **Figure 13: 33 kV lines from Aylesbury area** The trial was completed successfully and it is believed that the trial areas were a good representation of the rest of the network – it is anticipated that savings across the rest of the network would be similar. Depending on the results of on-going work, this could result in significant annual savings. A business-as-usual baseline survey of the entire network is planned by Q4 2014. Once completed, the results of this survey will enable us to quantify the savings across the rest of our network.
Collaborative Partners	None
R&D Provider	Network Mapping

Overhead Line Incipient Fault Detection

<table>
<tr><td>Description of Project</td><td colspan="4">This project aims to trial a solution to locate faults on overhead lines, using detection points installed on the HV overhead network.
The objectives are to:
• Help more rapidly identify network sections containing faults
• Predict and accurately locate a potential fault on the system before it occurs</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£3,123</td><td>£0</td><td>£1,140</td></tr>
<tr><td>Total</td><td>£3,123</td><td>£0</td><td>£1,141</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of overhead lines in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£417,468</td></tr>
<tr><td>Internal</td><td colspan="3">£48,683</td></tr>
<tr><td>Total</td><td colspan="3">£466,151</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£659,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">UK Power Networks is currently reviewing the scope of the project.</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">• Overhead line fault mechanisms and the extent to which they are associated with recognisable, repeatable waveforms
• Locating faults based on waveform time-of-arrival measurements</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>16</td><td>0</td><td>16</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The expected benefits of the project are:
• Development of a proactive approach to reducing interruption duration
• Reduce the amount of switching required to locate faults
• Reduction in recurring faults</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2014/15</td><td>Duration of benefit once achieved</td><td colspan="2">>10 years</td></tr>
<tr><td>Probability of success</td><td>50%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£215,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">The overall success probability is deemed to be low.

The installation comprises: three voltage sensors, a control unit for capturing fault propagation data, GSM for SMS messaging and GPRS for location / time stamping – all powered from an 11,000/110V VT and a 110AC/24VDC charger/batteries.

The following drawbacks of the systems have been identified and would need to be considered as part of a BAU adoption:
• Once commissioned, gaining access to the control unit to replace the SIM requires a network outage
• The installation has a maintenance requirement that includes replacing the batteries every 3-4 years</td></tr>
</table>

	Furthermore, only 86 systems have been installed to date in the European Union and the success rate for locating faults is currently low. It is mainly dependent on the severity of faults experienced and the quality of communications (i.e. GPRS / GSM) available at the location of the sensors.
Project Progress March 2014	An operating standard covering the installation and operation of the equipment was written and approved in 2012. Minor changes to the standard are now required to enable a simpler installation approach at intermediate pole locations. Terminal or transformer pole installations require long circuit outages and the installation of sensors has therefore been delayed. UK Power Networks is currently reviewing whether the scope of the proposed work with Altea should be reduced and an alternative solution trialled.
Collaborative Partner	Electricity North West
R&D Providers	ALTEA B.V

Development of Technologies to Extend the Life of Link Boxes and Mitigate the Impact of Cable Pit Disruptive Failures

<table>
<tr><td>Description of Project</td><td colspan="4">UK Power Networks has been working closely with Black & Veatch to develop a strategy for the inspection and management of cable pits, and to assess new mitigation strategies to reduce or eliminate the impact of disruptive cable pit incidents.

The strategy is similar to that used for managing link boxes, and has been incorporated into the cable pit inspection programme. This will enable UK Power Networks to prioritise the inspection of assets.

The inspection programme will record key asset condition data, which will be used to model future asset condition and replacement strategies.

Innovative cable pit footway and highway cover designs that can vent cable pit chambers, be locked and tethered will be used, and might include built-in monitoring equipment to send information about the state of the cable pit and covers to a central location.

The project will also assess the potential for link box refurbishment. The ERA Technology laboratory will inspect 50 link boxes that have been removed from the distribution network, in order to establish the root causes of failure, and possible mitigation of defects.

Work is also planned on prospective short circuit current (PSCC) testing, cyclic loading tests and testing to determine the suitability of a new frame and cover system.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£86,437</td><td>£351,948</td><td>£68,557</td></tr>
<tr><td>Internal</td><td>£3,397</td><td>£13,831</td><td>£2,694</td></tr>
<tr><td>Total</td><td>£89,834</td><td>£365,779</td><td>£71,251</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of link boxes and cable pits in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£216,312</td></tr>
<tr><td>Internal</td><td colspan="3">£8,024</td></tr>
<tr><td>Total</td><td colspan="3">£224,336</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,030,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £263,000
Internal £15,000
Total £278,000</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">• Implementation and evaluation of novel retrofit solutions to mitigate the impact of cable failures within pits
• Risk-based asset management of cable pits
• Investigation of link box failure mechanisms and potential innovative methods for link box refurbishment to prolong asset life</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12.8</td><td>-1</td><td>13.8</td></tr>
</table>

<table>
<tr><td>Expected Benefits of Project</td><td colspan="3">Benefits are expected to include:
Reduced risks to the public and UK Power Networks staff, through the continued implementation of mitigation measures
Greater consistency of asset health data and forecasts
Enhanced civil condition assessment capability
Improved confidence in long-term electrical asset degradation models and early warning of developing faults
Improved integration of a risk-based approach to asset management</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Started in 2013</td><td>Duration of benefit once achieved</td><td>20 Years</td></tr>
<tr><td>Probability of Success</td><td>90%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>£100,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="3">Confidence in the effectiveness of the mitigation strategy is continuously improving as it is further developed. On-going research and development with SSC and Saint-Gobain will further improve the effectiveness of footway and carriageway covers at reducing the impact of disruptions.

As the inspection and mitigation strategy moves into business as usual, its success will depend on the quality of asset condition data – which will be assured by training inspectors to accurately record condition and defects – and the correct installation of mitigation measures.

The inspections and mitigation strategies are already being implemented, and are significantly reducing both the likelihood and consequences of cable pit incidents. 1,700 mitigations have been successfully deployed to date (not funded using IFI), with a potential 5,000 further mitigations to be completed by March 2015.

We plan to use the learning from this project to develop a similar strategy for link boxes, which we expect will deliver similar benefits.</td></tr>
<tr><td>Project Progress March 2014</td><td colspan="3">The inspection programme for cable pits has been further developed to include new techniques such as partial discharge measurement, and bespoke high-resolution pole-mounted cameras. Structural and joint inspections continue to be successful, and have prevented potential disruptions.

Business-as-usual implementation is progressing well: A total of 6,000 cable pits have been visited, of which 1,700 have been successfully mitigated. This is funded through our normal allowance for inspection and maintenance.

The mitigation strategy has evolved to include vented/hinged footway and carriageway covers, sand infill of pits, and installation of fall restraint covers. Testing has proven that all current mitigation strategies successfully reduce or eliminate the impacts of a cable pit disruption.

The same mitigation strategies were also tested on link boxes. The learning from these tests is being used to develop similar inspection and mitigation strategies for link boxes.

See highlight for more information.</td></tr>
<tr><td>Collaborative Partners</td><td colspan="3">N/A</td></tr>
<tr><td>R&D Provider</td><td colspan="3">Black & Veatch Ltd, ERA Technology Ltd, SSC Ltd</td></tr>
</table>

Detection of Broken and Low-Hanging Conductors

Description of Project	Detection of broken and low-hanging conductors is a long-standing issue for UK DNOs, and there is no commercially available and proven technology for the reliable detection of these conditions. This project will explore new concepts for detection of broken and low-hanging conductors			
Expenditure for Financial Year		EPN	LPN	SPN
	External	£0	£0	£0
	Internal	£2,329	£0	£850
	Total	£2,330	£0	£850
	The costs have been allocated in proportion to the length of overhead lines in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£43,299		
	Internal	£1,605		
	Total	£44,904		
Total Project Costs (Collaborative + External + UK Power Networks)	£590,408	Projected 2014/15 costs for UK Power Networks	External £480,000 Internal £24,000 Total £504,000	
Technological Area and / or Issue Addressed by Project	Review of currently available products that may be capable of detecting broken and low-hanging conductors using both electrical and mechanical technologies. Following on from this work, new concepts will be explored to determine whether there is potential for development of a new solution.			
Type(s) of Innovation Involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		13.4	-2	15.4
Expected Benefits of Project	• Reduce the time it takes to detect broken or low-hanging conductors, which will reduce the corresponding risks of serious or fatal injury to people or livestock • Give control engineers greater visibility of broken or low-hanging conductors, allowing them to make better decisions when prioritising incident responses and mobilising staff • Identify innovative ways of using existing protection relays to improve their effectiveness • Overcome limitations of existing technology, e.g.: - Detection of faults on long overhead lines (i.e. far from the source substation) - Detection of short duration / transient faults • Enable a more focussed risk management strategy, by using mechanical sensors to monitor conductors that could fall into high risk (i.e. publicly accessible) areas			
Expected Timescale to Adoption	2014	Duration of benefit once achieved	20 Years	
Probability of Success	60%	Project NPV (Present Benefits – Present Costs) x Probability of Success	<£100,000 Safety benefits have not been monetised within this figure.	

Potential for Achieving Expected Benefits	It is expected that some of the methods trialled will be successful. The potential for achieving the expected benefits will be more accurately quantified once the initial trials are complete. The success of the electrical methods will mainly depend on their effectiveness at detecting actual faults, and immunity to spurious operation. The success of the mechanical methods will mainly depend on the cost-effectiveness of the final product, and the deployment strategy.
Project Progress March 2014	EA Technology found that some of the concepts investigated would not be able to cost effectively and reliably detect broken or low-hanging conductors. Therefore, only those deemed likely to yield a viable solution were shortlisted, namely: • Rate of change of earth fault current levels • Alternative electrical means of detecting fault arcing • Conditioning of earth fault protection on feeders by introducing a second current check from the incoming transformer supplies • Cost effective mechanical detection method **Electrical Detection Methods** In order to understand the levels of sensitivity needed for electrical detection of broken conductors, a number of primary substation sites were assessed for monitoring of balanced and unbalanced loads, and preferably network fault occurrences. This will assist in determining the optimum settings for both existing and new technologies. Following surveys in the EPN and SPN areas, which included assessing whether access to protection circuits was practicable, one primary substation with a history of 11kV faults was selected in each area to provide additional data for the assessment. Site monitoring will be undertaken during the second and third quarters of 2014. On completion of the monitoring, practical implementation of solutions will proceed, including modifications to existing protection schemes where protection devices have some form of inbuilt high-impedance fault detection. **Mechanical Detection Methods** There is currently no cost-effective and commercially available product that could be immediately deployed. A commercial partner (Nexans UK) has been identified to develop a mechanical sensor for the detection of broken and low-hanging conductors. If practical tests prove that the prototype is successful, trial installations will be carried out on the live system at a number of key locations. Wider-scale deployment will be dependent on the cost-effectiveness of the final product.
Collaborative Partners	Nexans UK
R&D Provider	EA Technology Ltd, Nexans UK

Earthing Design Tool

<table>
<tr><td>Description of Project</td><td colspan="4">The project will develop an MS Excel-based earthing design tool that can be easily used by distribution planning engineers and connections designers to design the earthing system for a secondary distribution (11kV/400V) substation.

This project uses the outputs from the HV/LV Earthing Transfer IFI project (reported under ENA Collaborative Programme section).</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£5,806</td><td>£3,723</td><td>£3,685</td></tr>
<tr><td>Internal</td><td>£1,023</td><td>£656</td><td>£649</td></tr>
<tr><td>Total</td><td>£6,829</td><td>£4,380</td><td>£4,335</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£57,499</td></tr>
<tr><td>Internal</td><td colspan="3">£7,049</td></tr>
<tr><td>Total</td><td colspan="3">£64,548</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£240,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £150,000
Internal £10,000
Total £160,000</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Currently, the only tools available to carry out earthing studies are very complex and costly, and therefore difficult to use by distribution planners and connections designers. This project will address this deficiency by providing a basic earthing design tool that encapsulates the complete earthing design process.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>-3</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Improved productivity at the design stage of new substation projects.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2014</td><td>Duration of benefit once achieved</td><td colspan="2">10 years</td></tr>
<tr><td>Probability of Success</td><td>100%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£100,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">It is expected that the benefits will be fully realised.</td></tr>
<tr><td>Project Progress March 2014</td><td colspan="4">Version 3 of the substation earthing design tool is now used throughout UK Power Networks by connections designers and distribution planning engineers to produce suitable earthing designs for all secondary substations.

The tool ensures compliance with UK Power Networks’ earthing standards, provides a consistent approach and helps to identify situations where a</td></tr>
</table>

	bespoke design or assistance from an earthing specialist may be required. The tool is also used by connections designers to provide a standard set of data to Independent Connection Providers (ICP) and to assess and verify ICP designs. Although the initial phases of the project are now complete, further work is being considered to carry out research into the effects of network contribution on earthing, provide better integration with outputs from the Earthing Information System project, and to develop additional functionality.
Collaborative Partners	None
R&D Provider	Earthing Solutions

Directional Earth Fault Passage Indicator (DEFPI)

<table>
<tr><td>Description of project</td><td colspan="4">Faults on HV networks are usually located by detecting the passage of fault currents using an Earth Fault Passage Indicator (EFPI).

Existing devices work well on radial networks, but in London, there are a number of circuits that are fed both ways on a closed ring, making the indications from the existing EFPIs unusable. This project looks to develop a directional EFPI that can be used on closed HV rings on the LPN network.

