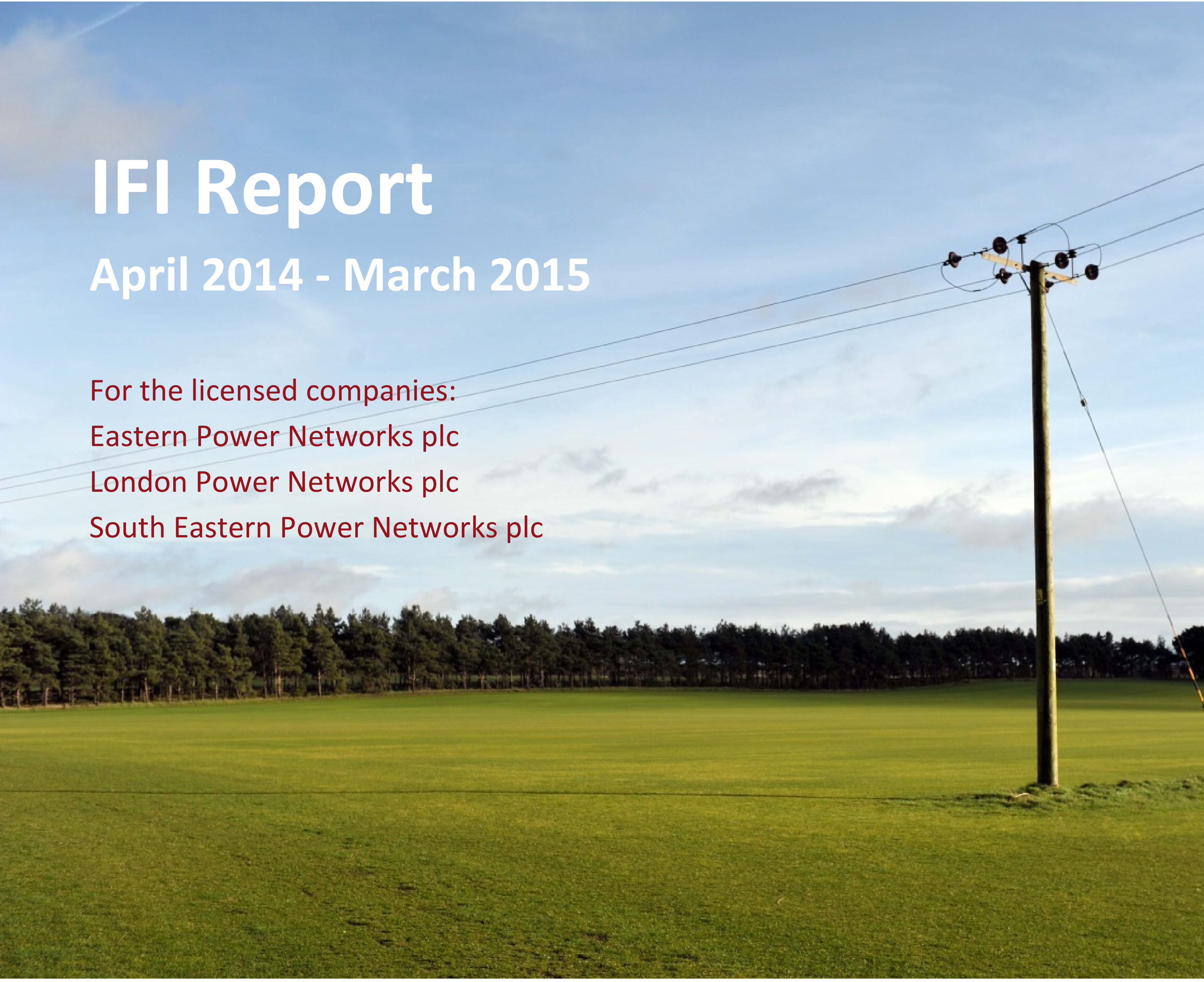
IFI Report

April 2014 - March 2015



For the licensed companies:
Eastern Power Networks plc
London Power Networks plc
South Eastern Power Networks plc

ukpowernetworks.co.uk

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 one of the most reliable and 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 final summary of innovation activities that have been funded by the Innovation Funding Incentive (IFI), which is now closed as of April 2015. Our activities funded by the IFI form only part of our overall innovation portfolio, and we utilise other sources of funding, such as the Low Carbon Network Fund (LCNF), which has now been replaced by the Network Innovation Allowance (NIA) and Network Innovation Competition (NIC) to carry out other strategic innovation.

You can keep up to date with developments on our ongoing larger-scale LCNF Tier 2 Smart Grid trials: 'Kent Active System Management', 'Smarter Network Storage', 'Flexible Urban Networks – Low Voltage', and 'EnergyWise' through their regular progress reports published on the Ofgem website[2]. Information on these projects, as well as those that have already completed, including 'Low Carbon London' and 'Flexible Plug and Play' can also 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; and
- 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

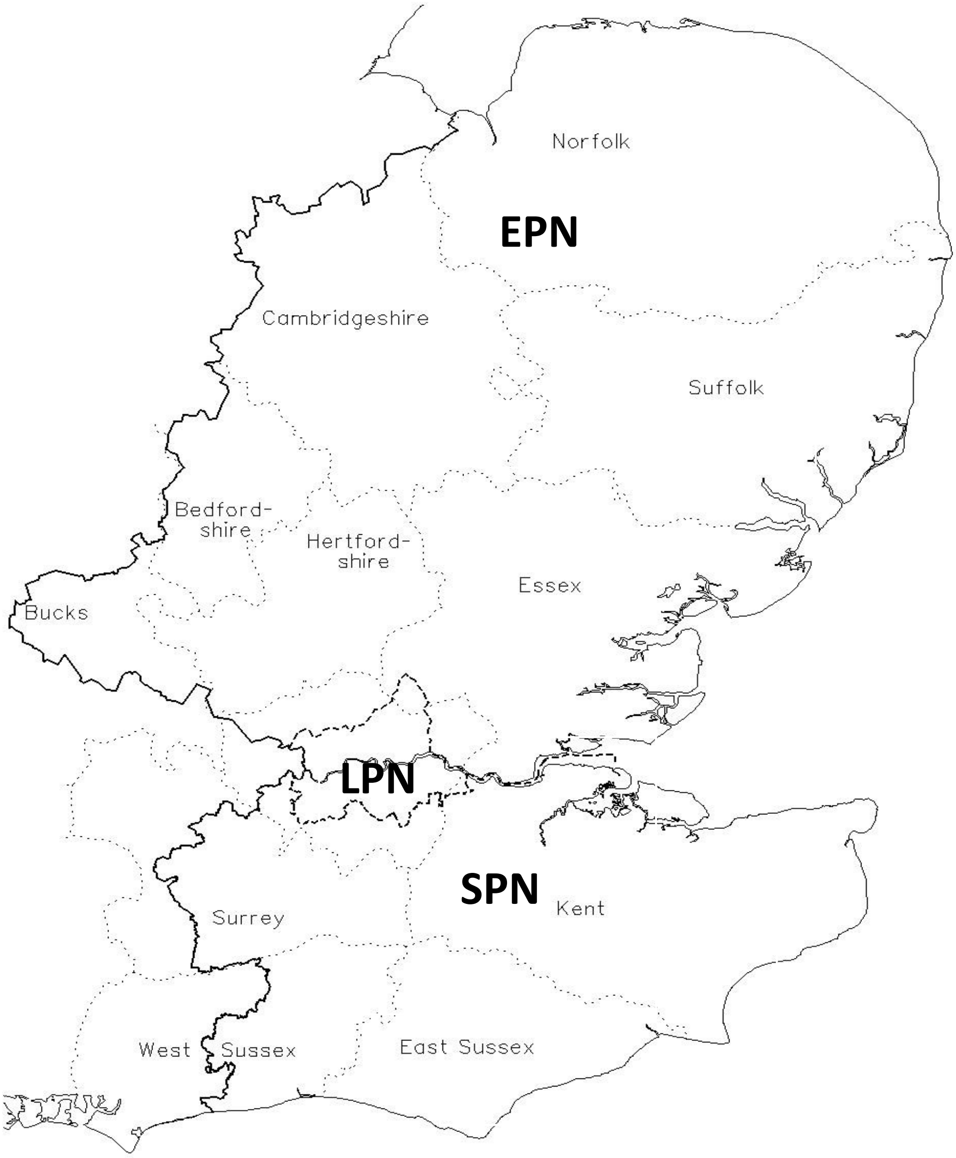


Figure 1: The areas served by UK Power Networks

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 has been strongly involved with Ofgem's LCNF[3], and is now utilising the successor funding mechanisms, the NIA and NIC.

Background to the Innovation Funding Incentive

The primary aim of the IFI was 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 were designed to create a risk/reward balance that is consistent with research, development, demonstration and deployment.

The IFI was 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 effective during Distribution Price Control Review 5. 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.

Eligibility for IFI Funding

Projects are 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.
- The reporting requirements have been met.

This report fulfils our reporting requirements for the regulatory year 2014/15 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

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

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 Innovation Projects over the Coming Year

Following the closure of the funding scheme, this represents the final report on IFI projects, and you can now read about new NIA and NIC funded 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.

