WESTERN POWER DISTRIBUTION

INNOVATION

INNOVATION FUNDING INCENTIVE

REGULATORY REPORT 2013/14

LCN Fund
Low Carbon Networks

Foreword

Welcome to Western Power Distribution's Innovation Funding Incentive Annual Report for 2013/14

At Western Power Distribution we use innovation to help maintain our position as a frontier performer in network performance and customer service. Given the ongoing focus on the price of energy, concerns over climate change and the recent winter storms, the focus on Network Operators to continually improve has never been greater. Innovation also demonstrates ways we can develop the network to accept heat pumps, electric cars and distributed generation. The IFI programme represents a fundamental foundation in our approach to new technology and operational practices. Along with the Low Carbon Network Fund (LCNF), IFI provides an essential mechanism to trial novel solutions and assess their suitability for wider business role out.

The IFI programme has delivered further benefits in 2013/14. Building on the success of the previous years we have seen a steady stream of projects transitioning from trials to business as usual activity. This includes applications such as Active Network Management and Dynamic Asset Rating which were developed through IFI, demonstrated under LCNF, and now form part of our alternative generation connection offers being rolled out from September 2014.

Throughout this year we have continued to work across the industry with other Network Operators, Universities, SMEs and wider industrial partners. Drawing on and sharing this expertise has led to an exciting range of projects with a great potential to drive the industry forwards while delivering value for customers.

Robert Symons
C.E.O. Western Power Distribution

Contents

1. Introduction

The Innovation Funding Incentive (IFI) mechanism was introduced by Ofgem with the Distribution Price Control Review which took effect on 1 April 2005 (DPCR4) and has been continued into the current Distribution Price Control Review, which started on 1 April 2010 (DPCR5). The success of the IFI mechanism and Ofgem's continued commitment to this is welcomed by Western Power Distribution, as it has facilitated the development of a portfolio of R&D projects, which should bring significant benefits to our customers in the future.

This report contains the IFI reports for the four licensed areas of Western Power Distribution: South West, South Wales, East Midlands and West Midlands. It covers the period from 1 April 2013 to 31 March 2014, and has been produced in accordance with the Distributed Generation Regulatory Instructions and Guidance (RIGs) issued by Ofgem and the Energy Networks Association (ENA) Engineering Recommendation G85 issue 2 - IFI Good Practice Guide (GPG G85/2).

1.1 IFI

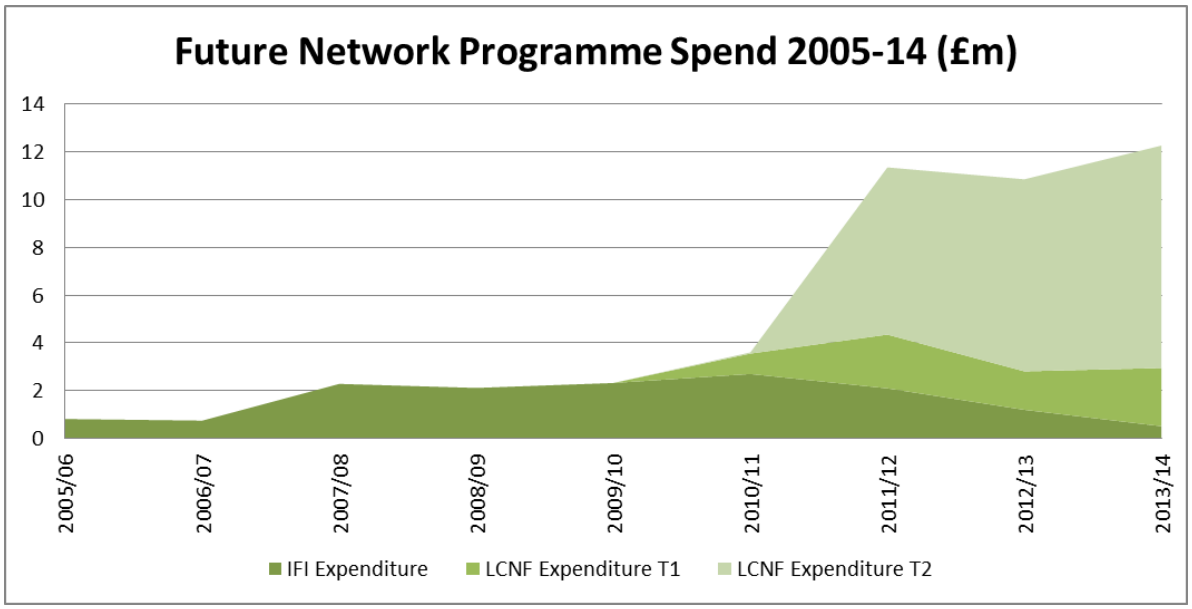
The Innovation Funding Incentive is intended to promote research and development activities within distribution network companies. It provides funding for technical development projects that deliver value to end consumers through financial, quality of supply, environmental or safety benefits. A definition of technical terms within the context of this guide is given in the glossary.

IFI projects can embrace any aspect of distribution system asset management from design through to construction, commissioning, operation, maintenance and decommissioning. A DNO may spend up to 0.5% of its Combined Distribution Network Revenue on eligible IFI projects, as defined by the industry Good Practice Guide G85/2. The DNO is allowed to recover from customers a significant proportion of its IFI expenditure and in DPCR5 period the percentage of project costs passed through to customers is set at 80%.

1.2 Low Carbon Networks Fund (LCNF)

In 2010, and continuing through to 2015, Ofgem introduced the Low Carbon Networks Fund (LCNF). The LCNF is designed to support the development of low carbon technologies within the UK electricity industry and facilitate the changes brought about by the Carbon Plan. It contains three elements; large scale projects funded through a competitive process (tier 2); smaller scale projects that are self-certified (tier-1) and a discretionary reward where Ofgem will provide additional income for companies that successfully develop learning that generates benefits for the industry.

Due to the increased focus of LCNF, there has been consequential reduction in IFI spend. Many new projects are now funded through LCNF that may have previously fallen under the remit of IFI. However, overall spend across the innovation programme has risen significantly within DPCR5 as the following chart demonstrates.



1.3 End of Year Report

The table below presents the End of Year Report for IFI.

Regulatory report for IFI
Reporting year 2013/14

Western Power Distribution

Innovation Funding Incentive (IFI)		South West	South Wales	East Midlands	West Midlands	Total
IFI Carry Forward	£m	1.584	1.258	1.831	2.052	6.726
Eligible IFI Expenditure*	£m	0.129	0.078	0.155	0.155	0.517
Eligible IFI Internal Expenditure	£m	0.019	0.012	0.023	0.023	0.078
increase over previous reporting year	%	-128%	-128%	-128%	-128%	-128%
Network Revenue by License Region	£m	342.70	267.10	397.30	441.40	1257.6
Number of Eligible Projects		28	28	28	28	28
Portfolio NPV of Benefits	£m	1.836	1.102	2.203	2.203	7.344

**includes internal expenditure*

2. Company Structure

Western Power Distribution is the electricity distribution network operator (DNO) for the East and West Midlands, South Wales and the South West. We deliver electricity to over 7.7 million customers in a 55,300 sq. km service area, stretching from the temperate Scilly Isles to the bracing beaches at Skegness, from the port of Milford Haven to the new town of Milton Keynes, from the Pennine villages north of Leek to the heritage coast at Lyme Regis. Within our service area is England's second largest city and the capital of Wales.

Our network consists of 216,000km of overhead line and underground cable, and 184,000 substations. We are responsible for:

- Maintaining this electricity network on a daily basis
- Repairing this electricity network when faults occur
- Replacing assets within the network when warranted by condition
- Reinforcing this electricity network to cope with changes in the pattern of demand
- Extending this electricity network to connect new customers

Western Power Distribution does not generate electricity or buy electricity from generating stations. We do not sell electricity to end-use customers. See the map below for the area WPD covers.

3. Overview

3.1 Western Power Distribution's Innovation Objectives

It is anticipated that in the future, electricity networks will be required to operate more flexibly, efficiently and reliably. Subsequently Western Power Distribution has developed the Future Networks Programme (FNP), a targeted Research, Development and Demonstration programme to meet these challenges, delivering benefits to our customers, improve network performance and help to tackle climate change.

This focused programme is delivered through a range of funding sources including the Low Carbon Networks Fund (LCNF), along with the IFI mechanism. These two complimentary initiatives allow us to develop ideas at an early stage of realisation with IFI, through to large scale demonstration projects through LCNF. The output from these schemes influenced the development of our business plans for the ED1 RIIO price control which will run from 2015 to 2023.

Our IFI projects facilitate the integration of new technologies in the network, aide improved management of existing assets and develop knowledge to better adapt for the future. These projects are designed to further improve our performance and provide us with the ability to meet the future challenges.

3.2 Programme Delivery

The Future Network Programme is delivered through a small team of dedicated innovation engineers supported with resources from the wider business. This includes technicians, engineers and craftsmen from Network Services across the company. This structure is utilised to deliver both IFI and LCNF schemes, across all four of WPD's licence areas. The Future Networks team form part of WPD's Policy function, allowing successful projects to be transitioned to business as usual activity.

3.3 Technology Readiness

Western Power Distribution's Future Networks Programme will include projects from aspects of Research, Development and Demonstration. We do not carry out "blue sky" research. As projects are developed they progress through the technology readiness timeline until they reach the stage where they can be adopted as Business as Usual. Western Power Distribution FNP programme will deliberately maintain a mix of projects with different Technology Readiness Levels (TRL), both in quantity and financial commitment.

3.4 Collaboration

Western Power Distribution's portfolio of IFI projects attempts to balance collaborative and independent projects seeking to minimise the cost of R, D & D whilst ensuring ideas can be taken forward in a timely manner. Western Power Distribution seeks to promote collaboration and cooperation between participating DNOs and other external organisations, such as universities and research establishments. This allows an exchange of academic knowledge and practical experience. Western Power Distribution also recognises the value of collaborating with other industry expertise and has continued to develop partnerships within all these sectors throughout the 2013/14 reporting year. The encouragement of collaboration within the IFI mechanism brings with it additional benefits beyond the immediate project outcomes, such as encouraging small and medium enterprises bring new products to the market.

3.5 Leverage

Collaboration has brought the opportunity of increasing the external funding to our programme. This leverage has increased through our collaboration with funding bodies, other network operators, manufacturers and external suppliers. In many cases the external funding for projects has risen to more than 75% of the total project funding.

3.6 IFI Project Benefits

The anticipated benefits of each project within Western Power Distribution's FNP clearly show the potential value of the IFI scheme both to Western Power Distribution and to its customers. It should be noted, however, that although quantified financially, not all the projects will result in tangible financial deliverables to Western Power Distribution in terms of direct savings or deferred investments. There are significant benefits to the wider community through:

- Network performance – improved reliability and resilience
- Environmental – emissions, waste, visual impact, etc.
- Safety to employees and public
- External risk mitigation
- Knowledge transfer – acquisition and dissemination of knowledge
- Creation of a platform for debate
- Enhancing the quality and relevance of research through direct linkage with industry, development of the available pool of expertise, greater exposure of own staff to direct engagement with research activity

While some of the new technologies and approaches that Western Power Distribution are exploring in these R, D & D projects will eventually result in the real practical benefits described in the individual reports, others will be less successful. The balanced portfolio approach reduces the risks and the G85/2 Residual Risk Rating calculation assists the selection process by quantifying risks in a structured manner. Although some R,D&D projects are unsuccessful and do not deliver the expected benefits, they can be valuable in that they will increase knowledge both in the Collaborating Partners and the R & D Provider.

3.7 Benefit Calculation

The anticipated benefits of each project have been determined using the methodology set down in ENA ER G85/2 - IFI Good Practice Guide. This is a two stage process involving a generic assessment of the project benefits and a specific assessment of the risk associated with the project. The Generic Assessment scores a range of benefits, including: Cost, Knowledge Transfer, Safety, Environment and Network Performance. Each item is weighted in accordance with company strategy and this score can be seen on each of the individual reports. For each project pursued it is expected that the present value costs will be exceeded by the present value of the benefits that it could deliver to customers.

The Risk Assessment calculation quantifies the potential risks inherent with each project by scoring risk (innovation level and development type) and mitigation factors (average annual spend per company, leverage, likelihood of implementation). No weighting is applied to these scores and subtraction of the value of the Mitigation Ratings from the Risk Ratings produces an overall Residual Risk value for each project. A high negative figure would indicate a low-risk project. The Residual Risk value is then subtracted from the Generic Assessment Score to produce the Overall Project Score. Both the Residual Risk Value and Overall Project Score can be seen on each of the individual project reports.

In line with ENA ER G85/2 GPG, projects falling below the de-minimis level set by the Good Practice Guide (£40k per licensed DNO, £160k for WPD) may be grouped to form programmes, with costs and benefits aggregated accordingly. A number of projects within the EA Technology Ltd STP modules, the ENA R&D programme, PNRA programme and EPSRC SuperGen programmes have been reported on in this way by WPD.

3.8 Adoption

Transferring research and development projects from demonstration to adoption is essential if benefits are to be delivered to customers and this is often the hardest hurdle for any organisation to achieve. Western Power Distribution has been able to implement a number of these projects into the wider business and continues to review the output from schemes for wider application.

4. Project Partners

WPD has been pleased to work with many project partners in the development of its programme of work. Brief descriptions of the research establishments and industrial partners are provided on the subsequent pages (these descriptions have been provided for inclusion by the individual companies).

ADAS - is the UK's largest independent provider of environmental consultancy, rural development services and policy advice. With expertise across the environmental sector, ADAS provide consultancy and contracting services to a diverse range of organisations in the private and public sectors, throughout the UK and internationally.

Bartlett Tree Research - was founded in 1907 by Francis A. Bartlett and is the world's leading scientific tree and shrub care company. From its nearly 100 offices worldwide, Bartlett helps both residential and commercial customers maintain beautiful, healthy trees.

BGS - founded in 1835, the British Geological Survey (BGS) is the world's oldest national geological survey and the UK's premier centre for earth science information and expertise. With a client base drawn from the public and private sectors both in the UK and internationally, they provide expert services and impartial advice in all areas of geoscience.

CRESATECH develops and markets technology solutions that address high cost, high impact operational issues within Power Transmission & Distribution, Telecoms, Transport and other critical service environments. Their products monitor and protect critical infrastructure, reducing costs, lowering risk and improving service continuity.

E.ON New Build & Technology - is part of the E.ON group and leads the group's Research and Development activities. E.ON New Build & Technology (formally Power Technology) is also an international consultancy to the power industry with core capabilities that span the range of interests appropriate to a vertically integrated energy company.

EA Technology Ltd - originally formed as the Research & Development centre for the UK electricity industry in the 1960s, it was transformed following electricity privatisation in the 1990s. The company became fully independent in 1997 with a management and employee buy-out and is now directly owned by its staff. EA Technology is a Power Asset Management Company with a world-class reputation for delivering innovative business solutions to companies, which supply, distribute and use energy. The company operates the internationally acclaimed Strategic Technology Programme (STP), of which all UK DNOs are members

Earthing Solutions - are involved with earthing system design and assessment, providing measurement, design, policy support, research & development and training services

Elimpus - delivers a range of radio frequency partial discharge monitoring products and services to electricity utilities, allowing them to manage high-voltage plant and equipment..

Embedded Monitoring Systems - Sub.net is the largest generation of substation monitoring systems from EMS, incorporating wide range monitoring and recording functionality for use in the electricity industry.

Engage Consulting Ltd - A consultancy organisation with extensive experience in the evolution of the GB Utilities markets.

ETI - The Energy Technologies Institute is a UK Based company formed from global industries and the UK government. It brings together projects that create affordable, reliable, clean energy for heat, power and transport. The ETI demonstrates technologies, develops knowledge, skills and supply-chains, informs the development of regulation, standards and policy, and accelerates the deployment of affordable, secure low carbon energy systems.

Isentropic is a UK-based private engineering company founded to exploit and further develop PHES technology.

Met Office - is one of the world's leading providers of environmental and weather related services. The Met Office's solutions and services meet the needs of many communities of interest…from the general public, government and schools, through broadcasters and on-line media, to civil aviation and almost every other industry sector in UK and around the world

Nortech Management Ltd - provide a range of telemetry products and central host software solutions for data collection systems. They design and supply remote site monitoring solutions and other specialist technology to electricity utilities, telecom network providers and others with geographically spread networks and assets

Rolls Royce - Power systems provider, designing, manufacturing and supporting a range of products and services for air, sea and land applications.

Schneider Electric - Schneider Electric offers integrated solutions across multiple market segments, including leadership positions in energy and infrastructure, industrial processes, building automation, and data centres/networks, as well as a broad presence in residential applications. Focused on making energy safe, reliable, and efficient.

Sibille Faeca Electric (SFE) - provide network technology that is completely focused on the safety of the people maintaining and constructing electrical structures on the low, medium and high voltage network

Sohn Associates was formed in 2003 by a group of former energy company executives. Their consultants have worked for major clients including regulators, large, medium and small energy companies, the Energy Saving Trust, Carbon Trust, carbon verification companies, metering companies, governance consultants and providers, financial institutions and renewable generation developers.

Smarter Grid Solutions (SGS) – an innovative technology company providing Smart Grid products and service to the power industry, enabling electricity network operators to cost effectively facilitate the transition to a low carbon economy.

Sterling Power - is a power engineering group composed of a number of individual companies who provide a unique range of services within the utility sector. The group has been established by personnel with a wealth of experience in the utility market.

Syngenta - a world-leading agri-business committed to sustainable agriculture through innovative research and technology.

TNEI - launched in 1992, TNEI is an independent company specialising in a range of energy services. Their Power Systems and Associated Technologies group specialises in power systems modelling and analysis and works with distribution network operators, project and technology developers, and the public sector

Willow Technologies - is a specialist supplier of electrical and electronic devices focused on the niche markets of sensing, switching and specialist resistors.