The project is split into two workstreams to identify separate devices that can be fitted to:
1. New RMUs that have separate current and voltage measurements for each phase
2. Legacy RMUs that only have one core balance CT</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£2,559</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£2,559</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN as the project is being carried out in this licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£479,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £250,851
Internal £182,400
Total £433,251</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="4">Fault location on closed ring HV networks.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>-2</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Reduction of CIs and CMLs by enabling remote fault restoration rather than staff attending sites to locate HV faults and restore supplies.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2020 for full penetration</td><td>Duration of benefit once achieved</td><td colspan="2">On-going</td></tr>
<tr><td>Probability of Success</td><td>80%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£950,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Workstream1: It is relatively easy to detect the direction of power flows if individual current and voltage measurements are available, therefore there is a high confidence that a device will work with modern switchgear.

Workstream 2 relies on new techniques for legacy RMUs and carries more risk than Workstream 1.</td></tr>
<tr><td>Project Progress March 2014</td><td colspan="4">The project was started in March 2014 and preliminary works carried out are as follows:</td></tr>
</table>

	• Nortech are reviewing design changes to their established NX41 Fault Passage Indicator • PPA have proposed alterations to the HV network at UK Power Networks' training centre to enable the DEFPI to be tested, which requires sufficient current while maintaining the correct HV and LV voltage phase relationship.
Collaborative Partners	None
R&D Provider	Nortech Management Ltd, PPA Energy

Fringe Fuses Monitoring

<table>
<tr><td>Description of project</td><td colspan="4">The central London network has operated as an interconnected LV mesh network across different HV feeders since the early twentieth century. The mesh generally operates as blocks of load (3MVA) which are interconnected at the boundaries with fuses (fringe fuses).

During high voltage faults, these fringe fuses maintain supply to the LV customers that would normally be fed by the faulted HV feeder. Fringe fuses are subjected to very high currents while the HV fault is flowing, and are then subjected to additional load during a holdup period until the HV supply is restored.

The purpose of this project is to monitor the fringe fuse and the energy let-through (I^2t) to assess whether the fuse is healthy or needs to be replaced if the value has exceeded a predetermined percentage of pre-arcing values.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£832</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£889</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£1,721</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN as the project is being carried out in this licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£82,744</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £67,389
Internal £8,500
Total £75,899</td></tr>
<tr><td>Technological area and / or issue addressed by project
If applicable only</td><td colspan="4">• Measurement of actual power flows in interconnected networks
• Measurement of I^2t values and making comparison with fuse characteristics
• Confirmation if fringe fuses are intact, but have been weakened</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12.8</td><td>-1</td><td>13.8</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Better understanding of LV power flows in LPN's interconnected networks during normal operations and during LV and HV fault conditions
• A means of remotely identifying blown fuses
• A means of predicting weakened fuses that if replaced could reduce the CI and CML impact of cascades during subsequent faults</td></tr>
<tr><td>Expected Timescale to adoption</td><td>Year 2016</td><td>Duration of benefit once achieved</td><td colspan="2">On-going</td></tr>
<tr><td>Probability of Success</td><td>60%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£130,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Preliminary work on this project started in March. It is too early to assess the potential for achieving the expected benefits.</td></tr>
</table>

Project Progress March 2014	The project will enhance the functionalities of Nortech's Envoy monitor to include I^2t and fuse condition monitoring. Agreement has been reached on a detailed technical specification with Nortech and GMC-I -ProSys (Nortech subcontract).
Collaborative Partners	None
R&D Provider	Nortech Management Ltd

Smart Heat

<table>
<tr><td>Description of project</td><td colspan="6">This project is developing and trialling the use of cable heating for assisting the process of locating leaks in underground fluid-filled cables. Once this method is developed, it is expected to replace the current method, cable freezing, and eliminate the associated risks and costs.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td colspan="2">EPN</td><td colspan="2">LPN</td><td>SPN</td></tr>
<tr><td>External</td><td colspan="2">£332</td><td colspan="2">£333</td><td>£289</td></tr>
<tr><td>Internal</td><td colspan="2">£2,777</td><td colspan="2">£2,791</td><td>£2,422</td></tr>
<tr><td>Total</td><td colspan="2">£3,109</td><td colspan="2">£3,124</td><td>£2,711</td></tr>
<tr><td colspan="6">The costs have been allocated in proportion to the length of fluid cables in each licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="6">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td colspan="2">£57,200</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £12,800
Internal £24,480
Total £37,280</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="6">Not all of our fluid-filled cable network has been tagged with Perfluorocarbon tracer (PFT), and this process will take many years to complete given the logistical issues involved and size of network. In the areas where the cables have not been tagged, a freezing technique is still used to locate the fault. Cable freezing has been the traditional method of finding cable leaks, but it has several drawbacks such as the hazards of handling liquid nitrogen, potential damage to the cable, and the long outage times required.

The project is being carried out in house by the EHV cables team to replace the freezing method and therefore improve the time taken and cable outage times for finding and fixing oil leaks.

Under the project:
• The parameters under which the heating method will work will be assessed. This includes the temperature to which the cable needs to be heated, the length of the section of cable and the size of the leak
• The safety requirements for this method will be assessed
• Results will be analysed
• Field trials will be carried out
• Training for other EHV team members will be completed and the method will be rolled out as another tool for the team to use when locating oil leaks</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological substitution from outside industry</td><td colspan="2">Project Benefits Rating</td><td colspan="2">Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td colspan="2">14.4</td><td colspan="2">-2</td><td>16.4</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="6">Benefits are expected to include:
• Shorter outages, as there is no need to wait for a cable freeze to thaw before re-energising. If the cable was required urgently, it could be brought back online much faster than with the freezing method
• Eliminates the costs and the risks of handling liquid nitrogen, which is needed for the freezing method
• Locating and repairing leaks faster than with the freezing method will reduce the costs of cable fluid leakage and maintenance</td></tr>
</table>

Expected Timescale to adoption	December 2014	Duration of benefit once achieved	On-going
Probability of Success	High	Project NPV (Present Benefits – Present Costs) x Probability of Success	£300,911
Potential for achieving expected benefits	The potential for achieving the expected benefits is high		
Project Progress March 2014	Trials to date have conclusively proved that this method works in controlled conditions. A significant increase in temperature in the direction of the leak was detected under a variety of leak rates and cable elevations. Further trials will confirm the conditions under which the method works, before deployment into business as usual later this year. See highlight for more details.		
Collaborative Partners	None – the project is being carried out in-house.		
R&D Provider	None		

Trial of Arc-Flash-Based Busbar Protection at Primary Sites

<table>
<tr><td>Description of project</td><td colspan="4">This project is trialling a busbar protection system based on optical arc-flash detection.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£2,346</td><td>£809</td><td>£1,847</td></tr>
<tr><td>Internal</td><td>£621</td><td>£214</td><td>£489</td></tr>
<tr><td>Total</td><td>£2,967</td><td>£1,024</td><td>£2,335</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of primary substations in each licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project 2013/14</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£35,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £16,100
Internal £10,000
Total £26,100</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="4">Differential busbar protection is usually impractical on primary substation switchgear as it requires additional CTs and wiring to be installed. Other conventional busbar protection techniques (rough balance and directional blocking schemes) have much longer fault-clearance times and hence only provide limited protection.

An arc-flash detection scheme could potentially detect and clear busbar faults much more quickly, greatly reducing the likelihood and severity of switchgear damage.

This project will demonstrate and evaluate an arc-flash detection system at a live operational substation, and develop the installation, commissioning, and operational procedures required to implement arc-flash detection for business-as-usual busbar protection.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological substitution from outside industry</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>15.2</td><td>-4</td><td>19</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">This project will enable faster and more reliable clearance of busbar faults, which will result in:
• Reduced damage to switchgear
• Reduced customer-minutes lost
• Reduced maintenance cost
• Reduced risk of arc-flash injuries</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td>Duration of benefit once achieved</td><td colspan="2">For the lifetime of the installed switchgear</td></tr>
<tr><td>Probability of Success</td><td>80%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£150,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Arc-flash detection as a busbar protection system has already been proven by overseas DNOs and GB industrial customers. Once we have successfully demonstrated a system, we will be able to endorse this method of busbar protection for both new and existing installations.</td></tr>
</table>

Project Progress March 2014	Progress to date is as follows: • A suitable substation for the trial installation has been selected • A supplier for the arc-flash detection equipment has been selected • The protection system design has been finalised • A draft engineering instruction detailing installation and commissioning requirements has been prepared • A training day to familiarise staff with the equipment, using a portable arc-flash detection demonstration unit has been held Installation and commissioning of the trial system is currently planned in Q4 2014.
Collaborative Partners	Hawker Siddeley Switchgear, Arcteq
R&D Provider	N/A

Leveraging Industrial and Commercial Demand Response and Dispatchable Generation

Freight Electric Vehicles in Urban Europe

<table>
<tr><td>Description of project</td><td colspan="4">The decarbonisation of freight delivery means there is a potential for a proliferation in EV use for vans and large vehicles, with the potential to affect the distribution network.

The objective of this project is to assess the impact of large freight EVs and the potential impacts of a larger-scale deployment on local energy distribution infrastructure. This will be done by monitoring and assessing freight EV charging at several demonstrator locations across Europe.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£81</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£5,786</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£5,867</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN as the project is being carried out in this licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£50,738</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £0
Internal £11,900
Total £11,900</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The aim is to investigate the impact on the grid from freight EV charging in a cluster and to identify opportunities for ‘smart’ applications to mitigate this impact.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental Innovation</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>6</td><td>-5</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Environmental: The solutions that can be developed and informed by this project will in the long term lead to the support of the proliferation of large EV fleets. This will in turn reduce the environmental impacts and typical congestion in urban areas
• Network Performance: The charging activity data will provide an insight into the nature of the additional load from large EVs and allow better management of the networks that support them
• Knowledge Transfer: The knowledge gained in this project and the subsequent vehicle-based trial will be of benefit to a wide audience in the UK and the wider international community</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2018</td><td>Duration of benefit once achieved</td><td colspan="2">10 years</td></tr>
<tr><td>Probability of Success</td><td>35%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">Small</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The potential for achieving the expected benefits of this project is high. The insights gained from the data collected is fundamental to identifying the characteristics of these loads, their connection requirements, and opportunities for regulating the load to defer network reinforcement costs. The data reviewed to date has yielded interesting insights which will be</td></tr>
</table>

	further developed as the project progresses.
Project Progress March 2014	A central assessment framework (CAF) has been developed to ensure that the assessment methods for the demonstrators across Europe are analogous. The data collected from monitoring to date is being analysed and reviewed by Imperial College London in line with the CAF.
Collaborative Partners	Westminster City Council, UPS
R&D Provider	Imperial College London

Managing Residential and Small and Medium Enterprise (SME) Consumer Demand

Supergen 3 – HiDEF Highly Distributed Energy Futures (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">The HiDEF programme, funded by the EPSRC (Engineering and Physical Sciences Research Council) researches the essential elements of a decentralised system that could be implemented over the period 2025 to 2050, to enable all end users to participate in system operation and real-time energy markets.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£82,000</td></tr>
<tr><td>Internal</td><td colspan="3">£6,553</td></tr>
<tr><td>Total</td><td colspan="3">£88,553</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£4,500,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">HiDEF has 5 work streams: Decentralised Energy, Decentralised Control, Decentralised Network Infrastructure, Decentralised Participation, Decentralised Policy and Macro Impact Assessment.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>7.2</td><td>-2</td><td>9.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Outputs from the HiDEF work streams have informed active debates in the industry and enabled the following benefits to be realised:
• Models of single and multiple DER (Distributed Energy Resource) units have been developed to perform the thermodynamic assessment, life cycle assessment and environmental cost benefit analysis, providing a quantification of performance
• Development of control solutions for single units, cells containing multiple DERs, and multiple cells
• Support and investment guidance for future decentralised network operation through the development of MV/LV architectures and planning tools
• Design of a distributed marketplace, enabling the investigation of market-based response, trading contracts and products, and defining the components essential to market realisation
• Inform future policy decisions by reviewing current policy delivery mechanisms in the UK, comparing market structures and examining the potential for alignment with various market aggregations</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Year 2013 onwards</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
<tr><td>Probability of Success</td><td>25%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">The consortium estimated that the work may have a long-run NPV of £2,000,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">The project has been completed with many examples of completed models and tools, published results, and impact on industry</td></tr>
</table>

	demonstrations and trials. Results have been made more accessible through London workshops, updated web resources, and a series of online videos.
Project Progress March 2014	The Decentralised Energy workstream has completed the realisation of open-source models of energy storage, conversion and demand components. The library of domestic building models has now been complemented with commercial building models featuring hybrid and low-carbon systems. Further progress has been made in the realisation and testing of new cell control solutions, including parallel inverter operation in an islanded micro-grid, single-phase single-stage transformer-less grid-connected PV systems, use of a static balancer to address phase unbalance in LV networks, and control of soft normally-open points. All control solutions have been tested within the team's hardware rigs and simulation environments. The Decentralised Network Infrastructure work stream has developed new power and energy system analytical techniques and tools applied to the analysis of industrial case studies. The Decentralised Participation team have further enhanced a spectrum of approaches that stimulate active participation from energy "prosumers". The team have also actively engaged with community projects where some of the models have been tested and refined. The Decentralised Policy and Macro Impact Assessment team have continued their assessment of the effectiveness of alternative policy measures including in Glasgow, Brighton & Hove, and Milton Keynes. The ability to conduct macro-economic modelling incorporating both the impact of renewables and advanced generation together with changes in household energy demand has proved useful. Journal and conference publications and the last HiDEF London workshop (April 2014) have supported wider dissemination.
Collaborative Partners	EPSRC and the following industrialists: Community Energy Scotland, Delta Energy & Environment, Intelligent Power Systems, National Grid, Western Power Distribution, Scottish Power Energy Networks, Scottish and Southern Energy.
R&D Provider	University of Strathclyde supported by: University of Bath, Cardiff University, University of Oxford, Loughborough University, Imperial College London.