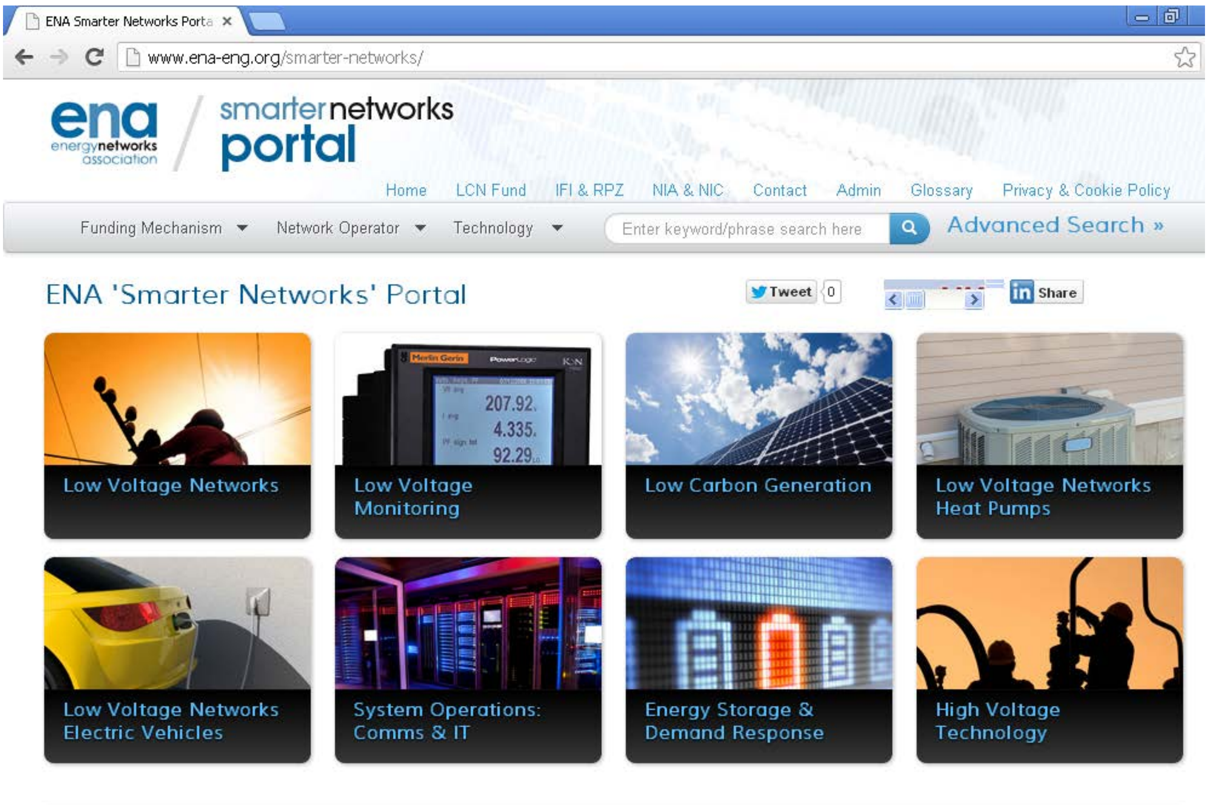


Figure 2: Smarter Network Portal

Summary of Expenditure

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

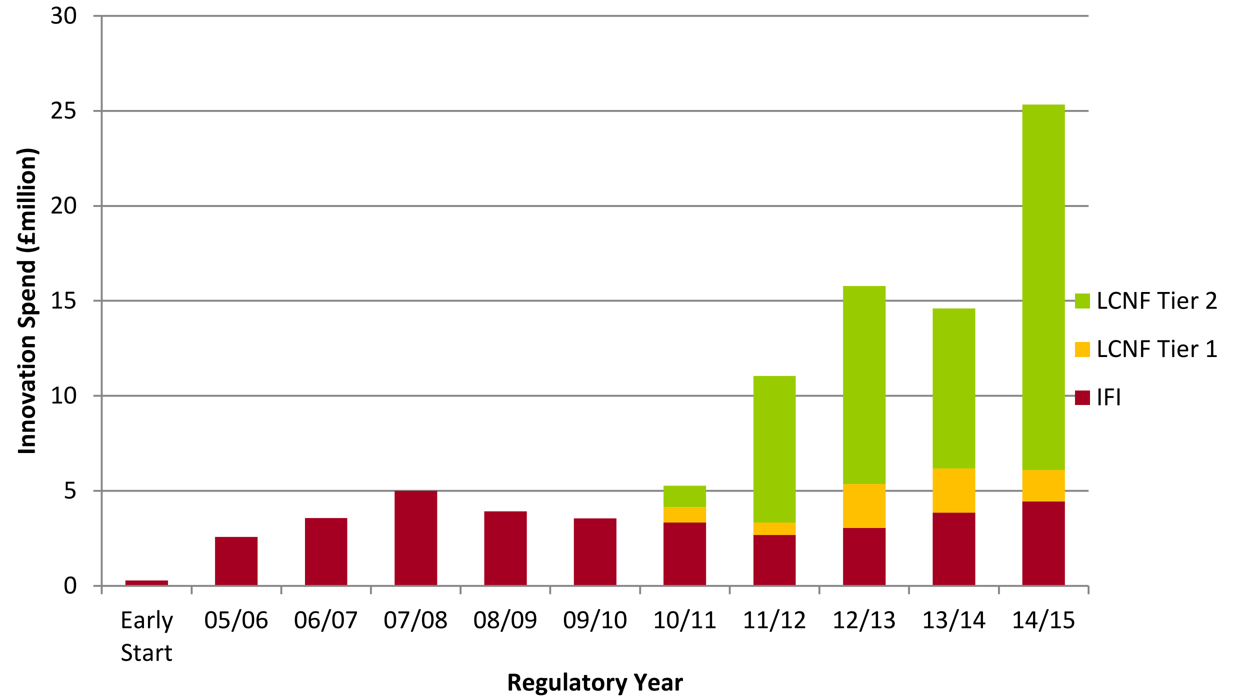


Figure 3: Trend of innovation spend

Regulatory Year	Total IFI Expenditure	IFI Allowance
This regulatory year 14/15	£4,449.6k	£7,020.5k
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	**£32,395.6k**	**£51,012.5k**

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 13/14 (£k)	£1,147.0k	£676.1k	£939.4k	**£2,762.4k**
Combined distribution network revenue (£m)	£561.9m	£458.3m	£383.9m	**£1,404.1m**
Allowance 14/15 (Including carry forward) (£k)	£3,956.5k	£2,967.6k	£2,858.9k	**£9,782.9k**
Eligible IFI expenditure 14/15(£k)	£1,812.5k	£1,630.1k	£1000.7k	**£4,449.6k**
Of which internal expenditure 13/14(£k)	£204.2k	£240.9k	£118.5k	**£563.6k**
The IFI carry forward to 15/16 (£k)	N/A	N/A	N/A	**N/A**

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

Expenditure from IFI Projects

Table 3 below details individual project expenditures from April 2014 to March 2015:

- Our innovation activities are organised into seven themes which describe the actions that need to be carried out to deliver innovation in a cost effective and timely manner.
- 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				
Overhead Line Fuse Saver*	302,153	195	83,933	386,281
Link Box Blanket	210,402	276,624	164,394	651,419
Overhead Lines Incipient Fault Detection	3,570	2	992	4,564
Vertical Transition Straight Joints Innovative Inspections*	10,873	173,968	32,619	217,460
Development of Technologies to Extend the Life of Link Boxes and Mitigate the Impact of Cable Pit Disruptive Failures	57,676	234,839	45,745	338,259
Detection of Broken and Low -hanging Conductors*	220,235	142	61,178	281,555
Earthing Design Tool	80,821	51,868	51,250	183,939
Directional Earth Fault Passage Indicator (DEFPI)*	-	205,165	-	205,165

£	EPN	LPN	SPN	Total
Fringe Fuses Monitoring	-	95,335	-	95,335
Smart Heat	12,188	12,371	10,735	35,293
Trial of Arc-Flash-Based Busbar Protection at Primary Sites	3,771	1,183	2,628	7,582
Leveraging Industrial and Commercial Demand Response and Dispatchable Generation				
Freight Electric Vehicles in Urban Europe*	-	14,207	-	14,207
Managing Residential and Small and Medium-Sized Enterprise (SME) Consumer Demand				
Building Management System to Grid	34,432	22,097	21,834	78,363
Vehicle to Grid (V2G)	110,896	57,494	69,724	238,114
Leading Indicators	32,713	20,994	20,744	74,452
New Options to Release Capacity at 11kV, 33kV and 132kV				
Solar Farm Operation Voltage Control	15,990	15,990	-	31,981
Increased Capacity from Existing Overhead Line Routes	12,385	8	3,440	15,834
Strategic Technology Programme (STP) Module 2 – Overhead Networks	19,485	12,505	12,356	44,346
Strategic Technology Programme (STP) Module 5 – Networks for Distributed Energy Resources	2,522	1,618	1,599	5,739
Fault Level Management Study	-	6,417	-	6,417
Understand Current and Future Performance of the 11kV and LV Network				
LV Remote Control and Automation / Smart Urban LV Network*	167,417	94,770	109,521	371,708
Strategic Technology Programme (STP) Module 3 – Cable networks	48,767	31,297	30,925	110,989
Strategic Technology Programme (STP) Module 4 – Substations	58,159	37,325	36,880	132,365
Rogowski Coil and Voltage connection Fuse Carrier	14,937	7,744	9,391	32,072

£	EPN	LPN	SPN	Total
Understand the Condition of our Assets				
Micro-helicopters	22,777	15	6,327	29,118
Transformer Research Consortium*	30,904	12,394	9,282	52,580
Underground HV Cable Research*	3,355	2,078	2,068	7,501
Develop Commercial Solutions and Products				
Bankside Heat Transfer	-	27,981	-	27,981
Collaborative Programmes				
Energy Innovation Centre*	161,124	103,860	108,665	373,649
Power Networks Research Academy	3,795	2,435	2,406	8,636
Collaborative ENA R&D Programme*	99,746	64,014	63,252	227,012
Closed projects that incurred cost	71,389	43,140	45,152	159,681
TOTAL (as reported in the RIGs)	**1,812,482**	**1,630,077**	**1,007,041**	**4,449,600**

*These projects are in the process of being transitioned to NIA.

Table 3: Allocation of expenditure per project and licence area

Please note the following:

- For readability, all the figures in the report have been rounded to the nearest £ or £k as appropriate – totals may therefore vary due to rounding.
- The Overhead Line Incipient Fault Detection project was stopped as the supplier, Altea, took the decision to exit the overhead line fault location market.
- A number of projects reported as completed in last year's IFI report incurred cost this year due to some closing activities taking place beyond March 2014 (last row of table 3). The projects are: Distribution Network Visibility, Urban Transformer Substation, Sustainable Asset Risk and Prioritisation Modelling, Earthing Information Systems and Technical Losses Review.
- Not all projects under the Energy Innovation Centre and ENA R&D programme are transitioning to NIA.

The next section presents the highlights from our IFI innovation programme.

Highlights

Portfolio highlights

Our IFI projects have delivered a number of successful outcomes. The table below highlights how the outputs and learning from selected projects (including two projects which completed last year) are benefiting UK Power Networks:

Sustainable Asset Risk and Prioritisation Modelling (report in the 13/14 report)	This project developed an Asset Risk and Prioritisation tool that enabled a more risk-based approach when deciding whether to replace, refurbish, or maintain existing assets. The new ARP models now cover 84% of the HI-reportable asset NRLE plan in EPN and SPN, and 64% in LPN, compared to the previously-used CBRM approach which only covered 15%.
Distribution Network Visibility (Reported in the 13/14 report)	This project developed a tool that can visualise and analyse data that was already collected from the network, enabling planners and designers to make better-informed decisions. Business as usual adoption has progressed well since the project concluded, and the DNV tool is now routinely used by 18 distribution planners and 8 connections designers.
Strategic Technology Programme (STP) Module 4 – Substations	The "transformer post-mortem" project found that 70% of decommissioned grid transformers were not yet at the end of their effective service life, validating UK Power Networks' decision to increase the amount of transformer refurbishment planned in RIIO-ED1.
LV Remote Control and Automation / Smart Urban LV Network	This project developed novel circuit breakers, switches, and control systems to provide a complete solution to monitor and automate LV networks. Following the successful transfer of the technology from TE Connectivity to EA Technology, the equipment is now manufactured under licence. To date, 69 circuit breakers and 36 link box switches have been installed as part of the Flexible Urban Networks Low Voltage LCNF Tier 2 project.
Link Box Blanket	UK Power Networks' LPN area contains approximately 45,000 link boxes, some of which have recently experienced disruptive failures due to a variety of reasons including gas leaks and water ingress. This project successfully developed a fire blanket that can be installed on existing link boxes to minimise the effects of disruptive failures, and proved their effectiveness in both laboratory tests and real-life failures. It is anticipated that 14,000 blankets will be deployed by Q4 2016.
Solar Farm Operation Voltage Control	This project demonstrated that solar PV farms can reduce their connection costs and curtailment by operating in voltage control mode. This involves varying their export power factor and coordinating with upstream voltage control devices, to maintain an acceptable supply voltage for all customers on their feeder.
Earthing Design Tool	This project developed a Microsoft Excel-based earthing design tool that allows distribution planners and connections designers to perform earthing studies that would normally need to be referred to specialists. The tool is currently used for all secondary substation earthing designs, allowing designs to be completed more quickly and cheaply.
Leading Indicators	This project developed a tool that forecasts the uptake of low-carbon technologies (LCTs) based on readily-available leading indicators. UK Power Networks is now using this tool to improve the accuracy of planning load estimates.
Rogowski Coil and Voltage connection Fuse Carrier	This project developed a novel fuse carrier that enables safer installation of current and voltage sensors on any type of LV switchboard, without needing to interrupt customers' supplies, or work near exposed live parts. This device is now available within UK Power Networks as a stock item.

Individual Project Reports

Managing Asset Risk and Improving Fault Performance

Overhead Line Fuse Saver

<table>
<tr><td>Description of Project</td><td colspan="4">Assessing the Fuse Saver as a potential alternative to auto-sectionalising links to achieve greater overhead line spur protection through enhanced fault detection and SCADA integration.</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>276,876</td><td>195</td><td>76,912</td></tr>
<tr><td>Internal</td><td>25,277</td><td>-</td><td>7,022</td></tr>
<tr><td>Total</td><td>302,153</td><td>195</td><td>83,933</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">-</td></tr>
<tr><td>Internal</td><td colspan="3">-</td></tr>
<tr><td>Total</td><td colspan="3">-</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£386,300</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Enhancing overhead line spur protection</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>17</td><td>-7</td><td>10</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:

Saving CI and CMLs – By protecting the customers on the whole overhead line from faults occurring on the spur, the Fuse Saver will reduce number of customers off supply and therefore reduce CIs and CMLs.

Customer Satisfaction / Reputational – Customers who live in rural areas traditionally incur greater number of faults due to less interconnection. Traditionally isolating a spur with an Automatic Sectionalising Link (ASL) requires the recloser on the main line to break the fault current, and the ASL will drop out and sectionalise the networks in the deadtime of the recloser. This means that all the customers on the main line will experience multiple short interruptions for every transient experienced by each spur. A Fuse Saver operates before the recloser and thus provides minimum disruption to all customers.

Enhanced Rural Network Monitoring – Rural networks currently have less monitoring capability than urban networks. The Fuse Saver coupled with an RTU would be able to communicate with the control system to aid the control engineer whilst storing monitored network loading and fault data for better long-term planning.

Cost Effective Alternative Solution – The Fuse Saver protects the spur fuse and thus reduces the operational cost of having to replace fuses for transient faults. The overall cost of installing a Fuse Saver with an RTU is more than installing the current spur protection arrangement of an Air Break Switch Disconnector and an ASL, but it provides increased</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">functionality, similar to that provided by the more expensive remotely controlled reclosers, which are currently only used on main lines.</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2015/2016</td><td>Duration of benefit once achieved</td><td>20 years</td></tr>
<tr><td>Probability of success</td><td>95%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>£368,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="3">The potential of success is high as feedback to date has been positive.</td></tr>
<tr><td>Project Progress
March 2015</td><td colspan="3">The project began in April 2014 and since then:
• The sites have been identified and surveyed
• The Hotglove installation process has been approved
• The optimal installation method has been ascertained
• A new symbol for the network control diagram has been developed
• Operational functionality has been proved at low voltage in laboratory conditions

Next steps to be completed under NIA (link to project) are:
• To complete SCADA integration
• Install the purchased devices onto the network
• Prove financial benefits of Fuse Saver</td></tr>
<tr><td>Collaborative Partner</td><td colspan="3">Siemens</td></tr>
<tr><td>R&D Providers</td><td colspan="3">Siemens</td></tr>
</table>

Link Box Blanket (Completed)

<table>
<tr><td>Description of Project</td><td colspan="4">There are approximately 45,000 link boxes currently operating within the LPN region of UK Power Networks, consisting of a mix of cast-iron bitumen-filled and plastic resin-filled construction.

