Annual Report 2010/11

nationalgrid

Innovation Funding Incentive

Electricity Transmission R&D Programme Detailed Reports

National Grid Electricity Transmission R&D Programme Detailed Report

During the financial year, 2010/2011 National Grid Electricity Transmission utilised 99% of the Innovation Funding Incentive across a number of programme areas. These programme areas and their associated projects are indexed below and the detailed progress reports follow.

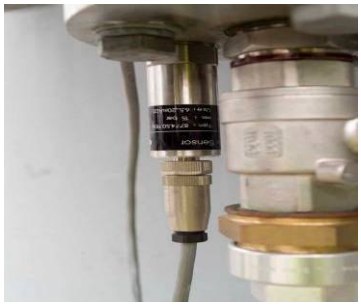
The report has been structured to show research project and the area of research they relate to spanning network wide projects to specific asset types.

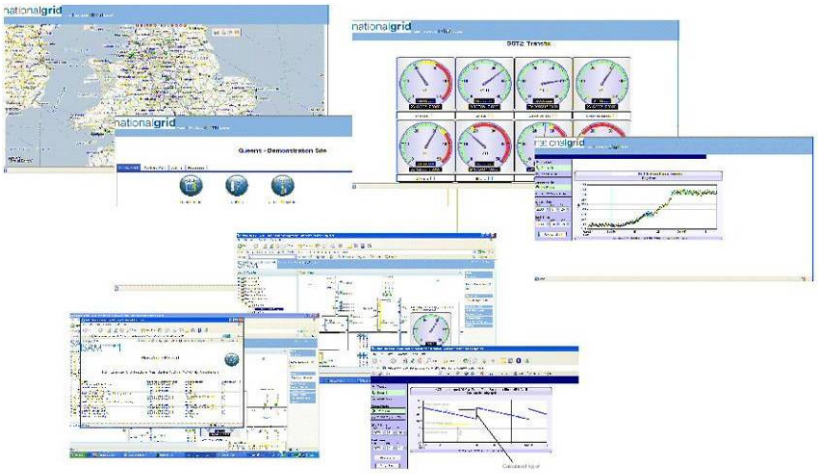
Contents

Network

<table>
<tr><td>Project title</td><td colspan="5">On line Monitoring Integration</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Carl Johnstone</td></tr>
<tr><td>Description of project</td><td colspan="5">To trial and implement a full on line monitoring system external of the business network, by the involvement of key stakeholders across the business. To retro install an online density system on gas insulated switchgear (GIS) substation were current monitoring in manual checking of gauges and a new GIS Substation where there is a stand alone online density system installed through construction, and then evaluate the benefit case for running a scheme to roll out to other substations.</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £3k
External £45k
Total £48k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £8k
External £204k
Total 212k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td colspan="2">£260k</td><td>Projected [next year] costs for [company]</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">More efficient management of GIS and sulphur hexafluoride (SF_6) filled equipment to move from reactive to proactive planning of resource, by applying modern monitoring techniques to order equipment where bigger benefits would be delivered.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>11</td><td>2</td><td colspan="2">9</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">The benefits are itemised for SF_6 but the business process benefits could apply to any online condition based measuring systems such as Drallim (cable oil pressure), Gas in Oil analysers (Hydra< Kelman) Partial Discharge (AIS and GIS).
Process
• To predict the time to intervene and action required then record and make information available to a wide audience and to other systems (planning, reporting to the regulator, ranking of leaks) maximising benefit by focusing on highest leaks, automated instruction to site staff on action required cost avoidance to deferred maintenance for resource constraint.
• Maximise expenditure by matching level of leak, to level of repair.
• Regulator incentive £10m over 5 year period.
• Carbon equivalent (£25/ton carbon x 23,000) cost if applied £837,411 (at Littlebrook 07-08)
• £14k/annum spent on SF_6 gas for top-ups (at Littlebrook 07-08)
• Man hours for top up and gauge survey (£3.5k/annum with travel time Littlebrook)
• Reduce call outs diverted resource to respond to gas alarms (£70k/annum to GIS sites)
• Reduced alarms to the NOC</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">Better Visibility
Easier to view current status (on-site or remote) to reduction of emissions, site targets, reduces need to attend site (travel time/carbon footprint)
better 'buy-in' for site staff and other business users due to clarity of drivers and contribution to the overall target
Reduced training requirements and understanding of proprietary software from different suppliers.
Efficiency
Better use of resource in areas where constraints (GIS and cables are generally based in London and South East) reducing deferred work.
Opportunity cost benefit for released resource - 25 man-days for sub routines for the four sites
Avoidance of inefficiencies associated with diverted resource
Maximise benefit of system already installed, currently under utilised.
Calculate volume of gas used in each gas zone removing need for weighing and mass flow meters.   </td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td>Duration of benefit once achieved</td><td>5 Years</td></tr>
<tr><td>Probability of success</td><td>60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>-£27k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">The project has now highlighted the benefits of online monitoring of SF_6. It shows the capability and viability of retro fitting, and how we specify technology on GIS substations. In particular:
Capability to upgrade ~ 30-year-old assets with modern technology without the need for an outage. Three generations of GIS included in this project.
Moving from reactive to proactive planning optimising resource. (optimised planning alignment with 3 month advanced warning).
Prioritisation of leaks to maximise leak reduction efforts.
Remotely assess criticality and impact of any alarm to provide appropriate response.</td></tr>
</table>

