Innovation Funding Incentive Transmission Report

for period 1 April 2012 to 31 March 2013

Scottish Hydro Electric Transmission plc.

Scottish and Southern Energy
Power Distribution

1. Executive Summary

Over the last year, Scottish and Southern Energy Power Distribution (SSEPD) has continued in its commitment to research and development (R&D) activities using the Innovation Funding Incentive (IFI).

During the year ended 31 March 2013, Scottish Hydro Electric Transmission plc (SHE Transmission) has initiated new projects and continued IFI projects started in previous years.

As in previous years, there are a wide range of activities ranging from national collaborations with multiple work packages to specific projects to address identified problem areas. In particular, we have projects aiming to improve the capability of the transmission network and facilitate the connection of renewable generation. Wherever possible we have sought to minimise the cost of R&D activities by seeking complementary funding and forming collaborations.

The total qualifying expenditure for the reporting period of 1st April 2012 to 31st March 2013 has been £488,000 for SHE Transmission. This total is an increase on the previous year's £475,000 total qualifying expenditure.

2. Introduction

As part of the April 2005 Distribution Price Control Review (DPCR), Ofgem (the regulatory body for the energy industry) introduced the IFI scheme. The primary aim of this incentive was to encourage distribution network operators to apply innovation in the way they pursue the technical development of their networks. The IFI was extended to the electricity transmission licensees in 2007. A Good Practice Guide (Engineering Recommendation G85 Issue 2 – December 2007) has been produced and is available free of charge via the website of the Energy Networks Association (ENA): www.energynetworks.org.

The IFI mechanism is intended to provide funding for projects primarily focused on the technical development of the networks to deliver value (i.e. financial, quality of supply, environmental, safety) to end consumers. IFI projects can embrace aspects of transmission system asset management from design through to construction, commissioning, operation, maintenance and decommissioning. SHE Transmission was allowed to spend up to 0.5% of its Base Transmission Revenue (subject to a minimum of £500,000) on eligible IFI projects.

Open reporting (i.e. available in the public domain) of IFI projects is required by Ofgem; this is intended to stimulate good management and promote sharing of innovation good practice. In line with this, we will publish our IFI report on the SSEPD website: www.ssepd.co.uk. To enhance accessibility, they will also be available on Ofgem's website: www.ofgem.gov.uk

3. Scope

This document contains SHE Transmission's IFI annual report produced in accordance with Special Licence Condition J5. It details activities in the period from 1 April 2012 to 31 March 2013.

An IFI regulatory report has been provided along with a summary listing of all IFI project costs incurred this year and one set of detailed individual project reports. These reports have been produced in accordance with the Regulatory Instructions and Guidance (RIGs) issued by Ofgem, and ENA Engineering Recommendation G85 Issue 2 – December 2007.

In addition to reporting on activities in 2012/13 we have included information on current projects and intended future developments. Three of the innovations trialled in current projects are featured in detailed case studies as appendices to the report.

4. Overview of IFI Activity

Within the Transmission Innovation Strategy submitted to Ofgem, as part of the RIIO-T1 process, we laid out our core purpose as the requirement to provide the energy people need in a reliable and sustainable way, and in order to succeed in this we must innovate. Without innovation organisations are overtaken and become uncompetitive. This belief permeates all parts of our organisation; as a result innovation comes naturally to many of our staff and is well supported at all levels within the business. We engage in horizon scanning activity and explore the latest work on future scenarios but, core to our values as a business, are the beliefs that innovation is principally about delivery and implementation rather than theorising and procrastination. The impacts of these beliefs have been demonstrated within SHE Transmission through the work undertaken to date within the IFI.

Our programme of IFI projects in 2012/13 consists of a number of projects which have originated as a result of collaborative work with external organisations in academia, such as the University of Manchester, and service providers, such as EA Technology Ltd (EATL), as well as others which have originated internally. The latter have emerged from our own analysis of areas of work which could benefit from an innovative approach.

In the SHE Transmission area, we continue to see considerable amounts of renewable generation development and connection to our network, consisting mainly of wind farms. It is clear that the pressure on networks to facilitate this growth will increase due to the targets set by the UK government. However, network issues and constraints have become apparent at both a transmission and distribution level and this has driven one of the key themes for our Transmission Innovation Strategy for the RIIO-T1 period.

It is clear that the years ahead will be challenging for the transmission network. One principal contributing factor is that the growth of renewable generation in Scotland is distributed across a vast geographical area with relatively sparse core infrastructure. The transmission system in the North of Scotland was designed and constructed to tackle a different set of challenges than the ones we face today; building the required transmission infrastructure will be a demanding task requiring considerable investment.

As the network's capacity is being reached, new transmission lines are being developed to enhance this capacity and to allow more generation to connect. As laid out in the Transmission Innovation Strategy Document submitted as part of RIIO-T1, SHE Transmission has a number of research and development projects focused on delivering novel and innovative methods of increasing capacity, utilising existing assets and infrastructure. Along with increasing the capacity of the network there is a focus on enhancing the life time of the assets and infrastructure through various means. We also have a number of projects working towards this end.

Increasing Capacity – SHE Transmission is committed to investigating methods of increasing the capacity of its network through innovative means. This includes investigating technologies that can increase the power throughput of a transmission route. SHE Transmission is carrying out projects utilising dynamic line rating technologies and insulated cross arms. Both these technologies have the potential to increase the power throughput of existing infrastructure. By increasing the capability of the existing infrastructure we aim to reduce the environmental impact of the increased power flows through our transmission network by minimising the need for new construction projects.

Extending Asset Life – Transmission assets generally have long life expectancy, usually 40 years or more. Asset failure is a costly scenario; as a result it is imperative that assets are maintained to achieve their expected life time. It has become apparent that a significant proportion of transmission assets can have their lifetimes extended beyond this initial 40 year period and it is SHE Transmission's aim to achieve this wherever possible. To this end, we are investigating novel and innovative condition monitoring systems to assist with this life time extension. Working with our partners and service providers, SHE Transmission is investigating methods for the detection of partial discharge in open busbar compound substations. This has the additional advantages of being a non contact and non invasive monitoring system making it a more flexible and mobile system to use. Other project work being carried out in this area includes:

- the Bellrock Lumen condition monitoring system that is being designed to combine multiple condition inputs and analyse them together rather than separately;
- asset prognostics techniques to determine whether components are reaching the end of their useful lives.