In recent years, there has been a rise in link box disruptive failures due to a variety of reasons including gas leaks and water ingress. This led to an increase in capital expenditure allowance for the replacement of link boxes, and UK Power Networks carried out a comprehensive end-to-end review of their link box processes to improve the management of these assets.

As part of this review, a low cost mitigation method was developed as opposed to a lengthy replacement programme. It has been found that cable damage blankets can further reduce the risk of failures having any external impact above ground.

In this project, a blanket specific for link boxes was developed and trialled to minimise the effects of these disruptive failures.</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>192,863</td><td>253,564</td><td>150,690</td></tr>
<tr><td>Internal</td><td>17,539</td><td>23,059</td><td>13,704</td></tr>
<tr><td>Total</td><td>210,402</td><td>276,624</td><td>164,394</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the number of link boxes in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">-</td></tr>
<tr><td>Internal</td><td colspan="3">-</td></tr>
<tr><td>Total</td><td colspan="3">-</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£651,400</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Installation of blankets to minimise the disruptive forces relating to a link box failure.</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>-2</td><td>13</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• Maintaining the safety of the public, our employees and contractors
• Minimisation of damage to third party assets by reducing the impact of link box faults</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2015</td><td>Duration of benefit once achieved</td><td colspan="2">30 years</td></tr>
<tr><td>Probability of success</td><td>70%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">£ 100,000</td></tr>
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Potential for Achieving Expected Benefits	The benefits to the safety of the public and network reliability have been proven to be successful (see progress report below).
Project Progress March 2015	Since commencing the project, there have been two disruptions in link boxes which had disruptive blankets fitted. During these incidents, there was no evidence of the covers lifting. All trialling, including research and development of the blankets was carried out by UK Power Networks internally. One trip to a test laboratory, Veiki in Hungary, was undertaken to prove the effectiveness of the blanket within a link box under controlled conditions. The testing proved its acceptability under test loading, without the bell housing or cover moving. The trials were completed in March 2015. As a result of the success of the trial, UK Power Networks has purchased a further 17,000 for deployment across LPN, SPN and EPN.
Collaborative Partner	AUS, the blanket producer worked with us to change the design of the blanket including labelling, strapping etc. This was funded by AUS.
R&D Providers	AUS, Veiki

Overhead Line Incipient Fault Detection

Description of Project	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			
Expenditure for Financial Year		EPN	LPN	SPN
	External	235	2	65
	Internal	3,335	-	926
	Total	3,570	2	992
	The costs have been allocated in proportion to the length of overhead lines in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£417,468		
	Internal	£52,946		
	Total	£470,414		
Total Project Costs (Collaborative + External + UK Power Networks)	£659,000	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological Area and / or Issue Addressed by Project	• 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			
Type(s) of Innovation Involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		16	0	16
Expected Benefits of Project	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			
Expected Timescale to Adoption	N/A	Duration of benefit once achieved	>10 years	
Probability of success	0%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£215,000	
Potential for Achieving Expected Benefits	The Overhead Line Incipient Fault Detection project was stopped as the supplier, Altea, took the decision to exit the overhead line fault location market.			
Project Progress March 2015	UK Power Networks is currently reviewing whether an alternative solution with a different supplier should be trialled under NIA.			
Collaborative Partner	Electricity North West			
R&D Providers	ALTEA B.V			

Vertical Transition Straight Joints Innovative Inspections

Description of Project	Between 1996 and 2013 switchgear changes in the LPN area of UK Power Networks were carried out and included the introduction of vertical straight joints (VSJs) inside substations. Between January 1998 and the present date there have been over 80 disruptive VSJ failures. To date no-one has been injured, but consequential damage to adjacent equipment has occurred. This project has seen the development and then trial of the PD Hawk and Ultra Tev+ equipment used to detect partial discharge in the VSJs identifying joints with potential defects. Further to this a mitigation blanket to encase the VSJ has been developed.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	8,543	136,687	25,629
	Internal	2,330	37,281	6,990
	Total	10,873	173,968	32,619
	The costs have been allocated in proportion to the number of vertical transition joints in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	-		
	Internal	-		
	Total	-		
Total Project Costs (Collaborative + External + UK Power Networks)	£280.839 (IFI) + £610,306 (NIA)	Projected 2015/16 to 2016/2017 costs for UK Power Networks	£0	
Technological Area and / or Issue Addressed by Project	The issue faced by Asset Management was the disruptive faulting of VSJs causing risk to operatives and the public.			
Type(s) of Innovation Involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		11	-4	15
Expected Benefits of Project	Benefits are expected to include: • The successful development of the PD Hawk and Ultra Tev+ used to detect partial discharge. This can be used to inspect VSJs on a regular basis to help identify deterioration in the joint. It will also be used by operatives as part of a pre-entry check when working inside a substation. This will reduce the risk when entering a substation • The development, testing and trial of the mitigation blankets will reduce the impact of a VSJ failure. A disruption will be contained by the blanket reducing the overall damage to the substation			
Expected Timescale to Adoption	2015	Duration of benefit once achieved	10 years	
Probability of success	70%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000	
Potential for Achieving Expected Benefits	The PD Hawk has demonstrated success in the trials so far and with a further trial to establish the acceptable partial discharge threshold it will be able to be introduced for widespread use in substation inspections. The mitigation blankets have been proven to provide benefit in reducing the			

	impact of a failure.
Project Progress March 2015	Mitigation blanket has been laboratory tested to ensure its suitability and has recently been installed on a sample of 100 VSJs at over 50 sites in LPN and trials completed. The project will focus on defining the bandwidth at which HV cable joints fail and this will be determined with the project undertaking the following activities: • A further round of inspections using the PD Hawk at VSJ sites to extract PD data collection on HV cable joints within substations of UK Power Networks • Analyse PD data recorded • Retrieve defective joint/s for forensic analysis to have a better understanding of joint failure and build confidence in the reliability and performance of the detection system • Data collected as part of another IFI project “Cable Pit Mitigation Strategy” will also be used • A final product “Canary” (that can remain in situ at the site) will be developed) as part of the project following the above activities which will be used to monitor the health of HV cable joints within substations, cable pits, tunnels and help identify high risk sites for controlled repair/replacement
Collaborative Partner	N/A
R&D Providers	Black &Veatch, EA Technology

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

<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, can be locked and tethered will be used, and might include built-in monitoring equipment to send information about the condition 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>49,189</td><td>200,282</td><td>39,013</td></tr>
<tr><td>Internal</td><td>8,487</td><td>34,557</td><td>6,731</td></tr>
<tr><td>Total</td><td>57,676</td><td>234,839</td><td>45,745</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">£723,254</td></tr>
<tr><td>Internal</td><td colspan="3">£27,946</td></tr>
<tr><td>Total</td><td colspan="3">£751,200</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,030,000</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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>

Expected Benefits of Project	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		
Expected Timescale to Adoption	Started in 2013	Duration of benefit once achieved	20 Years
Probability of Success	90%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000
Potential for Achieving Expected Benefits	The benefits to the safety of the public and network reliability has been proven to be successful following ongoing disruptive events in mitigated cable pits and a validation of the risk rating.		
Project Progress March 2015	The project is completed as of March 2015. The inspections and mitigation strategies developed as part of the project are authorised, adopted and progressing well into business as usual activity for UK Power Networks.		
Collaborative Partners	N/A		
R&D Provider	Black & Veatch Ltd, ERA Technology, SSC Ltd		

Detection of Broken and Low-Hanging Conductors

<table>
<tr><td>Description of Project</td><td colspan="4">Detection of broken and low-hanging conductors is a long-standing issue for GB 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</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>200,220</td><td>142</td><td>55,618</td></tr>
<tr><td>Internal</td><td>20,015</td><td>-</td><td>5,560</td></tr>
<tr><td>Total</td><td>220,235</td><td>142</td><td>61,178</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">£43,299</td></tr>
<tr><td>Internal</td><td colspan="3">£4,784</td></tr>
<tr><td>Total</td><td colspan="3">£48,083</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£590,408</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">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.</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>13.4</td><td>-2</td><td>15.4</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
Reduction in 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
Giving control engineers greater visibility of broken or low-hanging conductors, allowing them to make better decisions when prioritising incident responses and mobilising staff
Identifying innovative ways of using existing protection relays to improve their effectiveness
Overcoming limitations of existing technology, e.g.:<ol type="a">
Detection of faults on long overhead lines (i.e. far from the source substation)
Detection of short duration/transient faults
Enabling a more focussed risk management strategy, by using mechanical sensors to monitor conductors that could fall into high risk (i.e. publicly accessible) areas</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2016</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</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"><£100,000
Safety benefits have not been monetised within this figure.</td></tr>
</table>

<table>
<tr><td>Potential for Achieving Expected Benefits</td><td>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.</td></tr>
<tr><td>Project Progress
March 2015</td><td>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

<u>Electrical Detection Methods</u>
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 2015/16 period under a NIA project.

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.

<u>Mechanical Detection Methods</u>
There is currently no cost-effective and commercially available product that could be immediately deployed. A commercial partner (Nexans UK) has been identified and is developing a mechanical sensor for the detection of broken and low-hanging conductors.

Practical tests in Q4 2014 proved that a prototype sensor was able to detect a number of different low or broken conductor scenarios.

Work has now started on a new sensor which will be optimised for use on 11kV and 33kV overhead lines and the intention is that this will be tested during 2015/16. Wider-scale deployment will be dependent on the cost-effectiveness of the final product.</td></tr>
<tr><td>Collaborative Partners</td><td>Nexans UK</td></tr>
<tr><td>R&D Provider</td><td>EA Technology Ltd, Nexans UK</td></tr>
</table>

Earthing Design Tool (Completed)

Description of Project	The project will develop a 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 in previous years).			
Expenditure for Financial Year		EPN	LPN	SPN
	External	70,849	45,469	44,927
	Internal	9,971	6,399	6,323
	Total	80,821	51,868	51,250
	The costs have been allocated in proportion to the number of customers in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£70,713		
	Internal	£9,377		
	Total	£80,090		
Total Project Costs (Collaborative + External + UK Power Networks)	£264,000	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological Area and / or Issue Addressed by Project	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.			
Type(s) of Innovation Involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		11	-3	14
Expected Benefits of Project	Improved productivity at the design stage of new substation projects.			
Expected Timescale to Adoption	2014	Duration of benefit once achieved	10 years	
Probability of Success	100%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000	
Potential for Achieving Expected Benefits	It is expected that the benefits will be fully realised.			
Project Progress March 2015	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 and provides a consistent approach and helps to identify situations where a			

	bespoke design or assistance from an earthing specialist may otherwise 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. A new version 4 of the earthing design tool is currently being developed and will include the following features: • Research into the likely network contribution from existing cable networks • An enhanced circuits model to cater for a larger number of cables and overhead lines • Improved access and visibility of the data from the earthing maps IFI project • Additional functionality to improve the user experience • A compliance check with the latest earthing standards • A platform update to make it easier to support and update in the future
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. Modern 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>-</td><td>168,306</td><td>-</td></tr>
<tr><td>Internal</td><td>-</td><td>36,859</td><td>-</td></tr>
<tr><td>Total</td><td>-</td><td>205,165</td><td>-</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 rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">-</td></tr>
<tr><td>Internal</td><td colspan="3">£2,559</td></tr>
<tr><td>Total</td><td colspan="3">£2,559</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£479,000</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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>
</table>

Project Progress March 2015	• Nortech has developed their NX42 (a directional enhancement of their existing NX41 Fault Passage Indicator). The NX42 can be configured to detect the direction of earth faults, sensitive earth faults, overcurrent faults and phase-to-phase faults. At the end of March 2015, the installation method had been approved and 24 units installed on modern RMUs, where individual HV current measurements and voltage presence indicators are available. • The NX42 device replaces the existing fault passage indicator and provides local fault direction indication (via LEDs) as well as transmitting fault detection events through RTUs back to the centralised network management system. The straight-forward installation of the devices is facilitated by a field support kit, which gives the commissioning engineer a configurable graphical user interface. This allows the different types of fault direction detection "Into the RMU", "Away from the RMU" and "Indeterminate" to be tested and verified as part of the commissioning process. • The NX42 cannot be used on legacy RMUs with only a core balance CT. Installation and commissioning without the removal of meshing, has proved a challenge. PPA Energy (a practice of Ricardo-AEA) has successfully demonstrated their DEFPI and measuring algorithm on UK Power Networks' training centre. The Ricardo-AEA device makes use of the existing fault passage indicator wiring and existing RTU measurements (voltage and current) and can be quickly connected with HV circuit connected live. The orientation of the core balance CT and secondary wiring is essential to obtain correct direction indications. Four units have been installed. One unit has been commissioned. • Symbols have been added to PowerOn fusion providing the control engineer with visibility of the direction of fault current, communications, alarms, and reset operations have been validated • As faults occur on the ringed circuits the results are investigated to check that they have provided the correct indication and improved the restoration time for customers' supplies
Collaborative Partners	None
R&D Provider	Nortech Management Ltd, PPA Energy (a practice of Ricardo-AEA)