Other Partners - Western Power Distribution has collaboration agreements with a number of other Academic, Industrial and Research Partners. Where possible this information is given in the individual reports, but in some cases Western Power Distribution is bound by mutual confidentiality agreements not to disclose this.

5. Expenditure from IFI Projects

The following table details the expenditure during the April 2013- March 2014 IFI reporting period:

Internal expenditure has varied considerably between projects. The total internal expenditure is 15% of the total eligible IFI expenditure.

Project Title	Total External	Total Internal	Total Cost Internal & External
The Effects of Tree Growth Regulators (TGRs) on Fast Growing Trees and Application to Utility Arboriculture	£35,395	£2,940	£38,335
Information System for improved design of earthing systems including the impact of Climate Change and Seasonal Variation	£34,475	£2,864	£37,339
Carbon Tracing	£ nil	£2,687	£2,687
Identification and Prioritisation of Network Losses	£50,000	£4,153	£54,153
Demonstration of Distribution Scale Energy Storage	£16,489	£1,370	£17,859
Power Comms Meter	£7,182	£597	£7,779
Sensor Networks (Smart Dust)	£500	£859	£1,359
WPD South West Distribution Network Strategy Development	£45,000	£3,738	£48,738
Network Finger Printing	£14,590	£1,732	£16,322
Project Galaxy - Network Analytics	£20,000	£2,160	£22,160
Domestic Demand Response Network Study	£25,000	£3,955	£28,955
Transformer Oil Regeneration	£59,500	£5,596	£65,096
Phasor Measurement Trial	£ nil	£1,127	£1,127
Smart Grid Design	£9,250	£5,809	£15,059
Reactive Power Compensation for distribution networks	£ nil	£2,340	£2,340
Transient Fault Detection from Disturbance Recorders	£2,204	£2,157	£4,360
Technical assessment of Power Quality issues	£10,939	£2,882	£13,821
Harmonic detection and analysis	£2,204	£2,157	£4,360
Network unbalance source detection by optimum monitoring	£2,204	£2,157	£4,360
CuTS LV Overhead Line Project	£69,800	£6,452	£76,252
Power Networks Research Academy	£34,447	£3,628	£38,075
ENA R&D Group Programme	£ nil	£3,780	£3,780
EATL STP Overhead Line Module 2 and Forum	£ nil	£2,125	£2,125
EATL STP Cable Module 3 and Forum	£ nil	£1,308	£1,308
EATL STP Plant and Protection Module 4 and Forums	£ nil	£1,308	£1,308
EATL STP Networks for Distributed Energy Resources Module 5	£ nil	£6,316	£6,316
EA Technology - Partial Discharge Project and Forum	£ nil	£654	£654
EA Technology - Protective Coatings Forum	£ nil	£654	£654

Total	£439,178	£77,502	£516,680

6. Project Highlights

Western Power Distribution is pleased to report that R,D & D projects have continued to progress over the past year, with a number of these proving useful to the business. Highlights include:

- The Identification and Prioritisation of Network Losses project has now completed. It is envisaged that this scheme will give greatly improved visibility of the losses impact on individual network components with the aim of prioritising investment to reduce losses. It also forms a fundamental part out WPDs losses strategy and will inform both design and operational practices.
- The effect of Tree Growth Regulators (TGRs) has also completed. The project has concluded that the use of PBZ to control the growth of 11 genera of trees indicates that PBZ would be reduce tree growth and cost be effective
- Data from the Earthing design project with the British Geological survey has been integrated into WPDs GIS system, providing an additional valuable resource in designing earthing systems.
- Work with CREST at Loughborough University has concluded on the use of static balancers for LV networks. While this has determined that they can increase network utilisation, it has very little effect on reducing overall network losses.
- A study with Smarter Grid Solutions has been started to evaluate the potential of demand response in areas of high solar generation. This is building on existing modelling work from earlier IFI projects and will output findings in 2014. .

7. Future Intentions

During 2014/15, WPD will continue to develop projects through the Future Networks Programme guided by our Innovation Strategy. The IFI and LCNF projects will continue become more closely linked, to provide a better flow in the Research – Development – Demonstration process. New projects which will run beyond March 2015 (the start of ED1 price control period) will be evaluated in line with the Electricity Transmission Network Innovation Allowance (NIA) governance document in addition to G85.

IFI projects will also continue to invest in academic research and the development of products and services. There will continue to be larger demonstration projects such as the fault current limiter and the energy storage project.

New LCNF projects may take some of the more successful ‘smart grid’ concepts developed in the IFI portfolio and will incorporate them into larger demonstration projects.

Amongst other subject areas, future projects will investigate distributed intelligence, improved condition monitoring approaches and novel techniques for identification of the phase of service cables.

8. Individual Project Reports for Period April 2013 - March 2014

The following pages contain the Individual Project Reports for IFI projects undertaken by Western Power Distribution during the 2013/14 regulatory year.

<table>
<tr><td>Project Title</td><td colspan="4">Tree Growth Regulator</td></tr>
<tr><td>Description of project</td><td colspan="4">The project is investigated the effect of the plant growth regulator Paclobutrazol (PBZ) on tree vitality and growth rates of tree genera commonly found on or adjacent to overhead power lines (OHPL) . This five year project was initiated in 2009 and finished in 2013, and the final report was presented on 10 April 2014.

Six field trial sites were established throughout the UK representing a diverse range of bio-climatic zones. In addition two observational sites were established in each of the participating network operator’s licence areas. Tree species selected for PBZ evaluation are those that occur commonly on or near overhead networks.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,940
External £ 35,395
Total £ 38,335</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 249,447</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 720,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Application of the TGR Paclobutrazol (PBZ) to trees slows down the extension growth thus extending the pruning cycle and eliminating the need for annual visits to maintain clearances where restricted cuts exist; and eliminates the need to re-visit cycle busting trees midway through the pruning cycle; thus reducing maintenance costs.</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>22</td><td>-4</td><td>26</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The expected outputs from the project will be data and information on the effect of PBZ on tree extension growth rates following pruning across a range of species and bioclimatic zones. These data will comply with ORETO experimental requirements and will be used to apply to the Chemicals Regulation Directorate (CRD) for full approval of PBZ for use on amenity trees to regulate growth rates and for use within utility vegetation management (UVM) programmes.

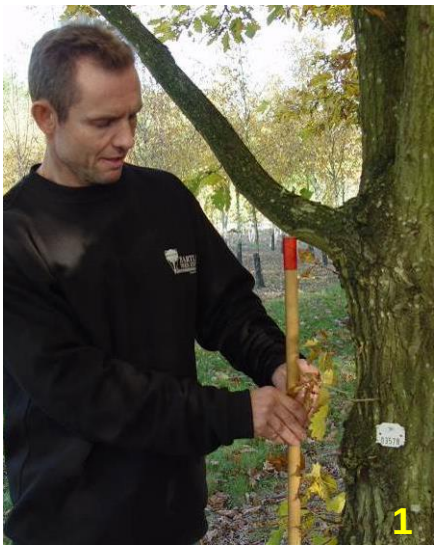
Once approved, PBZ could be used as part of UVM programmes to reduce growth rates on restricted cut sites and on high value amenity trees adjacent OHPLs to reduce overall vegetation management costs. This would also minimize the disturbance to landowners as a result of repeated annual or biennial visits to maintain clearances. This would result in reduced costs as the need for annual or biennial visits would be eliminated. In effect, application of PBZ to restricted cut trees would have the effect of bringing the trees into the normal cutting cycle of 4 to 5 years dependent upon voltage.</td></tr>
</table>

Expected Timescale to adoption	2014	Duration of benefit once achieved	20 Years
Probability of Success	75%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	> £1,000,000
Potential for achieving expected benefits	The potential for achieving expected benefits is believed to be high. Many phases of the project have already proved successful.		
Project Progress at March 2014	Six field sites and thirteen observational sites have been set up and PBZ applied at recommended dosage rates. Initial observations have indicated no phytotoxic effects. Following discussions with the DNO Project Director further planting of the tree species Leyland Cypress and Alder occurred on two sites in early 2010 that were treated with PBZ during summer 2010. The PSD, (now the CRD) granted an experimental licence and the work has been set up to meet ORETO research guidelines. An audit carried by ADAS compliance team has confirmed that the experiment complies with these guidelines. The principal result of the research is that the tree growth regulator (TGR) Paclobutrazol (PBZ) is effective and fit for purpose. The project assessed the effects of PBZ on two factors; (1) effects of PBZ on tree health and vitality; and (2) effects of PBZ on tree growth. **Conclusions:** To date objectives stipulated in the final IFI Research Project, "The effects of Tree Growth Regulators (TGRs) on Fast Growing Trees and Application to Utility Arboriculture" have been achieved. PBZ works and is fit for purpose. **PBZ registration & approval for use:** Syngenta have succeeded in getting PBZ listed on Schedule A of the list of compounds for re-approval at the EU level. However, because of the pressure from the EU to move away from chemical soil applications, Syngenta has been working with ADAS trialling a formulation of PBZ that can be systemically injected into trees. The preliminary results of the injectable formulation trials suggest that it has similar effects to the soil injected formulation in all genera except ash. Work on this aspect and adjusting the concentration and formulation is continuing.		

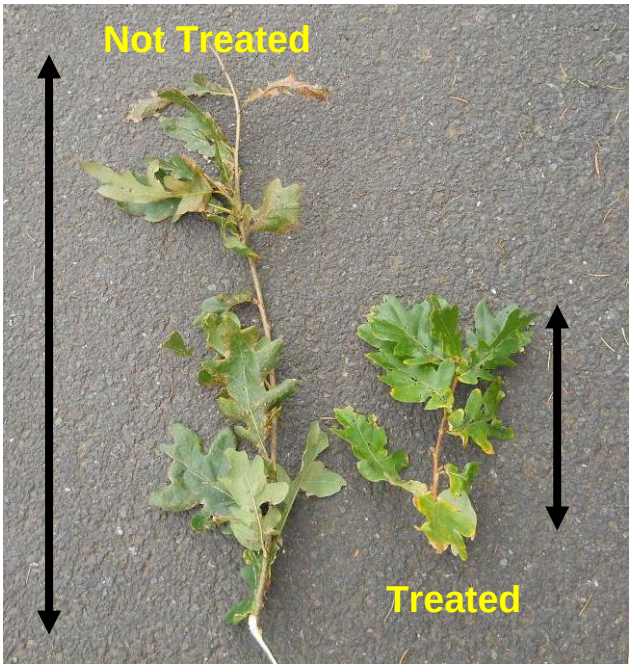
Project Progress at March 2014 (Cont)	The currently available formulation of PBZ 'Cultar' for soil application is being withdrawn from the market at the end of 2015 but it is likely to be replaced with a systemically injectable formulation. Such a formulation is likely to be approved for use in the UK. Product approval by CRD is supported by the Horticultural and Landscape industries. **Prognosis for use in the utility sector:** From the results of the trials, the use of PBZ to control the growth of 11 genera of trees indicates that PBZ would be effective and cost effective. Results from a previous IFI Project on tree re-growth rates[1] reveals that 77% of trees on or adjacent to the overhead line networks across the whole of the UK is comprised of just eight (8) genera of tree; i.e. alder, ash, birch, hawthorn, hazel, oak, sycamore and willow. Of these two genera (alder & hawthorn) are 'sensitive' to the effects of PBZ; and four (ash, birch, oak and sycamore) are in 'intermediate' in their response to PBZ. Of the remaining two genera (hazel and willow), hazel was not tested and willow is tolerant to the effects of PBZ, (poplar comprises <2% of the trees on the overhead line networks nationally). It is gratifying the see that Leyland cypress has intermediate sensitivity to PBZ as this species is a major problem on LV networks. The combined results of the TGR Trials and the Tree Growth Rate Study indicate that PBZ will be a cost effective way of slowing the growth of trees on or adjacent to overhead power lines. However the variation in effects between sites suggests that decisions on its use and on what species will have to be taken at the licence area level. One of the beneficial side effects of PBZ is that increases the growth of new roots and this assists tree stability. This effect is the subject of further investigation, but it is seen as a useful effect with application to 'resilience' trees, many of which are veteran trees.
Collaborative Partners	Scottish and Southern Energy, Northern Power Grid and UKPN
R&D Provider	ADAS, Bartlett Tree Research at Reading University and Syngenta Crop Protection (UK)

[1] Humphries, S J (2011) 'IFI Vegetation Management: Tree Growth Near Overhead Lines' ADAS Final Report July 2011

PBZ applied to the soil using the Rainbow Soil Injector®



Measurement of the trees (1) measuring dbh; (2) measuring extension growth



Samples of Oak from the Tipton observational site in 2011

<table>
<tr><td>Project Title</td><td colspan="3">Climate Change and Seasonal Variation Impacts on Electrical Earthing Installations</td></tr>
<tr><td>Description of project</td><td colspan="3">This project is developing an earthing prediction tool for incorporation into our GIS Mapping System to assist in the design and future maintenance of earthing systems. Soil and bedrock information will be provided. Suggested electrode design for a 20 ohm earth will be provided taking account of ground conditions; a graphical presentation of the comparative difficulty for the selected geographical area will be presented.

The risk due to climate and seasonal variation will be presented to assist in the optimum choice of electrode position in a given area and to help in prioritising future maintenance of earthing systems.

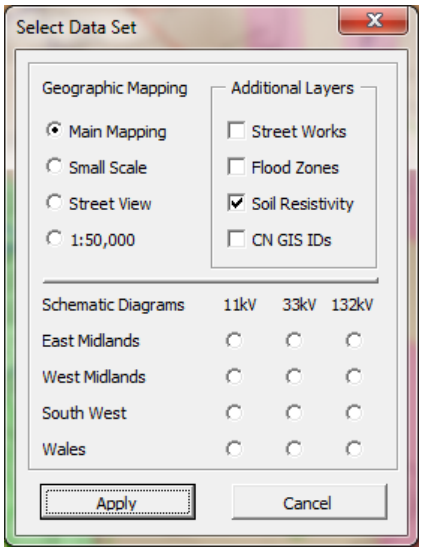
The project will also report on climate change and seasonal variation impacts on electrical earthing installations</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,864
External £ 34,475
Total £ 37,339</td><td>Expenditure in previous (IFI) financial years</td><td>Total £ 663,274</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£800,000</td><td>Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="3">The Phase 1 Electrical Earthing project – ‘An Information System to assist the installation of rural ground earthing systems’ was concerned with predicting the earthing requirements at sites within the network distribution areas of Western Power Distribution (Midlands) and UK Power Networks. The project assumed that the installation of vertically inserted deep drive rods was the normal method of providing earthing systems and that a horizontal trenched system would only be considered when the ground conditions prevented this normal method.

The Phase 2 Electrical Earthing project – ‘Climate change and seasonal variation impacts on electrical earthing installations’ aims to investigate the temporal changes in earthing resistance. It is recognised that the earthing resistance of a system will change with time as the resistivity of the ground varies exponentially in response to changes in water content and temperature. In particular the value of legacy shallow trench earthing systems will be particularly affected. A number of climate change scenarios are available from climate modelling and these indicate that parts of the UK could experience dryer or wetter conditions and that the seasonal ranges of precipitation and temperature could be more extreme than today.

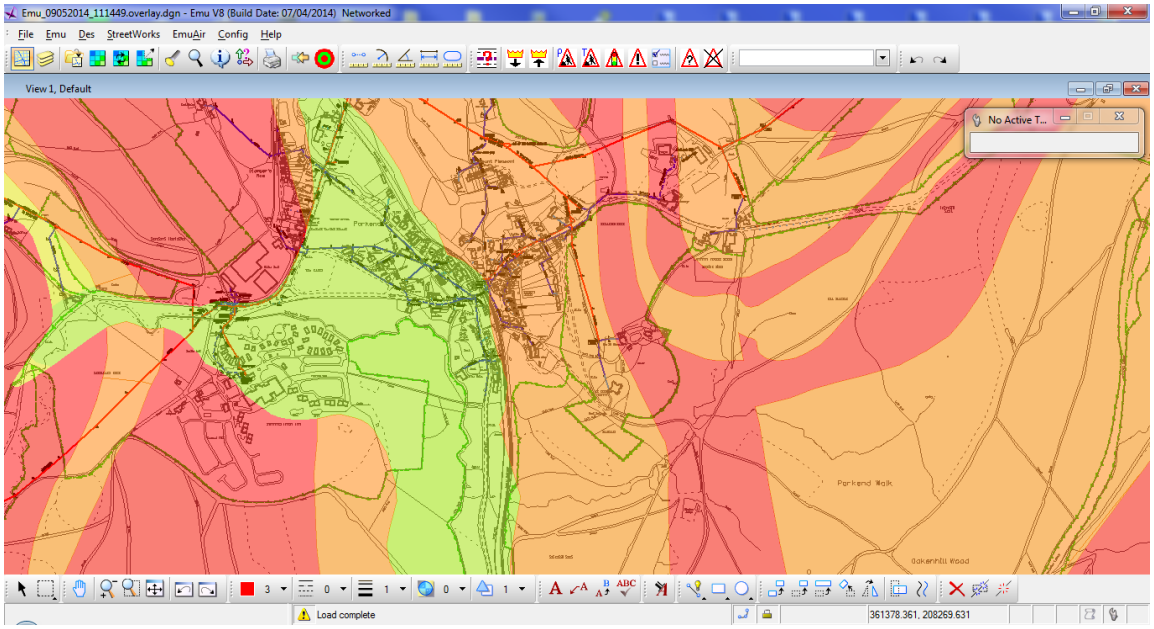
This project will provide qualitative and quantitative assessments of both seasonal changes and the impact of climate change on electrical earthing installations. The results of this study will provide a tool to identify those areas where earthing installations are most likely to go out of specification in future years.</td></tr>
</table>

<table>
<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>9</td><td>-4</td><td>13</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The expected benefits are:
Improved planning and costing of earthing.
Ability to take vulnerability to climate change and seasonal variation into account in planning earthing design and in prioritising maintenance.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2013-14</td><td colspan="2">Duration of benefit once achieved</td><td>20 years</td></tr>
<tr><td>Probability of Success</td><td>75%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£ 145,000</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The potential for achieving expected benefits is believed to be high. Many phases of the project have already been successfully implemented in all parts of Western Power Distribution.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">The project contains six main elements, now all complete:
Update to Phase 1
Revised set of modelled soil resistivities
Development of horizontal trench preference
Electrical earthing vulnerability to climate change
Quantitative assessments of the effect of climate change
Electrical earthing response to seasonal variations
WPD has added a layer to its EMU GIS to implement item 3 throughout WPD’s area and this is shortly to be released. This provides information that will aid our planners in accurately planning and costing the earthing element of new distribution transformer earths. It also includes information on soil and geology sensitivity to climate and seasonal change.