These techniques offer the potential to allow the detection and characterisation of discharges with the aim being to inform maintenance timetables and initiate preventative action when appropriate.

Alternative Construction Techniques – SHE Transmission is undertaking a large programme of tower construction over the coming decade. The conventional method of tower construction is to establish crane access to as many tower positions as possible, usually by creating temporary road ways. One of our current projects is trialling an alternative method of tower construction which could mitigate the need for cranes with the objective of avoiding some of the costs and environmental impacts associated with temporary road ways.

5. Benefits achieved from IFI projects

Now that the IFI programme has become established we are able to identify further benefits from the development of innovative methodologies and equipment.

Energy Storage Operators' Forum (ESOF) Information Sharing

A direct benefit of SSEPD Energy Storage Projects, including the Flow Battery Trial project , has been the creation of the Energy Storage Operators' Forum. This was set up by SSEPD in order to share the learning gained through these projects with other TNOs and DNOs, with the other parties also sharing their experiences from their own storage projects.

This sharing of knowledge is a cornerstone of the IFI and Low Carbon Networks Fund and has allowed those involved to increase their understanding of potential benefits and pitfalls. In turn this has created a good base level of understanding between the parties with advice being sought and given on specific issues being uncovered by later developing projects.

One of ESOF's current aims is to compile a Good Practice Guide to Energy Storage that will, in time, will help inform a set of standards covering the full life cycle of a networks storage project accounting for: procurement; design; construction; commissioning; operation and maintenance; and decommissioning. This will allow future storage projects to better understand what suitable systems there are available, how they can be used and how the business benefits stack up.

Alternative Tower Construction

This project was highlighted within the Transmission Innovation Strategy submitted as part of the RIIO-T1 submission, as an innovative method which could lead to considerable benefits for the environment as well as SHE Transmission and our customers.

The construction and deconstruction of transmission towers, at present, requires lifting equipment that can be difficult to get to site due to lack of suitable access roads. Creating these roads can damage environmentally sensitive areas with the large equipment that needs to be moved and the materials that need to be installed. Other impacts of creating these roads can include impacts on safety, project costs, timescales and planning.

The solution developed involves the use of a modular crane system known as an emergency restoration system (ERS) for use in pre-planned transmission tower projects. The components of the ERS can be transported separately and constructed on site which negates the need (and the associated cost) for temporary roads.

At this point in time the modifications requested to make the system easier to use, including those to the gin pole, pulley system, and winch, during the trials in 2011/12 have been implemented. The next stage is to trial the new system and get the appropriate accreditation for the relevant legislative requirements.

6. Financial Summary

Qualifying expenditure for the reporting period of 1 April 2012 to 31 March 2013 has been £488,000 for SHE Transmission of which £87,000 relates to internal costs.

Financial information on the IFI projects relevant to the reporting year 1 April 2012 to 31 March 2013 are contained in the individual reports for SHE Transmission set out in the following sections and listed in Appendix 1.

7. Conclusion

SHE Transmission recognises the key role that R&D can play in enabling our industry to meet the challenges of an ageing infrastructure, a need for continuous improvement in customer service and the challenges of a low carbon energy future with the growing importance of distributed energy resources.

Due to the scale of renewable generation developments now underway and planned for implementation within the SHE Transmission area over the coming decade, it is important for us to continue to innovate and find new ways of delivering our services.

We are committed to the successful exploitation of our current programme of projects and will develop our portfolio to address areas that will deliver further benefits and add value in the future.

8. Regulatory Reports of IFI Activities for April 2012 to March 2013

SHE Transmission IFI Report	
Base Transmission Revenue	£97,105,000
IFI Allowance	£500,000
Number of Active IFI Projects	11
Summary of benefits anticipated from IFI Projects.	Total Net Present Value (NPV) of SHE Transmission projects is over £32M Various customer, safety and environmental benefits will accrue along with more effective utilisation of existing assets
External Expenditure 2012/2013 on IFI Projects	£401,000
Internal Expenditure 2012/2013 on IFI Projects	£87,000
Total expenditure 2012/2013 on IFI projects.	**£488,000**
Benefits actually achieved from IFI projects to date.	£ 900,000
Regulatory Report for IFI Reporting year 2012/13 SHE Transmission	**£m**
Eligible IFI Expenditure (£m)	**0.488**
Eligible IFI Internal Expenditure (£m)	**0.087**
Base Transmission Revenue (£m)	**97.105**

9. Individual Transmission IFI Project Reports

IFIT_2007_02: Flow Battery Trial

Project Title	IFIT 2007_02 Flow Battery Trial				
Description of project	The project is to install the first flow battery on the UK network. The battery is sized at 100kW / 150kWh and will be connected to the substation DC supplies. The primary aims of the project are to understand how to safely operate the technology, define the advantages and to disseminate learning to benefit energy storage projects				
Expenditure for 2012/13 financial year	Internal £ 13,770 External £ 1,310 Total £ 15,080	**Expenditure in previous (IFI) financial years**	Internal £ 60,700 External £ 199,500 Total £ 260,200		
Total Project Costs (Collaborative + external + SHE Transmission)	£ 412,200	**Projected 2013/14 costs for SHE Transmission**	Internal £ 0 External £ 0 Total £ 0		
Technological area and/or issue addressed by project	The provision of DC auxiliary supplies at transmission substation sites has almost exclusively been provided by lead acid batteries. New technologies are now emerging which may offer superior performance with reduced maintenance costs but there has been limited operational experience within GB to date.				
Type(s) of innovation involved	Tech Transfer	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**	
		19	-8	27	
Expected Benefits of Project	There are five main objectives of the study: 1. To establish the suitability of a flow battery for providing substation DC supplies as an alternative to conventional lead acid batteries. 2. Gain operational experience in the operation and maintenance of an established flow battery technology. 3. Test the viability of monitoring conventional and new battery technologies remotely using proprietary software and a data link. 4. Validate the round trip efficiency claims for this type of energy storage device.				