Fringe Fuses Monitoring (Completed)

<table>
<tr><td rowspan="1">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>-</td><td>68,170</td><td>-</td></tr>
<tr><td>Internal</td><td>-</td><td>27,165</td><td>-</td></tr>
<tr><td>Total</td><td>-</td><td>95,335</td><td>-</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 rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£832</td></tr>
<tr><td>Internal</td><td colspan="3">£889</td></tr>
<tr><td>Total</td><td colspan="3">£1,721</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£82,744</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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 for making comparisons 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>
</table>

Probability of Success	60%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£130,000
Potential for achieving expected benefits	Within this project, monitoring equipment was developed and installed to indicate where fuses have blown and to measure these high currents and short time durations at seven secondary substations in the Kensington area of west London. This area was chosen because the LV network remains fully interconnected across HV feeders and there is a history of HV faults. The monitors developed by Nortech and GMC-I PROSyS detect fuses that have operated and measure high currents/time to indicate the actual duty the fuse was subjected to during a fault condition. This is in addition to the usual substation monitoring of volts, amps, power, power factor etc. with all data being stored and displayed on a web server hosted by Nortech. Both HV and LV faults were experienced and data collected by the monitors showed fuses had been subjected to high currents of up to 5000amps for up to 100mS which, although the fuse did not operate, may have weakened it. The monitor also detected and reported fuses operated due to LV faults where supplies were maintained by other fuses in the interconnected network that did not operate. These would otherwise have gone un-noticed until other equipment failed causing a loss of supply. The monitor also indicates power flow direction through the fuses. In a conventional radial network, this flow will normally be away from the substation, but in an interconnected network there is the opportunity for power to flow both ways. Reverse power flows were seen at a number of locations giving the operational teams and the planning department a better understanding of how the network is performing. As smart networks use more interconnection then this knowledge will become more important. The idea that fuses can become weakened is often disputed. An independent test station was chosen to subject fuses to currents to replicate the predicted and measured values during a fault and to see if the fuse would then perform adequately. A series of new fuses were conditioned by passing up to 5000amps for up to 200mS and repeating a number of times. The fuses were then deliberately operated (blown) with the operating time compared against the standard IEC 60269-2 (BS88-2:2013). Fuses recovered from the network both at the monitoring sites and from other LPN interconnected areas were also tested. The results showed a definite reduced operating time against a new fuse. These monitoring units will remain in place until July 2018, at which time they may continue or be moved to other locations as the company requires.		
Project Progress March 2015	This project successfully completed in March 2015 and has drawn the following conclusions: • A weakened interconnected network is likely to incur high CIs and CMLs in later faults • A network can be weakened if: - The running arrangement is not as designed		

	- Fuses have blown - Fuses have been weakened A weakened fuse can be considered as one where the time to operate is reduced; potentially causing premature loss of supply. Monitoring at individual substation fuses can identify weakened fuses both at the substation and at unmonitored positions on meshed cables. Effective monitoring would require this type of monitor to be ideally installed in at least 50% of the interconnected secondary substations. Some interconnected networks perform adequately and maintain LV supplies during HV faults and therefore at this stage would not require this type of detailed monitoring. Other interconnected networks are more prone to dropping supplies during HV faults and could benefit from enhanced monitoring. The actual feeder groups involved and the number of secondary substations to be monitored would need to be further assessed. The cost of the monitors used in the trial would not be cost effective to use on all interconnected networks in LPN but would be more acceptable if only on the worst performing networks or on a more targeted approach. This project and test results have shown that the high current events typically seen in a phase to phase HV fault weaken fuses. The type of monitor used can help show when running arrangements change, by changes to power flow patterns or by excess current reports. It can also show blown fuses and can indicate high current events that can weaken fuses. By showing power flow direction, the monitor provides a better understanding of how networks perform when interconnected. Some interconnected LV networks will be nominated to be converted to radial networks. Networks converted in the past have usually required subsequent redesign due to the lack of detailed network data. Monitors as used in this project could be used to gather data prior to radialisation to reduce the need for redesigns by a better first-time design relevant to actual network data. The Planning department can use the Fault Study Package (FSP) in network modelling software to identify these fuses. FSP can be run without the need to create an accurate load model and still give sufficiently accurate results. It will identify distribution substations that pass the high currents (for e.g. >5000 amps), then a visual check will identify which fuseways are interconnected (and therefore subject to the higher currents) and which are radial feeds. The interconnected fuseways can be targeted, so when a post HV fault network sweep is carried out, these fuses can be replaced as a matter of routine. The removed fuses can be clearly marked (R) and reused in radial networks where they will operate adequately. A revised network sweep policy taking account of the above comments and making full use of recording actions against Enmac log entries should be implemented.
Collaborative Partners	None
R&D Provider	Nortech Management Ltd

Smart Heat (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">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 of cable freezing and eliminate the associated risks and costs.</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>8,580</td><td>8,710</td><td>7,558</td></tr>
<tr><td>Internal</td><td>3,607</td><td>3,662</td><td>3,177</td></tr>
<tr><td>Total</td><td>12,188</td><td>12,371</td><td>10,735</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of fluid cables in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£954</td></tr>
<tr><td>Internal</td><td colspan="3">£7,990</td></tr>
<tr><td>Total</td><td colspan="3">£8,944</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£44,240</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Not all of our fluid-filled cable networks have 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>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14.4</td><td>-2</td><td>16.4</td></tr>
</table>

Expected Benefits of Project	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 • Elimination of 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		
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 2015	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. Field trials have proved successful for leak rates above 400 litres per month. Given these results this new method is a viable option to replace cable freezing for leak location work at higher leak rates.		
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 (Completed)

Description of project	This project is trialling a busbar protection system based on optical arc-flash detection.			
Expenditure for financial year		EPN	LPN	SPN
	External	3,237	1,016	2,255
	Internal	535	168	372
	Total	3,771	1,183	2,628
	The costs have been allocated in proportion to the number of primary substations in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£5,002		
	Internal	£1,324		
	Total	£6,326		
Total Project Costs (Collaborative + external + UK Power Networks)	£35,000	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological area and / or issue addressed by project If applicable only	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.			
Type(s) of innovation involved	Technological substitution from outside industry	Project Benefits Rating	Project Residual Risk	Overall Project Score
		15.2	-4	19
Expected Benefits of Project	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			
Expected Timescale to adoption	2015	Duration of benefit once achieved	For the lifetime of the installed switchgear	
Probability of Success	80%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£150,000	
Potential for achieving expected benefits	Arc-flash detection as a busbar protection system has already been proven by overseas DNOs and GB industrial customers. Until there is further certainty about the site works and a new NIA project is raised for the			

	successful demonstration of the system, we will only then be able to endorse this method of busbar protection for both new and existing installations.
Project Progress March 2015	Progress to date is as follows: • Installation of arc-flash detection system in switchgear at the manufacturer's premise and FAT has been undertaken • Verification of the Engineering Instructions detailing installation and commissioning requirements for the trial system have completed • Construction work at the selected substation site has been postponed due to optimisation of work plans which has removed the replacement work from the current programme of works. This has resulted in this project being terminated prior to the demonstration of the arc-flash detection system, until there is further certainty about the site works It is intended to raise a new NIA project to evaluate the demonstration in the future.
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>-</td><td>9,824</td><td>-</td></tr>
<tr><td>Internal</td><td>-</td><td>4,383</td><td>-</td></tr>
<tr><td>Total</td><td>-</td><td>14,207</td><td>-</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 rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£81</td></tr>
<tr><td>Internal</td><td colspan="3">£5,786</td></tr>
<tr><td>Total</td><td colspan="3">£5,867</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£50,738</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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 design and 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>80%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td colspan="2">Small</td></tr>
</table>

Potential for achieving expected benefits	The potential for achieving the expected benefits of this project is high. The insights gained from the data collected are 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 further developed as the project progresses.
Project Progress March 2015	Monitoring trials have now completed. This project primarily involves data capture and analysis of the power requirements of a fleet of EV delivery trucks. The data has been captured for 12 months from 18 charge points that provide power to a fleet of EV delivery trucks. The project has monitored the charge posts at 10min intervals recording current, voltage and power (kW). This data will be used to determine the profile power demand over the period of monitoring, defining charging profiles for commercial fleets. The analysis will be conducted by the technical assessment partners on the project – Imperial College London and the EU partner SINTEF. Currently, the data has been transferred to these partners and we are expecting the review and analysis. The conclusions will form part of the wider EU project learning outcome.
Collaborative Partners	Westminster City Council, UPS
R&D Provider	Imperial College London

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

Building Management System to Grid (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">This project investigated the potential capacity for commercial buildings to participate in Demand Side Response (DSR), by control and management of DSR events via incumbent Building Management System (BMS) typically installed in commercial buildings.

This project was the first phase of a potentially multi-phase project. It considered the mechanisms and interfaces that would be required, the costs and barriers of implementation, and modelling of building types and built to various building standards dependant on building regulations at the time of build.</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>31,425</td><td>20,168</td><td>19,928</td></tr>
<tr><td>Internal</td><td>3,007</td><td>1,930</td><td>1,907</td></tr>
<tr><td>Total</td><td>34,432</td><td>22,097</td><td>21,834</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">-</td></tr>
<tr><td>Internal</td><td colspan="3">-</td></tr>
<tr><td>Total</td><td colspan="3">-</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£78,400</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Assessment of commercial buildings ability to provide practical levels of demand side response. Gain understanding of the differential between buildings of different ages, and building to different standards (driven by the building regulations at the period of build).</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>12</td><td>-2</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The project made a valuable contribution to understanding:
The potential benefits of implementing a system such as BMSG
Cost assessments and barriers to the deployment of such systems as part of a DNO driven DSR scheme
Schedule of services within buildings which have the potential to response to BMS triggered DSR events
Modelled outputs of building load for both 2010 and 1995 building specifications for different building/tenancy types and weather years
Assessment of response type/capacity/duration available for DSR schemes via commercial buildings</td></tr>
</table>

<table>
<tr><td>Expected Timescale to adoption</td><td>Unlikely to proceed commercially</td><td>Duration of benefit once achieved</td><td>If developed this would be in line with more traditional DSR schemes therefore 1 to 4 years typically</td></tr>
<tr><td>Probability of Success</td><td>Unlikely to proceed commercially</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 primary output of the project is a report which details the findings of assessment and modelling outputs and focusses on the commercial buildings ability to respond to typical network requests for DSR, due to network peaks or faults. This would be via the deployment of pre-heating and pre-cooling (or other) that may be triggered via the BMS interface to flatten network demand as a pre-constraint and pre-fault precautionary measure.

The findings of the report detail the results for the various modelling runs, including hotels, office, retail and mixed use and show typically that buildings built to older (1995) building regulations had more potential to provide DSR due to the less efficient equipment and building fabric. This is an expected output.

The findings also show that typically, commercial buildings are unable to sustain response events for extended durations. Typically, performance beyond one hour is not sustained or sustainable. It also notes that costs for enabling DSR to be integrated with BMS systems are potentially significant and could not be recouped within typical DSR contract durations.

Without a more complex, aggregated and sequential despatch mechanism, DSR from commercial buildings, via BMS, is unlikely to provide a major constituent part of an aggregated DSR scheme for DNOs in the near term and unlikely to achieve the benefits due to the schemes' cost of deployment vs DSR ratio.</td></tr>
<tr><td>Project Progress
March 2015</td><td colspan="3">The project (phase 1) completed in January 2015 via the submission and review of a project report.

The report is available to other DNOs upon request and details the outputs of the project, including all modelling runs and findings. It also details the expected costs of deploying such schemes including deployment of new technology where required to enable such a scheme to go ahead.