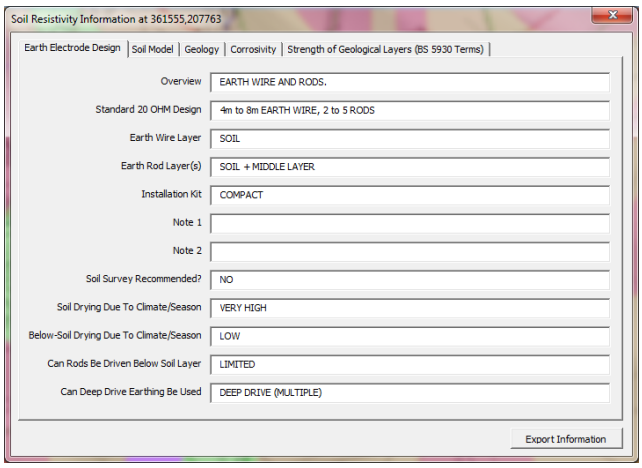
A report on climate change and seasonal variation impacts on electrical earthing installations has been produced</td></tr>
<tr><td>Collaborative Partners</td><td colspan="4">UKPN</td></tr>
<tr><td>R&D Provider</td><td colspan="4">British Geological Survey and Cranfield University</td></tr>
</table>



An additional data layer has been added to the EMU GIS tool which can be selected through the main Data Set menu.

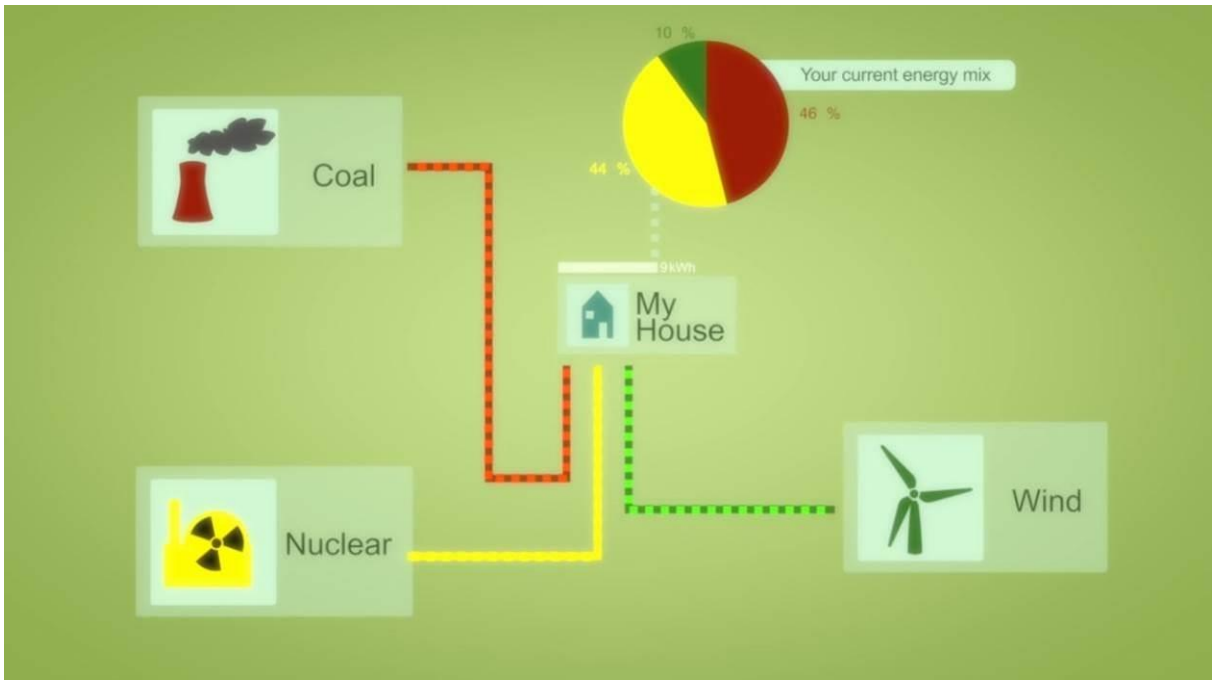


Screenshot of the earthing overlay displayed in EMU GIS software

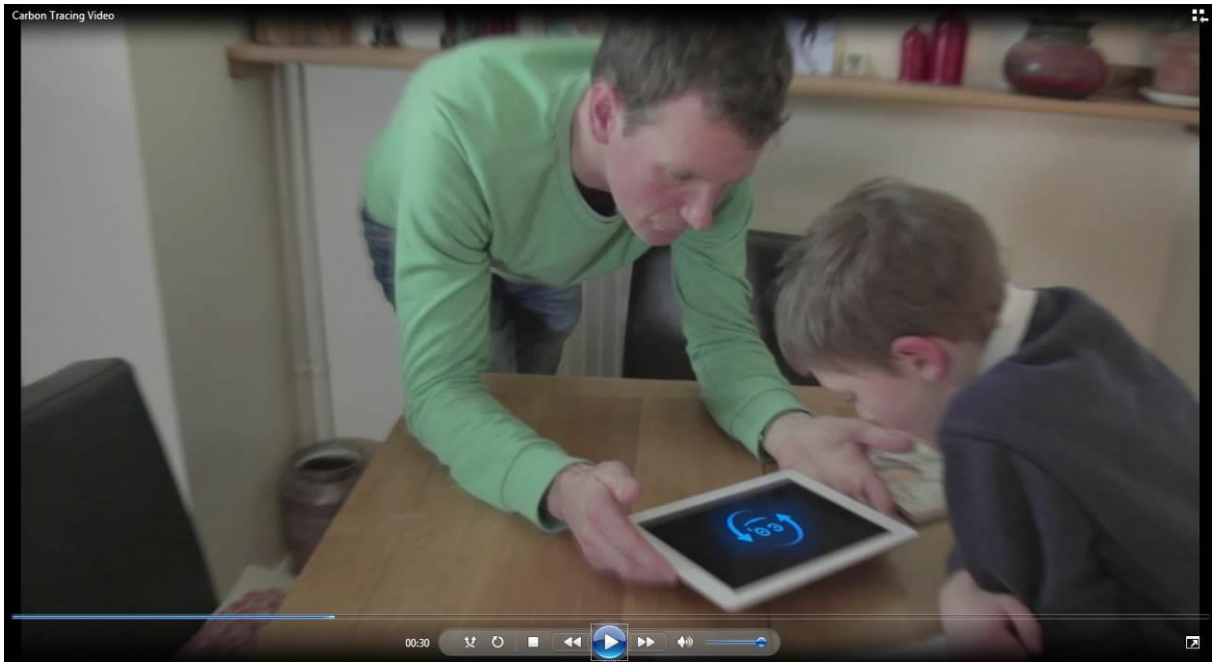


More detailed information can be gained through interrogating the system. An additional function has been added to allow this data to be exported for further application.

<table>
<tr><td>Project Title</td><td colspan="4">Carbon Tracing</td></tr>
<tr><td>Description of project</td><td colspan="4">The project sets out to develop a methodology and algorithms for tracing the electricity flows on distribution networks based on the carbon intensity of the associated generation. The project takes grid average for a GSP in South West England together with distributed generation based on fuel type. The project will develop a prototype demonstration for real time and historic energy flows for the St Austell BSP group. In addition to the methodology the project will also research innovative ways of communicating the concept to customers.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,687
External £ nil
Total £ 2,687</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 54,818</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 120,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 2,400
External £ 20,000
Total £ 22,400</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Network Losses, Environment</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution / Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10</td><td>-1</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The project will identify whether it is possible to accurately measure and report carbon intensity on specific section of the distribution network. Knowing the carbon intensity would enable DNOs to consider CO2 emissions more accurately, and discriminate between "green losses" and "carbon losses". It is expected that if successful the data will be made available to customers (initially in the trials area) possibly as part of a subsequent IFI or LCNF behavioural study.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2014</td><td colspan="2">Duration of benefit once achieved</td><td>30 Years</td></tr>
<tr><td>Probability of Success</td><td>60%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£30,164</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The modelling of the power flows uses standard IPSA tools, although some new algorithms need to be scripted. The demonstration element will require access to BSC raw data from Elexon.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">The project has completed a proof of concept and the integration of live data from the WPD Enmac system is ongoing. A customer video has also been produced.</td></tr>
<tr><td>Collaborative Partners</td><td colspan="4">None</td></tr>
<tr><td>R&D Provider</td><td colspan="4">Smarter Grid Solutions</td></tr>
</table>



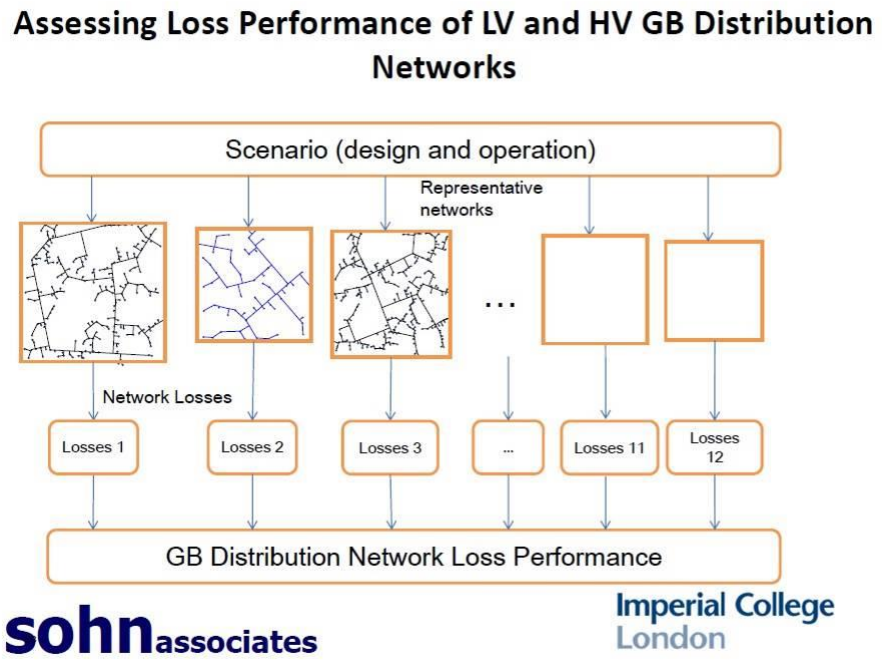
Visualisation of the generation sources feeding an individual property.

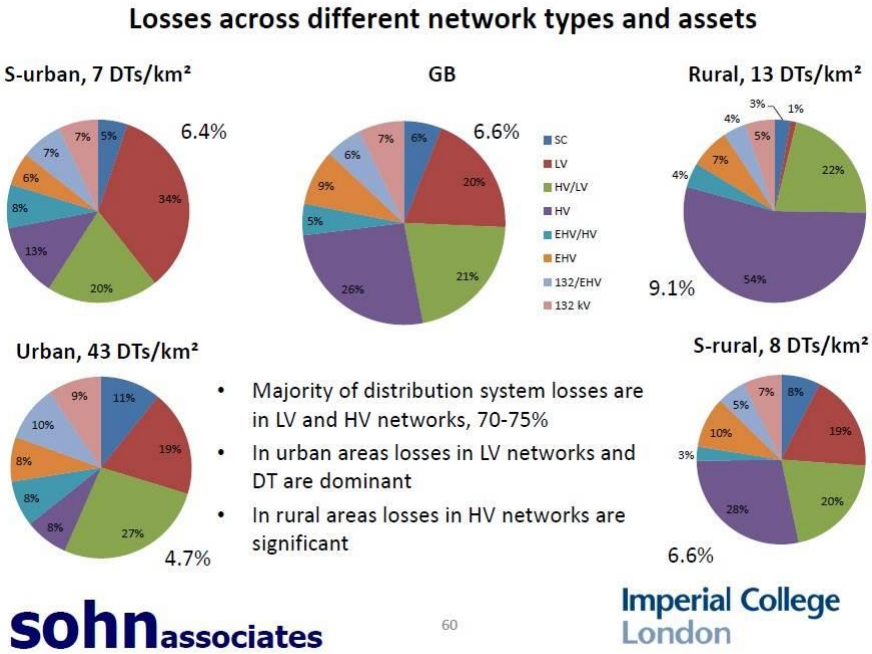


Screen shot from the customer video.

<table>
<tr><td>Project Title</td><td colspan="4">Identification and Prioritisation of Network Losses</td></tr>
<tr><td>Description of project</td><td colspan="4">The project builds on previous IFI studies undertaken for Western Power Distribution (Central Networks) by Imperial College London. The previous project developed generic networks and calculated losses to be used as a comparison against reported data (based on settlement algorithms). This project used the same models, but set out to identify the network areas and components where losses generated (such as Transformers, voltage levels, service cables, etc.). Further this study will propose intervention measures to reduce losses and deliver a prioritised list of such initiatives.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 4,153
External £ 50,000
Total £ 54,153</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 74,624</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 154,550</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Network Losses and Power System Modelling. The project also uses “smarter” intervention solutions within the power system model.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution / Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>0</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">If successful, this project will give DNOs and Suppliers access not just to the large volumes of data that will be available through the smart meter roll out, but to valuable information that can be extracted from this data. It will allow DNOs to look at trends and patterns in groups of consumers, whether it is in geographic areas or by the type of consumer.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>30 Years</td></tr>
<tr><td>Probability of Success</td><td>70%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£188,207</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Much of the technological risk of the project was elimination through the re-use of a previous power system losses model. It is therefore likely that the project will deliver a robust evaluation of potential loss mitigating techniques.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">The project final report was delayed to allow SOHN and Imperial to validate their findings through peer review. This included feeback from WPD and UKPN line teams. A presentation was given to WPD managers and engineering specialists in Bristol during May 2014. The final written report is due to be issued during the summer. Report findings will be</td></tr>
</table>

	incorporated into the WPD losses strategy for ED1.
Collaborative Partners	UK Power Networks
R&D Provider	SOHN Associates (Project management); Imperial College London (Technical analysis)





<table>
<tr><td>Project Title</td><td colspan="4">Demonstration of Distribution Scale Energy Storage</td></tr>
<tr><td>Description of project</td><td colspan="4">Western Power Distribution will demonstrate an innovative 1.4MW Pumped Heat Energy Storage device that is being developed by Isentropic Ltd using funds from the Energy Technologies Institute.

Isentropic are developing a 120kW prototype before developing a 1.4MW energy storage device capable of maintaining a four hour maximum output. Western Power Distribution are partnering with Isentropic to demonstrate the 1.4MW device on our network as we believe large scale storage could deliver significant benefits to distribution networks.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 1,370
External £ 16,489
Total £ 17,859</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 37,165</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 15,610,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 2,500
External £ 10,000
Total £ 12,500</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Networks are designed to operate with maximum demand with no contribution from Distributed Generation (DG) as well as minimum demand with maximum contribution from DG. Distribution Scale Storage is still a developing area and isn't currently a conventional network reinforcement technique due to its high capex, opex costs and asset life. Through this project WPD will be demonstrating an innovative Pumped Heat Energy Storage, the benefits of storage to the DNO and commercial models.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution / Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>-2</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The project aims to demonstrate the connection and operation of Pumped Heat Energy Storage, the benefits is successful could be;

• Flexible design and operation of distribution networks
• Transformer, tap changer, Overhead Line and Cable asset deferral
• Quicker and potentially cheaper connection of distributed generation
• Reactive power compensation, optimising the capacity of networks
• Improved power quality through contribution of fault current during network transients
• Potential benefits to other energy industry sectors
• Improved network security during asset maintenance, increased asset maintenance windows.</td></tr>
</table>

Expected Timescale to adoption	2020	Duration of benefit once achieved	25 Years
Probability of Success	40%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£52,654
Potential for achieving expected benefits	It has been predicted that the UK may require up to 40GW of energy storage by 2050, this is likely to be made up of different technologies, sizes for a wide range of energy purposes. Storage may be more commercial attractive if shared by more than one party, including DNOs. Demonstrating and learning how an innovative storage technology could be used to benefit the operation of the distribution network will determine if DNOs can use storage as a smart technique		
Project Progress at March 2014	Isentropic have finalised the detailed designed for the prototype energy storage system, built and tested individual sub systems. The prototype unit is currently in the manufacturing and assembly stage with full testing expected in Q2 2015. Two WPD primary substations within the East Midlands have been identified as suitable for the demonstration of energy storage after site surveys have been carried out. A planning application will be made on both sites and one of the substations will have the 1.4MW storage device installed. WPD have worked with Isentropic to assess the required specification of energy storage to solve a range of network limiting factors, triggered by both demand and generation. Further work will be carried out during 2014/15.		
Collaborative Partners	Energy Technologies Institute		
R&D Provider	Isentropic Ltd		

Isentropic storage tanks

<table>
<tr><td>Project Title</td><td colspan="3">Power Communications Meter</td></tr>
<tr><td>Description of project</td><td colspan="3">Development and demonstration of a cost effective remote monitoring device for small embedded generation sites connected at 11kV.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 597
External £ 7,182
Total £ 7,779</td><td>Expenditure in previous (IFI) financial years</td><td>Total £ 102,636</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>Phase 1 £ 77,000
Phase 2 £ 110,000</td><td>Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="3">Small scale embedded generation sites connected on the 11kV Distribution Network is increasing in number, but these sites are not normally monitored. Without data from these sites, the quantity of real demand on a feeder is effectively masked by the generation and this presents difficulties for both; real time operational decision making, and for network design.