<table>
<tr><td></td><td colspan="3">5. Determine the economic and operational benefits of using flow battery technology in existing substation asset replacement programmes.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>3 years</td><td>Duration of benefit once achieved</td><td>10 years</td></tr>
<tr><td>Probability of Success</td><td>50%</td><td>Project NPV=(PV Benefits-PV Costs) x Probability of Success</td><td>£115,137</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">Significant learning has already been gained from this project and multiple lessons learned have benefitted stakeholders in this sector including ESOF. In addition SHE Transmission has also used the experience to aid in the purchase and deployment of batteries in three current projects.</td></tr>
<tr><td>Project Progress March 2013</td><td colspan="3">The original unit installed on site in 2009 has been shut down due to multiple issues. SHE Transmission has worked extensively with the manufacturer Premium Power Corporation (PPC) to rectify these issues and has put in place revised monitoring points and made considerable design alterations to alleviate these issues. The revised unit was planned to be on site and commissioned by Autumn 2011, however due to an internal management changeover in PPC the unit was not installed this year. The new management approach is considerably more focused on testing and getting consistency across all the stacks. SHE Transmission invested significant time over the last year in conjunction with EA Technology ltd. (EATL) to analyse the results to ensure a robust product.

The existing unit was removed from site in February 2013 with involvement from a local chemical specialist and the manufacturer. The site has now been returned to the original condition.

As PPC still has a responsibility to supply SHE Transmission with a working unit, the intention is that it could be deployed on the site at Nairn or at the newly opened Power Networks Demonstration Centre to go through detailed testing and evaluation in this purpose built test environment. A new project, funded under the Network Innovation Allowance (NIA), would be initiated to take the preferred option forward.

The intention in the year ahead is to collate the learning into a useable format of reports and carry out further dissemination activities.

See Appendix 2 for more information</td></tr>
<tr><td>Collaborative Partners</td><td colspan="3">None</td></tr>
<tr><td>R&D providers</td><td colspan="3">PPC and EATL</td></tr>
</table>

IFIT_2007_05: CAT 1 Dynamic Line Rating Monitoring System

<table>
<tr><td>Project Title</td><td colspan="4">IFIT 2007_05 CAT 1 Dynamic Line Rating Monitoring System</td></tr>
<tr><td>Description of project</td><td colspan="4">The CAT-1 Transmission Line Monitoring System allows accurate real-time rating of transmission lines by monitoring the mechanical tension of both ruling span sections at a dead end structure. Sags, clearances, and average conductor temperature are all directly related to CAT-1 measurements. With line ampere data from a SCADA system, an actual line rating is calculated.

The purpose of the project is to establish the effectiveness of a dynamic line rating system on one of SHE Transmission’s 132kV transmission lines. We hope to gain accurate information on the rating of the line during summer and winter conditions, and utilise this information for optimum transmission performance.</td></tr>
<tr><td>Expenditure for 2012/13 financial year</td><td>Internal £ 8,490
External £ 1,610
Total £ 10,100</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £ 48,200
External £ 494,000
Total £ 542,200</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£ 552,300</td><td>Projected 2013/14 costs for SHE Transmission</td><td colspan="2">Internal £ 15,000
External £ 25,000
Total £ 40,000</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The maximum level of allowable generation is almost at its peak due to the static line rating of the 132kV circuit in question.</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>24</td><td>3</td><td>21</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Dynamic line rating data will:
Allow further generation connections to the transmission circuit.
Raise transmission capacity
Monitor sag in order to provide advance warning of impending clearance violations
Match line ratings to load and weather conditions</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2015</td><td colspan="2">Duration of benefit once achieved</td><td>15-20 years</td></tr>
</table>

Probability of Success	50%	**Project NPV=(PV Benefits-PV Costs) x Probability of Success**	£9,430,319
Potential for achieving expected benefits	There is potential to roll out this system on other transmission circuits that have limited capacity if the initial system proves successful. This will allow GB transmission network operators to accommodate increased generation on the transmission system.		
Project Progress March 2013	The 132kV circuits between Beauly and Fasnakyle (BFN/BFS) in the Highlands of Scotland were identified as possible locations to install the equipment for further testing. Work is ongoing to address some site installation issues. Work on the Beauly Mossford transmission upgrade has limited progress on this project. The intention now is to focus on other projects and outages where the equipment can be used. If no other overhead lines can be used, the next set of suitable shutdowns on BFN and BFS are in September 2013.		
Collaborative Partners	None		
R&D providers	Nexans/The Valley Group		

IFIT 2009_01: Insulated Composite Cross-Arm

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<tr><td>Project Title</td><td colspan="4">IFIT 2009_01 Insulated Composite Cross-Arm</td></tr>
<tr><td>Description of project</td><td colspan="4">The project carries on from work done between University of Manchester (UoM) and National Grid (NG). SHE Transmission was approached early in 2010 by UoM to participate in the development of the project beyond its current stage at that time, specifically to assist with the environmental testing of the designs. As such it was agreed that SHE Transmission would support a project to install a number of cross arms on an exposed dead transmission line on the Lecht which is subjected to some of the harshest weather possible on the British Isles and certainly the harshest any British transmission line is exposed to. Along with this a coastal trial site would be identified and a number of cross arms installed to test their ability to withstand pollution.