	• Remove need for routine checks, by providing automatic monitoring and reporting across business streams. • Future reduction of capital cost of monitoring hardware by up to 40%, and ongoing operational costs. • Validation of alternative techniques such as remote mass flow meters (See separate R&D project). • Understanding security and support framework of separating monitoring from operational data and processes. • A sustainable model of managing IT monitoring life expectancy with that of the primary asset life. The understanding gained from this project and applying the lessons learned into future specification and business processes has the potential to reduce typical capital costs per monitoring system by around £50k - £200k, reducing opex costs in stand-by, and systems and size of substations,
Project progress **[Year to End of March 2011]**	All the 157 gas zones are now being monitored and have had online true density transducers. The key types of adaptors to allow the transducers to be fitted to a live gas zone without an outage have been developed and fitted. These have also been developed to allow the transducer to be replaced non-outage in the event of it failing. The new type of fittings for top-ups are now standardised, removing the delay and cost in using non-standard fittings. The system now sends data automating to the remote TSAM (Tactical Strategic Asset Management) server allowing any business user access to the data on a web portal in a single platform utilising the same format as air compressors and online DGA monitoring, removing the need for training and refresher courses. The system predicts any leakage rate and provides an alerting date for planning. This project has shown the need and benefit of integrating data from multiple sources of SF_6 data and an increased prediction model when using pressure sensors not true density to compensate for temperature changes.  Current Gauge technology  Site is large and difficult to retro-fit  Single fitting adaptor for top-ups with transducer  True density transducer

	 Solution for Mk II type assets  Direct Tank fitting  TSAM end user viewing platform
Collaborative partners	Siemens have participating with the development of the system and knowledge of the primary assets.
R&D provider	Siemens/ C3 Amulet

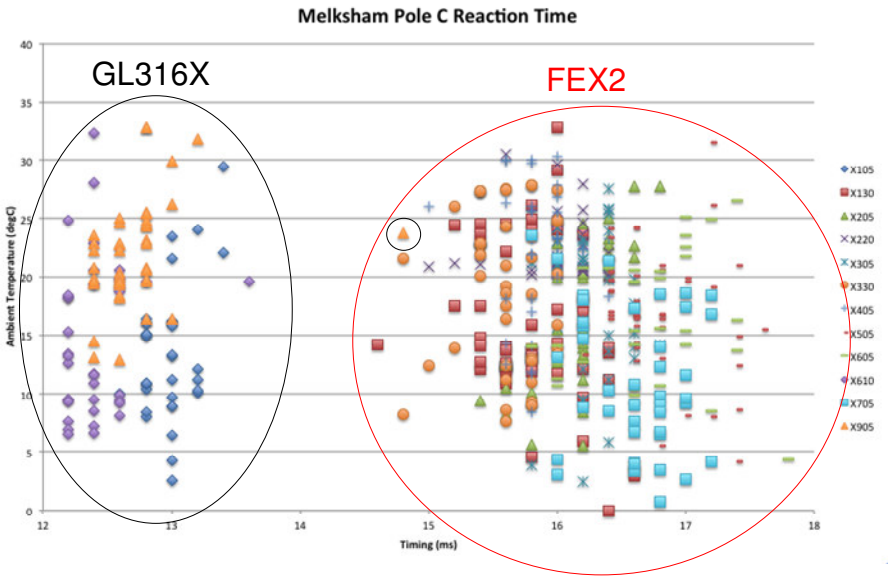
<table>
<tr><td>Project title</td><td colspan="4">Condition Monitoring (Assessment) of circuit Breakers</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Carl Johnstone</td></tr>
<tr><td>Description of project</td><td colspan="4">The project is aimed at improving the process used for Condition Monitoring of circuit breakers and to raise it to a feasibility level where a single monitoring specification can be used on any breaker on National Grid’s system. The feasibility will demonstrate the issues and benefits of centralisation of data to use and develop asset management tools for maintenance cycles and end of life. This information will be presented via the condition-monitoring web (SAM).

The outcome of this programme will direct the second phase of R&D which is automated knowledge for Asset Management and prioritisation tools.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £6k
External £93k
Total £98k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £5k
External £70k
Total £75k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£174k</td><td colspan="2">Projected 2010/11 costs</td><td>£0k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Existing Circuit Breaker (CB) monitoring already installed is not delivering its potential benefit or a clear strategy for meeting the increasing demands of asset managing circuit breakers.</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>4</td><td>1</td><td>3</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This R&D project is in-line with National Grid’s policy for condition monitoring and will provide input to the condition monitoring strategy.

The monitoring kit will be beneficial for reactive maintenance. It could potentially help to carry out planned maintenance in a cost beneficial, risk managed and outage controlled manner. It should also raise confidence in new technology. Monitoring applied at appropriate times gives engineers more knowledge and information of the asset and enables longer lead times and clear assessment of management decisions. Using data currently held, as well as new data, it will allow enhanced performance and maximum efficiency. In effect it’s the drive towards a cost effective, optimum timing device to enable National Grid to move towards condition/risk base maintenance.