A traditional SCADA RTU could be installed but this is not considered to be a cost effective solution.

The larger 11kV embedded generation sites need additional monitoring facilities and this is being addressed in a second phase of this project, which will provide the following:
Tripping of switchgear controlling the generation
Close inhibit control of the switchgear
G59 Protection operation indication</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Technical Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td>-4</td><td>18</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="3">Real time information (Voltage, current, power factor and alarms) displayed on the control System diagram will enhance network visibility when operating and will impact on network performance and safety.
This functionality will facilitate future Smart Grid development allowing the connection of more embedded generation.
Historic ½ hourly load information will improve the quality of network design and provide power quality information.
Additional control and monitoring facilities to be provided on larger embedded generation systems</td></tr>
<tr><td>Expected Timescale to adoption</td><td>Phase 1 – 2011
Phase 2 – 2012</td><td>Duration of benefit once achieved</td><td>25 years</td></tr>
<tr><td>Probability of Success</td><td>Phase 1 - 50%
Phase 2 – 75%</td><td>Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>Phase 1 £114,606
Phase 2 £143,702</td></tr>
</table>

Potential for achieving expected benefits	The initial trial has proven that the equipment can remotely monitor sites and operate correctly. An alternative prototype for monitoring Maximum Demand Indicators in LV cabinets has also been developed and installed as a demonstration. Data from these sites has been displayed on the iHost Communications Hub and an interface created between this and our ENMAC control system. The second phase linking the power communications meter to distribution substation remote control equipment to demonstrate compatibility should provide the facilities to monitor and control larger embedded generation sites.
Project Progress at March 2014	The first three trial units have continued to provide real time and ½ hourly historic information to the iHost Communications Hub. Two additional units with slightly modified functionality have been commissioned and more modified units will be installed to extend the trial to remotely monitor two large PV installations. This project has provided a useful piece of equipment that can be used to provide monitoring of embedded generators. The installation of various devices is on-going and has so-far confirmed that the product works adequately. The units developed in this project, are now in a position to be used as required in WPD's Active Network Management schemes.
Collaborative Partners	None
R&D Provider	Nortech and Schneider Electric

One of the remote Communication Power Units monitoring an 11kV site with embedded generation.

<table>
<tr><td>Project Title</td><td colspan="4">Sensor Networks (Smart Dust)</td></tr>
<tr><td>Description of project</td><td colspan="4">“Smartdust” is a concept developed by the University of California that is based on a self-configuring wireless sensor network, capable of transmitting low bandwidth information in a series of short hops. Data acquired and transmitted from sensors is relayed through a gateway for data interpretation. Scottish Power led a feasibility study into the use of this technology for detecting the passage of fault currents on 11kV overhead line networks.

Following on from this work, a collaborative project was scoped with Scottish Power to develop a product based on this principle for the remote signalling of fault passage indication on Overhead Line networks.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 859
External £ 500
Total £ 1,359</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 228,740</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 462,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 6,000
External £ 70,000
Total £ 76,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Fault Passage Indicators (FPIs) are pole mounted sensors that detect the passage of fault current in an overhead line via disturbances in the electro-magnetic field. Presently FPIs indicate the passage of a fault current via LED or beacon on the unit itself. This is used by linesmen on patrols to identify the source of the fault.

A cheap and reliable method of collection of fault passage indication data, a centralised location for Overhead Line Faults would significantly reduce the time required to resolve faults on the network and consequently reduce CML associated penalties. This technology would be especially suited to transitory fault location.

Significant analysis has been undertaken on the deployment characteristics of GSM/GPRS Fault Passage Indicators Vs. Radio communicating sensors, using fault histories. The analysis is considering the relationship between sensor cost, deployment penetration and improvement to CML figures. The key conclusion is that a cheap, low power semi-mesh radio based system:

• Allows a much higher percentage of locations of be monitored economically than any other option, across all price points and time savings

• Offers a much higher NPV than any other option

Owing to these factors, a significantly higher percentage of network can be monitored (from 10% for GSM devices to above 70% coverage for radio sensors), increasing the likelihood that they will be targeting faults (rather than solely focussing on worst performing circuits).</td></tr>
<tr><td>Type(s) of innovation involved</td><td>radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
</table>

		13	-2	**15**
Expected Benefits of Project	Sensor Networks implemented as a method of fault passage indication could have an enormous effect on how faults on the overhead network are located. Wireless Fault Passage Indication (wFPI) devices have the capability to communicate via radio frequency immediately upon detection of a fault current or loss of voltage field. Each wFPI sends a message to a dedicated gateway usually located at a substation, which in turn communicates to a centralised location the position of the fault. This system should decrease the time required to locate a fault and should therefore reduce customer minutes lost (CML) figures. This should result in an improvement in network performance for our customers and a financial saving for the network operator.			
Expected Timescale to adoption	2013	Duration of benefit once achieved	10 years	
Probability of Success	50%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£ 500,000	
Potential for achieving expected benefits	The project is still on track to deliver the expected benefits despite a number of delays through the project history.			
Project Progress at March 2014	Following initial delays, equipment has now been supplied for trail activity. It is expected that trials will be conducted during 2014/15 in the Cwmbran area. Following the trials, WPD staff will be trained on how to use the equipment for a range of network applications.			
Collaborative Partners	Scottish Power			
R&D Provider	Willow Technologies and E.ON New Build & Technology			

<table>
<tr><td>Project Title</td><td colspan="5">WPD South West Distribution Network Strategy Development</td></tr>
<tr><td>Description of project</td><td colspan="5">The electrical distribution network in the South West of England has been increasingly challenged in recent years with both reducing demand and significant step-changes in the level of embedded generation at all voltage levels from LV to 132kV. This generation ranges from diesel, biomass, and waste power plants on standard connection or short-term reserve contracts, to a large number of onshore wind farms and significant levels of green-field and domestic PV installations.

WPD South West is seeking the development of an innovative network master plan using a whole-network approach in order to accommodate the large level of PV generation into its distribution network in the coming years. This will take learning from transmission systems and emergent technology and commercial solutions to inform network development, taking into account short-term tactical solutions, as well as appropriate long-term strategic options with minimal stranding risk.

A two-phase system study detailed below will be delivered in order to meet the requirements:

• Phase 1 - Distribution System Performance Review
• Phase 2 – Network Strategy Reinforcement Options Development</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £ 3,738
External £ 45,000
Total £ 48,738</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ nil</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td colspan="2">£ 200,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 7,000
External £ 80,000
Total £ 87,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Whole-network analysis approach in order to develop strategies to accommodate large levels of PV generation</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 colspan="2">Overall Project Score</td></tr>
<tr><td>12</td><td>-4</td><td colspan="2">16</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">• Creation of up to date network model including generation connections
• Provide adequate headroom for future distribution network development
• Assessment of new technology applications
• Network Reinforcement Options Study</td></tr>
</table>

Expected Timescale to adoption	2015	Duration of benefit once achieved	30 Years
Probability of Success	60%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£817,171
Potential for achieving expected benefits	Potential for developing outputs is high. The project is mostly around network studies so the technical risk is low.		
Project Progress at March 2014	In Q4 2013, WPD worked closely with TNEI to provide TNEI with sufficient data for them to prepare a network model that represented all committed and connected generation in the South West. TNEI subsequently ran a series of studies to model the effect of the generation on WPD's network. TNEI produced a report in April 2014 presenting the outcome of their studies, which represented the end of Phase 1. Phase 2 will begin in May 2014 and will investigate a range of techniques to provide additional capacity on the South West network.		
Collaborative Partners	None		
R&D Provider	TNEI		

Project Title	**Network Finger Printing**		
Description of project	Electricity distribution networks may sometimes be required to absorb harmonic current emissions from equipment that is connected to it. As these current emissions travel through the electricity distribution network they will distort the shape of the voltage waveform that is supplied to network customers. The amount of distortion inflicted upon the voltage waveform by the harmonic current emissions is a function of both the magnitude of the current harmonics but also the frequency response of the distribution network. The frequency response of the distribution network can have a particularly large influence upon this problem as it is possible for resonant conditions to exist within the network which will serve to amplify distortion across a wide area of the distribution network. By understanding the frequency response of their network a network owner will be able to make more informed decisions during the planning process of new connections to the system. Western Power Distribution will work with Garrad Hassan to develop a process that allows calculation of changes in Harmonic Distortion on their 33 kV network using fixed tables.		
Expenditure for financial year	Internal £ 1,732 External £ 14,590 **Total £ 16,322**	Expenditure in previous (IFI) financial years	**Total £ nil**
Total Project Costs (Collaborative + external + Western Power Distribution)	£ 19,590	Projected 2014 – 2015 costs for Western Power Distribution	Internal £ 2,000 External £ nil **Total £ 2,000**
Technological area and / or issue addressed by project	Harmonic currents flowing through a distribution system will create harmonic distortion by virtue of the fact that they will flow through network impedance. The magnitude of this network impedance will be influenced by the series and parallel combinations of inductive or capacitive reactance presented by the wider network. Because these values of individual reactance will differ over the range of harmonic frequencies the magnitude of overall network impedance will vary across the harmonic frequency range. This is because these different combinations of reactance move in and out of resonance across the harmonic frequency range. It will therefore be understood that the use of a frequency sweep methodology allows the network owner to understand the likely frequency response of their network to the injection of harmonics. Furthermore by making suitable allowances for the natural damping of these resonances inherent in the overhead lines and transformers of the distribution network then a more accurate estimate of the magnitude of the harmonic impedances can be obtained. These harmonic impedances can be then used to calculate the resultant voltage distortion at the point of current injection.		

<table>
<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>9</td><td>-2</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">This project will clearly detail the network's characteristics. Generation Developers will then have a much better understanding on how their development will impact the network, the amount of studies they will need to undertake and a understanding if harmonic filtering may be required.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>1 Year</td><td colspan="2">Duration of benefit once achieved</td><td>5 Years</td></tr>
<tr><td>Probability of Success</td><td>50%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£18,877</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The project has a 60% change of achieving its expected project benefits.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">This project has identified the key factors in understanding the frequency response of their network, allowing a network owner to make a more informed decision during the planning process of new connections to the system.

The project has developed a process that allows calculation of changes in Harmonic Distortion on their 33 kV network using fixed tables for a number of BSP’s across the South West. The project has not yet taken into account 11kV feeder connections and 132kV Mechanically Switched Capacitors, this will be taken into account during stage 2 of the project.</td></tr>
<tr><td>Collaborative Partners</td><td colspan="4">None</td></tr>
<tr><td>R&D Provider</td><td colspan="4">Garrad Hassan</td></tr>
</table>

<table>
<tr><td>Project Title</td><td colspan="4">Project Galaxy - Network Analytics</td></tr>
<tr><td>Description of project</td><td colspan="4">As substation monitoring increases on the network, so does the amount of data being gathered. However, it is often difficult to identify the significant information from the data using manual analysis techniques.

This project is a feasibility study to determine if specific consumer electrical load profiles can be identified in an overall load profile of a suburban environment such that the specific profiles can be identified to a specific feeder and phase.

There are two phases of the project, the first to create a profile of the specific load and the second to electronically embed that into some real data collected from a typical substation installation and to determine if the specific load profile can be located.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,160
External £ 20,000
Total £ 22,160</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ nil</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 100,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 4,200
External £ 44,000
Total £ 48,200</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Development of distributed substation intelligence, paired with monitoring algorithms to detect specific network conditions.</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>8</td><td>-5</td><td>13</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">• Improved data manipulation
• Identification of specific load signatures
• Improve network visibility</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>30 Years</td></tr>
<tr><td>Probability of Success</td><td>60%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£2,772</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Potential for developing outputs is high. The project is mostly around building analytical tools on existing substation monitoring solutions so the technical risk is low.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">The initial start-up of the project has commenced with the establishment of a test bed to identify load signatures of specific appliances. Further work has also started to see if these can be seen and extracted from substation level monitoring data streams.</td></tr>
</table>

Collaborative Partners	EDF, Selex
R&D Provider	TTP

<table>
<tr><td>Project Title</td><td colspan="5">Domestic Demand Response Network Study</td></tr>
<tr><td>Description of project</td><td colspan="5">Although the potential of domestic DSM technologies to release network capacity may be significant, its future value is not yet well understood and quantified. This project is intended to enable WPD to quantitatively evaluate the opportunity of using flexible domestic demand and identify potential strategies to leverage DSM benefits, and provide insight into the impact of future technical, market and regulatory frameworks in the medium to long term, before committing to the expense of a significant trial or demonstration project.</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £ 3,955
External £ 25,000
Total £ 28,955</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ nil</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td colspan="2">£80,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 7,000
External £ 50,000
Total £ 57,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Potential scale of domestic demand response through control of space storage heating and hot water heating.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>13</td><td>-2</td><td colspan="2">15</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Domestic Demand-Side-Management (DSM) could provide a number of benefits to Distribution Network Operators (DNOs), including deferring network investment, aiding network outage management or increasing the amount of distributed generation that can be connected to the existing distribution network infrastructure. By scheduling flexible load to coincide with the time of minimum demand, the generation hosting capacity of the network, as calculated using worst-case conditions, can be increased and more generation connected. Conversely, by ensuring that flexible load is not scheduled to operate during peak demand periods, demand-driven network overload situations can be avoided. This project will deliver benefit through a desktop assessment of the potential scale of DSM interventions.</td></tr>
<tr><td>Expected Timescale to adoption</td><td colspan="2">2014</td><td colspan="2">Duration of benefit once achieved</td><td>30 Years</td></tr>
<tr><td>Probability of Success</td><td colspan="2">60%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£1,572,095</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="5">There is a high potential for success as a number of mitigation techniques will be required to manage the emerging constraints appearing on the network.</td></tr>
</table>

Project Progress at March 2014	A detailed network model has been created allowing a number of scenarios to be modelled for the Devon and Cornwall distribution networks. This includes detailed load history and connected generation. An assessment has also been made of the level of potential domestic load that could be called including electrical storage emersion heaters. Smarter Grid Solutions have run a number of scenarios with the network model to ascertain the level by which load could be called upon to take up some of the solar generation peak. The high density of generation is currently leading to a number of constraints that could prevent the connection of further low carbon power sources. A final report for this project is due in Summer 2014.
Collaborative Partners	None
R&D Provider	Smarter Grid Solutions

<table>
<tr><td>Project Title</td><td colspan="4">Transformer Oil Regeneration</td></tr>
<tr><td>Description of project</td><td colspan="4">This project is intended to provide a potential benefits of regeneration of transformer oil on a case by case basis</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £5,596
External £59,500
Total £65,096</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ nil</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 65,096</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 0
External £ 0
Total £ 0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Improvement in Transformer asset life and the life extension through the regeneration of transformer oil. The use of oil regeneration will be become a widely used tool for the improvement of transformer life and improving the health index associated with it in the next price review period. The project will help the understanding of what is required for an ideal candidate to defer change by as much as 10 years. Through improved oil analysis interpretation which will aid the choice of transformers.</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>14</td><td>-7</td><td>21</td></tr>
<tr><td>• Expected Benefits of Project</td><td colspan="4">• Improved oil analysis to feed into future decisions for transformer change
• Extension to life of correctly selected transformers through improved oil quality
• Improvement to insulation properties allowing for deferment of asset change
• Improved accuracy in health indices for outdoor assets.
• Improved data for currently adopted CBRM tool and therefore improved asset investment strategy
• Wider use within the RIIO ED1 price review period</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2014</td><td colspan="2">Duration of benefit once achieved</td><td>8</td></tr>
<tr><td>Probability of Success</td><td>85%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£450,658</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">There is a high potential for success with transformer oil regeneration if the right transformers are selected through correct identification through oil analysis, age of the transformer, system loadings, criticality to the network and condition assessment. The potential for success and improving an asset life by 5 years is highly likely and there is a high potential to improve the asset life by as much as 10 years. To improve the asset life by 10 years, early intervention needs to happen.</td></tr>
</table>

Project Progress at March 2014	Project at the time of writing is complete but a dramatic improvement of the transformer oil can be seen from the samples provided after just 7 passes through the mobile regeneration unit supplied by EOS (Electrical Oil Services Limited). Oil analysis shows improvement of acid levels a decrease in water levels, and an improvement in the breakdown voltage of the oil. The oil quality will be improved with the removal of gases present in the oil and the removal of sludge which has a detrimental effect on the paper insulation and the cooling of the transformer, removing this will slow the aging process
Collaborative Partners	None
R&D Provider	EOS Limited

<table>
<tr><td>Project Title</td><td colspan="4">Phasor Measurement Trial</td></tr>
<tr><td>Description of project</td><td colspan="4">This project aims to demonstrate the use of field Phasor identification equipment on 33kV, 11kV and LV networks, to identify operational and safety issues and equipment limitations.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 1,127
External £ Nil
Total £ 1,127</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 64,233</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 64,233</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">In future Smart Grids, it is likely to be necessary to identify the phase of connected non-symmetrical loads and embedded generation. Demonstrating equipment capabilities and understanding the expected amount of system phase shift in both a temporal and spatial context is necessary to develop reliable working practices.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Technological Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>-3</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Ensuring networks are balanced will maximise utilisation and reduce losses. Correct phase identification of controllable non-symmetrical loads and generation will aid network analysis. Understanding system phase shift across our extensive geographical area will determine optimum Phasor Base Station locations and working practices. Demonstrating the equipment will identify potential operational risks and training requirements that need consideration prior to adoption.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2014</td><td colspan="2">Duration of benefit once achieved</td><td>15 years</td></tr>
<tr><td>Probability of Success</td><td>75%</td><td colspan="2">NPV=(PV Benefits – PV Costs)x Success Probability</td><td>£51,410</td></tr>
<tr><td>Potential for achieving benefits</td><td colspan="4">The equipment has been used in Europe for similar applications.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">The unit has been successfully used to confirm the network phasor relationships across the Low Carbon Hub substations, Skegness, Ingoldmells, Chapel St Leonards, Trusthorpe, Bambers Wind Farm and Alford using a range of connection methods, Voltage Presence Indicating System (VPIS), live line connectors and the secondary outputs of a 33kV substation Voltage transformer.