The findings of phase 1 are comprehensive and show the potential of buildings, built at different times, to participate in demand response schemes. However, based on the findings as shown, there is a finite capacity per building using the typical equipment installed and physical building performance. As the following phases rely on these buildings, as modelled, it is not recommended to progress to subsequent phases.</td></tr>
<tr><td>Collaborative Partners</td><td colspan="3">N/A</td></tr>
<tr><td>R&D Provider</td><td colspan="3">AECOM (phase one)</td></tr>
</table>

Vehicle to Grid (V2G) (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">With consumer and governmental pressure to reduce transport CO2 emissions, automotive manufacturers are investing 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.</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>101,551</td><td>52,649</td><td>63,848</td></tr>
<tr><td>Internal</td><td>9,345</td><td>4,845</td><td>5,875</td></tr>
<tr><td>Total</td><td>110,896</td><td>57,494</td><td>69,724</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">£949</td></tr>
<tr><td>Internal</td><td colspan="3">£768</td></tr>
<tr><td>Total</td><td colspan="3">£1,717</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£239,8310</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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 by informing DNOs on the technical requirements for V2G deployment</td></tr>
<tr><td>Expected Timescale to adoption</td><td>3 years</td><td>Duration of benefit once achieved</td><td colspan="2">20 years</td></tr>
</table>

Probability of Success	35%	Project NPV (Present Benefits – Present Costs) x Probability of Success	Small
Potential for achieving expected benefits	UK Power Networks' view of V2G is that, at this stage, it has a number of issues to overcome in terms of user acceptance and business models which will need to rely on revenues from the wholesale or balancing markets in addition to any services or controlled discharging agreed with DNOs. In the longer term, this innovation will also depend on developments from third parties (e.g. will vehicle manufacturers 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 2015	The following project objectives have been completed: • Assessment of the suitability of a bi-directional charger/inverter for mounting within the car. It has been successfully demonstrated that through research involving a literature review, investigation of existing products available in the marketplace and the developed V2G enabled prototype EV that it is possible to fit an inverter into an existing electric vehicle to achieve vehicle to grid operation • The project has also successfully demonstrated the communications between the on-board vehicle charging equipment, vehicle charge points and remote charge point management system (back office) with vehicle equipment – this is required for autonomously managed V2G transactions. Direct charge/discharge regimes in a safe, robust and stable manner has been satisfactorily demonstrated on the project. This end-to-end system has been integrated into an EV and operation successfully demonstrated. Performance of the system solution has been in line with expectations • The products selected to perform the V2G functionality were sourced from a supply chain throughout Europe and there is confidence the technical functionality can be replicated. Finally, a prototype EV was developed which showcases the incorporations required on-board the vehicle for a V2G application • Investigations into the effect of the additional burden of V2G operation (charge/discharge cycle) on EV on battery life were also completed • An assessment of the efficiency of the charge/discharge cycle when applied to automotive lithium ion batteries was also conducted. However, this proved a difficult measure to attain with the data and approach taken on this project		
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		

Leading Indicators (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">This project has been undertaken to produce a tool that can be used to forecast future uptake of key low carbon technologies (LCTs), for integration into our current network load forecasting processes. Currently, our forecasts contain relatively static growth forecasts for the key low carbon technologies (photovoltaic, onshore wind, electric vehicles and heat pumps), based on data that is constantly changing.

The tool that has been developed tracks a number of key drivers (‘Leading Indicators’) that have been found to most influence future adoption rates of the technologies. The main indicators tend to be based around cost/cost savings, such as upfront capital charge, government incentives, cost of traditional electricity (and hence savings in consumers bills). For some of the technologies, the indicators include public attitudes towards the technology, and ‘hassle factors’ involved in the installation or use of the LCT. These leading indicators can then be tracked on a regular basis (up to a quarterly resolution), to see whether any significant changes may occur in the uptake of these LCTs, and integrated into our current load forecasting model to form part of our planning processes.</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>30,707</td><td>19,707</td><td>19,472</td></tr>
<tr><td>Internal</td><td>2,006</td><td>1,288</td><td>1,272</td></tr>
<tr><td>Total</td><td>32,713</td><td>20,994</td><td>20,744</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">-</td></tr>
<tr><td>Internal</td><td colspan="3">-</td></tr>
<tr><td>Total</td><td colspan="3">-</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£74,450</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Low Carbon Technology forecasting & addressing current lack of responsiveness to market changes in the current forecasting process.</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>8</td><td>-1</td><td>9</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:
• More advanced and accurate forecasting of generation in key areas of our networks
• Reduction in unplanned asset failure due to low carbon penetration, providing a financial saving (planned replacement is generally less expensive than unplanned)
• Improvement of network performance (CIs and CMLs), due to reduction in unplanned asset failure</td></tr>
</table>

Expected Timescale to adoption	2015	Duration of benefit once achieved	Ongoing
Probability of Success	100%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£600,000 - £700,000
Potential for achieving expected benefits	High potential of achieving expected benefits. The developer of the tool (Element Energy) have a strong track record of providing forecasting tools for DNOs, and this tool draws on all their existing knowledge, so the tool is expected to improve our forecasting ability.		
Project Progress March 2015	The project was completed in March 2015, with the tool providing forecasts that appear reasonable – when the model is used to predict historic uptake (using historic Leading Indicators), it tracks well to what has actually been observed. The tool will be regularly updated to ensure it continues to perform well, and adjustments made where necessary. The outputs have now been built into our existing planning and will form part of future consultations with stakeholders on low carbon take up. The revised forecasts on both PV and wind have been presented to external stakeholders including Ofgem.		
Collaborative Partners	None		
R&D Provider	Element Energy		

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

Solar Farm Operation Voltage Control (Completed)

<table>
<tr><td>Description of project</td><td colspan="4">The overall aim of the project was to assess the effect of a small scale PV farm (4.5MVA), connected onto the 11kV distribution network, when operating in voltage control mode, in terms of both the effect on the voltage at the point of common connection (PCC) and its effectiveness at maintaining a desired voltage targets at various load and generation conditions.</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>12,685</td><td>12,685</td><td>-</td></tr>
<tr><td>Internal</td><td>3,306</td><td>3,306</td><td>-</td></tr>
<tr><td>Total</td><td>15,990</td><td>15,990</td><td>-</td></tr>
<tr><td colspan="4">The costs have been allocated equally to EPN and SPN.</td></tr>
<tr><td rowspan="3">Expenditure in previous (IFI) financial years</td><td>External</td><td colspan="3">-</td></tr>
<tr><td>Internal</td><td colspan="3">-</td></tr>
<tr><td>Total</td><td colspan="3">-</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£32,000</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and / or issue addressed by project
If applicable only</td><td colspan="4">The project sought to monitor, analyse and optimise the performance of the scheme, prove that the connection to the closest 11kV OHL is a viable alternative to the cable connection back to Exning Primary and that the localised voltage control system will be able to communicate and cooperate effectively with the centralised Automatic Voltage Control (AVC) scheme currently in place at Exning Primary.</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>17</td><td>-3</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Benefits are expected to include:

• Validate initial assumptions and simulation results with the real time operational data
• Investigate how PV farm and AVC scheme control modes can be coordinated
• Select the correct operation mode of the AVC scheme at Exning primary
• Optimise the performance of the scheme
• Prove that the connection to the closest 11kV OHL is a viable alternative to the cable connection back to Exning Primary, and that localised voltage control systems are able to communicate and cooperate effectively with a centralised Automatic Voltage Control (AVC) scheme</td></tr>
<tr><td>Expected Timescale to adoption</td><td>6 to 12 months</td><td>Duration of benefit once achieved</td><td colspan="2">Lifetime of assets (>20 years) or enabled connections</td></tr>
</table>

Probability of Success	100%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£ 465,000
Potential for achieving expected benefits	Project is complete, all benefits were achieved.		
Project Progress March 2015	The automatic voltage control scheme at the local Primary was upgraded to SuperTAPP n+ with additional feeder measurement. To optimise the performance of the AVC system, a remote measurement was installed at the customer premises to provide real and reactive power measurements, with GPRS communication linking it with the AVC scheme. The AVC system at the primary substation was configured according to UK Power Networks voltage control policy with the aim of maintaining a suitable voltage profile on the network. The constant voltage at the remote point on the network was maintained by the AVC scheme with the use of load drop compensation, generation bias and remote measurements. A limit to the power factor of 0.9 Lead to Lag was applied to allow the generation a reasonable range of operation and to ensure that a power output of 4.5 MVA was achieved. It was demonstrated that this configuration provided acceptable level to enable a maximum of 4.5MW export under various load conditions. As the project was proved successful, the customer has benefited from an economically viable connection, with the connection on the OHL passing over the site instead of having to lay a 3km cable back to the primary substation. Additionally, this scheme provides the customer with a guaranteed firm generation output as opposed to the limited available capacity when not operating under voltage control mode (for the same point of connection). Similar savings are expected to be possible across GB with future generation connections that would otherwise be limited by network voltage constraints. One area of further development relates to the setting curves used for the voltage control mode at the PV farm. It is thought that further efficiencies could be made, whereby changes could reduce the level of reactive power absorbed by the generator.		
Collaborative Partners	Fundamentals Ltd		
R&D Provider	Fundamentals Ltd		

Increased Capacity from Existing Overhead Line Routes (Completed)

<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>8,389</td><td>8</td><td>2,330</td></tr>
<tr><td>Internal</td><td>3,996</td><td>-</td><td>1,110</td></tr>
<tr><td>Total</td><td>12,385</td><td>8</td><td>3,440</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">£433,127</td></tr>
<tr><td>Internal</td><td colspan="3">£56,585</td></tr>
<tr><td>Total</td><td colspan="3">£489,712</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£505,550</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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>75%</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 benefits which we expected to achieve associated with one of the case studies, and which we highlighted in our innovation strategy for RIIO-ED1, will not be achieved. Whilst the use of LIDAR to demonstrate increased capacity on the line was successful and demonstrated that there was some “slack” in the original build, this was then hampered by a number of new clearance issues which were found in the scan, and by condition assessments of the towers themselves. As such, the appropriate sections will be re-strung on new towers.</td></tr>
</table>

Project Progress March 2015	During this period the project has assessed further routes for application of reduced cost OHL reinforcement. The project has now been closed. During the project some uprating options were rejected and others included in a new guidance document for assessing uprating overhead lines. Specifically the detailed assessment of the route profile and conductor condition to determine whether a static temperature uprating is possible is the first choice method; Often some remedial works are required, typically at significantly lower cost than major reconstruction. In addition to this, and in agreement with local demand or generation which is willing to be curtailed if necessary, Real-time Thermal Ratings (RTTR) can then be applied using a weather station based solution. Trials in the Flexible Plug and Play Networks LCNF Tier 2 project have shown that RTTR is also a useful approach to enable quicker and cheaper new generation connections. If neither of the above approaches would provide sufficient additional capacity, or there are compounding condition problems with the OHL assets, another approach must be used. Each will be assessed on a case by case basis as to which of the following options provides the best value: • New conductor installed on the existing supports (including traditional, large size or High Temperature Low Sag (HTLS) conductors) • New conductor installed on new supports (re-build the line) • Add an additional circuit or other network re-configuration Two suggestions were raised and rejected, specifically the concepts of different daytime and night-time ratings; and ratings over four seasons rather than the current regime of only three seasons. Daytime/night-time ratings were shown to deliver no significant capacity increase. The revised four season ratings would lead to an improvement for summer constrained circuits but a detriment for winter constrained circuits. Work is on-going through the STP to confirm these findings and update ENA documents ACE104 and P27.
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 (Completed)

<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>16,963</td><td>10,886</td><td>10,757</td></tr>
<tr><td>Internal</td><td>2,522</td><td>1,618</td><td>1,599</td></tr>
<tr><td>Total</td><td>19,485</td><td>12,505</td><td>12,356</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">£422,008</td></tr>
<tr><td>Internal</td><td colspan="3">£41,134</td></tr>
<tr><td>Total</td><td colspan="3">£463,142</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£507,488</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The STP module 2 programme aimed 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 2-5 years – dependent on project</td><td>Duration of benefit once achieved</td><td colspan="2">Range 3-5 years – dependent on project</td></tr>
</table>

Probability of Success	Range 60-95% – dependent on project	Project NPV (Present Benefits – Present Costs) x Probability of Success	Range £60,000 to £350,000 Dependant on project
Potential for Achieving Expected Benefits	The STP Module 2 programme has now been closed. The improved statistical ratings for distribution overhead lines project is currently underway. Once the data collection and analysis phase has been completed, the benefits will start to be realised. This part of the project, which is due to be completed under NIA, is due to last a further two years.		
Project Progress to March 2015	The final STP module 2 meeting took place in June 2014 where final reports were presented for S2162 and S2151, as described below. The scope of the improved statistical rating project was also agreed amongst all DNOs. S2162 – residual strength of wood poles – the last batch of wood poles have been tested a final report with conclusions has been produced. The project found that on average, the poles tested lost 2% of their residual strength each year. This additional information will be factored in when making network investment decisions and increases the knowledge on our wood pole assets. S2151 – alternatives to wood poles – this project looked at the suitability of composite poles as an alternative to wood. The final report was presented in July 2014 and showed a number of advantages over wood poles. These include easier quality control, standardisation of strength, no creosote issues, no rot, and lighter weight. The findings of this project are being evaluated to decide whether trials of composite poles on the network should be carried out. PID0004 – Improved statistical ratings for distribution overhead lines – this project looked at the statistical ratings that have been historically applied to overhead lines. A test rig was constructed as part of phase 1 of this project at the WPD depot in Stoke, to monitor conductor under different weather conditions. The test rig construction phase of the project has been carried out under IFI. The data collection and analysis phase of the project will be carried out under the NIA funding mechanism (link to project).		
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 (Completed)