CB timing incurs a cost in time and resources that could be mitigated using a real time online methodology. It takes 2 people 1 day to perform timing tests on a single CB and approximately 60 CBs are timed each year. Also, it takes one person one day every month to download the data from CB watch equipment on site. Consequently, over a five year period 660 man days are spent timing circuit breakers and retrieving the data which equates to manpower costs of £165k.</td></tr>
</table>

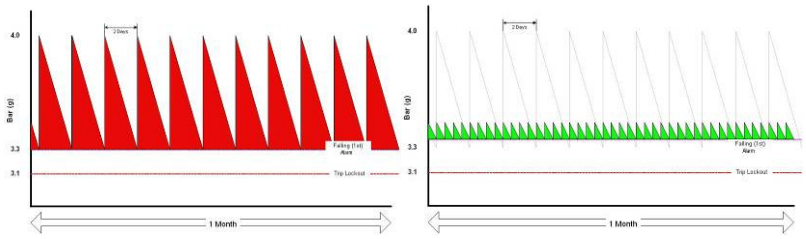
	The increased visibility of data achieved by centralised storage would enable the Asset Health and Switchgear teams to make use of data to which they previously did not have access. The risk of a CB failing when asset data was available that could have prevented this failure is a situation to which National Grid is currently exposed. 		
Expected timescale of project	2 Year	**Duration of benefit once achieved**	5 Years
Probability of success	80%	**Project NPV = (PV benefits – PV costs) x probability of success**	£ >100k depending on deployment
Potential for achieving expected benefits	This project was to see the potential and viability of taking the research further. Due to the success of this project, and similar complementary projects sponsored by Scottish Power (SP), the next phase is intended to increase scope to include multiple forms of data collection (online, offline, and protection relay data) in partnership with SP, with Areva interested in support and findings.		
Project progress **[Year to End of March 2011]**	The objectives of the project were met with the outcome exceeding expectation. Under blind data submission two distinctive 'clusters' where found using the measured parameters. Upon further investigation it was found that there were two types of CBs and fell clearly within a 'family norm'. This proves the viability of the resolution required to move from fixed parameters of unknown tolerance, to a level where each family can be uniquely categorised and benchmarked against. Any drift or movement from this will identify potential risks or defect supporting the move to Asset Health and Criticality regimes. This will ultimately assist with asset life projection and optimised maintenance regimes.		

	Concentrate on Melksham Pole C 
Collaborative partners	Power Link (Australia may provide extra data) and Areva (Supplier) are assisting with knowledge
R&D provider	Strathclyde University and C3 Amulet

<table>
<tr><td>Project title</td><td colspan="5">Remote Mass Flow Meters</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Carl Johnstone</td></tr>
<tr><td>Description of project</td><td colspan="5">To automate the sending of data from mobile SF_6 mass flow meters currently on trial in the field to a central server. The objective is to bring the data provided when each zone is topped-up to a central database, provide automatic reports, and provide better asset management. Also enable the user to remotely locate the mobile unit(s) on a site.</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £2k
External £4k
Total £6k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £5k
External £36k
Total £41k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td colspan="2">£47k</td><td>Projected [next year] costs for [company]</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">Remote measurement and assessment of SF_6 zones to enable more effective, efficient and economic asset management.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>10</td><td>-3</td><td colspan="2">13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">The business benefits are :-
Reduced risk of misreporting of data (undefined corporate fine, potential of >£1m)
Simple and easy validation recording of SF_6 usage
Minimised time spent locating test equipment (reduced travel and worktime)
Effective use of test equipment by increasing availability
Reporting can be aligned with online density monitoring. Single viewing platform for online and offline top-ups
Offer an alternative where it is not viable to fit online monitoring
Trial of a technology that could be transferred to others technologies (CB timing, SF_6 gas Sampling, etc).</td></tr>
<tr><td>Expected timescale of project</td><td colspan="2">2 years</td><td>Duration of benefit once achieved</td><td colspan="2">5 Years</td></tr>
<tr><td>Probability of success</td><td colspan="2">60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£23k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="5">The system will automate the process from top-up to reporting. This will enable accurate recording of all top-ups due to reduce human intervention and transfer errors between systems.

The automation of the top-up provides the functionality for the operator to optimise their time by being able to have parallel activities and being notified when the top-up is complete. When used in conjunction with further potential</td></tr>
</table>