Home Based Flexible Demand Management (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">The Technology Strategy Board (TSB) project explored how residential customers might be engaged in providing responsive demand and control the output of distributed generation on behalf of DNOs. The aim is to develop the scope for a technical solution, consumer proposition and business model which will allow for responsive demand to be utilised before the completion of the UK-wide smart meter rollout, and without the involvement of investment from the electricity supplier.

The trial solution utilised PassivSystems' open-architecture energy-management platform to create a scalable load management system, which will coordinate the grid and customer equipment to reduce peak loads. In the future, Interruptible demand could be managed remotely by utilising broadband or GSM connectivity, without detrimentally impacting the occupant comfort.

PassivSystems' control system will understand consumer requirements by monitoring real-time environmental variables in the home to build a profile of occupant behaviour, and will utilise local weather data to identify load that may be shed in response to a future DNO requirement.

This project is complementary to the work taking place as part of Low Carbon London, where smart meters are being utilised to modify demand profiles of residential customers.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>-£3,987</td><td>-£2,557</td><td>-£2,531</td></tr>
<tr><td>Internal</td><td>£8,258</td><td>£5,296</td><td>£5,242</td></tr>
<tr><td>Total</td><td>£4,271</td><td>£2,739</td><td>£2,711</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area. 50% of the UK Power Networks cost is funded by the TSB.</td></tr>
<tr><td rowspan="3">Expenditure in previous (IFI) financial years</td><td>External</td><td colspan="3">-£10,463</td></tr>
<tr><td>Internal</td><td colspan="3">£21,384</td></tr>
<tr><td>Total</td><td colspan="3">£10,921</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£150,302</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="4">The project will investigate the potential for a DNO to leverage Residential Sector Demand Response Services, to address network constraints and/or reduce the impact of network events such as faults.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological substitution from different application</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>7</td><td>-3</td><td>10</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The project set out to understand and quantify the potential ability and volume of DSR that might be available and accessible to a DNO. The project aims to develop a roadmap to facilitate a residential DSR platform which, in future, stakeholders including DNOs might access for network management and the deferment of network reinforcement.</td></tr>
</table>

Expected Timescale to adoption	Post 2020	Duration of benefit once achieved	10 Years
Probability of Success	30%	Project NPV (Present Benefits – Present Costs) x Probability of Success	Small
Potential for achieving expected benefits	The project measured electricity demand for a number of end-uses in a small number of homes in order to understand the potential for shifting demand, particularly during peak times in order to alleviate constraints on the distribution network. The project defined flexible demand end-uses where the use of electricity could be moved without any impact on the consumers' enjoyment of the energy service. Of the typical end-users found in UK homes, only loads from wet and cold appliances match this definition. The findings and analysis of data closely reflected the findings of other studies, including UK Power Networks led Low Carbon London; revealing limited scope for flexibility in the domestic demand profile from cold and wet appliances during network peaks.		
Project Progress March 2014	The Home Based Flexible Demand Management project closed in September 2013. The project successfully demonstrated a mechanism for modifying or managing residential demand connected at LV. The reports produced discuss which of the trialled household equipment had the most potential to make deferrable load or load reduction available for DSR. The project also looked at the value of such DSR services to a distribution network as well as mechanisms and barriers to participation. In summary, whilst successful in demonstrating that control systems can be established, the project was limited in the volume and demographic of homes tested. More extensive study is required to understand the potential value to a DNO for the control of cold or wet appliances, and if they may provide a viable option to defer network reinforcement. The project has identified future opportunities, specifically with full automation of smart appliances and the electrification of heat and transport where such a mechanism may be beneficial to a DNO. The approach deployed also demonstrates an alternative to smart meters as the medium for control of flexible load within residential properties.		
Collaborative Partners	PassivSystems Limited		
R&D Provider	PassivSystems Limited		

Vehicle to Grid (V2G)

<table>
<tr><td>Description of project</td><td colspan="4">With consumer and governmental pressure to reduce transport CO_2 emissions, automotive manufacturers are spending vast sums of money on developing alternatively-fuelled vehicles. EVs and associated hybrids have seen a number of manufacturers' products launched or about to be launched. One of the additional benefits of having increasingly large numbers of EVs is the potential to assist the grid in load and frequency management.

The aim of this project is to investigate the potential of battery-powered vehicles to use their excess rechargeable battery capacity to provide power to the grid in response to peak load demands.

This project is split into two phases:
• Phase 1 Laboratory Testing – Drive Cycle and V2G Simulator
• Phase 2 Vehicle Testing (The Decision on whether to proceed with this phase will be made at the end of phase 1).

The following only covers Phase 1 of this project.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£434</td><td>£240</td><td>£275</td></tr>
<tr><td>Internal</td><td>£351</td><td>£194</td><td>£223</td></tr>
<tr><td>Total</td><td>£785</td><td>£434</td><td>£498</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of substations in each licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£228,885</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £207,386
Internal £12,625
Total £220,011</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The aim is to investigate the feasibility of energy transfer from electric vehicle batteries to the grid, and to understand the technical challenges and potential countermeasures for widespread adoption.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Significant Innovation</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>6</td><td>0</td><td>6</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Environmental: EVs acting as distributed battery storage systems can provide balancing services to support the transition to a low-carbon economy and ensure the continued quality and reliability of grid power supplies
• Network Performance: V2G can improve the performance of the network by providing additional network capacity during periods of high demand or network constraint
• Knowledge Transfer: The knowledge gained in this project and the subsequent vehicle-based trial will benefit DNOs both within and outside the UK</td></tr>
<tr><td>Expected</td><td>3 years</td><td>Duration of benefit</td><td colspan="2">20 years</td></tr>
</table>

Timescale to adoption		once achieved	
Probability of Success	35%	Project NPV (Present Benefits – Present Costs) x Probability of Success	Small
Potential for achieving expected benefits	In the longer term, this will depend on developments from third parties (e.g. will OEMs open the communications protocol with the EV battery management system to activate the reverse power flow required for V2G mode?) and the development of a suitable commercial model to encourage adoption.		
Project Progress March 2014	Progress is as follows: • Legal documents between all parties (DNOs, multiple suppliers and academic bodies) have been signed • The batteries required for testing have been procured • The first phase laboratory trials to prove the technology is expected to begin in April 2014 • The laboratory at Southampton University has been set up, and is expected to begin performing test schedules on the different battery packs in June 2014 Work to develop the communications, integration and control system is progressing according to plan.		
Collaborative Partners	Scottish and Southern Energy, SP Energy Networks Western Power Distribution		
R&D Provider	Future Transport Systems (FTS) – Programme management Southampton University (SU) – Laboratory testing and reporting		

New Options to Release Capacity at 11kV, 33kV and 132 kV

Urban Transformer Substation (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">It is often difficult to reinforce circuits in densely populated areas mainly because there is limited physical space available. London substations were commonly built underground, making subsequent alterations expensive and potentially very disruptive during construction.

The project will evaluate if an urban distribution substation developed by a Spanish company (Twelcon) could help address these issues.

The urban substation houses an LV panel, Ring Main Unit (RMU), Remote Terminal Unit (RTU) and Transformer (up to 1,000 kVA). Twelcon currently uses continental equipment in the substation; hence development and further testing may be required to ensure that components meet UK Power Networks' specifications and perform efficiently and safely within the urban substation environment. The Twelcon substation also has four backlit advertising panels that could be used for public information.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£829</td><td>£458</td><td>£526</td></tr>
<tr><td>Total</td><td>£829</td><td>£458</td><td>£526</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of substations in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£18,805</td></tr>
<tr><td>Internal</td><td colspan="3">£4,442</td></tr>
<tr><td>Total</td><td colspan="3">£23,247</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£32,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £6,500
Internal £0
Total £6,500
Cost of dismantling, storage and international transport</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">• Reinforcement of stressed areas of the distribution network at 11KV
• Relocation of substations which are currently difficult to access, especially where asset replacement is likely to be expensive
• Provide the means to serve urban electric vehicle (EV) charging infrastructure (including rapid charge units)
• Potential solution for locations where aesthetics are important, such as airports</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Technological Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>15</td><td>-4</td><td>19</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits were expected to include:
• A reduction in street works disruptions
• Provision of additional support for the network; the additional headroom could enable electric vehicle charging points to connect to the distribution network</td></tr>
</table>

	• The purchase of the urban substation could be partially offset by revenue generated from the sale of its advertising space		
Expected Timescale to Adoption	N/A	Duration of benefit once achieved	20 Years
Probability of Success	50%	Project NPV (Present Benefits – Present Costs) x Probability of Success	The major benefits of the project are its visual impact, possibly unlocking new locations for substations
Potential for Achieving Expected Benefits	The following areas have been investigated to determine the potential for the technology to deliver benefits: • Safety considerations • Suitability of the electrical equipment for a UK electricity distribution network • Additional testing that may be required if the equipment inside the enclosure is changed • Cost of the substation Based on the outcome of these investigations (see 2012/13 IFI report), it has been decided not to proceed with a trial installation and the project has now been formally closed.		
Project Progress March 2014	This project is now closed.		
Collaborative Partners	N/A		
R&D Provider	Twelcon		

Increased Capacity from Existing Overhead Line Routes

<table>
<tr><td>Description of Project</td><td colspan="4">Re-conductoring overhead lines to increase their capacity can often be intrusive, requiring new structures, and as such may be less viable than installing the equivalent (but more expensive) cable circuit. This project is consolidating techniques for maintaining existing line routes and structures but providing greater ratings.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£131,359</td><td>£93</td><td>£47,959</td></tr>
<tr><td>Internal</td><td>£12,782</td><td>£0</td><td>£4,667</td></tr>
<tr><td>Total</td><td>£144,141</td><td>£93</td><td>£52,626</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of overhead lines in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£253,716</td></tr>
<tr><td>Internal</td><td colspan="3">£39,136</td></tr>
<tr><td>Total</td><td colspan="3">£292,852</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£850,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £92,400
Internal £12,686
Total £105,086</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">• Novel conductors for 33kV and 132kV lines
• Re-tensioning and minor modifications to structures
• Review of operating regimes (such as post-fault regimes)</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>13</td><td>-4</td><td>17</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The project aims to identify alternative, cheaper interventions to enable reinforcement or rebuild of the line to be deferred. In particular, the project will develop a manual and training which articulates design options and trade-offs so that alternative options can be identified at an earlier stage in future projects.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>1-2 years</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
<tr><td>Probability of Success</td><td>90%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£200,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">The potential for achieving the expected benefits is very high. Based on this learning from this project we have included a net saving of £8.6m in our RIIO ED1 business plan submission. This is on top of the savings already identified in DPCR5.</td></tr>
<tr><td>Project Progress
March 2014</td><td colspan="4">During this period the project has developed a business process to apply the early learning, including draft design guidelines for assessing overhead line routes.

Further routes were then assessed to test the application of this process. This resulted in some routes being identified for optimised uprating as described in UK Power Networks' Business Plan: Smart Grid Annex.</td></tr>
</table>

Collaborative Partners	N/A
R&D Provider	Mott McDonald and Manchester University (The project also builds on work carried out by EA Technology Ltd over recent years in the Strategic Technology Programme Modules 2 and 5)

Strategic Technology Programme (STP) Module 2 – Overhead Networks

<table>
<tr><td>Description of Project</td><td colspan="4">A DNO research and development collaboration hosted by EA Technology.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£27,935</td><td>£17,915</td><td>£17,731</td></tr>
<tr><td>Internal</td><td>£1,936</td><td>£1,241</td><td>£1,229</td></tr>
<tr><td>Total</td><td>£29,870</td><td>£19,156</td><td>£18,959</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£358,427</td></tr>
<tr><td>Internal</td><td colspan="3">£36,728</td></tr>
<tr><td>Total</td><td colspan="3">£395,152</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£459,681</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Projects carried out under the STP programme will now be reported individually</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The STP module 2 programme aims to optimise overhead network design, improve operational and financial performance, maximise potential benefits, and minimise risk associated with overhead networks.

A full list of projects and deliverables is available from UK Power Networks or EA Technology.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental, Tech Transfer, Significant, Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>16</td><td>-9</td><td>25</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Projects in this module have the potential to increase the safety and reliability of the network. In certain cases the asset life may also be extended.