The project has the potential to deliver huge benefits to transmission network owners and their customers by potentially reducing the cost of transmission upgrades along with shortening the planning period due to being able to use existing towers.</td></tr>
<tr><td>Expenditure for financial year 2012/13</td><td>Internal £ 9,020
External £ 121,880
Total £ 130,900</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £ 94,500
External £ 304,800
Total £ 399,300</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£2.12M</td><td colspan="2">Projected 2013-2014 costs for SHE Transmission</td><td>Internal £ 10,000
External £ 5,000
Total £ 15,000</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Overhead line cross arms.
The use of an insulating cross arm potentially allows the upgrading of an L3 275kV tower to be able to operate at 400kV or for other tower types to raise their voltage level and eliminate the use of insulator strings.</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>18</td><td>1</td><td>17</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">By utilising insulated cross arms SHE Transmission hope to be able to upgrade, either by current or voltage, a number of existing</td></tr>
</table>

	transmission lines and in doing so significantly reduce the cost of the upgrade when compared to a traditional reinforcement design. The original project funded by NG was to investigate the up-rating of L3 and L2 towers to 400KV. SHE Transmission has a number of these towers but of more value would be the ability to up-rate existing 132KV tower lines to higher voltages.		
Expected Timescale to adoption	5 Years	**Duration of benefit once achieved**	25 Years
Probability of Success	35%	**Project NPV=(PV Benefits-PV Costs) x Probability of Success**	£ 628,048
Potential for achieving expected benefits	All the testing that has been carried out at altitude and at the coastal site has given us a high level of confidence in the composite cross arm technology.		
Project Progress March 2013	The testing phase of this project has now been successfully completed and it will be closed after St Fergus decommissioning. The next phase is a live trial of the insulated cross arm, this is being progressed under project no. IFIT 2011_01.		
Collaborative Partners	none		
R&D provider	UoM and EPL Composite Solutions through Joint Venture Company Arago		

IFIT_2009_03: Alternative Tower Construction

<table>
<tr><td>Project Title</td><td colspan="4">IFIT 2009_03 Alternative Tower Construction</td></tr>
<tr><td>Description of project</td><td colspan="4">This project will assess the viability of using a modified emergency restoration system (ERS) as a Lightweight Tower Crane to be used during the construction and dismantlement of transmission towers from 132kV to 400kV.</td></tr>
<tr><td>Expenditure for 2012/13 financial year</td><td>Internal £8,640
External £99,380
Total £108,020</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £60,600
External £131,300
Total £179,400</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£287,420</td><td>Projected 2013/14 costs for SHE Transmission</td><td colspan="2">Internal £10,000
External £24,500
Total £34,500</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">This project is to develop and validate the use of ERS technology during the construction of towers to which access is difficult, impractical, or where the access route is environmentally sensitive. By employing this technique and using all terrain vehicles, the requirement for temporary roads will be significantly reduced or removed, and we anticipate a reduction in the impact on the environment. Successful implementation of this method will also provide a safer working environment and reduce construction costs.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Development</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>17</td><td>1</td><td>16</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Safety: This would be an inherently safer method of tower construction in areas with difficult access than the traditional 'derrick' method. Safety benefits include increased integrity of the construction equipment as well as a safer working method for construction staff.

Financial: The implementation of this construction method would reduce the need for temporary roads to be constructed at identified towers. The average length of temporary road to each tower is approximately 0.5km, and the cost of the construction and subsequent removal of the road is just under £300,000 per kilometre. Assuming the application of this technique to 70% of typical annual transmission line lengths, it can be seen that the cost saving on a 50km transmission line would be in the region of £10m. It would also reduce the environmental impact of the tower construction, which has a less tangible financial benefit, but will cut</td></tr>
</table>

	down on time and expense through the planning process and reduce licensable activities. **Environmental:** Use of the ERS would remove the need to build some temporary roads which are built solely to enable the transportation of cranes and large tonnages of steel. This would reduce damage to the surrounding environment and mitigate issues such as construction effects on peat and watercourses. It would also reduce CO_2 release from building tracks in peatland, reduce licensable activities and reduce the impacts on local communities and other land users.		
Expected Timescale to adoption	1-2 Years	**Duration of benefit once achieved**	40 years
Probability of Success	75%	**Project NPV=(PV Benefits-PV Costs) x Probability of Success**	£17M
Potential for achieving expected benefits	If proven to be successful the implementation of this method promises to save significant sums of capital expenditure and improve public perception of the company. The reduction in the environmental impact and the potential to reduce side effects on the environment will enable a faster and smoother planning process. Given the original purpose for the equipment and its successful use internationally, confidence is high that the new methodology is sound.		
Project Progress March 2013	The improvements identified in 11/12 have now been designed, manufactured and delivered and await trials. An independent mechanical assessment has been commissioned and negotiations are underway to commission accreditation for legislative requirements. **See Appendix 3 for more information**		
Collaborative Partners	None		
R&D providers	Acier Profile SBB, Capita Symonds (Independent Health and Safety Consultant), Norpower, LC Transmission Consultancy		

IFIT 2009_04: Mobile Condition Monitoring System for Open Busbar Transmission Substations

<table>
<tr><td>Project Title</td><td colspan="4">Mobile Condition Monitoring System for Open Busbar Transmission Substations</td></tr>
<tr><td>Description of project</td><td colspan="4">This technology can gather condition information whilst maintaining a high level of safety to facilitate decisions on replacement of plant based on accurate assessments of condition rather than age.</td></tr>
<tr><td>Expenditure for 2012/13 financial year</td><td>Internal £ 7,200
External £25,750
Total £32,950</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £ 23,800
External £ 146,000
Total £ 169,800</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£ 202,750</td><td>Projected 2013/14 costs for SHE Transmission</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Predictive maintenance</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>16</td><td>2</td><td>14</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Development of a new, non-contact, non-invasive condition monitoring system suitable for the condition assessment of Open Busbar Transmission Substations</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2 years</td><td>Duration of benefit once achieved</td><td colspan="2">6 years</td></tr>
<tr><td>Probability of Success</td><td>75%</td><td>Project NPV=(PV Benefits-PV Costs) x Probability of Success</td><td colspan="2">£83,611</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The potential to achieve the original project objectives are uncertain as the data sourced from the site trials with the PD trailer were found to be variable and are likely to be deemed to be too complex for simple extrapolation into maintenance procedures.</td></tr>
<tr><td>Project Progress March 2013</td><td colspan="4">The trailer was deployed at Knocknagael substation for most of the year and seemed to indicate large amounts of partial discharge. Subsequent survey suggested that there was no significant partial discharge. 3D array did not prove itself to be beneficial on this site trial. Correlations with weather reports were inconclusive. The trailer was redeployed at Beauly substation to collect further data to allow a re-appraisal of this technology. From these results a close-down report is being collated which lays out the learning outcomes from our experiences with this condition monitoring technology.</td></tr>
<tr><td>Collaborative Partners</td><td colspan="4">None</td></tr>
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R&D providers	Elimpus