	R&D for a prediction model and other SF_6 monitoring techniques, could move proactive planning, reducing call-outs while increasing resource availability (~£100/annum). As below this tachniques has already shown savings on the trial due to automating top up while an asset could not be removed from the system, leading to reduced leakage and better outage planning.
Project progress **[Year to End of March 2011]**	System is now in use. The system allows for the operator to type in the Site, asset ID, gas-zone target pressure, operators name and their mobile number. The device allows the operator to not have to be in full attendance during the top-up and text him on completion enabling them to do other duties and optimising their time. The data is also automatically sent in parallel to TSAM (Tactical Strategic Asset Management) web portal for viewing and reporting. During this trial, an issue arose when a large leak occurred on an asset that was unable to be removed from service for repair in the immediate term. This device has the functionality to choose the flow rate allowing it to be set as low as possible for a single top-up. This allowed the pressure to be reduced minimising gas released before it could be repaired and extending the time for the operator to attend, reducing call-out costs. The business needs to lead further development of this innovation to allow for the development of a continuous top-up device that is only used when all repair options are not possible. It automatically maintains the gas pressure at the low end of the operational scale. This reduces the amount of SF_6, removes call outs, while allowing the operator to request the status via text, the engineer is then notified if bottle pressure is low providing proactive management.  Mass flow meter with touch screen

	 Continuous top-up Unit (CTU) device  Automated text from CTU  Illustration of the way the CTU differs from traditional top-ups, and an example of how gas emissions are reduced
Collaborative partners	
R&D provider	A1Predicta and C3Global

<table>
<tr><td>Project title</td><td colspan="3">Review of Voltage Dependency of Load</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Mark Perry</td></tr>
<tr><td>Description of project</td><td colspan="3">The project will investigate the composition of loads connected to DNO networks, evaluate the current load models used in analysis work, and, if appropriate, recommend updated models. The project will undertake some validation of the models by comparing study results using them with measurements taken during large system voltage disturbances. There will be two deliverables:

A report describing revised composite load models applicable for the UK and indicating their impact within load flow studies in relation to VDL.

A report documenting the comparison of measured responses against a theoretical model based on current assumptions.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £24k
Total £27k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal
External
Total</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£</td><td>Projected 2011/12 costs for national Grid</td><td>£0K</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">It has been some time since the modelling assumptions underlying current composite demand models have been challenged with respect to voltage sensitivity. During this time the types of loads, and their performance characteristics, have changed, meaning that currently used models may not be representative. A number of important system planning and operational tasks (including voltage stability and the identification of initial conditions for fault level studies) would benefit greatly from revised models with improved representations of voltage dependency of load (VDL). This project will consider quasi-steady-state modelling only. Through liaison with DNOs it will improve the understanding of the composition of loads currently connected to the transmission system and develop updated models for use in system analysis studies to represent</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Incremental</td><td>Project Benefits Rating
5</td><td>Project Residual Risk
-1</td><td>Overall Project Score
6</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">An accurate model of the voltage dependency of load is essential to accurate fault level and transmission system voltage-performance assessment. Significant investment is based on fault level and voltage analysis, often in cases where system performance is expected to be only marginally outside of capabilities and / or standards. Where load models are not known pessimistic assumptions are made. Better modelling of loads is likely to result in a reduced requirement for reactive compensation plant (ranging in cost between £5 million and £20 million per compensation device) and lower requirements on switchgear.

The accurate calculation of fault levels operationally is essential to the safe operation of substations. Overstressed equipment may explode and substation-running arrangements have to take account of fault levels to ensure safety. In some cases substation splits, which are less desirable for security but help reduce fault levels, may be unnecessary and based on fault level calculations</td></tr>
</table>

	using pessimistic load assumptions. Improving knowledge of the composition of loads, and the development of accurate models, is likely to reduce transmission system investment and increase levels of system security.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£8k
Potential for achieving expected benefits	The success of the project depends on the level of information that can be obtained from DNOs regarding the composition of their load. It is expected that there will be mixed information from different DNOS, meaning that it is likely that there will be partial success, with further surveys of DNOs needed in the future.		
Project progress **[Year to End of March 2011]**	A literature review and analysis has been produced however a research Fellow who had been appointed left and was then replaced by a visiting Master's student to at least finish this first deliverable. The analysis showed that a load model is one of the most important elements in power system simulation and control. Accurate load models are required to correctly understand the potential for voltage collapse and system oscillations following system disturbances. Also the information/knowledge enables proper power system planning, reliable prediction of prospective operating scenarios and provides for adequate control actions to be chosen in order to prevent undesired system behaviour and ultimately system instability. Transmission power flow limits are determined from studies of these conditions and the accuracy of the load models is critical. Although the importance of load modeling on system dynamics has been well known, load modeling is still a very challenging problem and remains unsolved so far. In fact the load consists of various components with various characteristics, which nevertheless, have to be represented by one aggregated model. The main problems in building generic load models and finding the load model parameters are: • Changing load characteristics due to the emerging digital society and the increasing penetration of power electronic based loads; • Different load composition (i.e. industrial, commercial, agricultural, residential and other loads) of every load bus; • Difficulty to establish the exact load composition at medium and high voltage level; • Lack of precise information on the composition and mix of loads by users; • Penetration of new load composition into the system and diversity in the types of loads connected to the power system at any given moment; • The random load variation from hour-to-hour, day-to-day, and season-to-season which cause load level changes and load composition		

	changing, (i.e. when electrical power is used for air conditioning or heating); Further work will continue once a replacement researcher is identified.
Collaborative partners	ScottishPower Energy Networks
R&D provider	University of Strathclyde

<table>
<tr><td>Project title</td><td colspan="4">Demand Response</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Shanti Majithia</td></tr>
<tr><td>Description of project</td><td colspan="4">Task XIX (Micro Demand Response and Energy Saving) is a collaborative project under the International Energy Agency's Implementing Agreement on Demand Side Management (DSM). Historically, the majority of DSM offerings have focused on large consumers. The work will consider the potential for small consumers to participate in Demand Response and Energy Saving projects, focusing on the use of Time of Use pricing, remote/automatic demand switching and energy end use monitoring and feedback.