If the projects in this module are technically successful and the findings and recommendations from the projects are implemented, then the projects will potentially enable each DNO member of the programme to gain benefits including:
• Improvements in network reliability by identifying root causes of faults and developing solutions
• Safe early detection of potential defects that can then be repaired in a planned and timely fashion
• Cost effective and early identification of damaged insulators and discharging components, which if not addressed would result in faults
• Avoid redesign, reconstruction or refurbishment of overhead lines where this is driven by a perceived need to increase ratings or strengthen lines, and is required to conform with existing standards but which may be unnecessary</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Range 1-5 years – dependent on project</td><td>Duration of benefit once achieved</td><td colspan="2">Range 3-5 years – dependent on project</td></tr>
<tr><td>Probability of Success</td><td>Range 50-95% – dependent on project</td><td>Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td colspan="2">£40,000</td></tr>
</table>

Potential for Achieving Expected Benefits	All projects within STP module 2 show strong potential for delivering the expected benefits. Some projects are at risk of late delivery, but this does not affect their potential for achieving expected benefits.
Project Progress to March 2014	S2164 – Probabilistic wind and ice map for UK – has delivered software tools that allow wind and ice loads to be evaluated to a 500x500m resolution. These tools will provide more reliable weather loading calculations that may reduce steel tower build costs at 132kV and above. S2162 – Residual strength of wood poles – recently sourced the last batch of aged wood poles required to complete the destructive testing programme. The learning from this project will deliver savings by allowing us to plan refurbishment and replacement of our wood poles more accurately. S2126 (Monitoring of conductor temperature) – Analysis of all the conductor temperature data shows that there are flaws in ENA ACE104 and P27 overhead line ratings standards. To obtain the desired conductor design temperature, ratings potentially need to be reduced by ~10%. Further work is required to confirm gain sufficient data to accurately propose new ratings. S2148 (Re-appraisal of ACE 104) – Background assessments of Load Duration Curve (LDC) over P27 ratings show a potential increase in ratings by between 4% and 10%. Investigation into exceedences on single circuits could allow an overall 8.8% increase in line rating. This is likely to compensate for the reduced rating identified in project S2126.
Collaborative Partners	Scottish Power Energy Networks, Scottish and Southern Energy, Electricity North West, Western Power Distribution, Northern Power Grid
R&D Provider	EA Technology Ltd

Strategic Technology Programme (STP) Module 5 – Networks for Distributed Energy Resources

Description of Project	A DNO research and development collaboration hosted by EA Technology.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	£22,331	£14,321	£14,174
	Internal	£1,547	£992	£982
	Total	£23,879	£15,313	£15,156
	The costs have been allocated in proportion to the number of customers connected in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£372,143		
	Internal	£34,059		
	Total	£406,203		
Total Project Costs (Collaborative + External + UK Power Networks)	£460,625	Projected 2014/15 costs for UK Power Networks	Projects carried out under the STP programme will now be reported individually	
Technological Area and / or Issue Addressed by Project	The STP Module 5 programme aims to facilitate access to low-carbon technologies, including on-shore wind generation connected at 33kV, large distributed generators connected at 132kV, and electric vehicles being charged from the low-voltage network. A full list of projects and deliverables is available from UK Power Networks or EA Technology.			
Type(s) of Innovation Involved	Incremental, Tech Transfer, Significant, Radical	Project Benefits Rating	Project Residual Risk	Overall Project Score
		13.5	-8.5	22
Expected Benefits of Project	The projects have the potential to deliver a number of benefits: • Investigate distributed generation connection methods avoiding undue reinforcement • Increased understanding between all member companies on technical, commercial and regulatory issues and to develop effective solutions • Developing understanding of the implications of connecting low-carbon technologies to the distribution network in terms of safety, design, reliability, security and power quality			
Expected Timescale to Adoption	Range 1-3 years – dependent on project	Duration of benefit once achieved	Range 2-5 years – dependent on project	
Probability of Success	Range 50-100% – dependent on project	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£30,000	
Potential for Achieving Expected Benefits	A number of projects are science-based, and hence require further research and development to achieve improvements in operational performance and integration into our business environment. Other projects are well developed, and provide a clear view of achievable benefits.			

	For example, S5236 – Performance of Generation in P-V Mode – is expected to allow us to connect further generation into areas where conventional connections are not available due to voltage rise problems.
Project Progress to March 2014	S5236 – Performance of Generation in P-V Mode – is expected to guide UK DNOs on the implications and applications of generation running in real power and voltage control mode, rather than real and reactive power control mode. This will allow us to connect further generation into areas where conventional connections are not available due to voltage rise problems. Data gathering and analysis have shown useful results. Knowledge dissemination material is being prepared for use in communication / training within DNOs. S5264 – Consumer voltage optimisation – has shown that lowering consumers' supply voltage does not significantly reduce peak demand. The potential impact ranges from a 1% increase in summer demand to a 6% decrease in winter demand, with a likely overall reduction of 2%. S5195_1 – Energy Efficient Substations – has shown that significant savings could be made if renewable generation is incorporated in new substations, or if older buildings are retrofitted with additional thermal insulation. Potential savings are £500k per year per DNO, assuming that the installation costs and risks make implementation viable. S5194_4 – Standardising Firm Capacity – concluded that distributed generation should, but currently cannot, be considered when evaluating a network's capability to service demand, because there is currently no standard definition of firm capacity. The next step is to form a working group to develop a common approach to defining firm capacity, and seek to incorporate it into the next revision of Engineering Recommendation P2/6.
Collaborative Partners	Scottish Power Energy Networks, Scottish and Southern Energy, Electricity North West, Western Power Distribution, Northern Power Grid, NIE and ESB Networks.
R&D Provider	EA Technology Ltd

Fault Level Management Study

<table>
<tr><td>Description of Project</td><td colspan="4">The project will investigate the potential for modern fault level management technologies and designs to improve network fault levels, and the connection potential of embedded generation where its fault level contribution would currently impact on the generation connection prospects.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£10,485</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£311</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£10,796</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN as the project is primary looking to address fault level issues and scope a demonstration project in this licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£4,700</td></tr>
<tr><td>Internal</td><td colspan="3">£174</td></tr>
<tr><td>Total</td><td colspan="3">£4,874</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£42,670</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £25,000
Internal £2,000
Total £27,000</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Smart technologies to release capacity – management of system fault levels and optimal use of fault level headroom</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>16.8</td><td>-6</td><td>22.8</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Full visibility of costs, benefits, and maturities of modern fault level management solutions
• Network-specific modelling of performance of potential solutions
• Definition of follow-on projects required in order to deliver successful fault level management techniques and enabling significant improvements in generation connection potential</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>< 5 years</td><td>Duration of benefit once achieved</td><td colspan="2">Lifetime of assets (>20 years) or enabled connections</td></tr>
<tr><td>Probability of Success</td><td>40% - 60%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£70,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">The objective of the study is to produce the knowledge and feasibility studies required to scope a demonstration project, and to integrate smart fault level management solutions into UK Power Networks' practices. These have the potential to save Distributed Generation (DG) customers the cost of significant connection-driven network upgrades such as switchgear replacements driven by fault level.

However, the project work has shown that in the urban environments</td></tr>
</table>

	where fault level constraints are more likely to limit network access, there is a corresponding challenge to fault current limiter deployment in the form of limited physical space on network sites. This could decrease the number of opportunities to deploy fault current limiters.
Project Progress March 2014	The first two project deliverables have been successfully completed: the first reviewing the details of existing modelling assessment techniques with respect to system fault levels, and the second identifying the current industry-leading technologies that are available for development and deployment to manage network fault levels. Based on this work, a number of case study sites were selected from the LPN primary substations with existing fault level constraints. Substation records and site schematics were reviewed for these sites, and a site survey was conducted in order to understand the space available for additional asset installations. Additionally, the network topology and asset data sets required to support the detailed fault current limiter modelling were extracted and reviewed. Currently, the types and availability of modelling data on fault current limiter performance are being reviewed with device manufacturers in order to develop new device modelling parameters for inclusion in DNO network models. When complete, these device-level models will allow comparative assessments of the whole life performance of fault current management schemes.
Collaborative Partners	N/A
R&D Provider	Parsons Brinkerhoff

Understand Current and Future Performance of the 11kV and LV Network

Distribution Network Visibility (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">The project proposes to develop a solution that will allow UK Power Networks to evaluate the benefits that can be derived from improved utilisation of existing data sources such as Remote Terminal Units (RTUs), better visualisation of this data and enhanced monitoring of the distribution network where RTU installation is not possible, using optical current sensors.

The project was co-funded with the LCNF. The IFI-funded parts of the project related to asset condition and fault performance.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£583,329</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£52,522</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£635,851</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN as the trial is being carried out in this licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£200,009</td></tr>
<tr><td>Internal</td><td colspan="3">£10,693</td></tr>
<tr><td>Total</td><td colspan="3">£210,702</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£3,085,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">To develop an innovative monitoring solution:
Increase data collection, upgrade the operational data store (data warehouse – PI), develop visualisations, and improve interaction between business systems.
Demonstrate the benefits of an improved visibility of power flows:
• Maximise utilisation of the distribution network
• Better understand network behaviour: load profiles, power factor and imbalances
• Ability to automatically detect asset defects (e.g. tap changer faults)

Evaluate a range of non-invasive optical-fibre-based sensors:
• Main features: directional power flows, current, voltage, fault current measurement
• Application: Sites with no RTU, monitoring of complex networks</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental, Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14.6</td><td>-2</td><td>16.6</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Improved switching and load transfers using historical load and voltage trends
• Assist in network reinforcement schemes and particularly with new customer load connections by providing an overview to planning engineers in respect of load demands and profiles
• Easier planning processes to determine options for load growth and new load e.g. transfer or upgrade circuits
• Improved management of secondary substation ventilation
• Validation of existing tap changer maintenance policy leading to</td></tr>
</table>

	better more cost-effective maintenance • Enable a higher penetration of renewable generation • Visualisation of the load on the system, which should lead to improvements in the rebalancing of circuits following a system disturbance such as a fault		
Expected Timescale to Adoption	Adopted	Duration of benefit once achieved	10 Years
Probability of Success	100%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£532,000
Potential for Achieving Expected Benefits	A web-based application has been developed as part of this project and is now available to relevant teams within UK Power Networks. These teams have already realised network benefits by avoiding unnecessary reinforcement of assets through better visibility of loading. UK Power Networks is currently embedding the use of the application into business as usual to ensure that benefits can be realised and tracked.		
Project Progress March 2014	This project is now closed and the LCNF close-down report has been published (available on the UK Power Networks Innovation site). The main outcomes of the project are described below: • **Visualisation application:** A production web-based application was successfully developed to implement a suite of visualisations and analysis tools for network data. • **Remote Terminal Unit (RTU) upgrade:** 9,885 Secondary RTUs on the LPN network were upgraded to allow retrieval of a further 11 analogue network measurements in addition to the existing four previously available. • **Load Flow Tools:** Two commercially available load flow tools (GE DPF and CGI DPlan) were trialled, and recommendations made on what further work is required between DNOs and suppliers of these tools to ensure they deliver maximum benefits. • **Data Integration:** Data from six separate databases has been integrated into the visualisation application to ensure users are provided with useful information to support business decisions and deliver benefits. • **Advanced RTU features:** These were only partly assessed due to concerns principally relating to compromising the operational SCADA or communication systems, which resulted in only 27 independent RTUs being upgraded and a limited number of network events captured.		
Collaborative Partners	PPA Energy and Capula Ltd.		
R&D Providers	Remsdaq Ltd, GE Energy, PowerSense A/S		

Technical Losses Review (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">The project builds on previous IFI studies undertaken for Western Power Distribution by Imperial College London. The previous project developed generic networks and calculated losses to be used as a comparison against reported data (based on settlement algorithms).

This project investigates the extent to which losses could be economically reduced by appropriate policies and interventions, and where losses might be beneficially utilised as low-grade heating. The economic criteria are informed by Ofgem's RIIO-ED1 guidance on valuation of losses.

Areas of investigation include transformer specifications, transformer and cable optimum-peak-utilisation factors, power factor, phase imbalance and voltage set points.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£46,598</td><td>£29,883</td><td>£29,577</td></tr>
<tr><td>Internal</td><td>£1,381</td><td>£886</td><td>£876</td></tr>
<tr><td>Total</td><td>£47,978</td><td>£30,769</td><td>£30,453</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area.</td></tr>
<tr><td>Expenditure in Previous (IFI) Financial Years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£109,200</td><td colspan="2">Projected 2014/2015 costs for UK Power Networks</td><td>Project completed</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Network Losses and Power System Modelling. The project also uses "smarter" intervention solutions within the power system model.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution / Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>0</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The project is expected to make a valuable contribution to understanding:
• The economic ratings of transformers and cables, particularly at HV/LV and LV levels
• The potential for economically reducing losses through improving power factor and phase imbalance, and through managed voltage reduction at LV</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>Several price control periods</td></tr>
<tr><td>Probability of Success</td><td>70%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£190,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The real cost of electricity production is predicted to increase in order to meet international renewable and carbon-emission targets (as indicated by recently published strike prices), which increases the scope for policy changes and economic network interventions.</td></tr>
</table>

	Many of the recommendations have been incorporated in UK Power Networks' RIIO-ED1 losses strategy. The project report supports that strategy, and provides further quantified evidence of the potential economic savings in losses. It also provides some useful insights into uses of waste heat generated by transformers and cables.
Project Progress at March 2014	The final (draft) report was delivered later than first anticipated, in February 2014, due to requests for additional validation of the findings. One of the key conclusions is that adopting lower peak utilisation factors for transformers and cables (i.e. lower loadings relative to ratings) would reduce losses, particularly at HV/LV and LV voltage levels. Although the economic benefit does not necessarily justify retrospective action, economic loading criteria for newly-installed or replacement plant and cables would lead to significantly lower utilisation factors than current general practice. The report is currently undergoing a detailed review before final approval and publication.
Collaborative Partners	Western Power Distribution
R&D Provider	SOHN Associates, Imperial College London