Description of Project	A DNO research and development collaboration hosted by EA Technology.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	-	-	-
	Internal	2,522	1,618	1,599
	Total	2,522	1,618	1,599
	The costs have been allocated in proportion to the number of customers connected in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£422,969		
	Internal	£37,580		
	Total	£460,549		
Total Project Costs (Collaborative + External + UK Power Networks)	£466,288	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological Area and / or Issue Addressed by Project	The STP Module 5 programme aimed 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	The STP Module 5 programme has now been closed. A number of projects will require further research and development work to achieve improvements in operational performance and integration into our business environment. Other projects 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 2015	A number of projects were concluded this year: S5167 – Enhanced ratings for OHL connections to wind farms – has shown that unsheltered overhead lines connecting to wind farms (where high load is coincident with high wind) can safely have higher ratings. S5236 – Performance of Generation in P-V Mode – has shown that (wind) generation operating in voltage control mode better utilises its reactive power capability and reduces losses. On weak networks, this is likely to have significant improvements in network voltage. From the trial results a "dead band and slope" algorithm seems most efficient. Requirements for an assessment tool have been written to support DNO adoption. S5243 – AC cable connections – practical and electrical limits to their length – has made a number of recommendations. Firstly, it is necessary to know and accurately model the overall cable length, including customer side of the meter as this impacts the harmonics on the network. Secondly, the cable charging current must be considered when specifying connecting equipment to ensure it is adequately rated (or the cable is broken into sections). S5245 – designing networks with lower supply impedance – found that using larger cables with lower supply impedance can accommodate similar customer numbers and facilitate better interconnection. Voltage drop/rise is likely to be a much more significant constraint on LV networks. S5267 – generation diversity – assessment and visualisation – shows that although there is some diversity between different types of generation, this does not facilitate the ability to connect more generation. The diversity is generally very small and leads to some occasions of network overloading.
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 (Completed)

Description of Project	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.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	-	6,023	-
	Internal	-	394	-
	Total	-	6,417	-
	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.			
Expenditure in Previous (IFI) Financial Years	External	£15,185		
	Internal	£485		
	Total	£15,670		
Total Project Costs (Collaborative + External + UK Power Networks)	£22,090	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological Area and / or Issue Addressed by Project	Smart technologies to release capacity – management of system fault levels and optimal use of fault level headroom			
Type(s) of Innovation Involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		16.8	-6	22.8
Expected Benefits of Project	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			
Expected Timescale to Adoption	< 5 years	Duration of benefit once achieved	Lifetime of assets (>20 years) or enabled connections	
Probability of Success	40% - 60%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£70,000	
Potential for Achieving Expected Benefits	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, or, alternatively, may in some cases defer the need to uprate an HV or EHV switchboard for fault			

	level rating, allowing the board to continue to operate until health or load drivers otherwise require replacement. However, the project work has shown that in the urban environments 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. 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.
Project Progress March 2015	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. Following a review of the types and availability of modelling data on fault current limiter performance conducted with the device manufacturers, the project has determined that due to confidentiality restrictions with the manufacturers, the pace with which the device specifications are changing, and the complexity of configuring non-linear devices in existing modelling tools, it would not be possible to cost-effectively develop a common device model. This project has therefore now closed. UK Power Networks continues to assess network sites for potential schemes with a positive business case for fault current limiters, using the market knowledge developed in this project, and will work through established design and procurement processes with the device manufacturers to understand fault current limiting device performance and relative effectiveness.
Collaborative Partners	N/A
R&D Provider	Parsons Brinkerhoff

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

LV Remote Control and Automation/Smart Urban LV Network

<table>
<tr><td>Description of Project</td><td colspan="4">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.</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>139,224</td><td>78,811</td><td>91,078</td></tr>
<tr><td>Internal</td><td>28,193</td><td>15,959</td><td>18,443</td></tr>
<tr><td>Total</td><td>167,417</td><td>94,770</td><td>109,521</td></tr>
<tr><td colspan="4">The costs have been allocated in proportion to the length of installed LV cables in each licence area.</td></tr>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£2,141,701</td></tr>
<tr><td>Internal</td><td colspan="3">£147,725</td></tr>
<tr><td>Total</td><td colspan="3">£2,289,426</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£4,300,000</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and/or Issue Addressed by Project</td><td colspan="4">Management of the LV network</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>16.2</td><td>-2</td><td>18.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">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</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2016/17 for CB only solution</td><td>Duration of Benefit Once Achieved</td><td colspan="2">7 years</td></tr>
<tr><td>Probability of Success</td><td>70%</td><td>Project NPV (Present Benefits – Present Costs) X Probability of Success</td><td colspan="2">£3,035,815</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="4">During this regulatory year the project has:
• Carried out further testing of the “LVA” hardware on a LV test network and on the live network within the LPN license area
• Worked with the project’s collaborative partner and supplier, TE Connectivity, to resolve technical issues discovered during the testing</td></tr>
</table>

	that was done on the live network • Took delivery of approximately 70% of the trial equipment from the suppliers, thus moving the project one step closer to the demonstration of the expected benefits of the project • Reviewed the methods of installing the link box switches and controllers, with consideration given to the adoption of laying blankets on top of the controllers to prevent fire or explosions caused by possible overheating of the link boxes • Carried out deployment of Gateways/RTUs in 13 substations in City Road trial area. Circuit Breakers were also installed in two substations in the trial area UK Power Networks still aims to demonstrate the following use cases in the course of delivering the project's expected benefits:. • 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 2015	**Testing of LVA Hardware** The LVA equipment was successfully tested on UK Power Networks LV test network during 2014. The network is only able to generate low current and it was decided to test the equipment on part of the LPN distribution network. This testing was carried out on part of the live LV network in Ilford, London to ascertain how the equipment addressed typical network conditions on the LPN network. These tests provided more insight into the state of the LVA hardware and identified a number of improvements that should be made. TE Connectivity addressed and redesigned parts of the equipment before the main trial units were manufactured and delivered to UK Power Networks. Some of the issues uncovered and resolved include; overheating of the link box controller, which caused it to reset; replacement of gas-discharge tubes in the circuit breakers with fuses of much higher rupturing capacity, which prevented the fuses from blowing internally. UK Power Networks has been working with EA Technology and TE Connectivity to improve the design of the LVA hardware to make it more adaptable for use on distribution networks in Great Britain and beyond. **Deployment of Equipment for Use Case Trials** Deployment of the hardware in the City Rd trial areas was due to commence in July 2014. This was delayed to November 2014 due to hardware and software issues discovered during the testing that was done in the live distribution network. The project team has installed gateways in 13 substations and circuit breakers in two substations so far. The project team conducted a training session for network operations field staff at the UK Power Networks' training centre on the installation and operation of the LVA hardware. Training sessions were also held for the LV Control Engineers who monitor and control the LVA hardware remotely via PowerOn Fusion.
Collaborative Partner	TE Connectivity EA Technology Ltd

R&D Provider	TE Connectivity EA Technology Ltd

Strategic Technology Programme (STP) Module 3 – Cable networks (Completed)

<table>
<tr><td>Description of Project</td><td colspan="5">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 colspan="2">LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>46,246</td><td colspan="2">29,679</td><td>29,325</td></tr>
<tr><td>Internal</td><td>2,522</td><td colspan="2">1,618</td><td>1,599</td></tr>
<tr><td>Total</td><td>48,767</td><td colspan="2">31,297</td><td>30,925</td></tr>
<tr><td colspan="5">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="4">£496,196</td></tr>
<tr><td>Internal</td><td colspan="4">£43,257</td></tr>
<tr><td>Total</td><td colspan="4">£539,453</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£650,442</td><td colspan="2">Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="5">The STP Module 3 programme aimed to improve operational performance, maximise potential benefits, improve financial performance, and minimise risk associated with cable networks. The programme investigated 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 colspan="2">Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td colspan="2">-8</td><td>22</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">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 impact on the environment and avoiding disposal of soil to landfill</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">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">The STP Module 3 programme has now been closed and a number of projects are delivering tangible benefits, for example:
Project S3174_2 “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
Project S3245_1 “Development of CRATER 'Lite' led to the development of a new, more user friendly, cable rating software tool. This has the clear potential to improve the processes involved with cost effective and efficient design of underground cable networks</td></tr>
<tr><td>Project Progress to March 2015</td><td colspan="3">STP Module 3 has undertaken five projects in regulatory year 2014/15, covering a wide range of subjects, including:
Project S3174_2 – Evaluating the performance of service termination equipment” – Initial testing has been completed and further testing of alternative devices is planned under a new NIA Project
Project S3204_1 – “Design tool for bonding arrangements of cable circuits” – the project was successfully completed and produced a new software tool that can be used to calculate the cables ratings of cable circuits installed with various different sheath bonding arrangements (single point and cross bonding)
Project S3214_1 – “Research and evaluation of the effectiveness of Tan-Delta testing and polarisation index for condition assessment of ageing cables: Trial and evaluation for paper cables” – the project was successful and produced a detailed report that highlights the advantages and disadvantages of using these test methods for assessing the remaining life of ageing cables
Project S3216_1 – “Cross-bonding and segregation of cable systems in tunnels and shared resources by utilities: Researching the issues” – the project was successfully completed and produced a report that provides guidance for DNO users on the cross bonding and segregation systems required for tunnels shared with other utilities. It considers a range of potential scenarios, quantifies the potential issues for these scenarios and provides guidance to allow users to determine the most appropriate solution for their specific requirements
Project S3245_1 – “Development of CRATER 'Lite' – a cable rating tool was successfully developed</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 (Completed)

<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>55,638</td><td>35,706</td><td>35,281</td></tr>
<tr><td>Internal</td><td>2,5220</td><td>1,618</td><td>1,599</td></tr>
<tr><td>Total</td><td>58,159</td><td>37,325</td><td>36,880</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">£418,999</td></tr>
<tr><td>Internal</td><td colspan="3">£37,465</td></tr>
<tr><td>Total</td><td colspan="3">£456,464</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£588,829</td><td colspan="2">Projected 2015/16 IFI costs for UK Power Networks</td><td>£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">The STP module 4 programme looked widely across substation plant including transformers, switchgear and protection equipment. It looked at issues related to maintaining existing assets, including alternative insulating oils and means to assess the condition of equipment, as well as 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">The STP Module 4 programme has now been closed.</td></tr>
</table>

Project Progress to March 2015	The work in 2014/15 has been limited to the completion of S4181_10, the Transformer Post Mortem Testing project. A total of 33 transformers were tested, dismantled and examined to determine whether any residual life was left. Of the grid transformers tested, only 30% were considered to be at the end of their life, with the remaining units being decommissioned due to poor external condition, damaged bushings, severe corrosion or simply because larger units needed to be installed. This work has validated UK Power Networks' decision to increase the amount of transformer refurbishment planned for ED1.
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 (Completed)

Description of project	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.			
Expenditure for financial year		EPN	LPN	SPN
	External	14,021	7,269	8,815
	Internal	916	475	576
	Total	14,937	7,744	9,391
	The costs have been allocated in proportion to the number of substations in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	-		
	Internal	£545		
	Total	£545		
Total Project Costs (Collaborative + external + UK Power Networks)	£32,620	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological area and / or issue addressed by project If applicable only	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.			
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		10.2	-4	14.2
Expected Benefits of Project	The project successfully delivered the following benefits: • 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 are connected safely (i.e. without the need of having to connect sensors between live cables or busbars) • Easier connection of fault location and diagnostic equipment on existing LV boards, saving engineers' operational time on site			
Expected Timescale to adoption	2014	Duration of benefit once achieved	On-going	
Probability of Success	100%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£50,000	
Potential for achieving expected benefits	The potential for achieving the expected benefits remains high. The fuse carriers are now a standard stock item in UK Power Networks stores and available for deployment on the LV network. This will be further assessed following the installation of fuse carriers on the network as part of the Flexible Urban Networks LV project.			

Project Progress March 2015	The Henley fuse carriers were successfully deployed as part of the Fringe Fuse Monitoring Project   The fuse carrier enables the Rogowski coil to be safely deployed on an open LV board and is contained via the integral tube around the LV fuse. Voltage connections have been made available on the busbar and the load side of the fuse. This enables both busbar and load side voltages to be obtained without the need to connect directly to a busbar and provides a common way of using a Rogowski coil regardless of the type or make of LV board. “Engineering Approval Standard EAS 13-0054 Renley Voltage And Rogowski Coil Fuse Link Carrier” was approved by the Asset Management department and the fuse carrier has now been made available as a standard stock item for deployment on the network.
Collaborative Partners	N/A
R&D Provider	Renley Ltd.