The principal deliverables will be two reports, covering both the information collated from the UK participants and the International partners. The first of these will define the requirements for the implementation of Micro demand Response and Energy Saving schemes, along with options for effective delivery. The second will build on the first to assess the business case for delivering such schemes.

The work commenced in January 2009 and tt is anticipated that it will require 15 months to complete.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £7k
Total £10k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £4k
External £8k
Total £12k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£422k</td><td>Projected [next year] costs for [company]</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The project assesses the potential for and likely business case/s to support the delivery of Micro Demand Response (DR) and Energy Saving projects to Residential and SME customers. The three techniques for demand side management that will be focused on are Time Of Use pricing, remote/automatic demand switching and End Use Monitoring and Feedback (EUMF).

Whilst the primary interest is in relation to developments within the UK market, the project is coordinated under the International Energy Agency's Implementing Agreement on Demand Side Management. This provides an opportunity to look at the possibilities in a broader context, and to understand developments within the other participating countries.</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>5</td><td>-5</td><td>10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The anticipated benefits of participating in this project are as follows:
• An opportunity to influence Residential & SME DR terminology and understanding within the UK;
• Gain an independent view of the technology and techniques available for the largely untapped Residential & SME market;
• Knowledge of international approaches and opportunity to learn with others to develop 'best practice' approach to small consumers;
• Understand the role of demand side in energy markets through the use of DR programmes and mechanisms;</td></tr>
</table>

	• Evaluate the advantages and disadvantages of different technologies and techniques; • Quantify infrastructure needs for load control and energy saving options; • Assess the potential of time of use or developed profile metering in achieving objectives; and • Opportunity to work with a number of UK stakeholders and gain an awareness of current developments in this area.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£17k
Potential for achieving expected benefits	The potential for achieving the expected benefits is high. EA Technology has delivered a number of similar projects and has a robust project management system in place. As it is a collaborative project, there is a potential risk of limited contribution by other members of the UK team.		
Project progress [2011]	The project commenced in January 2009 and consisted of an initial phase of confirming what would be required to deliver the project. This led to the first two meetings for the National Representatives' and the first meeting for the UK team being held. These meetings brought the relevant teams together to agree the work programme. This project has now completed the final report being delivered in July 2010. This project has increased the knowledge that National Grid has on demand management and has now brought in Network Operation, Contracts and Management to see how the practical application of this research could be implemented.		
Collaborative partners	British Gas New Energy, Department for Energy & Climate Change, EdF Energy, E.ON Engineering – Innovation team, Scottish & Southern Energy. International partners – France, India, Finland, Spain, Greece, Netherlands		
R&D provider	EA Technology Ltd		

Project title	**SALVO**
Project Engineer	Gill Duffy
Description of project	SALVO is a project to research and develop innovative approaches to decision-making in the management of mature assets. SALVO aims to develop simple, flexible and practical guidance and tools for determining what to spend and when in the following common, yet critical, decision scenarios: "As the equipment ages, what changes to inspection, condition monitoring, functional testing or planned maintenance should I make?" "When is the optimal time to replace (or decommission) this equipment, and what are the cost/risk effects of delay?" "Should I replace with the same design (like-for-like), or with a technology change/upgrade/alternative design?" "Is it worth refurbishing the current equipment, to extend its life and, if so, by how much?" "Is a (non-cyclic) modification project worthwhile, and how does this compete for value/priority with timing-sensitive or cyclic tasks (e.g. maintenance/renewal)?" Programme integration level (only possible once the above questions can be answered individually and quantitatively): "What is the optimal (life cycle value) combination of capital investment and operating/maintenance expenditures for a particular class of assets (i.e. optimising the mix inspection, maintenance and renewal)?" "What is the optimal integrated work programme (multiple activities for multiple assets) over the next XX years (including coordination opportunities, resource smoothing etc)?" "Given a specific capital investment budget, which projects or tasks should I spend it on?" "What are the investment and maintenance budget/resource needs for my asset portfolio in the next XX years?" These questions all draw on certain common technical and process requirements. Such core components determine the SALVO R&D technical work elements (figure 1).