IFIT 2011_01: 132kV Insulated Composite Cross-Arm Trial

<table>
<tr><td>Project Title</td><td colspan="4">IFIT 2011_01 132KV Insulated Composite Cross Arm Trial</td></tr>
<tr><td>Description of project</td><td colspan="4">The project carries on from work done between UoM, NG, and SHE Transmission. Previous work (IFIT_2009_01) has focussed on the construction of environmental test areas; one at high altitude and the other at a coastal location. This project is focussed on the creation of a live network trial.</td></tr>
<tr><td>Expenditure for financial year 2012/13</td><td>Internal £ 9,050
External £ 39,530
Total £48,580</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £ 35,700
External £ 130,000
Total £ 165,700</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£605,000</td><td colspan="2">Projected 2013-2014 costs for SHE Transmission</td><td>Internal £ 15,000
External £ 163,000
Total £ 178,000</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Overhead line cross arms. The use of an insulating cross arm potentially allows the upgrading of an L3 275 kV tower to operate at 400 kV or other tower types to raise their voltage level and the elimination of the insulator strings.</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>18</td><td>-1</td><td>19</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">By utilising insulated cross arms SHE Transmission hope to be able to up-rate a number of their existing transmission lines and in doing so reduce markedly the cost against a traditional reinforcement design. The original project funded by NG was to investigate the up-rating of L3 towers to 400KV. SHE Transmission has a number of these towers but of more value would be the ability to up-rate existing 132KV tower lines to higher voltages.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2 years</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>£ 2.16M</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">As a follow on to a previous project jointly funded by various partners this project focuses on the trial demonstration of the device in a live operational environment. If successful the device could potentially be considered for a full scale line demonstration.</td></tr>
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Project Progress March 2013	The six cross-arms for live network trial have been constructed and specific towers have been agreed on the Kintore – Craigiebuckler line during the outage window (July-August) to install the six cross-arms on the PL16-132kV tower.
Collaborative Partners	None
R&D provider	UoM and EPL Composite Solutions through Joint Venture Company Arago

IFIT 2011_04: VOAS Optical CT

<table>
<tr><td>Project Title</td><td colspan="4">IFIT 2011_04 VOAS Optical CT</td></tr>
<tr><td>Description of project</td><td colspan="4">Development of Optical CT prototype in conjunction with UoM.</td></tr>
<tr><td>Expenditure for 2012/13 financial year</td><td>Internal £8,950
External £1,610
Total £10,560</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £ 7,400
External £66,400
Total £ 73,800</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£ 194,000</td><td colspan="2">Projected 2013/14 costs for SHE Transmission</td><td>Internal £ 7,500
External £ 1,600
Total £ 9,100</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Development of an innovative optical CT for the high voltage network</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10</td><td>1</td><td>9</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">An optical CT could potentially improve the operation and provide technological improvements in HV CT operation.</td></tr>
<tr><td>Expected Timescale to adoption</td><td>2013</td><td colspan="2">Duration of benefit once achieved</td><td>10 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>£ 246,583</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">There is potential that suppliers may further develop this technology into a commercially viable product, which would reduce costs of substation build/refurbishment if the prototype and testing are successful.</td></tr>
<tr><td>Project Progress March 2013</td><td colspan="4">Start up meeting held with UoM. The University is currently in the process of recruiting research students. Work on the design expected to commence in July.

The project has been delayed due to the contract not being signed and significant problems in recruitment for a UoM PhD student. The contract issues have been resolved, and a suitable candidate identified, however there are outstanding issues regarding the student visa. Everything is in place for the project to proceed as planned once this is in place.</td></tr>
</table>

Collaborative Partners	NG
R&D providers	UoM

IFIT 2011_05: Nano Composite HVDC Insulation Material

<table>
<tr><td>Project Title</td><td colspan="4">IFIT 2011_05 Nanocomposite HVDC Insulation Material</td></tr>
<tr><td>Description of project</td><td colspan="4">Develop an improved cast resin insulation material to improve reliability and reduce size and cost of electrical apparatus with a particular focus on HVDC applications. Present cast resin systems use fillers at a micrometre scale to improve the properties of a base resin. This project proposes to use fillers at a nanometre scale.</td></tr>
<tr><td>Expenditure for 2012/13 financial year</td><td>Internal £7,580
External £33,720
Total £41,300</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £ 3,900
External £ 0
Total £ 3,900</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£ 829,000</td><td colspan="2">Projected 2013/14 costs for SHE Transmission</td><td>Internal £10,000
External £30,425
Total £40,425</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Electrical insulation materials</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>10</td><td>-3</td><td>13</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Reduced cost of HVDC converter equipment</td></tr>
<tr><td>Expected Timescale to adoption</td><td>5 years</td><td colspan="2">Duration of benefit once achieved</td><td>30 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>£604,530</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">A HVDC converter station costs around £100 million. This project is targeted at reducing the size and improving the reliability of the insulation associated with such converter stations. This should result in a reduction in cost which has been conservatively assumed as 1%.</td></tr>
<tr><td>Project Progress March 2013</td><td colspan="4">Issued review of properties and agreed target properties required: improved thermal conductivity, improved electrical stress, better resistance to partial discharge.