Understand the Condition of Our Assets

Micro-helicopters (Completed)

<table>
<tr><td>Description of Project</td><td colspan="5">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 colspan="2">LPN</td><td>SPN</td></tr>
<tr><td>External</td><td>20,619</td><td colspan="2">15</td><td>5,728</td></tr>
<tr><td>Internal</td><td>2,158</td><td colspan="2">-</td><td>599</td></tr>
<tr><td>Total</td><td>22,777</td><td colspan="2">15</td><td>6,327</td></tr>
<tr><td colspan="5">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="4">£198,755</td></tr>
<tr><td>Internal</td><td colspan="4">£10,869</td></tr>
<tr><td>Total</td><td colspan="4">£209,624</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£238,740</td><td colspan="2">Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="5">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. a 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 colspan="2">Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14.4</td><td colspan="2">0</td><td>14.4</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Benefits of micro-helicopters are:
• 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:</td></tr>
</table>

	- Short sections of overhead line, or individual towers - Primary/grid substations - 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.		
Expected Timescale to Adoption	2015	Duration of benefit once achieved	On-going
Probability of Success	80%	Project NPV (Present Benefits – Present Costs) x Probability of Success	£100,000
Potential for Achieving Expected Benefits	The micro-helicopters have continued to deliver benefits in this reporting period: • **Safety:** the use of micro-helicopters has transitioned from a project only activity to one where UK Power Networks staff regularly use the micro-helicopters to inspect overhead lines as well as completing thermal imaging surveys of equipment within grid substations. • **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.		
Project Progress March 2015	UK Power Networks staff in the EPN and SPN licence areas have continued to operate the four SkyDroid Scout micro-helicopters. One of our staff in the SPN area holds a professional licence for operating micro-helicopters and regularly flies the droids for visual and thermal surveying. The devices have now been adopted into business as usual and the project was closed during quarter one of 2015. **Progress:** • **Cameras**: The new cameras have enabled high quality images to be captured during all stages of flight and enabled the operators to maintain safe operating distances from the plant being surveyed and reduces the risk of inflight damage to the micro-helicopters • **Inspections:** Micro-helicopters continue to be used to inspect 132KV and 33kV towers and poles, grid substations, and primary substations. The thermovision cameras have successfully identified developing transformer faults in grid substations enabling the affected transformers to be safely switched out, isolated and repaired • **Flying hours**: As part of the transition to BAU the project undertook a		

	review of the teams currently operating the micro-helicopters. A key finding of the project was that operators needed to maintain their flying hours in order to remain confident in all flying conditions. Whilst this worked well with some of the teams, others did not work regularly enough together. The project recommended that in the EPN licence area overhead line inspectors were best placed to operate the micro-helicopters on a regular basis
Collaborative Partners	N/A
R&D Provider	SkyDroid

Transformer Research Consortium

<table>
<tr><td>Description of project</td><td colspan="4">The main aim of the project is to develop new tools for the management of existing transformer fleet at grid/primary site for the analysis of health conditions, and to inform the future maintenance and replacement strategies. In addition, it aims to inform design criteria for new transformers ensuring transformer designs are optimised and aiding a DNOs procurement process for new transformers.

The project includes four research packages, studying ageing and end-of-life management; partial discharge diagnostics; dissolved gas analysis (DGA) on-line devices assessment and transformer thermal performance and optical fibres.</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>29,005</td><td colspan="2">11,632</td><td>8,711</td></tr>
<tr><td>Internal</td><td>1,900</td><td colspan="2">762</td><td>571</td></tr>
<tr><td>Total</td><td>30,904</td><td colspan="2">12,394</td><td>9,282</td></tr>
<tr><td colspan="5">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="4">£38,041</td></tr>
<tr><td>Internal</td><td colspan="4">£1,188</td></tr>
<tr><td>Total</td><td colspan="4">£39,229</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>The total cost of the project is £1,005,000</td><td colspan="2">Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and / or issue addressed by project If applicable only</td><td colspan="5">Equipment design and operational improvement</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>6</td><td colspan="2">-6</td><td>12</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">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
• Alternative transformer fluids to be reviewed</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2016</td><td colspan="2">Duration of benefit once achieved</td><td colspan="2">40 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 colspan="2">£100,000</td></tr>
</table>

Potential for achieving expected benefits	All the progress indicators show that the project is on track to realise the expected benefits, as illustrated in further detail of next section. The project meetings are held quarterly, with research presentation, technical discussion & debate and regular progress checking by the steering group. PhD students are also regularly visiting UK Power Networks, SPN and NG for data collections and technical discussions. In addition, there are 12 technical papers published in international conferences e.g. IEEE International Conference on Dielectric Liquids (ICDL), International Symposium on High Voltage Engineering (ISH). The research work done by the students of this project have won 4 conference awards, e.g. Best student paper in Euro TechCon 2014.
Project Progress March 2015	Progress is described for each individual working package as below: Work Package 1 • Multiple databases of oil test results pertaining to in-service transformers operating at primary voltages of 33kV, 132kV, 275kV and 400KV from UK Power Networks, SPEN and NG were analysed • An nationwide early degradation phenomenon was identified, which could be due to a change in oil chemistry around late 1980s and early 1990s. A list of transformers which require special attentions were identified and provided to UK Power Networks • A Head Space Gas Chromatograph Mass Spectrometry (HS-GC-MS) based technique was developed to measure methanol and ethanol in oil, which are the promising early paper ageing indicators. Understanding this new technique can give a utility the possibility to develop a new tool to identify “thermal” design issue with new transformers and a better indication of paper ageing for their operating transformers than conventional used 2-FAL parameter • Laboratory ageing experiments were conducted for oil-paper insulation systems in a sealed condition at 120 °C for up to 280 days. The results showed that methanol in oil increases linearly with paper ageing and it is higher than the conventional paper ageing indicator 2-FAL in oil till the DP reaching around 400 Work Package 2 • PD characteristics of both mineral oil and alternative synthetic liquids were investigated using needle-to-plane divergent field and plane-needle-plane quasi-uniform field • It was found that PD inception voltage (PDIV) depends on the electrode geometry, but the calculated PD inception field (PDIF) is independent of the electrode geometry. Excessive local stress is always the reason for PDs to occur. This conclusion bears the significance for quality control of transformer manufacture process • Effects of oil conditions on PD behaviours were investigated. Compared with PD magnitude, pulse repetition rate is more sensitive to the oil condition Work Package 3 • A DGA thermal fault test platform, which enables tests of both Serveron TM8 and Kelman Transfix on-line DGA devices, was established • DGA fingerprints of both mineral oil and alternative gas-to-liquid mineral oil, were obtained under three different thermal fault levels (T1, T2 and T3) Work Package 4

	• Thermal modelling of both mineral oils and alternative ester liquids was conducted based on computational fluid dynamic (CFD) simulations • The operational conditions to avoid oil back flows under various winding geometrical configurations were obtained • An experimental test rig was established to verify the modelling results, where advanced Particle Image Velocimetry (PIV) technique was used to measure the flow distribution and Fibre Optics sensors were used to measure the temperature distributions.
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 tests 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>207</td><td>128</td><td>127</td></tr>
<tr><td>Internal</td><td>3,148</td><td>1,950</td><td>1,941</td></tr>
<tr><td>Total</td><td>3,355</td><td>2,078</td><td>2,068</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 rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£134</td></tr>
<tr><td>Internal</td><td colspan="3">£9,638</td></tr>
<tr><td>Total</td><td colspan="3">£9,772</td></tr>
<tr><td>Total Project Costs (Collaborative + external + UK Power Networks)</td><td>£17,270</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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 40,000km of underground HV cable throughout its three licence areas. 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 six 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
• Improve system reliability by improving the understanding of HV cables</td></tr>
</table>

Expected Timescale to adoption	Year 2017	Duration of benefit once achieved	10 Years
Probability of Success	70%	Project NPV (Present Benefits – Present Costs) x Probability of Success	>£1,000,000
Potential for achieving expected benefits	There is a high potential of achieving expected benefits. Based on the output of this project UK Power Networks will have a better understanding of HV underground PILC cables which will help Asset Management proactively replace sections of cables in poor condition before a fault occurs improving the reliability of supply to our customers.		
Project Progress March 2015	Progress to date is as follows: • The scope of the project has been refined and increased to collect more samples due to the number of faults from HV PILC underground cables to gain a better understanding of condition of cables lay in three regions of UK Power Networks • Project suppliers have been identified and contract is in progress to start the sample collections work • Initial analysis has been carried out to identify areas for the collection of HV PILC cable samples Following the analysis to identify the right areas for the collection of samples, the second phase (to be completed under a separate project) will focus on the collection of samples.		
Collaborative Partners	N/A		
R&D Provider	ERA Technology Ltd		

Develop Commercial Solutions and Products

Bankside Heat Transfer (Completed)

<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.</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>-</td><td>26,265</td><td>-</td></tr>
<tr><td>Internal</td><td>-</td><td>1,716</td><td>-</td></tr>
<tr><td>Total</td><td>-</td><td>27,981</td><td>-</td></tr>
<tr><td colspan="4">The costs have been allocated to LPN where the installation is located.</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>£842,100</td><td colspan="2">Projected 2015/16 IFI costs for UK Power Networks</td><td>£0</td></tr>
<tr><td>Technological Area and / or Issue Addressed by Project</td><td colspan="4">Use of waste heat for greater efficiency.

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:
• Use of low-carbon heat by a third party, replacing a high-CO_2 heat source
• Use of energy that would otherwise be lost
• Fewer maintenance interventions for cooling, leading to potentially reduced replacement cost
• 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>5%</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 2015</td><td colspan="4">The Tate's intention is to use the waste heat once the Tate opens its new galleries. We are working to improve the performance of the system by installing additional equipment to reduce the water flow rate so that it can pick up more heat, in time for the Tate's opening.</td></tr>
<tr><td>Collaborative Partner</td><td colspan="4">Tate</td></tr>
</table>

R&D Providers	Wilson Transformers and Arup

Collaborative Programmes

Energy Innovation Centre

Description of Project	UK Power Networks continues to grow its portfolio of projects with the Energy Innovation Centre (http://www.energyinnovationcentre.com/) and now has seven projects in the portfolio: **Project 1: Cable Paper Moisture Meter (started 2012/13)** The project proposed 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 would have enabled this operation to be performed more safely than the currently-used oil or paraffin solutions. Stage 1 was successfully completed, but following analysis of the market, It was agreed with EATL that the commercial case for this product was insufficient to continue with the project therefore, it was decided that the project would be closed down. **Project 2: Oilcable-Care (started 2012/13)** The project sought to identify, develop and assess self-repairing systems for oil-filled cable sheaths such that damages would self-heal. This would have avoided oil leakage, the resulting environmental clean-up, as well as prevent contamination of the cable that could compromise its performance and lead to premature failure. This project was terminated following the project supplier (Gendrive) being placed in administration. **Project 3: Smart 3ph LV Network Power Regulator (started 2013/14)** The project was 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. This project was terminated following the project supplier (Gendrive) being placed in administration **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. **Project 6: Ultrapole (started 2014/15)** There are currently several invasive instruments on the market for detecting wood rot in wooden poles used by the DNOs which are based on both acoustic (hammer in nail, tap and listen) and ultrasonic (slice shadow) technologies. Current products on the market adopt a variety of techniques but all are restricted to detecting rot in very close proximity to the point at which the measurements are being taken. To satisfy the DNOs objective of assessing the condition of their pole assets, there is a need for an instrument that is easy to use in the field,

<table>
<tr><td></td><td colspan="4">takes non-intrusive measurements, and has the ability to operate at ground level over the entire length of the pole. Such an instrument would prevent the need for digging around the base of the pole disturbing previously good ground conditions, or climbing the pole to take measurements at height. This project is to conduct a study into the feasibility for such a device.