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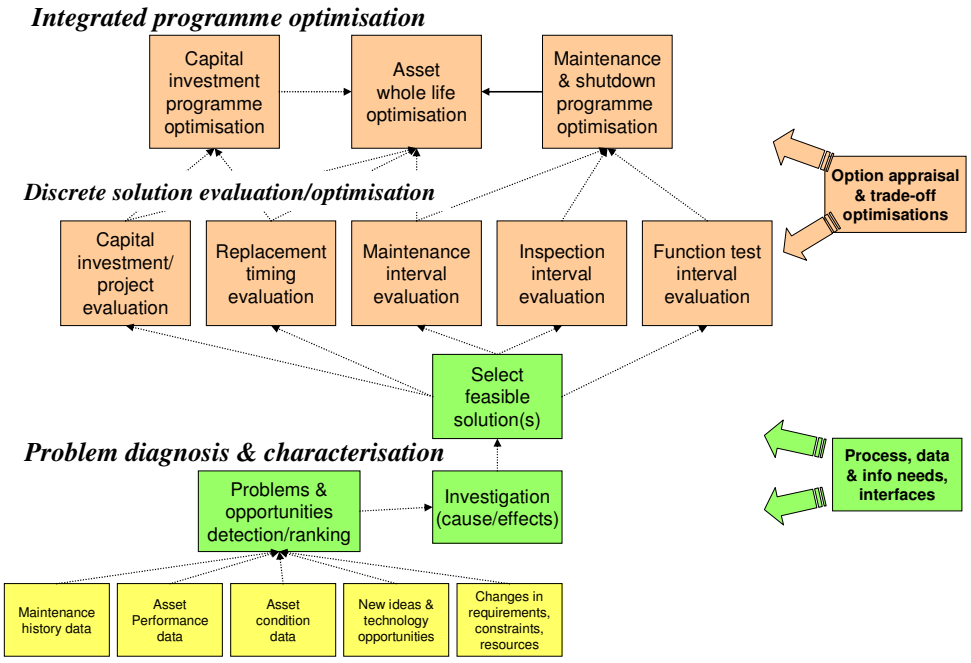
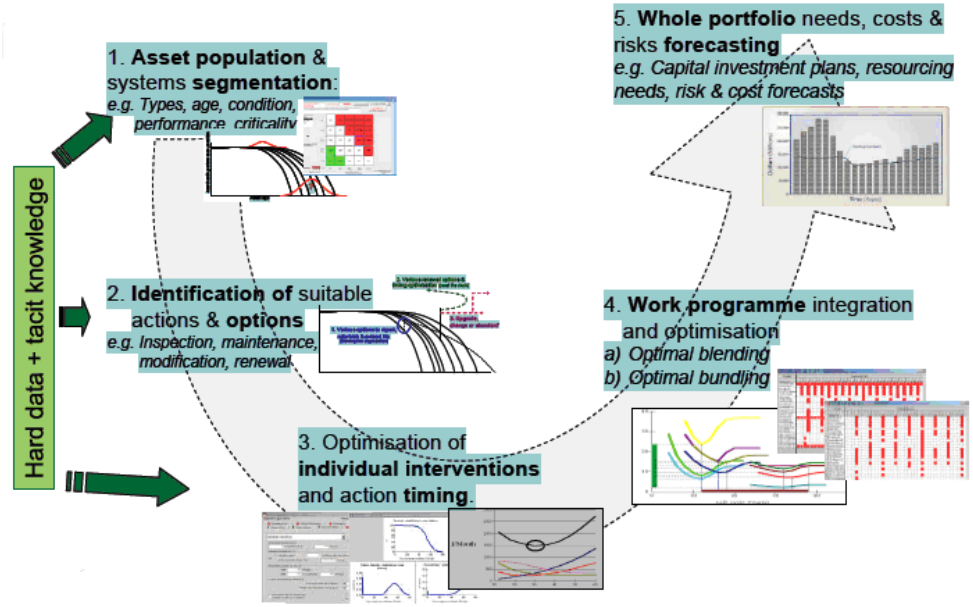
<tr><td></td><td colspan="4"> 

Figure 1 Technical module development requirements</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £23k
External £25k
Total £48k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £27k
External £50k
Total £77k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£318k</td><td>Projected 2010/11 costs</td><td colspan="2">£60k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">See project description</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>-2</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Asset management is a core capability for National Grid to enable optimal management of its assets across the whole life cycle. National Grid is committed to enhancing its asset management capability. It was the first utility in the world to gain BSI PAS 55 certification and is actively involved in developing asset management practice both internally and externally e.g. through leading and participation in Institute of Asset Management projects. National Grid sponsored and was an active contributor to the MACRO project and has extensive experience both developing and using asset-management decision support tools.

National Grid uses asset management to address current and future challenges and opportunities e.g. managing an ageing asset base, building a network to facilitate change in generation to meet climate change targets, maintaining the high reliability levels experienced by UK consumers, ensuring consumers get value for money whilst maintaining at acceptable levels, ensuring the network is sustainable in the future. This asset management requires sophisticated analytical assessment and balancing of costs, risks and performance.</td></tr>
</table>