LV Remote Control and Automation / Smart Urban LV Network

Description of Project	This project aims to provide a complete solution to monitor and automate the LV network. Retrofit load-break/fault-make switches for underground link boxes will be developed, as well as fault-break/fault-make circuit breakers (CBs) for low-voltage panels in substations. The scope of the LV Remote Control & Automation IFI project, which developed prototype devices, has been significantly extended to cover the development aspects of the Smart Urban Low Voltage Network LCNF Tier 1 project (both projects will be run in parallel); and will also part fund the deployment, which will investigate potential quality of supply benefits. Once both projects are completed, approximately 50% of the technology development cost will have been funded by UK Power Networks.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	£392,736	£223,214	£256,611
	Internal	£20,596	£11,706	£13,457
	Total	£413,332	£234,920	£270,069
	The costs have been allocated in proportion to the length of installed LV cables in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£1,269,140		
	Internal	£101,966		
	Total	£1,371,106		
Total Project Costs (Collaborative + External + UK Power Networks)	£4,300,000	Projected 2014/15 Costs for UK Power Networks	External £281,759 Internal £22,145 Total £303,904	
Technological Area and/or Issue Addressed by Project	Management of the LV network			
Type(s) of Innovation Involved	Significant	Project Benefits Rating	Project Residual Risk	Overall Project Score
		16.2	-2	18.2
Expected Benefits of Project	The main benefits expected are as follows: • Improved safety for utility engineers and the public by using arc-free switching technology and novel fault-make switching capability • Remote and rapid restoration of supplies • Reduction of customer minutes lost (CML) and customer interruptions (CI) • Better understanding of power flows and network load monitoring			
Expected Timescale to Adoption	2015 / 2014 for CB only solution	Duration of Benefit Once Achieved	10 years	
Probability of Success	80%	Project NPV (Present Benefits – Present Costs) X Probability of Success	£3,100,000	
Potential for Achieving Expected Benefits	During this regulatory year the project has: • Completed the testing of the industrialised hardware developed during the IFI project. This equipment has been tested on a LV test network and the previous site of the trials in Ilford			

	• Integrated the LV hardware with a SCADA-based control system utilising LV connectivity models. This work has been completed and tested successfully The deployment has been delayed due to a change of manufacturer and issues discovered during final testing. UK Power Networks is still confident that the expected benefits will be realised and the following use cases demonstrated: • Investigate how a greater understanding, visibility and control of the network can lead to LV active network management, and facilitate the connection of low-carbon technologies • Quantify the expected improvement to quality of supply when using remote control and automation to create a self-healing LV Network • Use the unprecedented visibility of the LV network available (single phase load monitoring at link box level) to validate current LV modelling and increase our understanding of the LV network
Project Progress March 2014	**Availability of the Technology** In 2013, TE Connectivity made UK Power Networks aware that they had made a commercial decision to cease the development and production of the technology. In order to ensure that the technology remains available to all the DNOs going forward, UK Power Networks worked closely with TE Connectivity for several months to identify and meet with companies interested in acquiring the technology. Following a lengthy process, EA Technology Ltd has been granted rights to manufacture and support the technology under licence from TE Connectivity, and formal knowledge transfer has been completed. **Industrialisation of LVA hardware** TE Connectivity completed work to industrialise the hardware. This included a number of design changes identified by UK Power Networks engineers. Testing of the equipment has been completed on a LV test network that has been built by UK Power Networks to test the equipment and connectivity to the control system. Testing on the LV test network along with site acceptance testing at Ilford has identified a number of opportunities to improve the installation process used on site, and ensure that the RTU/Gateway can be isolated when telecommunications staff work on the unit. The testing of the hardware is in its final stages and a final deployment on the test network at Ilford is imminent. **Integration of LV hardware with a SCADA based control system** GE has delivered an interactive LV control SCADA system that enables the Control Engineer to fully interact with the hardware via PowerOn Fusion. New diagram symbols have been finalised and successfully tested with the circuit breakers and link box switches. RTU templates have been created to allow the hardware to communicate with the LV control system. DNP3 testing has been completed including the testing of the PLC communications on the UK Power Networks LV test network and the trial network at Ilford. **Deployment of equipment for use case trials**

	Deployment of the hardware in the City Rd trial areas is due to commence in July 2014. This has been delayed due to the change of manufacturer and issues identified when testing the industrialised version of the equipment. The project team is currently assessing the impact of this delay. An e-learning package has been developed to train field staff in the use of the LV circuit breaker and switches. All relevant staff who will be installing or using the equipment have been on a training course at UK Power Networks' training centre and will be issued with a user manual.
Collaborative Partner	TE Connectivity (formerly Tyco)
R&D Provider	TE Connectivity (formerly Tyco)

Strategic Technology Programme (STP) Module 3 – Cable networks

<table>
<tr><td>Description of Project</td><td colspan="4">A DNO research and development collaboration hosted by EA Technology.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£33,849</td><td>£21,707</td><td>£21,485</td></tr>
<tr><td>Internal</td><td>£2,345</td><td>£1,504</td><td>£1,489</td></tr>
<tr><td>Total</td><td>£36,194</td><td>£23,211</td><td>£22,973</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£419,155</td></tr>
<tr><td>Internal</td><td colspan="3">£37,919</td></tr>
<tr><td>Total</td><td colspan="3">£457,074</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£539,452</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td>Projects carried out under the STP programme will now be reported individually</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The STP Module 3 programme aims to improve operational performance, maximise potential benefits, improve financial performance, and minimise risk associated with cable networks. The programme is currently investigating issues with individual cable construction components, such as ducts, sealants, backfill materials, and methods to verify the integrity and condition of cable circuits.

A full list of projects and deliverables is available from UK Power Networks or EA Technology.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental, Tech Transfer, Significant, Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td>-8</td><td>22</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Projects in this module will positively contribute to an increase in the performance and reliability of the cable network. In many cases the cable asset life may also be extended.

If the projects are technically successful and the findings and recommendations from the projects are implemented, then the projects will potentially enable each DNO member of the programme to gain the following benefits, including:
• Use of an effective tool to improve the leak management of fluid-filled cable circuits, reducing the risk of potential costly failures
• Successful and practical methods for sealing ducts
• Alternatives to current design and installation practices that offer benefits in lower lifetime cost and higher performance (e.g. increased ratings)
• Reduced risk in environmentally sensitive areas
• A reduction in the number of accidents / incidents, hence increasing safety of staff and the public
• Reduction in excavation required in locating leaks from fluid-filled cables, reduction in the times and costs of leak location and also reduced outage times
• A reduction in digging, causing less disruption to the public, reducing</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">impact on the environment and avoiding disposal of soil to landfill
Offset future increases in CAPEX and OPEX
Reduced cable purchase costs
Implementation of strategies for reducing cable failures, resulting from excessive forces
Reduction in number of cable faults
Reduced design costs.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Range 1-2 years – dependent on project</td><td>Duration of benefit once achieved</td><td>Range 3-5 years – dependent on project</td></tr>
<tr><td>Probability of Success</td><td>Range 45-100% – dependent on project</td><td>Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£40,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="3">Projects within STP Module 3 are either already delivering tangible benefits, or have strong potential to do so.

For example:
Project S3168_4 “Comparing Future Designs of HV and EHV Polymeric Cables” will lead to the development of new ENA standards for more efficient and reliable cable systems and accessories
Project S3174_1 “Evaluating the performance of service termination equipment” will eventually lead to the development of more innovative cut-out designs. This has a clear potential to improve the safety and reliability of cut-outs, which are used at every customer’s premises
Some projects are at risk of late delivery; however, their potential to achieve their expected benefits is not affected.</td></tr>
<tr><td>Project Progress to March 2014</td><td colspan="3">STP Module 3 has undertaken nine projects in regulatory year 2013/14, covering a wide range of subjects, including:

S3168_4 – Comparing future designs of HV and EHV Polymeric Cables – has shown that the requirements and test methods in the existing cable standards are overall valid and appropriate, but has also suggested a number of improvements for the next revision of the standards.

S3174_1 – Evaluating the performance of service termination equipment – is in the final stages of building and commissioning the test rig. Testing will be completed under stage 2.

S3187_4 – Development of an ENA Engineering Recommendation for the use of sealant systems for cable ducts and transits – is complete, and concluded that its learning should be published as a technical specification, rather than an engineering recommendation. Once approved and adopted by the ENA, this technical specification will improve the reliability of duct sealant systems, and hence reduce the risks of flooding and explosive atmospheres in substations.

S3214_3 – Research and Evaluation of the effectiveness of Tan Delta & Polarisation Index for Condition Assessment of Ageing Paper Cables – is progressing, but is having on-going difficulty in obtaining suitable samples of aged paper-insulated cable for testing.</td></tr>
<tr><td>Collaborative Partners</td><td colspan="3">Scottish Power Energy Networks, Scottish and Southern Energy, Electricity North West, Western Power Distribution and Northern Power Grid</td></tr>
<tr><td>R&D Provider</td><td colspan="3">EA Technology Ltd</td></tr>
</table>

Strategic Technology Programme (STP) Module 4 – Substations

<table>
<tr><td>Description of Project</td><td colspan="4">A DNO research and development collaboration hosted by EA Technology</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£24,394</td><td>£15,644</td><td>£15,483</td></tr>
<tr><td>Internal</td><td>£1,690</td><td>£1,084</td><td>£1,073</td></tr>
<tr><td>Total</td><td>£26,084</td><td>£16,728</td><td>£16,556</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£363,478</td></tr>
<tr><td>Internal</td><td colspan="3">£33,618</td></tr>
<tr><td>Total</td><td colspan="3">£397,095</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£456,463</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td>Projects carried out under the STP programme will now be reported individually</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The STP module 4 programme looks widely across substation plant including transformers, switchgear and protection equipment. It looks at issues related to maintaining existing assets, including alternative insulating oils and means to assess the condition of equipment, as well as looking at new plant options.

A full list of projects and deliverables is available from UK Power Networks or EA Technology.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental, Tech Transfer, Significant, Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>16.5</td><td>-9.5</td><td>26.0</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The projects have the potential to deliver a number of benefits:
• Optimising safety and environmental requirements for management of insulating oils and SF_6
• Technical liaison with international utilities to share new technology and failure modes
• Development of condition-based assessments, or tests, to determine asset condition
• Extended serviceable life of switchgear and transformers</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Range 1-4 years – dependent on project</td><td colspan="2">Duration of benefit once achieved</td><td>Range 1-6 years – dependent on project</td></tr>
<tr><td>Probability of Success</td><td>Range 30-95% – dependent on project</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£30,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">There are a number of projects with the potential to directly influence the way assets are managed within UK Power Networks.

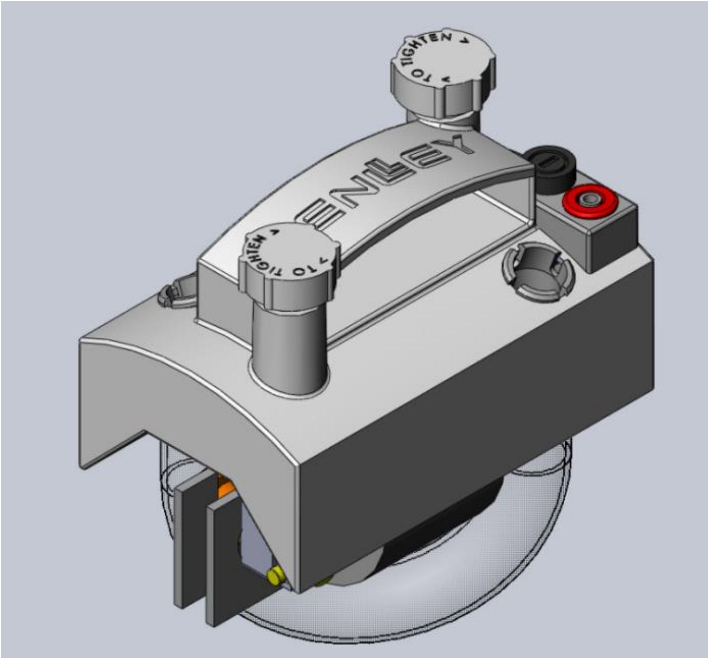
For example, S4181_9 – On-going Programme of Transformer Post Mortem Testing 2013-14 – will give us the confidence to operate transformers closer to their end of life, enabling significant capital savings by deferring transformer replacements.</td></tr>
</table>

	Other projects will deliver savings by identifying alternative plant maintenance products and determining best practice in plant refurbishment techniques.
Project Progress to March 2014	Progress in 2013/14 has been good, with reports delivered on 16 different projects. S4268_1 – Technical Evaluation of BS5730 and IEC60422: Insulating Oils in Service – has highlighted several important differences in the way the oil should be tested. We will use the learning from this project to modify our maintenance techniques to ensure continued reliable operation. S4181_9 – On-going Programme of Transformer Post Mortem Testing 2013-14 – completed five transformer post-mortems this this year, analysing condition of the paper insulation and windings, which cannot be directly measured in service. S4309_1 – Examining voltage potential indicating systems and voltage detection systems on switchgear up to and including 33kV – concluded that Voltage Potential Indicating Systems (VPIS) are suitable for phase comparison, and recommended that future efforts should focus on developing management and operational procedures.
Collaborative Partners	Scottish Power Energy Networks; Scottish and Southern Energy; Electricity North West; Western Power Distribution; Northern Power Grid and ESB Networks
R&D Provider	EA Technology Ltd

Rogowski Coil and Voltage connection Fuse Carrier

<table>
<tr><td>Description of project</td><td colspan="4">This project aims to develop and test a low-cost LV Fuse Carrier incorporating facilities for utilising a Rogowski coil current measuring device and incorporating a direct voltage connection.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£249</td><td>£138</td><td>£158</td></tr>
<tr><td>Total</td><td>£249</td><td>£138</td><td>£158</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of substations in each licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£28,545</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td>External £26,000
Internal £2,000
Total £28,000</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="4">Rogowski coils have been used to measure currents on LV switchboards for some time, but their use has been limited to switchboards where sufficient space is available for the sensors to be fitted.