A PhD student has been appointed to look at dispersal methods at Warwick University</td></tr>
</table>

	Materials are being selected: base resin has been chosen and a shortlist of potential fillers identified. Options for test product are being considered. Dispersal tests are underway at Warwick and Gnosys.
Collaborative Partners	NGC, SPEN and TSB
R&D providers	Gnosys, Alstom, Mekufa, Southampton and Warwick Universities

IFIT 2012_01: Bellrock Lumen-Condition Monitoring Decision Support

<table>
<tr><td>Project Title</td><td colspan="4">IFIT 2012_01 BellRock Lumen - Condition Monitoring Decision Support</td></tr>
<tr><td>Description of project</td><td colspan="4">This project will formalise requirements and demonstrate how Bellrock Technology's intelligent decision support platform, Lumen, could assist engineers at SHE Transmission to monitor and manage their critical assets. Specifically, the project will focus on the management of power transformers.</td></tr>
<tr><td>Expenditure for 2012/13 financial year</td><td>Internal £6,320
External £52,320
Total £61,640</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Total Project Costs (Collaborative + external + SHE Transmission)</td><td>£61,640</td><td colspan="2">Projected 2013/14 costs for SHE Transmission</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Data gathered to monitor equipment condition is currently held within several separate management systems, provided by various original equipment manufacturers (OEMs) and service companies. This makes it difficult to compare, review in context, and feed into planning and asset management decision making. Lumen brings this data together within a single, user-configurable system and can expose it to advanced analytics to automatically extract useful information. Lumen is flexible enough to support a range of user groups and is currently being piloted by Maintenance and Major Projects teams.</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>5</td><td>2</td><td>3</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="4">Maintenance: improved decision making for assessing maintenance requirements at local and remote sites; increased maintenance intervals; decreased overall costs through better targeted use of engineers' time, materials and equipment.

Major Projects: better informed refurbishment vs. replacement decisions; greater evidence to support refurbishment verdicts when appropriate; asset life extension; deferred capital expenditure.

Total expected benefits (once Lumen is adopted) are estimated to be of the order of £1M per annum for these user groups only. Annual</td></tr>
</table>

	licence costs for use and support are estimated to be of the order of £80,000 per annum.		
Expected Timescale to adoption	1.5 years	**Duration of benefit once achieved**	20 years
Probability of Success	30%	**Project NPV=(PV Benefits-PV Costs) x Probability of Success**	£ -52,465
Potential for achieving expected benefits	High		
Project Progress March 2013	The project commenced on 22nd October 2012. It suffered early delays due to difficulties in finding suitable engineering resource that could support the project. As a result, the first project milestone was delivered on 31st January 2013, around 6 weeks behind schedule. This deliverable was a Formal Requirements Specification, detailing how Lumen should be used to deliver power transformer condition information and provide asset management support. The project is now in a concentrated phase of software development. This will produce a demonstrator system illustrating the gathered requirements and the user experience that Lumen could provide to engineers. The demonstrator system will be delivered to SHE Transmission for evaluation on 8 May 2013. The project is now being evaluated in order to decide whether the system is a viable tool to analyse the condition monitoring information, and if it is then new funding will be sought to progress further development under a new project.		
Collaborative Partners	Energy Innovation Centre		
R&D providers	Bellrock Technology Ltd		

IFIT 2012_03: Asset Prognostics

Project Title	IFIT 2012_03 Prognostics and Health Monitoring of Grid Connected Assets		
Description of project	Initially, a literature review of the science of Prognostics and Health Management (PHM) will be conducted to identify optimal tools for determining asset health and forecasting remaining useful life (RUL). Knowledge from the review will be applied in the development of a small scale condition monitoring and prognostics system for predicting the RUL of an electromagnetic relay with a failure history which appears to exhibit a correlation between life expectancy and the applied voltage. The aim of this stage is to help the researchers involved develop the necessary toolchains and improve their PHM experience prior to embarking on a project at a larger scale. Subsequently, an online oil condition monitoring and prognostics system prototype will be developed incorporating a dedicated intelligent sensor system with data handling and communication capability. Once tested in the lab and optimised, the prototype will be demonstrated on decommissioned transformers in SHE Transmission's licence area.		
Expenditure for 2012/13 financial year	Internal £6,970 External £20,490 Total £27,460	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total Project Costs (Collaborative + external + SHE Transmission)	£108,550	**Projected 2013/14 costs for SHE Transmission**	Internal £15,000 External £43,000 Total £58,000
Technological area and/or issue addressed by project	Improving asset management capabilities in line with the Smart Grid principle e.g. more intelligent monitoring of assets' remaining life. PHM is, broadly speaking, the science of analysing the operating and environmental parameters of a system and using those data points to predict the remaining useful life of the system. PHM generally falls into three categories: Data Driven, Physics of Failure and Fusion. Data Driven prognostics uses historical knowledge of the system to build statistical models that can predict system condition and system life. Physics of Failure prognostics uses the underlying physics of an identified failure mechanism to predict the progression of the failure. Fusion prognostics take both of these models and fuse their results to obtain a broader and more accurate measure of failure.		

Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	-1	10
Expected Benefits of Project	The learning generated from this project will directly benefit all transmission network licensees and Distribution Network Operators since they are all running ageing assets. The system can potentially provide better and more accurate assessment of an operational transformer's health and condition and help system planners make informed asset management decisions Should the project be successful other network licensees could find use of the technology in assessing other assets on the grid thereby extending the potential financial benefits from the system.			
Expected Timescale to adoption	3 years	**Duration of benefit once achieved**	20 years	
Probability of Success	5%	**Project NPV=(PV Benefits-PV Costs) x Probability of Success**	£136,125	
Potential for achieving expected benefits	This initial stage of the project has designed and validated the tool chains and we have gained experience in the capture of failure data and the development of prognostic systems. This knowledge will feed into the main project, which is intended to demonstrate the novel use of the sensing solutions transferred from other industries. The likelihood of success is high due to the fact that this sensing solution has functioned well in other industries.			
Project Progress March 2013	The project is in its initial stages, however progress has been made in review of the literature, a preliminary list of assets of interest has been developed and a small demonstrator project focusing on condition monitoring of power relays has been started. This small project is designed to validate tool chains and gain experience in the capture of failure data and the development of prognostic systems.			
Collaborative Partners	Heriot-Watt and, Strathclyde Universities			
R&D providers	Heriot-Watt and, Strathclyde Universities			