A guide to operation will be written during 2014/2015 and the units deployed across the midlands for use in a range of operational scenarios and will be completed as a business as usual activity</td></tr>
</table>

Collaborative Partners	None
R&D Provider	Sibille Faeca Electric (SFE)

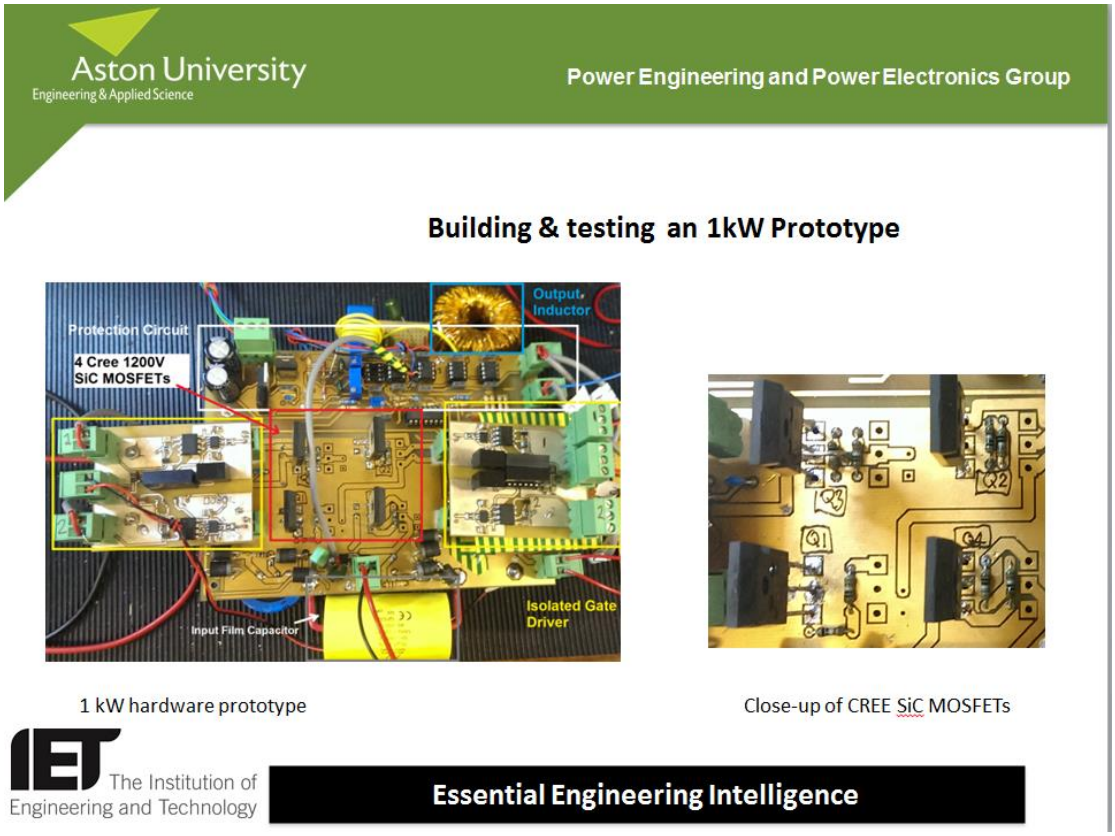
<table>
<tr><td>Project Title</td><td colspan="4">Smart Grid Design</td></tr>
<tr><td>Description of project</td><td colspan="4">Identify optimal network design configurations and arrangements for new and existing networks; identify potential changes in operational strategies and any required equipment characteristics.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 5,809
External £ 9,250
Total £ 15,059</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 148,450</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 650,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 3,200
External £ 20,000
Total £ 23,200</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">As part of the initial phase of this smart grid project, alternative network topology will be analysed to identify the advantages and limitations of different operational arrangements both under existing demand patterns and with a view to accommodating new low-carbon, distributed generation (DG) on the network. A second part to resolve issues associated with improving available network data using statistical techniques is under consideration. In particular validating estimations based on, transformer maximum demand records, demand profiles and DG intermittency.

A separate phase will consider the use of a power electronic converter unit to be installed at the load end of the LV distribution network (i.e. on the distribution side of customer’s meter). Development of a prototype converter unit is part of this project.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Technological Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>1</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">The initial phase evaluated the benefits of different network topologies at 11kV and LV. Currently networks at these voltage ranges are typically operated in radial configurations with normally-open points between different feeders as this allows design and operational simplicity.

One alternative network topology involves meshing networks permanently, to give the benefit of balancing the load between feeders and an increase in diversity. This should result in reduced conductor (I^2R) losses, and may free up more network capacity to connect low carbon distributed generation (DG).

Development of a converter unit which can passively provide; as a minimum ‘voltage control at the point of delivery’, but also has the functionality to ensure other statutory requirements of the electrical distribution network operators can be delivered, has the potential to revolutionise future LV networks.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>20 years</td></tr>
</table>

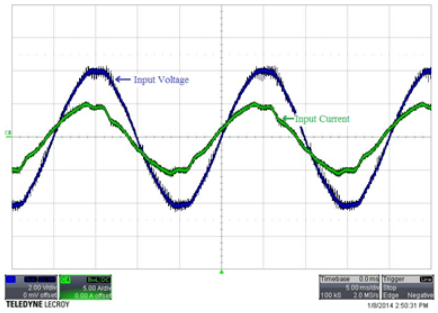
Probability of Success	25%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£313,013
Potential for achieving expected benefits	The Knowledge Transfer Partnership allows close collaboration between academia and distribution network expertise, while the involvement of the Power engineering and power electronics, Computer science, and Non-linearity and complexity research groups provides access to the necessary expertise.		
Project Progress at March 2014	**Power Electronic AC/AC Converter** The thermal outputs of existing power electronic devices and configurations has been thoroughly researched and modelled to determine the limiting factor and desired efficiency required to house the equipment into existing meter-box sizes. The latest power electronic devices are promising to utilise different materials to enable low cost, high powered devices which would fulfil the efficiency requirements. There is particular potential for technology transfer from the Electric Vehicle market, as these devices will operate in the same voltage, efficiency and duty regimes. The innovative research has been presented in a number of poster sessions at power electronic events such as the European Conference on Power Electronics and Applications and has also featured in published conference white papers presented as part of PEMD 2014.		
Collaborative Partners	EPSRC (through sKTP and CASE awards)		
R&D Provider	Aston University and E.ON New Build and Technology		



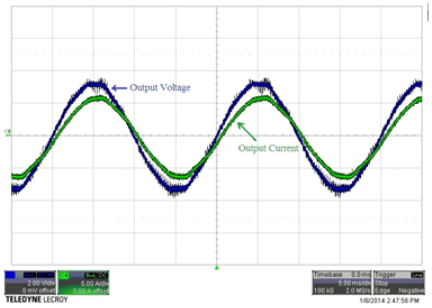
Aston University
Engineering & Applied Science

Power Engineering and Power Electronics Group

Prototype Results



Module input voltage (200 V/div) and current (5 A/div) waveforms for 1 kW, 0.98 power factor output power (5ms/div)



Module output voltage (200 V/div) and current (5 A/div) waveforms for 1 kW, 0.98 power factor output power (5ms/div)

The Institution of Engineering and Technology

Essential Engineering Intelligence

<table>
<tr><td>Project Title</td><td colspan="4">Reactive Power compensation for distribution networks</td></tr>
<tr><td>Description of project</td><td colspan="4">This project will analyse reactive power compensation as a method to increase capacity and improve voltage control on LV networks, today and with predicted future increases of Low Carbon Technologies.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,340
External £ nil
Total £ 2,340</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 44,349</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 63,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 500
External £ 15,000
Total £ 15,500</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Predicted increases in Distributed Generation, the electrification of transport and heating may require networks to have an increased capacity and improved voltage control. New ideas are being researched as an alternative to conventional network reinforcement. This project will model the effectiveness of reactive power compensation on the LV network and the impact on the rest of the distribution network under steady state and transient conditions.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution / Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>13</td><td>-3</td><td>10</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">This project will provide an understanding of the impact when installing reactive power compensation on the Low Voltage Network:
• The improvements in capacity and voltage control,
• The characteristics under steady state
• The characteristics under and transient conditions
• The impact on the rest of the distribution system, 11kV, 33kV and 132kV if adopted on a wide scale.

The outputs from this project will provide guidance as to whether Reactive Power Compensation is a technique that could be used for improving future networks.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>25 years</td></tr>
<tr><td>Probability of Success</td><td>25%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£44,255</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The project will be run by Cardiff University and managed by WPD.

The insight gained from the project will be directly applicable and relevant to all network operators preparing long term business plans.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="4">This project will be completed in Q2 2014. The project is structured in two stages, the first has been finalised with a report of the steady state impact of reactive power compensation. The project has evaluated several different types of LV networks, urban, sub urban and rural</td></tr>
</table>

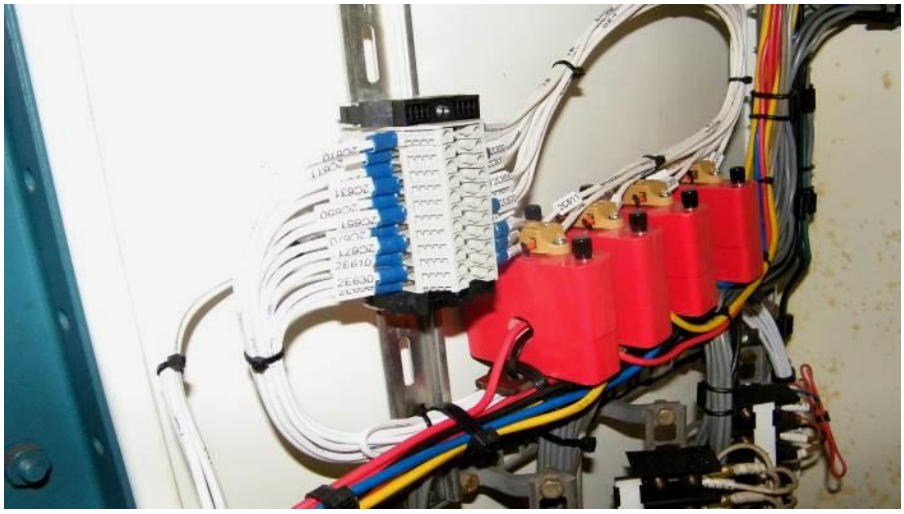
	locations. The detailed network data from the LCNF Tier 2 LV Network Templates project was used to quantify the effects of reactive power on the distribution networks. The second stage will be finalised during the next reporting period and will include steady state and transient performance on LV and 11kV networks, The optimum placing and sizing of reactive compensation using the current network demands, future network demands, changing power factors and a high penetration of embedded micro generation has shown where and when reactive compensation should be installed.
Collaborative Partners	None
R&D Provider	Cardiff University

<table>
<tr><td>Project Title</td><td colspan="4">Transient Fault Detection from Disturbance Recorders</td></tr>
<tr><td>Description of project</td><td colspan="4">Use of disturbance recorder information to determine a search area for of potential faults by interpreting the waveform characteristics associated with self-healing pecking faults.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,157
External £ 2,204
Total £ 4,360</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 367,309</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>Phase 1 £ 265,000
Phase 2 £ 107,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Pecking faults are small discharges caused by voids within the insulation of distribution cables, or surface tracking over compromised insulation on equipment. The discharges are insufficient to cause circuit protection devices to initiate a trip signal and will self-heal temporarily.

As these network disturbances do not cause loss of supply and are difficult to detect, they are normally ignored, but evidence suggests that they can re-occur at irregular intervals and are often the precursor to the development of a more serious fault. If these incipient faults can be identified with equipment that can detect the small dips on the voltage waveform and short surges in current, then proactive action could be taken. If the pecking fault waveform changes are sufficient to allow the disturbances to be interpreted as an impedance value to the point of fault, then this information can be used with GIS data to determine search areas allowing these potential faults to be located and rectified before they cause a loss of supply to any customers.

The project has been extended so that data collected from the monitoring of the substation battery can be used to identify the time of operation of the trip coil so that protection and switchgear operating times can be differentiated, allowing identification of any incorrect protection or circuit breaker clearance operation.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>13</td><td>2</td><td>11</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Detection of incipient self-healing faults will improve network performance and reduce customer interruptions by determining the location of potential faults and enabling proactive asset management.
The early identification of incorrect protection or circuit breaker clearance operations will improve network performance.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2013</td><td colspan="2">Duration of benefit once achieved</td><td>20 years</td></tr>
<tr><td>Probability of Success</td><td>25%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£ 303,600</td></tr>
</table>

Potential for achieving expected benefits	Initial focus has been on the design and installation of the distribution disturbance recorders at a number of 132/11kV substations and this has resulted in a cost effective, non-evasive installation arrangement which can be easily retro-fitted to existing substation sites either; using an existing relay panel; or in a dedicated wall cabinet. These disturbance recorders have the capability to provide various data reports, which include information on; substation battery operation, power quality; network stability, unbalance; harmonics and certain asset condition information. The analysis of this vast array of information is beyond the scope of this particular project and further projects using information from similar recorders have been started. One area which this project has been extended to include is the analysis of the battery waveforms at time of fault to identify if protection and switchgear clearance times are as expected. As both these projects required analysis of data collected during faults there were benefits to combining this work. The reports are sent by the instruments to a central location via a standard GPRS connections and this facility is providing a hub for the collection of other condition data at these sites.
Project Progress at March 2014	Installation and commissioning of multiple event recorders at 11 urban 132/11kV sites has been completed for this project. The data from any faults occurring on the networks supplied from these 11 substation sites is being collected. There have been a wide number of technical issues associated with the data collection and retrieval associated with this scheme. It has now been deemed to be unfeasible to continue with the project and unlikely to be adopted for business as usual applications. A summary report of findings has been produced for internal circulation.
Collaborative Partners	None
R&D Provider	Elimpus (Strathclyde University), Embedded Monitoring Systems (EMS) Ltd, Sterling Power and E.ON New Build & Technology



Current connections made with split CTs on the secondary wiring within an existing relay cabinet. This arrangement minimises the recommissioning work needed to install disturbance recorders, when retro fitting existing sites.

<table>
<tr><td>Project Title</td><td colspan="4">Technical assessment of Power Quality issues</td></tr>
<tr><td>Description of project</td><td colspan="4">Confirm the extent of suspected power quality issues on an extensive sub-transmission network and consider the effect of alternative mitigation measures.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,882
External £ 10,939
Total £ 13,821</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 157,043</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 226,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 5,000
External £ 50,000
Total £ 55,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Power quality issues are an increasing concern for our customers and all distribution network operators. Computer technology, automated processes and sensitive electronic equipment are in widespread use across all customer sectors.

Short duration interruptions and voltage sags are the most frequent cause of loss of revenue to commercial and industrial customers as they can result in mal-operation of equipment.

Installation of low loss distribution equipment and network configurations designed for optimizing the connection of low carbon devices may allow power quality issues to propagate further with single events disrupting more customers.

Monitoring an extensive sub-transmission network, which is suspected to contain sources of power quality issues, will provide the opportunity to identify the extent of the propagation of power quality issues and allow alternative mitigation measures to be considered and possibly demonstrated to evaluate their effectiveness.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Technological Substitution</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">Deliver a better understanding of power quality issues and the cost effectiveness of potential mitigating solutions on customers.

Determine the extent of propagation of power quality issues on a real network and allow the assessment of low loss distribution equipment and proposed future network configurations.

Verification of previous research methods, which of assessed alternative techniques to improve power quality</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>8 years</td></tr>
<tr><td>Probability of Success</td><td>25%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£187,770</td></tr>
</table>

Potential for achieving expected benefits	Information from previous project on power quality explored the uncertainties posed by sag performance estimation from voltage sag monitoring and demonstrated how different methods and durations of monitoring periods affect accuracy of sag profile modelling. It also considered how to assess alternative mitigation techniques to determine optimal solutions for different customer / in various network scenarios. Assessed techniques included dynamic voltage recovery, redundant supplies and various network infrastructure improvements. This background work provides useful information, which will be incorporated into this project to increase the probability of success.
Project Progress at March 2014	Various sources of unbalance have been modelled, looking at how this propagates across the network. Data from the monitors is now being collected and returned to a central data repository. Work has been ongoing to develop parse and correlate algorithms to allow the data to be processed for further evaluation. Further work has taken place to upgrade the communications technology associated with the monitoring with checks to ensure that all installations are correctly calibrated. It is intended that the data being collected will inform the business strategy for further rollout of power quality monitoring.
Collaborative Partners	None
R&D Provider	Manchester University, Embedded Monitoring Solutions, Sterling Power and E.ON New Build and Technology

<table>
<tr><td>Project Title</td><td colspan="4">Harmonic detection and analysis</td></tr>
<tr><td>Description of project</td><td colspan="4">Use of disturbance recorder information to determine harmonic levels on a rural 33kV network with a large penetration of cable connected intermittent distributed generation.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,157
External £ 2,204
Total £ 4,360</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 225,764</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 230,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">With a growing penetration of non-linear loads, distributed generators (DGs) and flexible AC transmission system (FACTS) devices that employ power electronic converters, harmonic voltage distortion on the distribution network are increasing.