The fuse carrier to be developed as part of this project will make monitoring and management of the LV Network safer.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10.2</td><td>-4</td><td>14.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The expected benefits of the project are expected to include:
• A low-cost solution for monitoring current and voltage on all existing LV Network equipment.
• Safer data monitoring and network checks – Measurement devices and other equipment can be connected safely (i.e. without the need of having to connect sensors between live cables or busbars)
• Potential reduction in Customer Minutes Lost (CML) due to improved fault diagnosis on site once the carriers become standard on the network
• Potential reduction in short-duration customer interruptions associated with LV fuse carriers having to be removed to test for blown fuse links
• Easier connection of fault location and diagnostic equipment on existing LV boards, saving engineers' operational time on site</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2014</td><td colspan="2">Duration of benefit once achieved</td><td>On-going</td></tr>
<tr><td>Probability of Success</td><td>100%</td><td colspan="2">Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>£50,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The potential for achieving the expected benefits is high as the fuse carriers have been developed and tested successfully. This will be further assessed following the installation of fuse carriers on the network.</td></tr>
<tr><td>Project Progress</td><td colspan="4">A technical specification for the equipment has been produced and a</td></tr>
</table>

March 2014	number of prototype carriers have been developed and successfully tested at Renley Ltd. Tests included: temperature rise, flammability, dielectric, and making and breaking current.  **Figure 14: Modified fuse carrier** 100 fuse carriers were delivered to UK Power Networks in November 2013 and will be trialled on the distribution network.
Collaborative Partners	N/A
R&D Provider	Renley Ltd.

Understand the Condition of Our Assets

Sustainable Asset Risk and Prioritisation Modelling (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">UK Power Networks’ asset engineers have been working closely with EA Technology to further develop its ‘Condition Based Risk Management’ (CBRM) tool into a more holistic ‘Asset Risk and Prioritisation’ (ARP) model.

The model provides a step forward with respect to the existing CBRM functionality by providing the capability to trade off the financial and technical consequences of future decisions to replace assets, refurbish assets or introduce an enhanced maintenance regime. The tool has also been developed so that that in future it may recognise both plant loading and condition in the optimisation process.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£131,344</td><td>£72,550</td><td>£83,309</td></tr>
<tr><td>Internal</td><td>£10,958</td><td>£6,053</td><td>£6,950</td></tr>
<tr><td>Total</td><td>£142,301</td><td>£78,602</td><td>£90,260</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of substations in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£787,601</td></tr>
<tr><td>Internal</td><td colspan="3">£168,750</td></tr>
<tr><td>Total</td><td colspan="3">£956,351</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,267,514</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">• Modelling the future condition of assets and replace/refurbish/maintain decisions on individual components
• Inconsistency in asset modelling and information gathering
• Preparation for an optimisation that might include plant loading as a parameter</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>20</td><td>1</td><td>19</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Greater accuracy of asset health modelling
• Enhanced trending capability
• Improved confidence of long-term degradation and early warning of developing faults
• Integration of risk-based approach to asset management</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2014</td><td>Duration of benefit once achieved</td><td colspan="2">10 years</td></tr>
<tr><td>Probability of Success</td><td>65%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£4,500,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">After reviewing the lessons learnt from previous project phases and before phase 3 of the project (i.e. further refinement of the models) was initiated,</td></tr>
</table>

	detailed user specifications were developed for all models to ensure high quality outputs. All phase 3 model developments were demonstrated to end-users to ensure all changes were aligned to the initial user specifications, and before being implemented on UKPN development server for user acceptance testing (UAT). UAT test scripts have been developed jointly by EA Technology and UK Power Networks to ensure the upgraded models will fulfil both technical and business requirements. End-users will be invited to attend two calibration sessions with EA Technology experts to ensure the upgraded models will provide accurate asset health, criticality and risk outputs.
Project Progress March 2014	With the latest development, the ARP model covers nine of the major asset groups in our EPN and SPN licence area, and seven in our LPN licence area. Below is a summary of the main developments carried out over the past 12 months: • Each model's criticality index calculation has now been reconfigured to ensure alignment to the regulatory criticality index framework • Criticality index has been built into the tower steelwork and foundation components • Improvements of FFA calculation for the EHV transformer model have been carried out • Development of distribution transformer model to enable the ARP modelling approach to be applied to distribution transformers • Completion of a feasibility study to assess the potential for further enhancing the current non-load-related ARP model through incorporation of load-related modelling. This involved exploring the following three areas: - Trial/calibration of potential load related methodology - Develop a full specification for an application to incorporate the load-related methodology into the existing ARP system
Collaborative Partners	N/A
R&D Provider	EA Technology Ltd

Helicopter Mounted Partial Discharge Locator (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">This project aims to mount a radiometric partial discharge (PD) locator to a helicopter and automate the analysis of data to allow fast screening of potential PD defects during normal overhead line patrol flights.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£652</td><td>£225</td><td>£513</td></tr>
<tr><td>Total</td><td>£652</td><td>£225</td><td>£513</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of primary substations in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£58,437</td></tr>
<tr><td>Internal</td><td colspan="3">£6,145</td></tr>
<tr><td>Total</td><td colspan="3">£64,582</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£65,973</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td>Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Improved management of assets: detection of overhead line and substation equipment defects.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>-9</td><td>21</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Avoidance of major disruptive incidents
• Ability to carry out surveys on sites before commencing major work (switchboard replacement, major refurbishment, etc.), hence reducing risk
• Overhead line and substation condition assessment
• Improved productivity by removing the requirement to fund separate flights, as the technology will be used during scheduled patrol flights</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>10 Years</td></tr>
<tr><td>Probability of Success</td><td>75%</td><td colspan="2">Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>£470,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">Initial trial flights have shown positive results, but a change of aircraft used by Western Power Distribution will require a redesign and retesting of the PD locator mounting equipment.
The project partners are currently reviewing the scope of the project.</td></tr>
<tr><td>Project Progress
March 2014</td><td colspan="4">Discussions are on-going with the R&D provider to carry out a review of the “airborne” sensors market, and establish whether the use of a combination of sensors (e.g. LiDAR, Infrared, etc.) together with advanced analytics has the potential to significantly enhance the value of helicopter inspections.

Once a decision has been made, it is likely that a follow-up project will be registered under the Network Innovation Allowance.</td></tr>
</table>

Collaborative Partners	Western Power Distribution and Scottish and Southern Energy
R&D Provider	Elimpus

Micro-helicopters

<table>
<tr><td>Description of Project</td><td colspan="4">UK Power Networks is trialling the use of micro-helicopters to conduct aerial photographic and thermographic surveys of its assets, which include overhead lines and substations.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£145,525</td><td>£99</td><td>£53,131</td></tr>
<tr><td>Internal</td><td>£7,962</td><td>£0</td><td>£2,907</td></tr>
<tr><td>Total</td><td>£153,486</td><td>£99</td><td>£56,038</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of overhead lines in each licence area.</td></tr>
<tr><td>Expenditure in Previous (IFI) Financial Years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£229,623</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £10,000
Internal £10,000
Total £20,000</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">There are several business-as-usual activities that require visual inspection of distribution network assets, including:
• Routine visual condition inspections
• Thermographic inspections
• Post-storm inspections
• Fault location
• Before-and-after inspections of tree-trimming activities

For some of these activities, an aerial survey by manned helicopters is more appropriate, typically where a large area must be covered in a short time e.g. long overhead line over a wide area.

Where an aerial survey by manned helicopter is not feasible or cost-effective, a ground-based survey is conducted on foot. These can only cover a limited area, are time-consuming, expose staff to hazards, and are often less effective than aerial surveys. In many of these cases, a micro-helicopter aerial survey provides a quicker, more convenient, more effective, and safer alternative, at a fraction of the cost of a manned helicopter survey.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Technological substitution from outside industry</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14.4</td><td>0</td><td>14.4</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">If successful, Micro-helicopters will:
• Reduce the need for manned helicopter patrols on short overhead line routes. The benefits of this include:
- Cost savings
- Reduced CO_2 emissions
- Less disruption to livestock and dwellings
- Aerial inspection activities are less constrained by resources (helicopters & pilots)
• Enable aerial surveys where they were previously difficult due to cost, lack of resources, or would be too environmentally disruptive, for example:
- Short sections of overhead line, or individual towers
- Primary/grid substations</td></tr>
</table>

<table>
<tr>
<td></td>
<td colspan="3">- Locations near livestock or dwellings
- Emergency inspections – i.e. where there is not enough time to mobilise a manned helicopter
- Ad-hoc aerial inspections during routine foot patrols
• Other benefits include:
- Thermographic surveys are more effective when conducted from the air because hot spots show up more readily against the cold background of the ground
- Faster response after storms and other incidents
- Faster fault location than on foot
- Aerial inspections can be conducted by local staff who know the area
- Staff currently used for foot patrols can be made available for other tasks, and are less exposed to hazards in the field
- Routine foot patrols will have the opportunity to perform an immediate aerial inspection if they notice something that requires a closer look - the micro-helicopters are light and portable enough to be carried in van or backpack, and are quick and easy to deploy in the field.</td>
</tr>
<tr>
<td>Expected Timescale to Adoption</td>
<td>2014</td>
<td>Duration of benefit once achieved</td>
<td>On-going</td>
</tr>
<tr>
<td>Probability of Success</td>
<td>80%</td>
<td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td>
<td>£100,000</td>
</tr>
<tr>
<td>Potential for Achieving Expected Benefits</td>
<td colspan="3">The micro-helicopters are already delivering benefits:
• Safety: Micro-helicopters were used to inspect islanded or partially flooded primary and secondary substations during the Christmas 2013 floods. The micro-helicopters improved safety by eliminating the need for staff to traverse fast-flowing floodwaters, and enabled inspections that would have been too dangerous to conduct on foot.
• Structural inspections of grid substation roofs normally require system outages to enable safe access to the site. Micro-helicopters were used to take aerial photos and thermographic images of the roofs in a short period, reducing or eliminating the need for system outages.</td>
</tr>
<tr>
<td>Project Progress
March 2014</td>
<td colspan="3">Four SkyDroid Scout micro-helicopters with HD cameras and two Thermovision cameras were purchased, and eight members of staff were trained to operate them safely under Civil Aviation Rules. An operating policy was developed to ensure the micro-helicopters are operated safely and do not cause public concern or complaints.

Progress:
• Inspections: Micro-helicopters have been used to inspect 132KV and 33kV towers and poles, grid substations, and primary substations. The inspections have been successful, and have even found post-storm faults that were missed by the manned helicopter inspections. For example, crews were able to take close-up photos of a 132kV overhead conductor where some of the stands had parted mid-span.
• Photos: The micro-helicopters were initially fitted with GoPro HD cameras. These cameras could not be controlled from the ground, so they were set to automatically take one photo every ten seconds. The quality of the photos was excellent, but sorting through the photos after the flight was too time-consuming. We are now using a Pentax weatherproof camera that can be controlled from the ground, and is equipped with a gimball mount and four-stage zoom lens which allows it to take photos at a safer (further) distance from structures and live</td>
</tr>
</table>

	conductors. • **Costs:** The micro-helicopters have negligible operating costs, except the direct costs of the staff operating them, and the very small amount of energy required to charge the batteries from mains power or in a vehicle. Maintenance costs are negligible unless the micro-helicopter is accidentally damaged. The spare parts are quite expensive, so this is a risk that requires careful on-going management. • **Business as usual usage:** The trials have shown clear benefits from adopting the use of micro-helicopters, especially with the improved cameras. • **Next steps:** - Get more experience with the thermographic cameras and the new photographic cameras - Focus on improving pilots' flight skills to reduce the risk of accidental damage to the micro-helicopters - Encourage business-as-usual use of micro-helicopters to replace traditional inspection methods - Trial web-viewing of live video downlink and 3D Mapping - Make photos available to Asset Management engineers by mapping photos to the asset database
Collaborative Partners	N/A
R&D Provider	SkyDroid

Transformer Research Consortium

Description of project	The main project aim is to develop new tools for the management of the existing transformer fleet, the analysis of transformer health conditions, and the future maintenance and replacement strategies for grid and primary transformers. The project will also generate valuable knowledge for optimising the design of future transformers and defining the criteria for transformer operating conditions. The project will therefore include studies on transformer-related topics such as ageing and end-of-life management, partial discharge diagnostics, dissolved gas analysis (DGA), assessment of on-line devices, transformer thermal performance and optical fibres.			
Expenditure for financial year		EPN	LPN	SPN
	External	£19,327	£7,694	£11,020
	Internal	£604	£240	£344
	Total	£19,931	£7,935	£11,365
	The costs have been allocated in proportion to the number of primary substations in each licence area.			
Expenditure in previous (IFI) financial years	This is a new project 2013/14.			
Total Project Costs (Collaborative + external + UK Power Networks)	£1,300,000	Projected 2014/15 costs for UK Power Networks	External £37,500 Internal £1,200 Total £38,700	
Technological area and / or issue addressed by project If applicable only	Equipment design and operational improvement			
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		12	-7	19
Expected Benefits of Project	Benefits are expected to include: • Enhanced analysis and trending of transformer fleet condition data • Reliable and accurate condition information • Improved understanding of transformer ageing • More cost-efficient methods of gas-in-oil analysis • Better-informed procurement of condition-monitoring equipment • Improved understanding of asset condition • Improved reliability of new transformers from better-informed transformer design standards • Prolonged life from more effective monitoring of transformer cooling systems • Review of alternative transformer fluids			
Expected Timescale to adoption	2016	Duration of benefit once achieved	40 years	
Probability of Success	90%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000	
Potential for achieving expected benefits	The progress made so far indicates that there is a good potential for achieving the expected benefits. Regular project meetings held and			

	progress controls carried out by the project steering group ensure that the project remains on track.
Project Progress March 2014	The progress made for each individual work package of the project is described below: **Work Package 1**: Ageing of transformer insulation • A methodology for data presentation and analysis of transformer oil databases was developed • Population trend analysis of transformer oil databases from UK Power Networks, Scottish Power Energy Networks and National Grid has been completed • An early peak of acidity at age of around 20-25 years was identified, which was consistently observed across the UK • A Head-Space Gas Chromatograph Mass Spectrometry based technique was developed to measure methanol in oil, which is expected to be a novel indicator of paper ageing **Work Package 2:** Partial Discharge (PD) diagnostic of transformer insulating fluids • PD behaviours of various oils were documented using the IEC 61294 electrode configuration • Effects of oil conditions on PD behaviours were investigated • In general, MIDEL 7131 shows higher PD magnitude and larger PD numbers than two other oils tested • Effect of electrode configuration on PDIV was studied **Work Package 3:** Dissolved gas analysis; measurement and data interpretation • On-line DGA systems using the Kelman Transfix and the Calisto-2 DGA devices have been set up • A DGA test platform using multiple DGA devices is being developed **Work Package 4:** Thermal analysis of transformer insulation systems • Literature review of transformer thermal performance using modelling and experimental approaches was completed • A small-scale thermal test rig, which enables studying various cooling structures, is being developed In addition, three papers were published; two in the IEEE International Conference on Dielectric Liquids and one in EuroTech Con.
Collaborative Partners	National Grid, M & I Materials, Shell, Scottish Power, TjH2b, Weidmann and UK Power Networks
R&D Provider	Manchester University