NIA 2013_01: Transformer Intrascope

Project Title	NIA 2013_01 Transformer Intrascope		
Description of project	The project is based on the development of an in-situ electrical insulation analyser with particular application to power transformers. GnoSys have developed a methodology based on wide-wavelength spectroscopy allowing for condition assessment of transformer internal insulation. However, it is currently limited in application to de-tanked transformers using a hand held probe which limits its usefulness for on-site, in-situ testing. The project involves working with GnoSys to develop a new probe system (intrascope). This will be based on a clinical endoscope concept which will be better suited to the end user requirements in allowing the in-situ testing of transformers. The benefits of the intrascope system will allow simultaneous visual inspection, condition assessment and property measurement of insulation within the transformer. The project will commence with the design development of a probe based system prior to being assembled in GnoSys' laboratory. This will then lead on to laboratory testing prior to advancing to field based testing of spare, non-operational transformers. This field based testing will provide operational experience in using the probe. This will allow refinements to be made to the system. Providing this testing is successful, the probe will then be used for demonstration on an operational transformer on the network. The transformer to be investigated is SGT3 (supergrid transformer) at Tealing substation because there have been a number of faults and problems with this unit previously. Providing operational testing of SGT3 is successful, the solution can then be considered for transfer to business as usual.		
Expenditure for 2012/13 financial year	Internal £1,170 External £0 Total £1,170	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total Project Costs (Collaborative + external + SHE Transmission)	£400,000	**Projected 2013/14 costs for SHE Transmission**	Internal £20,000 External £295,000 Total £315,000
Technological area and/or issue addressed by project	We have a vast number of power transformers on our network, many of which are aging and approaching the latter part of their operational lives. It is becoming ever more important, particularly with the aging transformer population, to monitor the condition of our units and to be able to accurately estimate how much longer we can reliably and safely operate them. Transformer condition assessment is also important in making optimum asset replacement decisions. It is difficult to monitor and estimate a power transformer's likely		

	remaining life with any degree of accuracy. The condition and rate of deterioration of the transformer's internal insulation is important in assessing its likely remaining life. The way we currently assess transformer health is through regular analysis of oil sampling, a process known as Dissolved Gas Analysis (DGA). This involves the analysis and periodic taking of oil samples to assess transformer health and monitor any changes in composition which could indicate a low-level internal fault or insulation degradation. The accuracy of this method is a topic of much debate and also does not allow fault location to be determined. We don't have any other tools that allow us to directly access and analyse the internal insulation of a transformer without the need to dismantle (known as de-tanking) the transformer in a factory off site. Internal inspection through de-tanking is an expensive and time consuming option especially for larger transformers. A valuable tool would be a probe that we could use in-situ, to directly access and assess the internal insulation on site without the need for de-tanking the transformer. This probe would also allow us to verify the results of the DGA.
Expected Benefits of Project	Greatly reduced costs, time, labour and outage time associated with the assessment of the internal insulation condition of a large power transformer as opposed to having to de-tank the transformer off-site. Another benefit is the ability to correlate and verify the results of DGA evaluation. This tool will provide better guidance on transformer asset replacement decisions.
Potential for achieving expected benefits	High
Project Progress March 2013	Preparation and completion of collaboration agreement for the project by end of March 2013. Project commencement is due to start in April 2013 through the NIA funding scheme. **See Appendix 4 for more information**
Collaborative Partners	GnoSys Global Limited
R&D providers	GnoSys Global Limited

Appendix 1: Summary Listing of IFI Project Costs

Transmission Projects:

Reference	Project Title	Internal	External	Total
IFIT 2007_02	Flow Battery Trial	£13,770	£1,310	£15,080
IFIT 2007_05	Cat 1 Dynamic Line Rating	£8,490	£1,610	£10,100
IFIT 2009 01	Insulated Composite Cross-Arm	£9,020	£121,880	£130,900
IFIT 2009_03	Alternative Tower Construction	£8,640	£99,380	£108,020
IFIT 2009_04	Mobile Condition Monitoring	£7,200	£25,750	£32,950
IFIT 2011_01	132KV Insulated Composite Cross-Arm	£9,050	£39,530	£48,580
IFIT 2011_04	VOAS Optical CT	£8,950	£1,610	£10,560
IFIT 2011_05	Nano Composite	£7,580	£33,720	£41,300
IFIT 2012_01	Bellrock Lumen	£6,320	£55,320	£61,640
IFIT 2012_03	Asset Prognostics	£6,970	£20,490	£27,460
NIA 2013_01	Transformer Intrascope	£1,170	£0	£1,170
	Total	**£87,160**	**£400,600**	**£487,760**

Appendix 2: Flow Battery Trial

This project looked to investigate the Zinc Bromine Flow Battery Technology by installing it a Grid Substation and using it to provide auxiliary power supplier for the site. The battery unit installed was the Power Block 150 sized at 100kW/150kWh and was supplied by Premium Power Corporation. The results from the trial would allow a comparison between flow cell technology and the standard Lead-Acid systems currently used for supplying auxiliary supplies. The factors used for comparison are installation, operation, maintenance & overall system performance.

The PowerBlock is a compact and modular system that provides enhanced electric reliability and power quality for utilities and power consumers. The 150 kilowatt-hours (kWh) of energy stored in the Powerblock system can be dispatched on demand at power levels ranging from 1 kilowatt (kW) to 100 kW.

This system combines high-capacity, long duration energy storage with advanced control electronics to deliver power to the required function (an illustration of the block diagram is shown below).