Project 7: LiveAlert (started 2014/15)
The Energised Alert is a high voltage detection device, currently capable of detecting voltages of above 2kV. The project’s objectives are to:
• To extend the voltage sensing range downwards from 2,000 volts
• To undertake a full market appraisal
• To undertake full evaluation of technology whilst in operation</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>147,000</td><td>94,846</td><td>99,273</td></tr>
<tr><td>Internal</td><td>14,124</td><td>9,014</td><td>9,392</td></tr>
<tr><td>Total</td><td>161,124</td><td>103,860</td><td>108,665</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>
<tr><td rowspan="3">Expenditure in Previous (IFI) Financial Years</td><td>External</td><td colspan="3">£233,683</td></tr>
<tr><td>Internal</td><td colspan="3">£8,932</td></tr>
<tr><td>Total</td><td colspan="3">£242,615</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,463,768</td><td colspan="2">Projected 2015/16 IFI costs for UK Power Networks</td><td>£0</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>
</table>

<table>
<tr>
<td rowspan="1"></td>
<td colspan="4">Project 6: Ultrapole
Ultrasound can be used to detect changes in wood density which results in an acoustic path impedance variation between different wood densities. This change can be caused by rotted fibres within the pole, or other features such as drilled holes etc. This density change produces a discernible energy reflection at the boundary which can be analysed and visualised in an instrument. Current techniques use ultrasound to analyse cross sections of the pole, ‘slices’, which are normally at ground level. This project aims to develop a technique to use ultrasound longitudinally and thus from one point across the top and bottom of the pole.
Project 7: LiveAlert
The Energised Alert senses any increase in electrical potential, above a predetermined threshold, of devices to which it is attached. Once triggered it is linked to an audible alarm, allowing the recognition and management of this potentially deadly hazard in a controlled manner. Its use will, therefore protect the operator, other employees and any members of the public in the vicinity from casual, but more importantly, avoidable electrocution.</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>Projects range from 8.6 to 18</td>
<td>Projects range from 2 to -5</td>
<td>Projects 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 may have resulted 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
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</td>
</tr>
</table>

<table>
<tr><td></td><td colspan="3">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.

Project 6: Ultrapole
The use of ultrasonics has the ability to:
• Scan very rapidly long pole lengths for the presence of acoustic anomalies such as the presence of rot in the pole
• Increase knowledge and understanding of condition of wood poles, allowing targeted maintenance and replacement based on condition of asset
• Reduce cost of surveying poles (no climbing of pole).
• More accurate assessment therefore less waste from misdiagnosis
• Reduced failure of wood poles leading to reduced CIs/CMLs from overhead lines and improved network performance
• If this non-intrusive testing methodology is proven it will reduce risk exposure for linesmen, operational staff and third parties

Project 7: LiveAlert
Successful development of the Energised Alert will:
• Help prevent electrocution accidents and fatalities
• Ensure ‘live line’ maintenance can be carried out in a safe manner
• Allow operators to proactively respond to incidents on their network</td></tr>
<tr><td>Expected Timescale to Adoption</td><td>2015-2018</td><td>Duration of benefit once achieved</td><td>Greater than 10 years in all cases</td></tr>
<tr><td>Probability of Success</td><td>Ranging from 10% to 60%</td><td>Project NPV (Present Benefits – Present Costs) x Probability of Success</td><td>£ 1,980,000</td></tr>
<tr><td>Potential for Achieving Expected Benefits</td><td colspan="3">Project 1: Cable paper moisture meter
This project was terminated at the end of Stage 1.

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.</td></tr>
</table>

	Project 3: Smart 3ph LV network Power regulator This project was terminated following the project supplier (Gendrive) being placed in administration. **Project 4: Cable Core Temperature Sensor** The project has successfully proved the concept. **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 6: Ultrapole** Tests have shown that it will not be possible to scan a complete pole from a single location, but detection in the underground portion is possible which will save excavation. **Project 7: LiveAlert** The project has been closed early at the end of Stage 4.
Project Progress March 2015	**Project 1: Cable paper moisture meter** Stage 1 was successfully completed, but following analysis of the market, EATL outlined that the commercial case for this product was insufficient to continue with the project therefore it was decided that the project would be closed down. **Project 2: Oilcable-Care** A scoping assessment of prospective repair technologies to assess their ability to function in cables subjected to damage was competed in September 2014. Evaluation of best candidate repair technologies was completed in March 2015 and recommendations on which technologies to commercialise provided. The project has been successfully completed and a final report was issued in March 2015. **Project 3: Smart 3ph LV network Power regulator** After the project supplier (Gendrive) was placed in administration in March 2014, there has been no change in the project status. **Project 4: Cable Core Temperature Sensor** The laboratory prototype proof of concept was successfully completed in July 2014 and was subsequently verified by a live trial on the network. The project has been successfully completed and a final report was issued in March 2015 **Project 5: VTOL** The BVLOS Operational Requirements, Financial Analysis and CAA BVLOS Concept of Operations approval were all successfully completed in September 2014, while the establishment of base operational simulation environments were completed in January 2015. The Project is currently in Phase 3 (Development of ConOps incorporating flight manoeuvres and flight paths within the simulation environment for evaluation and test) and will be transitioned to NIA Funding in April 2015. **Project 6: Ultrapole** An exploration, science review and technology assessment were completed in September 2014. This identified that the ultrasonic scanning of a complete pole was not possible from a single location, but that the benefits could still be obtained from scanning the underground portion without excavation. Legal issues when ENW & NPG wished to leave the

	project caused delays, but the project has been transitioned to NIA funding with SSEPD, SSEPD & UK Power Networks. **Project 7: LiveAlert** This project has been closed following the completion of ten prototype units for live trials.
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 **Project 6: Ultrapole**: Scottish and Southern Electricity Power Distribution, Scottish Power Energy Networks, Electricity Northwest and Northern Power Grid **Project 7: LiveAlert**: Scottish and Southern Electricity Power Distribution, Scottish Power Energy Networks, Northern Power Grid and Electricity Northwest
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 EA Technology Ltd **Project 4: Cable Core Temperature Sensor:** The Technology Partnership Ltd **Project 5: VTOL**: VTOL Ltd **Project 6: Ultrapole**: Acuity Products Ltd **Project 7: LiveAlert**: Live Alert Ltd

Power Networks Research Academy (Completed)

<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>3,216</td><td>2,064</td><td>2,040</td></tr>
<tr><td>Internal</td><td>578</td><td>371</td><td>367</td></tr>
<tr><td>Total</td><td>3,795</td><td>2,435</td><td>2,406</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">£258,240</td></tr>
<tr><td>Internal</td><td colspan="3">£29,111</td></tr>
<tr><td>Total</td><td colspan="3">£287,351</td></tr>
<tr><td>Total Project Costs (Collaborative + External + UK Power Networks)</td><td>£1,915,000</td><td>Projected 2015/16 IFI costs for UK Power Networks</td><td colspan="2">£0</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
• 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">All of the PNRA projects have now reached their conclusion, but two projects were awarded a PNRA Technology Development Initiative Grant to allow a short period of further development and the implementation of a demonstration of the research:

Overhead lines measurement system
The initial project was successfully completed proving that the communication method can successfully work in simulated laboratory conditions.</td></tr>
</table>

	Alternatives to SF_6 as an insulation medium for distribution equipment The initial project demonstrated that an environmentally friendly insulation gas known as Trifluoroiodomethane (CF_3I) and its mixtures with carbon dioxide (CO_2) could be applied in distribution equipment as an alternative to the global warming gas Sulphur Hexafluoride (SF_6).
Project Progress March 2015	Only relevant progress for projects of most interest to UK Power Networks is presented below. **Overhead lines measurement system** Following the successful completion of the initial project, meetings have taken place to facilitate the development of a prototype sensor and transmitter device suitable for application to a live overhead line. At the present time work is continuing to create this prototype version and once this has been evaluated, a decision on future work will be taken. **Alternatives to SF_6 as an insulation medium for distribution equipment** A PhD thesis on the findings of the research into the design, testing and performance of CF_3I in HV switches and Ring Main Units (RMUs) has been completed with recommendations for DNOs. The main contributions of this work are: • A review of present day SF_6 switchgear and an extensive appraisal of the properties of CF_3I and CF_3I gas mixtures • Report on the development and implementation of a novel test rig that can be used to test CF_3I-CO_2 as an alternative insulation medium in practical MV switchgear • Experimental investigation and demonstration of CF_3I-CO_2 insulation capabilities • Development of a simulation approach in COMSOL that can determine whether a specific mixture of CF_3I-CO_2 can insulate equipment. This uses calculated effective ionisation coefficients of various CF_3I-CO_2 gas mixtures • A proposal for equipment containing vacuum interrupters to use CF_3I gas mixtures as replacement insulation to SF_6 gas UK Power Networks is currently reviewing potential next steps taking into consideration the NIA project recently registered by National Grid (link here)
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

Description of Project	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.			
Expenditure for Financial Year		EPN	LPN	SPN
	External	88,278	56,654	55,980
	Internal	11,468	7,360	7,272
	Total	99,746	64,014	63,252
	The costs have been allocated in proportion to the number of customers connected in each licence area.			
Expenditure in Previous (IFI) Financial Years	External	£737,055		
	Internal	£102,633		
	Total	£839,688		
Total Project Costs (Collaborative + External + UK Power Networks)	£1,066,700	Projected 2015/16 IFI costs for UK Power Networks	£0	
Technological Area and/or Issue Addressed by Project	The projects listed below address issues which have been identified by the ENA working groups as significant, requiring technical investigation and development. There are a number of projects that have been completed and reported in previous IFI years and for that reason these projects are not reported here. Reactive Power (REACT): In the last three 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. Whilst minimum active power demands have fallen by around 15% in the last 5 years, reactive power has declined by 50% in this time. Trends for 2012 show that this reduction is continuing, broadly, across the country. In order to better understand the challenge of manage voltage levels within licence standards and to plan for additional future reactive compensation requirements, a thorough understanding of the reactive power trend needs to be developed. DS2030: The DECC/Ofgem Smart Grid Forum was created by DECC and Ofgem to support the UK's transition to a secure, safe, low carbon, affordable energy system. The main issue discussed within the DECC/Ofgem Smart Grid Forum is how electricity network companies will address significant new challenges as they play their role in the decarbonisation of electricity supply. The Smart Grid Forum has established a number of Work Stream (WS) to examine particular aspects of future networks.			
Type(s) of Innovation Involved	Incremental Innovation	Project Benefits Rating	Project Residual Risk	Overall Project Score
		6.2	-10	16.2
Expected Benefits of Project	These projects have the potential to provide a wide range of benefits as described in the potential for achieving the expected benefits section.			
Expected Timescale to Adoption	Year 2015	Duration of Benefit Once Achieved	10 – 20 Years	

<table>
<tr><td>Probability of Success</td><td>75%</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">Reactive Power (REACT): The project is expected to deliver the expected benefits:
• The methodology to improve original DNO network models in order to mimic in time-series simulations the GSP behaviour during periods of minimum load.
• The identification of historic changes and trends using DNO network and monitoring data.
• The quantification of effects on reactive power from PV penetrations, network changes and demand trends in primary substations.
• The assessment of future reactive demand at GSPs of four DNOs for different trend-based scenarios.

DS2030: The DS2030 project is expected to achieve its intended benefits. It will provide a set of generic nodal distribution network models that have been demonstrated to be technically viable to meet the needs of 2030 users. These models have now been developed and their viability will be demonstrated in the coming months.

The models will be used to show how specific methods/solutions can be used to ensure technical viability of the networks and when particular methods/solutions may need to be applied. This analysis will be provided in the Stage 4 &5 results report.

The final Stage 6 report for the project will use the outcomes of the studies to address the questions posed by the Smart Grid Forum about future distribution system operation, including a discussion of the roles and responsibilities of a DNO in 2030 in terms of supporting whole system optimisation, contrasted with the position today. Where appropriate this will highlight further specific development work that could be carried out</td></tr>
<tr><td>Project Progress March 2015</td><td colspan="3">Reactive Power (REACT): The objectives corresponding to the First Year Report Stage 1 and the Second Year Six-month Report have been met within the last 12 months (May 2014 to May 2015) and the corresponding reports delivered. Two additional brief project status reports have also been delivered.

The Second Year Final Report Stage 2 is on track and will be completed by August 2015.

The outcomes of the project are in accordance with the initial objectives of the project proposal. More specifically, the following tasks have been accomplished:
• Identification of historic network and demand changes and trends.
• Quantification of effects on reactive demand during minimum load from different distribution-based factors (i.e., demand trends in primary substations, network changes, penetration of photovoltaics).
• Assessment of future reactive demand at transmission-distribution interfaces of different DNOs.
• Production of improved network models, which unlike original DNO models mimic transmission-distribution interfaces during periods of minimum load, to be used for further studies

DS2030: During the second half of 2014, the project focussed on defining the four representative networks that will be used for the study and the future scenarios that will be applied. The base networks were finalised and agreed in November 2014 and, following additional development work, the scenarios were finalised in early 2015.</td></tr>
</table>

	In addition, an international review was conducted to capture learning from work in other countries and this was concluded in September 2014. An updated version will be produced towards the end of the study to ensure other recent work is identified. Towards the end of 2014, the key questions the DS2030 project aims to answer were reviewed. Minor revisions were agreed with the project Steering Group and WS7 in February 2015. Since the start of 2015, efforts have focussed on defining the detailed methodologies to be used in the network analysis studies. These were presented as a series of discussion papers which were reviewed and agreed by the Steering group and WS7. This stage was largely concluded by May 2015 and studies are now commencing. Both projects have been transitioned to the NIA scheme.
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