Underground HV Cable Research

<table>
<tr><td>Description of project</td><td colspan="4">The aim of this project is to develop a better understanding of the condition of high voltage underground cables. A number of samples of undamaged HV paper-insulated lead-covered (PILC) cable will be recovered during post-fault repairs, and laboratory test will be carried out to determine their actual condition. This will improve our understanding of how and why HV PILC cables fail, and the relationship between Partial Discharge activity and the actual cable condition.
This is expected to lead to reduced CIs, CMLs, and cable repair costs by identifying opportunities to:
• Improve existing processes (e.g. the information recorded after cable faults).
• Pro-actively replace sections of cable in poor condition. This is expected to be done by using the knowledge developed as part of this project to refine the algorithms embedded in online condition monitoring equipment.</td></tr>
<tr><td rowspan="5">Expenditure for financial year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£134</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£4,311</td><td>£2,675</td><td>£2,652</td></tr>
<tr><td>Total</td><td>£4,445</td><td>£2,675</td><td>£2,652</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of installed HV cables in each licence area.</td></tr>
<tr><td>Expenditure in previous (IFI) financial years</td><td colspan="4">This is a new project for 2013/14.</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£183,810</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £164,480
Internal £8,000
Total £172,480</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="4">UK Power Networks currently operates more than 40,000 km of underground HV cable throughout its three licence areas. The average age of these cables ranges from 39 to 45 years: the majority were installed in the 1960s, but some cables predate the 1920s. Over the past 10 years, there has been a trend of increasing faults on underground paper-insulated lead-covered (PILC) cables.

This project will recover approximately sixty 500mm-long samples during routine post-fault repairs over 6 months, and deliver them to ERA Technology for invasive testing to assess the actual condition of the cable. It will also develop a visualisation tool to help engineers identify clusters of HV faults.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14.6</td><td>-2</td><td>16.6</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Reduce CIs, CMLs, and cable repair costs.
• Develop a better understanding of the condition of high voltage PILC underground cables
• Improve the accuracy and quality of data recorded following HV faults
• Help asset management engineers make better decisions when considering asset replacement
• Better understanding of the relationship between PD activity and actual cable condition</td></tr>
</table>

Expected Timescale to adoption	2016	Duration of benefit once achieved	10 Years
Probability of Success	60%	Project NPV (Present Benefits – Present Costs) x Probability of Success	>£1,000,000
Potential for achieving expected benefits	Although it is too early to establish whether the analysis of cable samples will enable the benefits to be realised, there should be few impediments to obtaining the required number of cable samples, and our confidence in ERA Technology's test methods is high.		
Project Progress March 2014	Progress to date is as follows: • Agreement has been reached with operational staff within the LPN licence area to commence sample collection. • Tubes have been procured to facilitate the collection and transport of recovered samples. • Contract negotiations with ERA Technology are in progress.		
Collaborative Partners	N/A		
R&D Provider	ERA Technology Ltd		

Develop Commercial Solutions and Products

Smart Power Distribution (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">This project, which is partly funded by the Technology Strategy Board (TSB), built on learning obtained in the LCNF Tier 2 funded “Low Carbon London” project in which Active Network Management and Demand Response activities are being assessed to understand their suitability as well as the opportunity available for DNOs.

The learning obtained within the Low Carbon London project has indicated that the existing commercial opportunities for Combined Heat and Power (CHP) systems, particularly small-scale units, limits their ability to provide ancillary services.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>-£7,189</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£14,926</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£7,737</td><td>£0</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN as the project is being carried out in this licence area.
50% of the UK Power Networks cost is funded by the TSB.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">-£12,238</td></tr>
<tr><td>Internal</td><td colspan="3">£24,956</td></tr>
<tr><td>Total</td><td colspan="3">£12,717</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£166,736</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">Project completed</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">This project investigated technical developments required to enable the control functionality needed for CHP systems to participate in VPP activities.

The project examined the potential realisation of benefits from the many distributed energy resources embedded within the distribution network. These could include network voltage regulation, peak lopping, and load index improvements.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9.6</td><td>-4</td><td>13</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Improved understanding of the technical and commercial requirements for operating multiple CHP sites as a coordinated ‘virtual power plant’</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>< 10 years</td><td>Duration of benefit once achieved</td><td colspan="2">8 Years</td></tr>
<tr><td>Probability of Success</td><td>20% - 40%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£284,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">The outputs of the project show that there is significant opportunity for VPP systems to provide benefits to the distribution network, and to demonstrate a positive business case for customer implementation with minimal dependence on DNO service provision. This is due to the low</td></tr>
</table>

	level of conflicts between wholesale energy prices and DNO demand-response programmes. Future realisation of the benefits of DNO utilisation of a VPP will, however, depend upon customers' widespread use of CHP and control systems that are fit for this purpose, as well as customer commercial willingness to deliver sufficient recruitment and participation.
Project Progress March 2014	The project has been completed and the outputs include: • A definition of the requirements for a CHP-based virtual power plant to provide demand response to the distribution network. This definition was used as an input to the VPP system performance modelling completed by the project partners. • A detailed analysis of the degree to which CHP units operating to meet customer heat demands coincide with network winter peaks. For the five-generator sample and associated substation data, significant coincidence was observed, with 75% to 99% of generation export occurring during network peaks. This indicates that VPP systems need not significantly change their operations to provide material support to the network. • The detailed VPP system performance modelling completed by the project partners demonstrated a positive business case for such an active system, where wholesale energy prices and network support programmes can be accessed by the system when making control and set-point decisions. Notably, these systems showed very few conflicts.
Collaborative Partners	Advanced Digital Innovation Limited, Flexitricity Limited, Smarter Grid Solutions Limited, Ener-G Combined Power Limited
R&D Provider	N/A

Bankside Heat Transfer

<table>
<tr><td>Description of Project</td><td colspan="4">Substation transformers generate heat, particularly during peak loads. This heat is normally lost to the environment, often through energy-intensive forced cooling. The upgraded substation at Bankside, adjacent to the Tate Modern, has used transformers with water-cooled heat exchangers. It is proposed that the waste heat from the transformers will be used by the Tate Modern to assist with their space heating. This will benefit the Tate by providing low-carbon heat. The benefits for UK Power Networks are that less energy will need to be expended within cooling fans at the substation, and lower maintenance and replacement cost will be incurred. The overall carbon footprint of the site and assets will be reduced.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Internal</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td>Total</td><td>£0</td><td>£0</td><td>£0</td></tr>
<tr><td colspan="4">No expenditure has been incurred this year since the project is awaiting full-scale use.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£719,080</td></tr>
<tr><td>Internal</td><td colspan="3">£95,035</td></tr>
<tr><td>Total</td><td colspan="3">£814,115</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£846,115</td><td colspan="2">Projected 2014/15 costs for UK Power Networks</td><td>External £30,000
Internal £2,000
Total £32,000</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The oil-to-water heat exchangers at this scale and for this purpose are novel, as is the specific heating arrangement.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>4</td><td>1</td><td>3</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Heat used by a third party, replacing a high-CO_2 heat source
• Use of energy that would otherwise be lost
• Fewer maintenance interventions for cooling
• Less energy expended for cooling via less auxiliary electricity consumption
• Lower noise level from cooling fans</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved. Expected to be commissioned and handed over to the Tate in late 2013</td><td>20 Years</td></tr>
<tr><td>Probability of Success</td><td>75%</td><td colspan="2">Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>£200,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">After a short trial, the Tate has decided to wait until their new extension is ready before taking the hot water on a routine basis.</td></tr>
<tr><td>Project Progress
March 2014</td><td colspan="4">The small wiring modifications required to enable monitoring from the Tate control centre have been completed.</td></tr>
</table>

	A further modification is to take place by reducing the flow from the water pumps to attempt to increase the water temperature. This was supposed to take place in 13/14 but has been delayed due to availability of Wilson Transformers to carry out the work.
Collaborative Partner	Tate
R&D Providers	Wilson Transformers and Arup

Collaborative Programmes

Energy Innovation Centre

<table>
<tr><td rowspan="1">Description of Project</td><td colspan="4">UK Power Networks continues to grow its portfolio of projects with the Energy Innovation Centre (http://www.energyinnovationcentre.com/) and has started three new collaborative projects this year:

Project 1: Cable Paper Moisture Meter (started 2012/13)
The project proposes to develop a paper moisture analyser, an instrument that will be used by cable jointers to test the moisture level in paper-insulated cables.

The instrument will allow this operation to be performed more safely than the currently-used oil or paraffin solutions. The instrument will produce quantifiable results with a higher level of confidence and will require a shorter time to perform each measurement.

Project 2: Oilcable-Care (started 2012/13)
The project seeks to identify, develop and assess self-repairing systems for oil-filled cable sheaths such that damages will self-heal. This will avoid oil leakage, the resulting environmental cleanup, as well as prevent contamination of the cable that could compromise its performance and lead to premature failure.

Project 3: Smart 3ph LV Network Power Regulator (started 2013/14)
The project is seeking to develop a compact piece of equipment which can be used to add a control point into rural overhead LV networks. UK Power Networks does not currently have the ability to manage voltage along an LV feeder.

Project 4: Cable Core Temperature Sensor (started 2013/14)
This project will validate a concept for an easily retrofitted sensor for measuring and/or deducing the temperature of the core of a three-phase HV power cable. Using cable temperature to infer the current in a cable offers the possibility to provide a low cost alternative to both current transformers and fibre-optic cable temperature sensing. Additionally, the measurement of the core temperature can be used to gauge when a cable reaches its thermal limit, independent of the current flow.

Project 5: VTOL (started 2013/14)
The use of helicopters to inspect overhead line assets is expensive and significant cost savings could be realised by the deployment of unmanned aerial systems. UK Power Networks are already successfully using unmanned aerial systems (UAS) for inspection tasks, however these systems are not suited to Beyond Visual Line Of Sight (BVLOS) operations. To achieve this demanding goal requires an expert approach to addressing the critical issues particular to overhead power lines.

Several additional opportunities are currently being considered.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£62,705</td><td>£44,533</td><td>£44,045</td></tr>
<tr><td>Internal</td><td>£2,490</td><td>£1,637</td><td>£1,748</td></tr>
<tr><td>Total</td><td>£65,195</td><td>£46,170</td><td>£45,794</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area. The expenditure includes the Energy Innovation Centre annual subscription fee.</td></tr>
</table>

<table>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£82,400</td></tr>
<tr><td>Internal</td><td colspan="3">£3,057</td></tr>
<tr><td>Total</td><td colspan="3">£85,457</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,463,768</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £247,000
Internal £10,000
Total £257,000</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Project 1: Cable Paper Moisture Meter
• Safety of staff
• Cable jointing
• Underground cable faults

Project 2: Oilcable-Care
• Fluid-filled cable leaks
• Environmental impact

Project 3: Smart 3ph LV Network Voltage Regulator
• LV network voltage and power quality control

Project 4: Cable Core Temperature Sensor
• Measurement of cable temperature using a low cost sensor attached to the outer sheath of a cable.