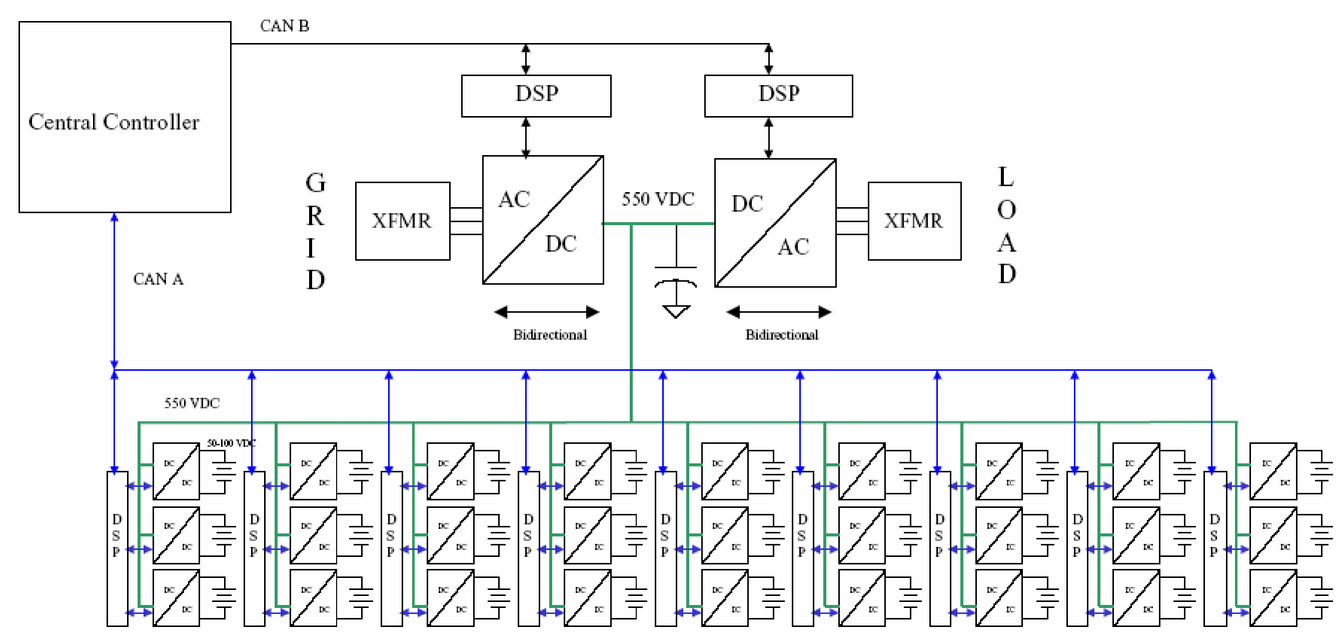

Figure 1 Battery architecture

The PowerBlock system is designed to operate in the following scenarios:

- Grid-interactive, which are on-line systems providing uninterrupted power from the electric power grid.
- Grid-independent, which are also known as “distributed” power generation systems that are not connected to the power grid
- Grid-parallel, which are systems that are connected to the grid in order to provide high quality uninterrupted power and are combined with on-site power generation systems to deliver additional power for peak loads that are higher than the capacity available from the power grid.
- Operate as a Uninterruptible Power Supply (UPS) in order to provide site supplies in the event of failure of incoming AC site supplies.

Appendix 3: Alternative Tower Construction

The project was conceived due to the challenges of moving equipment needed in the construction and deconstruction process of transmission towers.

The challenging aspects of the current method involve the movement of necessary equipment and materials to site. To get this material to site requires the construction of access roads strong enough to cope with the heavy materials and the cranes required to move them. The particular example in question is getting the hoisting equipment used in these operations to site. An example of this is shown in operation in the illustration opposite.

The construction of these roads poses safety, cost, time and environmental concerns for any transmission tower project. These issues are further compounded by the fact that planning consent generally requires them to be removed once the construction works are completed.

Movement of this equipment also poses a risk to any environmentally sensitive area it moves through: either indirectly through the need for construction of the roads to accommodate the large vehicle, or directly through the damage it causes while in transit.

Figure 2 Conventional tower construction using crane

Figure 3 Alternative tower construction using emergency restoration system (ERS)

This solution involves using a tower crane system designed by SBB. These towers, known as emergency restoration systems (ERS), are modular in design, allowing for safer, easier and cheaper transportation to site. The ERS is then assembled utilising a hoist system connected to the tower section already constructed to pull up the next section of the ERS (please see illustration opposite). In this way, the ERS can be scaled up in order to hoist sections of the transmission tower being worked on at different heights as the construction (or deconstruction) work progresses.

Appendix 4: Transformer Intrascope

The project relates to trying to determine the condition of internal electrical insulation within a power transformer. In particular, it relates to the older generation of transformers (i.e. those that have been operating for 50 years or longer) all of which vary in size, capacity, design, and manufacturer. These factors, combined with the varying operation & maintenance regimes over their respective lifespans, along with the differing environmental conditions that have existed for each transformer site means that determination of remaining asset life (of which the condition of the internal insulation is an important variable) cannot be derived but needs to be measured instead.

The way we currently assess transformer health is through regular analysis of oil samples known as Dissolved Gas Analysis (DGA). This involves periodically taking oil samples and analysing them in order to assess transformer health and monitor any changes in composition which could indicate a low-level internal fault. If there is any deterioration with the internal insulation there will be by-products present in the oil which the DGA detects. However, there are limitations with this method, namely the limited accuracy with which remaining transformer lifespan can be determined, and it does not indicate the source of the fault.

Figure 4 Transformer windings

At present, if it is deemed necessary to investigate in more detail the remaining lifespan of an asset or clarify the particular source of the fault flagged up by DGA. This can only be done by de-tanking the transformer. This involves dismantling the transformer in a factory off-site (Figure 4). The costs of this can be expensive, with the cost involved in de-tanking a single large supergrid transformer in the range of £250,000.

The concept under development in conjunction with GnoSys Global Limited consists of a probe system based on the endoscope concept utilised in the medical profession (Figure 5). With the construction of this new probe, the aim is to be able to perform a more detailed analysis in-situ rather than having to de-tank the transformer in question. This should lower the costs associated with such an analysis as well as reducing time that a transformer is out of service.

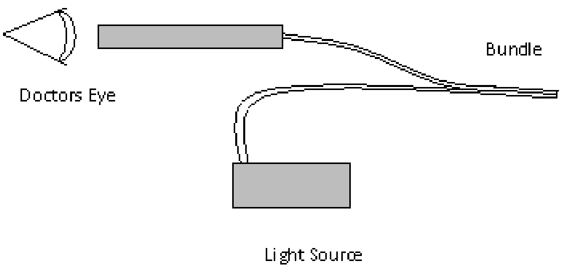

Figure 5 Schematic representation of medical endoscope system