Harmonic voltage distortion has been recognised as a cause of:
• interference to telecommunication and control systems
• increased losses in circuits and equipment
• overheating of rotating plant, transformers and capacitors, the latter being particularly susceptible to harmonic damage
• increased voltage stress on equipment
• increased vibration and noise emissions
• spurious tripping of control circuits and relays, and mal-operation of any equipment using zero crossing waveform technology, including digital timers
• general degradation of fuse elements

Identifying the source of harmonic distortion is not always easy as the magnitude depends upon network parameters.

This project aims to monitor a network which is suspected of having a high level of existing harmonic distortion. The data collected will be used to determine methodologies to identify the source of harmonics and to improve the harmonic content of the electricity supply in the future.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Technological Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td>0</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">This project will give better understanding of harmonic distortion in a rural network with large penetrations of DG. The measurement of actual network values will allow the theoretical network studies to be verified. This will enable methodologies to be developed to identify the source of harmonics distortion and the effectiveness of potential mitigation techniques tested. This knowledge will allow a potential barrier to the connection of renewable distributed generation to be removed.</td></tr>
</table>

Expected Timescale to adoption	2014	Duration of benefit once achieved	20 years
Probability of Success	75%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£527,630
Potential for achieving expected benefits	System studies on the 33kV network, which will be used for the data collection have identified that harmonic distortions at high even orders (between 20th- 30thorders) could become close to exceeding the planning levels specified in ENA Engineering Recommendation (ER) G5/4-1. It is believed that these harmonics are caused by the power electronic technology associated with the wind generation, which is cable connected to this network. It is therefore likely that the disturbance recorders will be able to verify the high levels of harmonics and analysis should enable the objectives of this investigation to be achieved.		
Project Progress at March 2014	Thirteen disturbance recorders have been installed at six primary substations on this rural 33kV network to give complete coverage of the distribution network. Various sources of unbalance have been modelled, looking at how this propagates across the network. There have been a wide number of technical issues associated with the data collection and retrieval associated with this scheme. It has now been deemed to be unfeasible to continue with the project and unlikely to be adopted for business as usual applications. A summary report of findings has been produced for internal circulation.		
Collaborative Partners	None		
R&D Provider	Embedded Monitoring Solutions (EMS) Ltd, Sterling Power and E.ON New Build and Technology		

The limited space in the primary substation control rooms and the general civil arrangements, dictated that free standing panels had to be installed at these sites instead of the more usual wall panels.

<table>
<tr><td>Project Title</td><td colspan="4">Network unbalance source detection by optimum monitoring</td></tr>
<tr><td>Description of project</td><td colspan="4">This project aims to determine a method of identifying the source of unbalance on a 33kV mesh network using a minimal number of monitors.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,157
External £ 2,204
Total £ 4,360</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 235,997</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 240,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ nil
External £ nil
Total £ nil</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">Network unbalance can be an issue for customers and distribution network operators. It can cause damage to equipment, increase system losses, reduce network capacity, and prevent optimal feeding arrangements. Historically, voltage unbalance occurred due to the connection of single phase loads and conventional corrective action methods involved the permanent reconnection of specific loads to other phases.

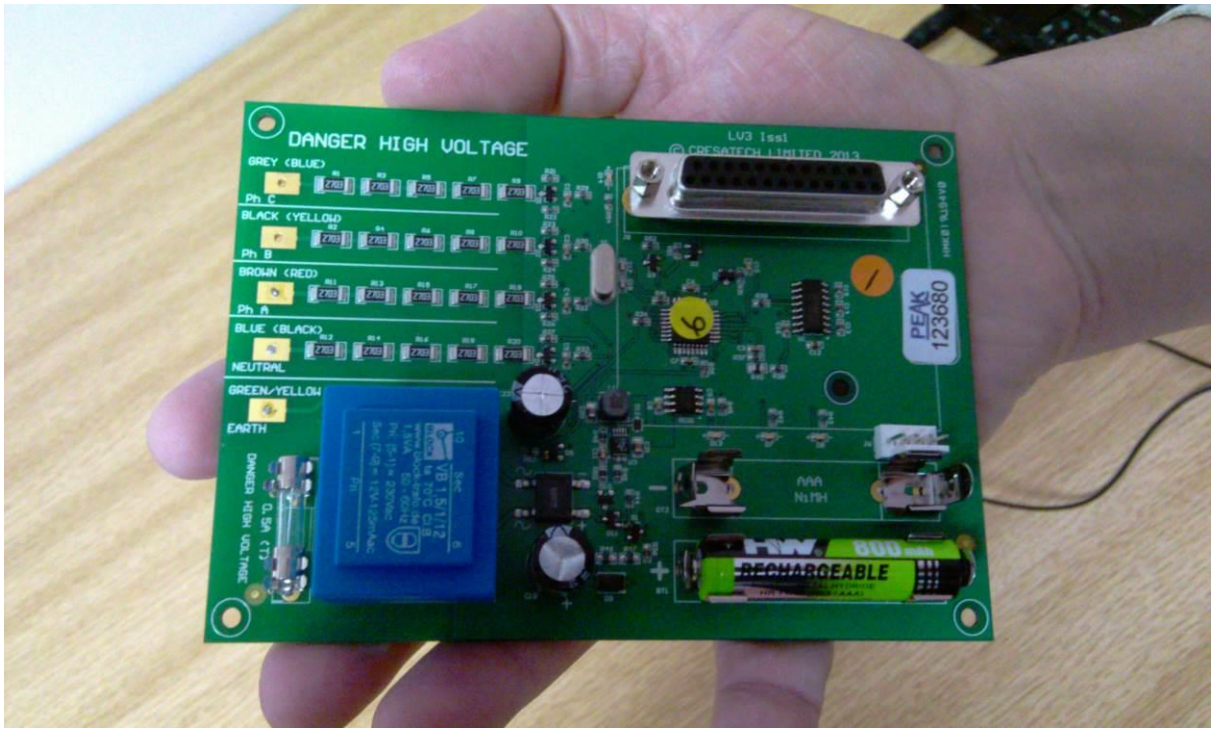
The increased in single phase distributed generation is expected to cause a rise in voltage unbalance issues, which will become more noticeable, especially as voltage unbalance on the network can prevent the connection of three phase distributed generation. As much of the future distributed generation will be intermittent (Wind, PV, etc.), detecting the source of the voltage unbalance and applying conventional corrective action is also likely to become more difficult.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Technological Substitution</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">The objects of this project are to develop:
A methodology for the optimal placement of a limited number of monitors in a network (taking in to account any existing monitor installations) to provide full network observability.
A distribution state estimator to trace unbalance in distribution networks allowing identification of the primary source.
A real time display of network unbalance that can be used by the distribution network operator.
The project aims to demonstrate how knowledge of network unbalance can be used to identify the most appropriate corrective action.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2013</td><td colspan="2">Duration of benefit once achieved</td><td>20 years</td></tr>
</table>

Probability of Success	75%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£349,486
Potential for achieving expected benefits	The design of an optimal monitor placement methodology build on previous project work carried out at Manchester University. While the data recorded from the installed network monitors will confirm the theoretical conclusions. Three-phase load flow and least square methods will be applied to achieve state estimation, which forms the basis of the methodology of detection of voltage unbalance location and source. Here the data recorded from the installed network monitors will allow the practical application of the theory. These two deliverables will be integrated to form a real-time graphical display program, indicating the health status of the network.		
Project Progress at March 2014	Eight disturbance recorders have been installed at three substations and configured to provide the required voltage and current monitoring facilities. Five more disturbance recorders were installed during summer 2011. Various sources of unbalance have been modelled, looking at how this propagates across the network. There have been a wide number of technical issues associated with the data collection and retrieval associated with this scheme. It has now been deemed to be unfeasible to continue with the project and unlikely to be adopted for business as usual applications. A summary report of findings has been produced for internal circulation.		
Collaborative Partners	EPSRC		
R&D Provider	University of Manchester, Embedded Monitoring Solutions (EMS) Ltd, Sterling Power and E.ON New Build and Technology		

Disturbance recorders installed at the 132/33kV source substation to act as remote current monitors on the three 33kV feeders, which supply the unbalanced meshed network

<table>
<tr><td>Project Title</td><td colspan="4">CuTS LV Overhead Line Project</td></tr>
<tr><td>Description of project</td><td colspan="4">Development of an early warning/alarm system to send notification of network interference.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 6,452
External £ 69,800
Total £ 76,252</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 22,534</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 120,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 2,500
External £ 17,000
Total £ 19,500</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">To detect removal of neutral and/or any one or all phases between customer premises and distribution transformer.
• The unit should be sufficiently intelligent to provide information on which specific lines are down e.g. whether P1, P2, P3 or N/PE.
• The unit should be able to be adapted to multiple three phase or single phase delivery formats using the main earthing type standards: TNCS, TNC etc.
• The unit should be able to provide alarm functionality with or without external power present for a reasonable period.
To ignore/automatic reset, upon momentary fault events.
• To ensure momentary events do not cause unnecessary call outs /alarms, the unit should be able to filter out very short term events.
Quick to install and set up by Craftsperson.
• For most installations it is anticipated that the only connections necessary will be feeds from the supply side of the user switchgear/meter to the unit.
Alarm Communications.
• The alarm needs to communicate which specific fault event has occurred e.g. If a Phase failure, which Phase(s) and/or a Neutral failure.
• The data output will integrate with WPD monitoring systems.
• • Alarm communication will need to be transmitted wirelessly. The most likely approach will be to utilise IP or SMS via GSM/GPRS on board modem.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technological Substitution / Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td>-3</td><td>17</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">• Reduce Customer supply interruptions resulting from overhead metal theft.
• Reduce material losses.
• Potential for possible future adaptation to provide supply side smart grid information.
• Low Unit cost
• Quick and easy to deploy</td></tr>
</table>

Expected Timescale to adoption	2015	Duration of benefit once achieved	30 Years
Probability of Success	50%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£12,752
Potential for achieving expected benefits	As the project progresses confidence that a suitable product can be developed increases. The deployment strategy remains key to delivering the benefit for the project. Proportionally the amount of theft on out network continues to be small compared with the size of the overall system and recent number sown a reduction. It continues to be vital to identify and target areas of the network that are most likely to experience theft. This will be done through identifying hot spots with the police and other interested agencies.		
Project Progress at March 2014	The decision was taken to combine phases 2 (Proof of concept in lab/development environment and production/test of initial prototype) and 3 (Development, Integration and test of required Communications) of the project. Cresatech have submitted combined Phases 2 / 3 Report and a prototype Unit has been produced and demonstrated to WPD that will be used for on-site trials. During the initial scoping meeting with Cresatech, WPD also discussed a variety of possible other uses of a network monitoring device (once developed) with considerable emphasis placed on the importance of a low unit cost. The Unit that Cresatech have developed maintains the desire low unit cost and is capable of capturing data relating to a variety of supply characteristics, with the potential to expand the uses of a fully functioning system once finalised. In order to maximise the uses and benefits of the units, further development of the central analytical software application may be required. The project is currently entering phase 4 and 200 units are in production.		
Collaborative Partners	The Service Provider has explored opportunities to work with other Organisations but is currently working alone to develop and provide the technical solution.		
R&D Provider	Cresatech LTD		



Prototype theft detection unit

<table>
<tr><td>Project Title</td><td colspan="3">Power Networks Research Academy</td></tr>
<tr><td>Description of project</td><td colspan="3">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, related manufacturers and consultants, that will fund and support PhD researchers in power industry related projects and help maintain and improve the research and teaching capacity in power engineering subjects.

Projects are selected from a number of submissions, using a two tier process. This process comprised; an initial sift to determine the project's industrial relevance and an independent peer review to determine their academic excellence. Scholars were subsequently recruited for each of these projects.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 3,628
External £ 34,447
Total £ 38,075</td><td>Expenditure in previous (IFI) financial years</td><td>Total £ 242,360</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 1,500,000</td><td>Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 1,600
External £ 20,000
Total £ 21,600</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="3">The projects for the first intake of Academy scholars are:
• Overhead Lines Measurement System
• System Impacts and Opportunities of HVDC Upgrades
• Application of Artificial Immune System Algorithm to Distribution Networks

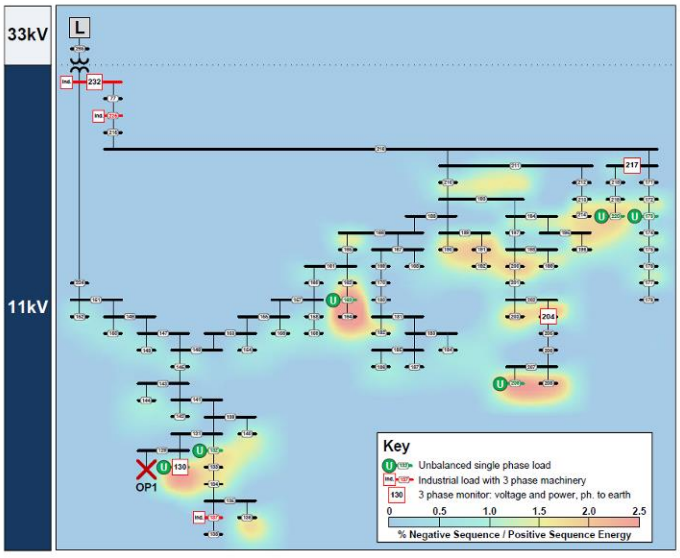
The projects for the second intake of Academy scholars are:
• Early Frequency Instability Predictor based on Synchronised Wide Area Measurements (E-FIP)
• Electrical Network Fault Level Measurement for Distributed Generation and Other Applications
• Protection of Converter-Dense Power Systems
• Chemical Approaches Towards Intelligent Insulation
• Protection Issues of Inverter-Interfaced DG
• Reactive Power Dispatch Using Distributed Generation

The projects for the third intake of Academy scholars are:
• Influence of oil contamination on the electrical performance of power transformers
• Protection of Series Compensated Transmission Lines based on Synchronised Measurement Technology
• Alternatives to SF6 as an insulation medium for distribution equipment
• Reducing the Risk of Sub-Synchronous Resonance in Meshed Power Networks with Increased Power Transfer Capabilities
• Solid state devices for electrical power distribution</td></tr>
</table>

<table>
<tr><td></td><td colspan="4">The projects for the fourth intake of Academy scholars are:
• Using Power Electronics to increase Power Capacity without changing Infrastructure
• Effect of climate change on design and operation of meshed networks
• State Estimation for Active Distribution Network
• Influence of wind uncertainty on National Grid’s Operating Reserve</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</td><td>-1</td><td>10</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">It is expected that the Academy will:
• promote a stronger, more active and robust R & D environment in power networks disciplines at UK universities;
• provide capacity and capability to undertake the specialist research needed by industry and wider stakeholders;
• strengthen the teaching capability at those institutions;
• focus on building the health of discipline across a number of power research universities;
• facilitate a resource of trained engineering staff with academic capability, who will be capable of tackling electrical power engineering challenges;
• deliver research output that is industrially relevant and beneficial.
See online for further information at
http://www.theiet.org/about/scholarships-awards/pnra/</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2013</td><td colspan="2">Duration of benefit once achieved</td><td>20 years</td></tr>
<tr><td>Probability of Success</td><td>25%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£ 200,000</td></tr>
<tr><td>Potential for achieving expected benefits.</td><td colspan="4">There are now a wide range of projects and information from all the individual research projects is regularly shared amongst the members. In addition each project is also allocated to an industrial sponsor for them to provide direct support and direction This also maximises the opportunity for them to benefit from individual research projects.
Western Power Distribution is directly involved in three projects. The potential for achieving expected benefits and progress reports for the other projects can be found in the IFI reports of their supporting companies. The information for the projects with which Western Power Distribution is directly involved can be found below:</td></tr>
</table>

Project Progress at March 2014	**Application of Artificial Immune System Algorithm to Distribution Networks (Manchester University)** The identification of the worst served customers in the network has now been expanded to cover: voltage weak areas, voltage sags and unbalance. Published research on all topics include 5 conference papers and one journal paper as well as one further conference paper and two further journal papers which have been submitted, but not yet published. Methodologies have been developed for to allow Western Power Distribution and other DNO's to optimally monitor their network for voltage sags, unbalance and voltage stability and also intelligently process the gathered information using artificial intelligence techniques. The methods developed are practical and customer focussed. Recent work on voltage unbalance and state estimation has been applied to a real section of Western Power Distribution's network and it is hoped this will be used to help solve specific issues within their network. Research has been completed on collating all the developed techniques into an overall system state estimator capable of identifying the worst served and weakest areas of the network. This research has been compiled and written up as a thesis, which has been examined and passed at the University of Manchester. **Protection Issues of Inverter-Interfaced DG (Imperial College. London)** A study of the risks of islanding and LoM algorithms has been undertaken. This work concluded that islanding is not a risk while the penetration of DG is low. As DG increases however, the risk of islanding will increase and more sophisticated islanding detection algorithms will be required. A paper for UPEC 2010 was written and presented in Cardiff. The required 15-month transfer report has been submitted and examined. **Solid State Devices, for Power Dense, Electric Power Distribution Networks (Strathclyde University)** • Literature Review - Each of these topics were explored in depth, on their standard operation and how they would be implemented in order to increase low voltage power capacity. High frequency transformers, soft normally open points, DC networks and point of use regulation; with particular focus on low voltage distribution in the UK. • Viability Study - The first main segment of research of this PhD was a viability study using Powerworld simulator. The simulation was based on Sheridan Road in Bristol and has found that voltage regulation is a viable method of easing voltage congestion on a modern urban low voltage distribution system.