	£5 Billion in capital investment is identified to be needed in electricity transmission infrastructure in the next 5 years. Reasonable projections for the resultant savings in maintenance, capital investment (avoidance/ deferral/ improved value) and earlier adoption of high performance technologies represents a net estimated benefit to National Grid of £20-100 Million. This project will contribute an estimated 10% of the potential benefits.		
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£636k
Potential for achieving expected benefits	The confidence level in achieving these benefits is rising as the project progresses – the first trials by collaborators during August-Sept 2010 (of the prototype tool for asset renewal timing decisions) yielded consistent significant financial and risk reduction benefits (each case >£700k annualised impact) compared to existing strategies/practices. Corresponding prototypes for evaluating enhanced maintenance, condition monitoring and plant modifications (to extend asset life) are expected to identify further benefit areas later this year.		
Project progress **[Year to End of March 2011]**	The overall process mapping workstream has identified 5 primary steps in the management of aging assets, within which more detailed requirements and guidance have now been scoped and developed for most of the first three steps (problem definition and prioritisation, identification of feasible solutions, evaluation of discrete feasible solutions). These processes have been documented, and illustrations of their component sup-steps are currently being collated for inclusion in the final guidance materials. Step 3 (evaluation of discrete options and their optimal timing/intervals) has several branches, of which the primary one (evaluating asset renewal timing, in both like-for-like and obsolescence/upgrade versions) was converted into software prototypes and field trialled in Aug-Sept 2010. Enhanced functionality and graphical user interface for this 'module' are being specified currently. Other branches of Step 3 (e.g. enhanced maintenance, condition monitoring and 'step-change' projects) are in the functional requirements specification stage, with a view to issuing prototypes for field trials later this summer. The working practices of the project have evolved into a backbone of regular intensive 2- or 3-day workshops during which working group participants address key areas for best practice identification, debate and definition. Technical requirements specifications, case examples and niche developments are then placed as actions on sub-groups or other nominated working parties. This seems to be retaining momentum well and all participants have commented on the useful and in-depth contributions of the individuals involved.		

	 A milestone workshop occurred in November 2010, at which overall progress was reviewed, field trial results discussed, and 'associate' organisations to the project were invited to comment and contribute. This was deemed very successful and good feedback was received by the project managers. The next such milestone workshop is scheduled for November 2011.
Collaborative partners	Scottish Water, London Underground, Scottish Power, SASOL, Forbo Flooring Systems
R&D provider	The Woodhouse Partnership Ltd, The University of Cambridge

<table>
<tr><td>Project title</td><td colspan="3">Optimising the operation of an integrated DC link within an AC system</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Alex Carter</td></tr>
<tr><td>Description of project</td><td colspan="3">Determination of how the system should be operated with the introduction of offshore HVDC lines to maximise the exploitation of renewable energy resources, especially wind and the types and amounts of reserve that are likely to be required.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £4K
External £21K
Total £25K</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£121K</td><td>Projected 2010/11 costs for national Grid</td><td>£14 K</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">National Grid has a good history of operating the AC network and also utilising a DC link as an interconnector. However National Grid has no experience in operating an integrated HVDC link in conjunction with the AC system.

The first intra-network HVDC line is planned to be operational from 2013 to accommodate the significant increase in wind generation being installed in Scotland. It will be the responsibility of the System Operator to determine the optimum power flow on this link by balancing the risks and flows between the parallel AC and DC networks.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Radical</td><td colspan="2"><table><tr><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td>10</td><td>0</td><td>10</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">Ensure that the correct balance between security and efficiency is maintained by advising on the best strategies to approach setting the flow between the parallel AC and DC networks. This will need to factor in transmission losses and stability for a range of different operating conditions and understand the consequences that this will have.

The main benefits to the system will be a study enabling the understanding of:

• The risks associated with different levels of power dispatched pre-fault on the HVDC link that is being operated in parallel with the AC

• Advice on suitable levels of dispatch on a parallel HVDC link.

The dimensions of risk are expected to include: risk of overloads on the AC system; and risk of rotor angle instability on the exporting side of a boundary following a fault outage. The scope for different levels of inter-trip to manage the above risks will also be explored alongside the need that remains for pre-fault constraint of generation under different circumstances. Finally, through liaison with CIGRE JWG C4.B4.C1.604 (“Embedded HVDC”), knowledge will be sought on emerging international practice in respect of the above and on fault rates on the HVDC side.

This study will be critical into maximising the exploitation of the renewable energy resources in the North of Britain. As well as ensuring minimisation of balancing services costs associated with operating the system.

Analysis was carried out in July 2010 to assess the Interim Connect and</td></tr>
</table>

	Manage over the period 2010/11 to 2014/15 and shows that the boundary between England and Scotland will remain congested and constraint costs are likely to be approximately £75k/MW/year. The cost of the project is therefore equivalent to the constraint cost of reducing pre-fault flows by 2MW for one year.		
Expected timescale of project	4 year	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£187k
Potential for achieving expected benefits	An encrypted version of the GB network model is now available and Strathclyde has the correct level of knowledge so this project has a high likelihood of success.		
Project progress **[Year to End of March 2011]**	A PhD student has been appointed from the University of Strathclyde's partnership scheme with North China Electric University. Co-funding has been obtained from the Scottish Energy Technology Partnership (ETP). Objectives in the first year have concerned attendance of Master's level classes to improve background knowledge and conducting analyses of power system steady state security. A recently developed 29-node representation of the GB main interconnected transmission system has been used to allow key phenomena to be studied without overwhelming the investigator with detail and data issues. The ENSG 2020 "Gone Green" scenario has been studied including the west coast 'bootstrap'. A number of different operational scenarios have been studied including variation of demand, level of wind power available and whether Torness is available to run or not. The aim has been to discover how much power should be dispatched on the HVDC link in such a way for the system to be secure against either loss of one pole of the link or a double circuit on the AC side. Two cases have been explored relying solely on pre-fault actions where necessary, or assuming that post-fault actions could be implemented sufficiently quickly. A report of the steady state analyses is being prepared with a view to sharing it with National Grid in September 2011. The plan for year 2 will then be expanded and is expected to include stability issues.		
Collaborative partners	STP		
R&D provider	University of Strathclyde		