Project 5: VTOL
• The goal of this project is to define an electricity-industry-standard specification for Remotely Piloted Aircraft Systems operating Beyond Visual Line Of Sight for electricity distribution network aerial inspection operations, and to have this approved by the UK Civil Aviation Authority. This will allow DNOs to decide whether they want to invest in such systems in the future and identify necessary acquisitions or development, with the goal of introducing BVLOS operations in an incremental manner, in close co-operation with and as agreed with the CAA.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Significant through to radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>Range from 8.6 - 18</td><td>Range from 2 to -3</td><td>Range from 5.6 to 21</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Project 1: Cable Paper Moisture Meter
Successful completion of the project will result in:
• Improved reliability of cable jointing, reducing fault re-occurrence
• Safer method of assessing the moisture level in cables
• Reduced environmental impact through reduced excavation as a result of fault re-occurrence
• Reduced CI and CMLs from more reliable repairs

Project 2: Oilcable-Care
Indicative data shows that the current cost of this problem is of the order of several million pounds per year across the UK. Financial savings would be achieved from the reduced need to repair cables. The project is also expected to result in:
• Improved reliability of cables
• Reduced environmental impact through a reduction in the amount of oil leaking from cables
• Reduced CI and CMLs as a result of more reliable cables</td></tr>
</table>

	Project 3: Smart 3ph LV Network Power Regulator The creation of a system that can control the voltage on an LV feeder will provide: • Balanced voltage and current across the phases • Corrected power factor on each phase • Reduced total harmonic distortion (THD) • Regulated and reduced neutral currents **Project 4: Cable Core Temperature Sensor** The development of this sensor would give networks the increased ability to manage peak currents. The sensors would improve understanding of network condition, which will help increase network utilisation and deferral of capital expenditure by extending the life of cables through peak temperature management. **Project 5: VTOL** A UAS offers significant cost savings when compared to helicopter deployment. Being able to operate beyond the visual line of sight will result in significantly greater circuit lengths being surveyed during inspection periods. Other benefits of unmanned aerial systems include: • Minimising environmental impact with reduced fuel consumption • Minimised disruption to landowners, livestock and local residents during inspection • Reduced risk to life by using unmanned apparatus to retrieve data • Reduced Civil Aviation restrictions in the vicinity of airports, chemical plants, MOD land, etc • Limit the effect of stand-down time due to bad weather or strong winds • Reduced numbers of “missed towers” by not having to avoid motorways, railways or housing estates etc		
Expected Timescale to Adoption	2015-2018	Duration of benefit once achieved	Greater than 10 years in all cases
Probability of Success	Ranging from 10% to 60%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£1.53m
Potential for Achieving Expected Benefits	**Project 1: Cable paper moisture meter** EATL has progressed well with the project and many of the concerns present at earlier stages have been addressed. Outputs from experimentation have been promising, showing a clear correlation between moisture content and impedance through multi-frequency scanning. Further stages will build on this promising start and are showing real potential to deliver the expected benefits identified at the start of the project. **Project 2: Oilcable-Care** Gnosys have identified a number of chemistries that have the potential to create the desired blocking effect when a fluid leak is present. These chemistries will be advanced through further experimentation. There has been a good level of engagement with the ENA fluid-filled cable working group and their experience has been valuable. There is confidence that the chemistries identified will be able to provide the benefits identified at the start of the project. **Project 3: Smart 3ph LV network Power regulator**		

	The first stage of the project identified the limitations of the initial GenDrive approach, however a redesign has led to optimism that this project could deliver the technical benefits sought. **Project 4: Cable Core Temperature Sensor** Initial work has shown that cable core temperature can be predicted with reasonable accuracy from easily accessed measurements of the cable exterior, and there may be techniques to improve the impacts of thermal lag so that a temperature-sensing method can provide a range of useful measures to assist with network management. **Project 5: VTOL** The approach of this project is designed to address the CAA requirements at every stage in order to increase the potential for achieving the expected benefits.
Project Progress March 2014	**Project 1: Cable paper moisture meter** The project has successfully completed the feasibility stages with results favourably compared against the existing test method. A technology and system has been identified that can operate with the necessary levels of sensitivity, whilst also being small and portable for ease of use by cable jointers. **Project 2: Oilcable-Care** An interim report produced in February 2014 showed good progress on identifying healing additives and mechanisms. Analysis of aged oils is allowing project theories to be tested in the laboratory test rigs. **Project 3: Smart 3ph LV network Power regulator** The project had successfully been completed to the end of stage 2 when the supplier (Gendrive) was placed in administration in March 2014. As a result the project has been placed on hold and no further work has been carried out. Various options are being investigated to either continue or end the project. **Project 4: Cable Core Temperature Sensor** The project started in January 2014, and the analytical and experimental proofs of principle have been completed. The direct temperature measurement technique has been adopted as the preferred method. **Project 5: VTOL** Project to start in April 2014.
Collaborative Partners	**Project 1: Cable paper moisture meter**: Electricity Northwest, Scottish Power Energy Networks and Northern PowerGrid **Project 2: Oilcable-Care**: Northern Power Grid and Electricity Northwest **Project 3: Smart 3ph LV network Power regulator:** Scottish and Southern Electricity Power Distribution, Scottish Power Energy Networks, Electricity Northwest and Northern PowerGrid **Project 4: Cable Core Temperature Sensor:** Scottish and Southern Electricity Power Distribution, Scottish Power Energy Networks, Electricity Northwest and Northern PowerGrid **Project 5: VTOL**: Scottish and Southern Electricity Power Distribution, Northern PowerGrid, Northern Gas Networks, Scotland Gas Networks, Southern Gas Networks

R&D Provider	**Project 1: Cable paper moisture meter**: EA Technology Ltd **Project 2: Oilcable-Care**: Gnosys Global Ltd, EDF R&D and EA Technology Ltd **Project 3: Smart 3ph LV network Power regulator:** GenDrive Ltd supported by EATL **Project 4: Cable Core Temperature Sensor:** The Technology Partnership Ltd **Project 5: VTOL:** VTOL

Power Networks Research Academy

<table>
<tr><td>Description of Project</td><td colspan="4">The Power Networks Research Academy (PNRA) has been established through a strategic partnership agreement between the Engineering and Physical Sciences Research Council (EPSRC), electricity transmission and distribution companies, and related manufacturers and consultants. The Academy funds and supports PhD researchers in power-industry-related projects and helps maintain and improve research and teaching capacity in power engineering subjects.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£9,593</td><td>£6,152</td><td>£6,089</td></tr>
<tr><td>Internal</td><td>£284</td><td>£182</td><td>£180</td></tr>
<tr><td>Total</td><td>£9,878</td><td>£6,335</td><td>£6,270</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£236,406</td></tr>
<tr><td>Internal</td><td colspan="3">£28,465</td></tr>
<tr><td>Total</td><td colspan="3">£264,871</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,915,000</td><td>Projected 2014/15 costs for UK Power Networks</td><td colspan="2">External £6,788
Internal £1,000
Total £7,788</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The projects of most interest to UK Power Networks are:
• Overhead lines measurement system
• Reactive power dispatch using distributed generation
• Alternatives to Sulphur Hexafluoride (SF_6) as an insulation medium for distribution equipment

Further projects related to the distribution and transmission networks are also being carried out.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Significant, Technological substitution and Radical innovations</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9.4</td><td>0.0</td><td>9.4</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Industry, the IET and academia have agreed that the projects are beneficial to both DNOs – through potential breakthroughs that could lead to new practices or products, and to academia – by raising the profile of power engineering.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Year 2014 onwards</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
<tr><td>Probability of Success</td><td>25%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£200,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">Most of the projects are progressing according to plan and have the potential to deliver benefits. Some of the highlights are presented below:

Overhead lines measurement system
Two laboratory prototypes have been successfully developed.

Reactive power dispatch using distributed generation
Progress continues to indicate that both power system losses and voltage</td></tr>
</table>

	profiles can be enhanced with the involvement of DG, as performed on the IEEE 30 bus system. As such, it is believed that the expected benefits of the project can be realised. **Alternatives to SF_6 as an insulation medium for distribution equipment** It is expected that the benefits of this project will be accomplished as the work continues to progress well. This is backed by the interest shown by switchgear manufacturers, e.g. Schneider Electric, and the progress that has been made producing a suitable test rig to test the characteristics of Trifluoroiodomethane (CF_3I) alongside the facilities available at Cardiff University.
Project Progress March 2014	Only relevant progress for projects of most interest to UK Power Networks is presented below. **Overhead lines measurement system (completed)** Following its completion, this project has been awarded the first PNRA Technology Development Initiative grant. This competitive initiative is designed to allow further development, implementation and development of research by the PNRA scholar with one or more industrial partner. Over a six month period, Cardiff University will work with UK Power Networks and WPD to make the developed transmitter and receiver prototypes suitable for application to a live overhead line and demonstrate its capabilities under real conditions. **Reactive power dispatch using distributed generation** Several papers have been published and presented at the Power & Energy Society's General Meetings (2013 & 2014) and at the Power & Energy Society's PowerTech conference (2013). These presented results from a balanced voltage control algorithm and discussed the need for an unbalanced voltage control algorithm that can be utilised in order to maintain network voltages by dispatching reactive power from distributed generators. The algorithms have three significant control actions. Firstly, available reactive power reserves are utilised. Then, if required, distributed generation's active power output is curtailed. Finally, curtailment of non-critical site demand is considered. The unbalanced control algorithm utilises phase-dependent reactive control dispatch to control and help balance network voltages. This is presented in detail in two draft papers, which demonstrate for a given island on the Orkney islands that the individual non-firm generation can increase their active power exports when the networks' reactive power is managed by the unbalanced control algorithm. The ability to control voltage and aid network balancing through phase-dependent reactive power is also demonstrated. **Alternatives to SF_6 as an insulation medium for distribution equipment** Switch-disconnectors provided by Schneider Electric and Ring Main Units (RMUs) provided by a DNO have been used to test different mixtures of CF_3I-CO_2 as an alternative switchgear insulation medium to SF_6. In particular, the rated lightning impulse withstand voltage of the switch-disconnectors and RMUs have been tested. These tests have examined the ability of the different gas mixtures (in comparison to SF_6) to withstand simulated lightning impulses in the switchgear. A novel test rig developed at Cardiff University has been used to gas, de-

	gas and filter the switchgear with CF_3I and CF_3I-CO_2 gas mixtures. Testing has now been completed and the submission of the PhD Thesis is soon to be completed.
Collaborative Partners	EPSRC, The IET and the following industrial partners: Western Power Distribution, EA Technology Ltd, National Grid and Scottish and Southern Energy
R&D Providers	Universities of Cardiff, Manchester; Queens (Belfast), Southampton, Strathclyde, and Imperial College London

Collaborative ENA R&D Programme

<table>
<tr><td>Description of Project</td><td colspan="4">The Energy Networks Association (ENA) represents all the UK network operators. Several projects have been initiated by the ENA R&D working group and funded through the IFI.</td></tr>
<tr><td rowspan="5">Expenditure for Financial Year</td><td></td><td>EPN</td><td>LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>£37,725</td><td>£24,193</td><td>£23,945</td></tr>
<tr><td>Internal</td><td>£8,234</td><td>£5,281</td><td>£5,226</td></tr>
<tr><td>Total</td><td>£45,959</td><td>£29,474</td><td>£29,171</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of customers connected in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£651,192</td></tr>
<tr><td>Internal</td><td colspan="3">£83,892</td></tr>
<tr><td>Total</td><td colspan="3">£735,084</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£940,500 (Includes live projects only)</td><td>Projected 2014/15 Costs for UK Power Networks</td><td colspan="2">External £110,000
Internal £10,000
Total £120,000</td></tr>
<tr><td>Technological Area and/or Issue Addressed by Project</td><td colspan="4">The projects listed below address issues which have been identified by the ENA working groups as significant – requiring technical investigation and development.

Development of the ‘Transform’ model to assess Smart Grid investments
The project took the impact of Britain’s future energy scenarios into key strategic directions for network development, identifying the needs for network expansion, and the opportunities for Smart Grid techniques to drive cost-efficiency and deliver new services. It considers the enablers for change, including the necessary development of commercial and regulatory frameworks.

DC Injection
Investigation into the corrosive effects of DC injection on DNO networks with specific emphasis on assessing the impact of DC currents in neutral conductors.

Reactive Power (REACT)
In the last two years, there have been significant difficulties in managing voltage levels during minimum demand periods. Analysis of this issue has shown that the root cause is related to the significant decline in reactive power relative to active power.</td></tr>
<tr><td rowspan="2">Type(s) of Innovation Involved</td><td rowspan="2">Incremental Innovation</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>6.2</td><td>-10</td><td>16.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">These projects have the potential to provide a wide range of benefits. In some cases, they will help to understand key asset-related issues and allow designs to be altered to address them. In other cases they will allow us to better understand risks to our network, whether from significant load growth or from DC injection, and opportunities to mitigate them.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>Year 2014</td><td>Duration of Benefit Once Achieved</td><td colspan="2">10 – 20 Years</td></tr>
</table>

Probability of Success	75%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000
Potential for Achieving Expected Benefits	The Development of the 'Transform' model to assess Smart Grid investments and DC injection projects have both been completed. The Transform model has assisted both the DNOs and Ofgem in assessing the business case for Smart Grid innovations when approaching the RIIO-ED1 price control.		
Project Progress March 2014	**Development of the 'Transform' model to assess Smart Grid investments** The project has now successfully completed. **DC Injection** The review concluded that normal corrosion rates in soils for metallic components typically used in LV circuits can range from < 1 µm/yr up to 100 µm/yr in very aggressive conditions. However, in the majority of cases expected corrosion rate in soils would be between 1–10µm/yr. If stray DC currents occur, they could significantly increase the corrosion rate and could lead to early failures, but this would be dependent on the current density at the point of discharge (i.e. dependent on the amount of current and surface area of discharge). Where the current density exceeds 10 µA/cm² (100 mA/m²) on copper and steel components, the stray current corrosion will become high enough that a problem could be expected within 10 to 20 years. Lead cable sheaths are likely to be the most susceptible components. Based on a review of the earthing arrangements typically adopted in the UK (i.e. PME), any problems would most likely occur at LV substations, mainly on the substation earthing arrangement, at additional PME points and on lead-sheathed cables. Damage to components located at a PV inverter location is unlikely, unless a TT or IT system is used. The complex and variable nature of the DC injection from PV systems is such that estimating the actual amount of cumulative DC will be difficult, and either a probabilistic model or worst-case assessment will be required. **Reactive Power (REACT):** All Grid Supply Points (GSPs) were analysed considering the active and reactive power during minimum demand recorded by National Grid from 2005 to 2012. Three indices were created to cater for the 2012 Reactive Power / Real Power (Q/P) ratio, its decline from 2005, and relative size of the GSP. Finally, the combination of these indices produced the list of the top 10 critical and control GSPs per DNO. The lists of critical and control GSPs are being used to discuss with the DNOs of which final selection of the GSPs that will be modelled in detail. In addition, half-hourly data for these top critical GSPs have also been provided by National Grid for further analysis. Good progress has been made in terms of network modelling, including retrospective modelling.		
Collaborative Partners	National Grid; Scottish Power Energy Networks; Scottish and Southern Energy; Electricity North West; Western Power Distribution and Northern Power Grid		
R&D Providers	EA Technology Ltd (and partners), Capsis		