Project Progress at March 2014	• Converter Topologies - The second segment focused on the creation of power electronic converter topologies in Matlab Simulink. Two topologies were simulated for comparison. One circuit topology was then chosen over the other for implementation of voltage regulation. • Review Session - As part of the University of Strathclyde first year review, a detailed technical report was created and a presentation given on the progress to date. A poster was also created and presented at the University of Strathclyde annual Research Presentation Day (RPD) event. • Hardware Prototype Build - Work has begun on creating a circuit based on the earlier chosen topology.
Collaborative Partners	EPSRC, IET, National Grid, Scottish and Southern Energy, UKPN and EA Technology Ltd
R&D Provider	Universities of Cardiff, Manchester, Queens (Belfast), Southampton, Strathclyde, and Imperial College London.



Project on Artificial Intelligence produced a heatmap of the network showing the worst served customers for unbalance, identified using the techniques developed in this PhD and a limited set of monitors

<table>
<tr><td>Project Title</td><td colspan="5">ENA R&D Group Programme</td></tr>
<tr><td>Description of project</td><td colspan="5">The Energy Networks Association (ENA) represents all the UK network operators. Several projects have been initiated by the ENA R&D working group and have been funded through the IFI.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 3,780
External £ nil
Total £ 3,780</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td colspan="2">Total £ 569,988</td></tr>
<tr><td>Total Annual Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 598,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td colspan="2">Internal £ 4,000
External £ 20,000
Total £ 24,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">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.

Harmonic Impedance Modelling: The project addresses the detailed modelling of cable and overhead line components, to develop cable models appropriate for distribution networks

Earthing Project – HV/LV Earthing Transfer: The aim is to develop new techniques to assess the impact of lower voltage earth electrodes on higher voltage ‘hot zones’ and to measure the resistance of distribution substation earth systems

Smart Grid Forum Workstream 3 Phase 1 & 2: Takes the impact of Britain’s future energy scenarios into key strategic directions for network development, identifying the needs for network expansion and the opportunities for smart grid techniques to drive cost-efficiency and deliver new services. It considers the enablers for change, including the necessary development of commercial and regulatory frameworks

DC Injection: Investigation into the corrosion effects of DC on DNO networks with specific emphasis on assessing the impact of DC flows in the neutral conductors and providing evidence that a max of 20 milliamps as per British Standards is suffice .</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental / Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td colspan="2">Overall Project Score</td></tr>
<tr><td>6.2</td><td>-10</td><td colspan="2">16.2</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">These projects have the potential to provide a wide range of benefits. In some cases, they will help to understand key asset-related issues and allow designs to be altered to address them. In other cases they will allow us to better understand risks to our network, whether from climate</td></tr>
</table>

	change or changes in demand. The smart metering project is already making a valuable input to the overall smart metering consultations and the development of the national Smart Metering Equipment Technical Specification (SMETS).		
Expected Timescale to adoption	Year 2012	Duration of benefit once achieved	10-20 Years
Probability of Success	75%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£ 100,000
Potential for achieving expected benefits	Work on the harmonic impedance modeling (G5/4) will help DNOs understand harmonics issues on distributed networks and produce a revised revision of G5/4. The transfer potential projects will assist with understanding earthing issues in differing situations. The remaining projects are still in progress and it is hoped they will demonstrate the benefits explained.		
Project Progress at March 2014	**Harmonic Impedance Modelling** The project addresses the detailed modeling of cable and overhead line components, to develop cable models appropriate for distribution networks. These will be incorporated in to a new revision of G5/4 to a new simplified Stage 3A methodology for simple and low harmonic connections. Work is ongoing to establish this simplified stage. Tests have been progressing and will be published in the new G5/4 in due course. Final document has been received from the ENA R&D Working Group (WG). The document was authorised for circulation within the ENA R&D WG in the first instance, with a view to wider circulation once approved. **Earthing Project – HV/LV Earthing Transfer** This project has developed new techniques to assess the impact of lower voltage earth electrodes on higher voltage 'hot zones' and to measure the resistance of distribution substation earth systems up to 33kV. It is proposed this is now extended to the 132kV networks with a new calculation method being developed to accurately estimate transfer potential between EHV, HV and LV earthing system. The new calculation method will be designed with different arrangements and soil resistivity in mind. Under the previous stage of this IFI project, an MS Excel based calculation tool has been developed for analysing the earth fault current distribution for the full range of representative 11kV cables required by the member companies. This was now complete up to 11kV. A CD was provided by Earthing Solutions (ES) which included modelling calculations. The extension to the project to include voltages from 33kV up to 400kV. This new proposal is to add a representative sample of DNO 33kV, 66kV and 132kV cables into the routines. The 33kV and 66kV circuits and cables		

	have many similarities to those previously modelled and can be added using the methods already developed. The 132kV circuits are more complex in terms of cable construction, circuit configuration, end resistance value (low) and circuit length (quite long). The work proposal includes 6 key deliverables and the price quoted by ES to complete this work is in total £25.5K. As of March 2013 further information is still being acquired for the projects potential transfer to the transmission system. **Smart Grid Forum Workstream 3 Phase 1, 2 & 3** The phase 1 report translates the impact of UK's future energy scenarios into key strategic directions for network development, identifying the needs for network expansion and the opportunities for smart grid techniques to drive cost-efficiency and deliver new services. It considers the enablers for change, including the necessary development of commercial and regulatory frameworks. It focuses on 2020 and 2030, and casts a forward look towards 2050 to consider the enablers for change, including the necessary development of commercial and regulatory frameworks. Phase 2 will develop a technical model and cost benefit analysis network investment tool for a range of typical network types from EHV to LV. The model will be run against synthetic networks at each voltage level under a range of low carbon uptake scenarios. Phase 2 completed successfully with the tool complete and able to be used for ED1 Business Plans. Phase 3 involved reviewing cost data and updating expected low carbon technologies in line with DECC's revised forecasts. Transform was used to inform the ED1 Business plan and has moved from its development phase to one of support and maintenance. **DC Injection:** Project is underway, project objectives have been raised, project currently progressing through early stages.
Collaborative Partners	National Grid; Scottish Power Energy Networks; Scottish and Southern Energy; Electricity North West and Northern Power Grid
R&D Provider	TNEI; Engage Consulting Limited; Imperial College London; Met Office; EA Technology Ltd (and partners); Earthing Solutions; KEMA and Redpoint Energy; Inertek; CAPCIS.

<table>
<tr><td>Project Title</td><td colspan="4">EA Technology - Strategic Technology Programme
EATL STP Overhead Line Module 2 and Forum</td></tr>
<tr><td>Description of project</td><td colspan="4">Research and development into all aspects of Distribution Overhead Lines</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 2,125
External £ nil
Total £ 2,125</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 721,807</td></tr>
<tr><td>Total Annual Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 325,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 4,200
External £ 110,577
Total £ 114,777</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The Module 2 programme aims to optimise overhead network design, improve operational performance, maximise potential benefits, improve financial performance, and minimise risk associated with overhead networks, whilst having due regard for the environment and energy efficiency. The programme also aims to deliver continuous improvement in terms of safety and environmental performance of the overhead network to meet the individual business requirements of Member Companies. Several of the projects contribute to the industry’s knowledge of variation in climate change. The projects all address real problems that have been identified by the module steering group members as significant and which require technical investigation and development.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental, Technical Transfer, Signifiant, 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 will significantly 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;
Development of tools, technology and techniques to reduce risk or cost, or to increase speed of capital deployment of Member Company programme delivery;
A better understanding how overhead line assets perform in service which can be used to determine the overall asset management policy ;</td></tr>
</table>

	• Reduce levels of premature failure of assets; • 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; • Co-operation between European countries in the development of forecasting methods of atmospheric icing and for the exchange of forecasting tools; • Comparison of new covered conductor with known performance of older types; • Increasing scientific understanding of processes and climatic conditions leading to icing; • Extend the service life of poles and reduce potential levels of failures; • Reduce lifetime costs by the appropriate use of alternative materials; • Improved methodology for determining conductor ratings will provide greater confidence; • Positive impact on environmental performance and many have positive impacts on safety; • Give Members a better understanding of novel conductors for new-build or re-conductoring lines that gives lower capital cost, minimum visual impact, and environmental acceptance.		
Expected Timescale to adoption	Range 2012 - 2016 Dependent upon project	Duration of benefit once achieved	Range 3-5 years Dependent on project
Probability of Success	Range 49 - 95% Dependent on project	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£ 42,652
Potential for achieving expected benefits	There are a huge variety of projects within the work programme for Module 2. A number of these projects are scientific based and will require further research and development to achieve improvements in operational performance and integration into the Network Operators business environment. Projects in these areas are mainly stages of much larger multi-stage projects and require further work to optimise network design, financial and operational performance from which the customer and stakeholders will benefit Other projects were looking at better ways of improving the operational performance, management and reliability of Overhead Networks, by minimising the impact on the environment and the safety of both the operators and the public, in a manner that could be implemented straight away. Collectively, the work programme demonstrates the development of innovative products, processes and techniques that improve the management of Overhead Networks; in terms of safety, design, environment, reliability, security and power quality. STP has also delivered a number of notable innovations since its		

	inception.
Project Progress at March 2014	The 2013/14 portfolio of projects is largely complete. The key project areas and their outcomes are summarised below: **S2126, S2174, and S2148:** These three projects all related to overhead line ratings. **S2126 (temperature monitoring of conductors),** completed last year, has provided further insight into the probabilistic nature of overhead line ratings, and has improved our understanding of the seasonal variation of ratings compared to the original research carried out in the late 1970's and early 1980's. The results from this work has now fed into the recently completed **S2148 (ACE 104 review),** and has provided improved guidance for the selection and calculation of overhead line ratings by taking into account load profiles representative of today's networks. Complementing both these projects is **S2174 (CIGRE participation),** where STP project findings contribute to the update of one of the main, internationally recognised standards for overhead line rating calculations (CIGRE TB 207). STP involvement is now complete, with CIGRE due to publish its revised Technical Brochure (following Study Committee approval in August this year) early in 2015. **S2164 and S2183:** The final outcome of this work relates to revised conductor wind and ice load determination applicable to UK overhead lines. The key deliverable from the **S2164 (probabilistic wind & Ice map for the UK),** project was a software tool allowing revised mapping to be implemented by line designers. In addition, the ice mapping will now incorporated into the UK NNA of EN 50341 (the European Standard for line design above 1kV). In most cases, the loadings from the revised mapping are less onerous, with the benefit that many lines can be re-furbished / built at lower cost for the same design level of reliability. Supporting this project is the **S2183 (relationship between ice loads & conductive size)**, aimed at improving our understanding of the relationship between conductor diameter and ice accretion. **S2151: Alternatives to Wood Poles** The third stage of this project, investigating alternatives to wood poles, has now been completed. They key outcome has been the gaining of experience of using composite poles. A short trial line was constructed involving a large range of structure configurations which has confirmed the compatibility of wood pole standard pole-top constructions with the new composite poles. In addition, full scale load tests have been carried out in order to further develop detailed aspects of the designs. Overall, this project will allow us to confidently assess composite poles as a viable alternative to creosoted wood poles, feeding into the UK industry response to the future threat of creosote being outlawed by the EU biocides directive. Updated information can be found at:- https://www.stp.uk.net

Collaborative Partners	CE Electric, UKPN, Electricity North West, Northern Ireland Electricity, Scottish & Southern Energy and Scottish Power
R&D Provider	EA Technology Ltd

The effect of severe ice loads on an 11KV overhead line in winter 2010. STP Module 2 Project S2164_1 is looking at designs for future ice accretion and wind loads.

<table>
<tr><td>Project Title</td><td colspan="4">EA Technology - Strategic Technology Programme
EATL STP Cable Module 3 and Forum</td></tr>
<tr><td>Description of project</td><td colspan="4">Research and development into all aspects of Distribution Cables and underground equipment</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 1,308
External £ nil
Total £ 1,308</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 829,771</td></tr>
<tr><td>Total Annual Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 424,600</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 2,200
External £ 82,549
Total £ 84,749</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The STP Cable Networks programme aims to optimise underground cable network design, improve operational performance, maximise potential benefits, improve financial performance and minimise risk associated with underground cable networks, whilst having due regard for the environment and energy efficiency. The programme also aimed to prevent cable failure modes and to deliver continuous improvement in terms of safety and environmental performance of all aspects of the underground cable network to meet the individual business requirements of Member Companies. Several of the projects contribute to the industry’s knowledge of variation in climate change.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Type(s) of innovation involved</td><td>Incremental</td><td>Type(s) of innovation involved</td></tr>
<tr><td>14</td><td>-8</td><td>22</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Projects in this Module will significantly increase the performance and reliability of the cable network. In many cases the cable’s 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:

• Identifying more suitable grades of sheathing materials to prevent shrink back of cable sheaths.
• Extending the life of cables installed in contaminated ground
• A test to determine the remaining life of XLPE and EPR cable circuits enabling better targeting of investment.
• Alternatives to current design and installation practices which offer benefits in lower lifetime cost, higher performance (e.g. increased ratings);
• Reduce risk in environmentally sensitive areas;
• A reduction in the number of accidents / incidents so increasing safety of staff and the public;
• Reduce excavation required in locating leaks from fluid-filled cables, reduce the times and costs of leak location, and also reducing outage time;
• A reduction in digging, causing less disruption to the public,</td></tr>
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<table>
<tr><td></td><td colspan="3">reducing impact on the environment and avoiding disposal of soil to landfill;
• Offset future increases in CAPEX and OPEX;
• CI/CML savings per connected customer;
• Reduce cable purchase costs;
• Enforce Network resilience;
• Implement strategies for reducing cable failures, resulting from excessive forces;
• Reduction in number of cable faults;
• Reduce design costs.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>Range 2012 - 2013
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>£42,013</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">There are a huge variety of projects within the work programme for Module 3. A significant number of these projects are interlinked with previous projects. The technical development consists of numerous single projects, but collectively form part of much larger suite of projects over more than one financial year which require further research and development in order to optimise the financial, operational performance and asset management from which the customer and stakeholders will benefit.

Other projects were looking at better ways of improving the operational performance, management and reliability of Cable Networks, by minimising the impact on the environment and the safety of both the operators and the public, in a manner that could be implemented straight away.

Collectively, the work programme demonstrates the development of innovative products, processes and techniques that improve the management of Cable Networks; in terms of safety, design, environment, reliability, security and power quality.

STP has also delivered a number of notable innovations since its inception.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="3">There are many projects in this Module, each at different stages. However, the outputs of the some projects that have already identified potential benefits and opportunities for further innovative technical development work are provided below:

S3214: Research & evaluation of the effectiveness of tan delta and polarisation index for condition assessment of ageing cables (stages 1,2 and 4)

• Tests were carried out to evaluate the suitability of both tests on artificially aged XLPE and EPR 11kV cables. By correlating all the results, it shows that Tan δ tests are more suitable and could be</td></tr>
</table>

	useful in the field to predict the remaining useful life of cables in service. • These tests also showed that XLPE performed very well when subjected to accelerated aging. **S3228_1: Determination of the amounts and types of ground contamination which may affect cable sheaths** • The objective is to determine the levels and types of ground contamination which may affect the long term performance of the cable sheath, identify typical amounts of ground contamination that may be encountered in the UK and understand what mitigation options are available. • This will be used to aid design and knowledge of cables systems laid in contaminated ground, reduced cable fault levels, maintain network security and improve overall reliability. **S3207_1 Shrink-back of Polymeric Over-sheath Materials: Study of Type and Process** • The objective is to understand how significant the selection of PE grade is on retraction of the PE over-sheath used in the manufacture of MV and HV cables. This is of great importance to both manufacturers and users of MV and HV cables. • A fault on a single MV or HV circuit caused by shrink back is more costly (in comparison with a single LV circuit) in terms of repair and customer minutes lost. The cost of replacing cable and joints on a single circuit due to a failure could be at least £50k and up to £250k on a 132kV circuit **S3175_1: Bentonite grouts for ducted cable circuits** • Bentonite grouts have been used for many years to improve the thermal resistance of ducted cable circuits. Bentonite is used in differing compositions, all of which affect its thermal resistivity, thermal diffusivity, pumpability, cost, etc. • The objective of this project is to obtain relevant data on different Bentonite grouting compositions to enable cable ratings of ducted circuits to be accurately determined by calculation (CRATER) • There are potential cost reductions from increasing the rating of ducted circuits, by enabling the load to be carried without increasing the cable size. Alternatively duct filling can eliminate the need for system reinforcement. The environmental benefits include reducing digging, causing less disruption to the public and avoiding disposal of soil to landfill **S3168_4: Comparing future designs of HV (≥1000V to 66kV) and EHV (>66kV up to and including 400kV) polymeric cables**

	• Since polymeric insulated cable was introduced into the power distribution industry 30 years ago, there have been continual advances in materials and manufacturing methods, leading to improved operational reliability. • The implications of design choices, such as electrical stress levels and insulation thickness, on the long-term ageing of polymeric cables must be understood. The UK and European standards are particularly influential in this regard and familiarity with their content is vital. The purpose of the project is to provide up-to-date guidelines so that the selection process becomes more accurate and thereby reduces the probability of early cable failure. **S3174_1: Evaluating the performance of service cut outs** • The reliability of Cut outs has always been a contentious issue with the DNOs, who operate a varied range of cut out types from several manufacturers, with some cut outs being several decades old. • There are also increasing demands on the requirements of a cut out regarding load profile and peak rating, which, when combined with its original specification, greatly affects its reliability and end of life. • This project is concerned with collating information and determining a health status, and using real time operational data to predict probability of failure in the form of a reliability index. • The first stage involves testing cut-outs in accordance with the British Standard to establish a bench mark before more onerous tests are carried out **S3187_4: Development of an ENA Engineering Recommendation for the use of sealant systems for cable ducts and transits** • Duct sealing plays a vital role in protecting substations against ingress of ground water, fire and gas, since the cable duct is literally a potential conduit for all of the aforementioned agencies. Any one of these environmental factors can result in consequential damage. • At present there are no formal Electricity Industry recommendations for the use of sealants for cable ducts and transits, although there is a WIMES (water industry) specification laying down types of acceptable sealant – without prescribing test methods and properties. Given the importance of sealing cable ducts there is a strong case for creating an appropriate Engineering Recommendation under the aegis of the Energy Networks Association (ENA). • This project is to develop this proposal and submit it to the ENA for review and subsequent approval.

	S3214_3 Research & evaluation of the effectiveness of tan-delta testing and polarisation index for condition assessment of ageing cables: Trial and evaluation for paper cables • Stage 3 of this project seeks to replicate the testing using in-service aged paper cable repeating the Tan Delta, Polarization Index, partial discharge testing and AC breakdown tests. • The results will be assessed and then correlated with the result obtained from XLPE and EPR cables in Stages 2 & 4. . **S3218_2: Development of a specification for silicone-based filling compounds to be used in EHV cable terminations** 1. The planned approach to this project is to draft a new specification based on the transformer standards. In the case of silicone oil, there will be a great deal of overlap and it seems sensible to preserve as much commonality as possible. The proposed 'models' are: IEC 60836 Specifications for unused silicone insulating liquids for electrotechnical purposes and IEEE C57.111 IEEE Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers. • It will be necessary to identify the salient differences between the oils used for the two applications – for example, the use of higher viscosity oils in terminations. For the newer filling compounds, it will be necessary to consider requirements and tests related to parameters such as dielectric strength, permittivity, electrical resistivity, thermal conductivity and elasticity (to cope with temperature differences) etc. • The ENA template will be used to write the draft specification and this will be handed over to STP 3 Members so that it can be issued to the ENA. **S3245_1: Development of CRATER 'Lite'** • The objective of this project is to deliver a web hosted CRATER software tool that provides reduced complexity for the less experienced user. Predetermined parameters will be available for Module 3 Member Companies that will provide specific control over options for selectable cable items within the CRATER Lite solution. • Updated information can be found at:- https://www.stp.uk.net
Collaborative Partners	CE Electric, UKPN, Electricity North West, Scottish & Southern Energy and Scottish Power
R&D Provider	EA Technology Ltd

<table>
<tr><td>Project Title</td><td colspan="4">EA Technology - Strategic Technology Programme
EATL STP Plant and Protection Module 4 and Forums</td></tr>
<tr><td>Description of project</td><td colspan="4">Research and development into all aspects of Distribution Plant and Protection equipment</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 1,308
External £ nil
Total £ 1,308</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 703,560</td></tr>
<tr><td>Total Annual Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 329,000</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 2,200
External £ 133,554
Total £ 135,754</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The STP Substations programme aims to improve operational performance, maximise potential benefits; improve financial performance and minimise risk associated with substation assets, whilst having due regard for the environment and energy efficiency. The projects aimed to provide cost effective solutions to increase reliability and deliver continuous improvement in terms of safety and environmental performance of existing and future substation assets, to meet the individual business requirements of Member Companies.</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>-9</td><td>26</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Projects within this Module have been cost effective and help improve reliability and safety of substations in distribution networks in line with government policy.

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:
Increased reliability and continuous improvement in terms of safety and environmental performance of existing and future substation assets;
Collaborative evaluation of battery installations and operational practice to ensure a safer and more reliable network;
CI/CML savings per connected customer;
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;
Offset future increases in CAPEX and OPEX;
Development of condition based assessments, or tests, to determine asset condition;
Preventing failures of oil-filled equipment, tap changers, earth switches will improve safety and avoid unnecessary scrapping</td></tr>
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<tr><td></td><td colspan="3">of serviceable components, which will alleviate environmental impact;
• Extend serviceable life of switchgear and transformers;
• Further develop technical understanding of protection system maintenance requirements;
• Understand the degradation and failure processes of substation plant and equipment, and quantify the risks associated with those processes,
• Further develop technical understanding of operational staff in complex electrical issues;
• Mitigate risk to environment;
• Increased safety of staff and public by reducing risk of fire and the number of accidents / incidents.
• Reduce lifetime costs and improve functionality by the appropriate use of new technology.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>Range 2012 - 2015
Dependent on project</td><td>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>Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£ 32,721</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">There are a huge variety of projects within the work programme for Module 4. A significant number of these projects are scientific based, researching technical developments in degradation and understanding the failure processes of substation plant and equipment, whilst quantifying the risks associated with those processes.

Projects in these areas are mainly single stages of much larger multi-stage projects which require further research and development of condition based assessments, and/or tests, asset management tools, systems and methodologies in order to optimise the financial, operational performance and design of Substation plant from which the customer and stakeholders will benefit.

Other projects were looking at better ways of improving working, the performance and reliability of Substation plant, maintenance regimes, minimising the impact on the environment and the safety of both the operators and the public for Asset Managers, in a manner that could be implemented straight away.

Collectively, the work programme demonstrates the development of innovative products, processes and techniques that improve the management of Substation assets; in terms of safety, design, environment, reliability, security and power quality.

STP has also delivered a number of notable innovations since its inception.</td></tr>
<tr><td>Project Progress to March 2014</td><td colspan="3">There are many projects in this Module, each at different stages. However, the outputs of the some projects that have already identified potential benefits and opportunities for further innovative technical development work are provided below:</td></tr>
</table>

	S4255_2: Transformer OLTC Contact Wear Indication Technologies The study has identified Tear Index (tear strength divided by paper grammage) offers an alternative to the use of degree of polymerisation values that is a cost effective and reliable method of identifying the transformer insulation-paper condition. **S4181_9: Transformer Post Mortem Project** Helping to assist in better health index and condition based assessment of transformers and the replacement of aged transformers Quantification that oil analysis DP figures are correct or are a little on the conservative side **S4296_1: Power Transformer Mid Life Refurbishment** With current OFGEM drivers to increase the use of transformer refurbishment and regeneration, evaluation of services is required and the best options available to extend the life. Updated information can be found at:- https://www.stp.uk.net
Collaborative Partners	CE Electric, UKPN, Electricity North West, ESB Networks, Scottish & Southern Energy and Scottish Power
R&D Provider	EA Technology Ltd

<table>
<tr><td>Project Title</td><td colspan="3">EA Technology - Strategic Technology Programme
EATL STP Networks for Distributed Energy Resources Module 5</td></tr>
<tr><td>Description of project</td><td colspan="3">Research and development into all aspects of Network design and management to enable an increased connection of distribution energy.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 6,316
External £ nil
Total £ 6,316</td><td>Expenditure in previous (IFI) financial years</td><td>Total £ 589,700</td></tr>
<tr><td>Total Annual Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 516,600</td><td>Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 8,000
External £ 57,672
Total £ 65,672</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="3">The STP Networks for Distributed Energy Resources programme aims to maximise potential benefits and reduce costs and risks associated with facilitating the design, development and operation of networks for the integration of low carbon technologies into future network design, whilst having due regard for the environment and energy efficiency. The programme also aims to cost-effectively improve the operational efficiency and business performance of Member Companies within prevailing regulatory constraints.</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</td><td>-8</td><td>22</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="3">Projects within this module have been cost effective and help improve reliability and safety of generation connection in distribution networks in line with government policy.

If 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:
Investigate distributed generation connection methods without undue reinforcement, while at the same time improving supply quality by reducing CMLs and voltage unbalance;
Positive impact on environmental performance and many have positive impacts on safety;
Increased understanding between all Member Companies on technical, commercial and regulatory issues and to develop effective solutions to these issues;
Developing understanding of the implications of connecting low carbon technologies to the distribution network in terms of safety, design, reliability, security and power quality;
Where possible, try and optimise the Government’s low-carbon strategy and accommodate the likely growth of DG;
Improved management of the implications of connecting distributed resources to the distribution network in terms of the statutory, regulatory and commercial frameworks;
Investigating low carbon network designs and plan transition</td></tr>
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<table>
<tr><td></td><td colspan="3">from passive to active networks;
• Improve power quality issues due to dynamic load change;
• Enabling the development of strategies to manage PQ levels and customer expectations;
• Reduction in losses for DNOs;
• Highlight the issues and benefits of Smart Grids, Smart Meters and Active Network Management Systems, ultimately improving CMLs;
• Significant benefits in terms of enhanced knowledge and awareness of overseas best practice in DG system integration, which can be applied, as appropriate in the UK;
• Ensure that all participants optimise network design, financial and operational performance as the levels of storage, managed-demand and distributed generation increase on the distribution networks;
• Developing and emerging distributed generation, demand-side management, storage technologies.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>Range 2012 - 2014
Dependent on project</td><td>Duration of benefit once achieved</td><td>Range 2 - 5 years
Dependent on project</td></tr>
<tr><td>Probability of Success</td><td>Range 51 - 100%
Dependent on project</td><td>Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£ 28,841</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">There are a huge variety of projects within the work programme for Module 5. A number of these projects are scientific based and will require further research and development to achieve improvements in operational performance and integration into the Network Operators business environment. Projects in these areas are mainly stages of much larger multi-stage projects and require further work to optimise network design, financial and operational performance from which the customer and stakeholders will benefit.

Other projects are looking at better ways of improving working and productivity for network planners, in a manner that could be implemented straight away.

Collectively, the work programme demonstrates the development of the technical understanding in relation to connecting and integrating low carbon technologies onto the distribution network; in terms of safety, design, reliability, security and power quality.

STP has also delivered a number of notable innovations since its inception.</td></tr>
<tr><td>Project Progress at March 2014</td><td colspan="3">There are a range of different projects in the STP5 portfolio, 20 have been delivered by March 2014, with a further 9 still to be delivered from the 2013/14 programme.

Several projects have looked at solving some of the technical issues associated with the increased penetration of Distributed Generation at different network voltages. These include assessing the harmonic distortions caused by inverter connected generation, Voltage</td></tr>
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	depression ride through of embedded generation, strategic network planning for distributed generation and reducing the potential conflict between mobile generators when supplying PV clusters. Two projects have assessed how overhead lines connecting wind farms and generation transformers could be dynamically rated, where it is appropriate and the risks associated with dynamic rating. Two projects are also increasing DNOs knowledge as to how voltages can be better optimisation. The first project has configured several DG locations to operate in PV mode, varying the DG's reactive power output based on the network voltage. The performance of the generators, how the network voltage responds and the factors for the most appropriate settings are being considered. Another project is reviewing how a DStatcom (Static compensator) can be operated by a DNO to boost voltage profiles and control step changes. Updated information can be found at:- https://www.stp.uk.net
Collaborative Partners	CE Electric, UKPN, Electricity North West, ESB Networks, Northern Ireland Electricity, Scottish & Southern Energy and Scottish Power
R&D Provider	EA Technology Ltd

<table>
<tr><td>Project Title</td><td colspan="4">EA Technology - Partial Discharge Project and Forum</td></tr>
<tr><td>Description of project</td><td colspan="4">Research and development into all aspects of partial discharge in distribution equipment.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 654
External £ nil
Total £ 654</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 427,715</td></tr>
<tr><td>Total Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 515,146</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 1,200
External £ 6,650
Total £ 7,850</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The projects undertaken address real problems identified by the group members as significant and which require technical investigation and development. Projects are aimed at providing:
Improved management of assets through better understanding of Partial Discharge through targeted investigative research and development work,
Reduced fault rates by early detection of insipient faults
Improvements in Safety
Demonstration of cost effective permanent partial discharge condition monitoring and measurement systems using Transient Earth Voltage and Ultrasonic detection techniques.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Technical Substitution/ Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>15</td><td>-7</td><td>22</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Partial discharge is becoming an essential technique when assessing failure probabilities in both an aging population of traditional distribution assets and certain new equipment, which has been found to have less tolerant insulation mechanisms.
Early detection of faults allows controlled remedial action and provides:
Financial benefits derived from the reduction in fault repairs
Improved network performance and operator safety
Improved quality of supply for customers
In addition the PD user group allows information to be shared to; increase confidence in interpretation of results, assist in the development of operational practice, influence functionality and ergonomics of future instrument design.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2010</td><td colspan="2">Duration of benefit once achieved</td><td>10 Years</td></tr>
</table>

Probability of Success	75%	Project NPV = (PV Benefits – PV Costs) x Probability of Success	£ 46,829
Potential for achieving expected benefits	The demonstration installations have already been successful, with investigations at several sites where significant partial discharge was detected. This directly lead to remedial action to rectify deterioration, which if left unchecked would have caused permanent damage to the switchgear. Indications are that this project will deliver the expected benefits.		
Project Progress at March 2014	**Substation Wiki** The Substation Wiki is a Wikipedia type website of information containing useful user contributed information on PD related issues for various switchgear types. It is private to members of the PD User Group. Work has been ongoing this year and the wiki has grown to over 700 articles on various types of switchgear. The wiki also contains historic PD User Group minutes dating back over 10 years and is a valuable source of information. **Surface Tracking** This is an on-going project to gain further understanding of surface discharge activity in order to predict end of life of switchgear. Several samples of different cast resin insulation have been taken to failure whilst carrying out time lapse photography, TEV and Ultrasonic measurements in order to help members understand the correlation between the TEV and Ultrasonic readings and the physical condition of the insulation. This will aid in determining intervention strategies when dealing with surface partial discharge. **Best Practice Guide** Work has been ongoing over the year to produce a 'Best Practice Guide' to carrying out partial discharge testing and using the information obtained to maximise business benefits. This guide was formed on the basis of the best practice questionnaire carried out in 2012-2011. The document is a guide that encompasses the best current practice for obtaining and verifying PD activity with suggestions and guidance for making best use of the data to minimise, costs, risk to the business and aid in condition based asset management. Significant work has been done on the guide which has been issued in draft form for review. Work is expected to continue on the guide with a final version issued within the next 12 months. The demonstration trial of the EATL Partial Discharge alarm units, which remotely monitors the partial discharge activity at eighteen 33kV and 11kV substation sites across Western Power Distribution, is continuing. The following projects have also been undertaken during 2013-2014 through the user group and forum run by EA Technology		

	Review of UltraTEV Detector Through feedback from member companies it was found that a number of companies had a large number of PD "red lights" to deal with. EA Technology are working with the PD user group via to help alleviate the number of false alarms, through an UltraTEV detector training guide was issued that can be used to increase operator awareness of the correct use of the instrument, improvements in the instrument and the best practice guide. This should help member companies to focus their efforts on abnormal readings that warrant further examination. **IVIO Circuit Breaker Examination** An IVIO type circuit breaker removed from the field with PD activity was tested and stripped down at EA Technology's HV laboratory to help members understand the cause and severity of the PD activity. This type of work helps members understand the severity of partial discharge within common equipment types and can influence the strategy of dealing with older equipment with PD issues. **Surge Arrestor Testing** Testing and examination of surge arrestors removed from the field with high levels of partial discharge was carried out. This helped to establish the cause of partial discharge within a relatively new piece of equipment and can be used my member companies to influence purchasing and installation of surge arrestors. **PD Database** The PD database contains historical data which is of critical importance in interpreting PD results. This year it has undergone a large update and has doubled in size to over 20,000 records. Work has been on-going to move the database onto the internet and it is now available online for member companies to use.
Collaborative Partners	AWE, CE Electric, CLP Hong Kong, UKPN, Energy North West, ESB Networks, Guernsey Electricity, Manx Electricity Authority, MoD, Northern Ireland Electricity, Scottish and Southern Energy, Scottish Power and Singapore Power
R&D Provider	EA Technology Ltd

<table>
<tr><td>Project Title</td><td colspan="4">EA Technology - Protective Coatings Forum</td></tr>
<tr><td>Description of project</td><td colspan="4">Research and development into all aspects of protective coatings on distribution equipment</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 654
External £ nil
Total £ 654</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Total £ 60,966</td></tr>
<tr><td>Total Annual Project Costs (Collaborative + external + Western Power Distribution)</td><td>£ 42,500</td><td colspan="2">Projected 2014 – 2015 costs for Western Power Distribution</td><td>Internal £ 1,200
External £ 7,295
Total £ 8,495</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="4">The projects undertaken address real problems that have been identified by the forum members as significant and which require technical investigation and development. Projects are aimed at providing:
Cost effective protective coatings for distribution equipment either by reducing operating costs or capital investment.
Reduction of the environmental impact of associated activities to comply with CEPE (Guide to VOC Reduction in Protective Coatings) in preparation for EC National Emissions Ceiling Directive.
Improvements in safety and applications.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental/ Technological Substitution</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>-6</td><td>18</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Development of a Volatile Organic Compound (VOC) compliant paint system that performs at least as well as the currently used solvent based systems on towers and other structures. This will ensure a smooth transition to environmentally friendly paint systems in accordance with the anticipated legislation.

The various other tests and trials will have benefits in the particular area that is being addressed.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2010 - 2012
Dependent on adoption of legislation</td><td colspan="2">Duration of benefit once achieved</td><td>3 - 10 Years</td></tr>
<tr><td>Probability of Success</td><td>50%</td><td colspan="2">Project NPV = (PV Benefits – PV Costs) x Probability of Success</td><td>£ 25,533</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The project costs are at an early stage and the project costs not always reflect the likely full costs of implementation. These will be identified providing the outcome of the projects is positive.</td></tr>
</table>

Project Progress at March 2014	EA Technology Ltd has continued to maintain paint batch testing records with on-going testing of paint samples delivered from site from members. This process in in place to ensure that quality control is maintained with the existing approved coating supplier Assessments have been made of two more potential paint suppliers including initial testing and factory visits. Further assessment of Pronto has resulted in them being added to the approved supplier list.
Collaborative Partners	CE Electric, EDF Energy, Electricity North West, National Grid, Scottish & Southern Energy and Scottish Power
R&D Provider	EA Technology Ltd

Application of the first yellow coat, of a two coat painting system, to the de-energised side of a 132kV tower