<table>
<tr><td>Project title</td><td colspan="5">Communication of system wide quantities using emerging communications technologies to enhance the stability of distributed generation during grid system disturbances.
(Satellite based LOM)</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Dr William Hung</td></tr>
<tr><td>Description of project</td><td colspan="5">The unreliability and instability of Loss of Mains (LoM) protection is a well know problem. This protection is designed for avoiding any embedded station being islanded but is triggered unnecessarily by disconnection of generation under large system disturbances conditions (eg large loss of infeed or generation). This could be a risk to system security. As the volume of embedded plant has increased to over 6 GW and is expected to continue to increase, the risk on the system will become unmanageable. There is therefore an urgent need to improve the reliability performance of this type of protection. The proposed project is to explore an alternative way of using up-to-date technology for LoM protection without jeopardising system security.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £14k
Total £17k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£77k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td colspan="2">£6k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">This research project will investigate the potential for further improvement of the stability of DG connections during system-wide events by taking advantage of existing and emerging communication technologies such as satellite and/or internet. Satellite communications may form a particularly viable solution for remote and offshore locations (where many wind farms are, or will be, installed); whereas internet could preferably be used in urban areas. Satellite communications have not been widely applied in protection systems due to the assumed limited (or rather unknown) reliability of this medium. Therefore, it is believed that in addition to the development of novel LoM methods, the key to the successful deployment of such technologies in the protection domain is the rigorous assessment of the reliability of the communication media.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Tech Transfer</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td colspan="2">Overall Project Score</td></tr>
<tr><td>7</td><td>-6</td><td colspan="2">13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">The key benefits of the project can be summarised as follows:
• for power system utilities – by using new improved protection methods the network operators will be able to accommodate more energy sources;
• for protection manufacturers – by adopting new protection methods and algorithms the manufacturers will be able to develop and offer new products meeting the demands of the future active power systems;
• for distributed generation developers – by using new protection solutions the developers will be able to connect new energy sources at lower connection costs.
• for the engineering standardisation and regulatory bodies – the</td></tr>
</table>

	outcomes of this research should lead to major changes and standardisation in the fault performance of the distributed energy sources. • for the society – improved level of stability and security of electrical power delivery.		
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£18k
Potential for achieving expected benefits	The University of Strathclyde has already undertaken a substantial body of investigative research into the assessment of the existing LoM protection methods and the development of new algorithms. Moreover, the University has a state of the art real time simulation facility (RTDS) for hardware testing under realistic system conditions. The above factors greatly increase the potential for meaningful practically applicable results.		
Project progress **[Year to End of March 2011]**	The project progress has been delayed because of difficulties of recruiting the appropriate PhD student for the project. This problem has now been resolved. NGET is also pleased that SSE is also participating in the project. The first project meeting was held on 24 June and there were very constructive discussions on the subject, mainly the impact of small embedded generation because of the inconsistent ROCOF operation on transmission system performance. The project is to focus on using other means (ie Satellite based) of LoM protection rather than relying solely on independent ROCOF relay operation.		
Collaborative partners	EPRC Doctoral Training Grant £46k The project partners are University of Strathclyde, National Grid, Scottish and Southern, AREVA.		
R&D provider	Strathclyde University		

<table>
<tr><td>Project title</td><td colspan="3">EU-Real Smart</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Alex Carter</td></tr>
<tr><td>Description of project</td><td colspan="3">The overall scientific and technical aim of the EU REAL-SMART project is to take a pivotal role in the creation of technology for intelligent operation of wide-area AC transmission grids using emerging measurement technologies. The project integrates in-depth understanding of the operational issues with analysis of state-of-the-art measurements and first-principles physical knowledge to invent and develop tools that will be deployed in the field in case studies with the transmission operator partner.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £0
Total £3k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£1,090k</td><td>Projected 2010/11 costs for national Grid</td><td>£3k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Electrical transmission and distribution in Europe is entering a period of significant renewal and technological change. Transmission grids such as the Nordic system, the National Grid in the UK and the UCTE system in continental Europe are accepting power injections from new and variable energy sources, especially from large-scale wind power generators, and will therefore face major future challenges to operate and control. Policy documents from the US DOE, EU, UCTE and the National Grid have highlighted (i) the need for improved grid infrastructure and advanced control technologies and (ii) the importance of emerging measurement-based technology in enhancing the stability and security of AC transmission in an increasingly complex operating environment.

Changes happening in the process industries also have an impact on electrical supply. Sustainability, efficiency and maintenance considerations are leading to electric motors taking over from traditional gas turbine drivers for rotating machinery such as compressors. Understanding and managing the interface between these large and variable electrical loads and the transmission grid is of great interest for smooth operation of the transmission system.

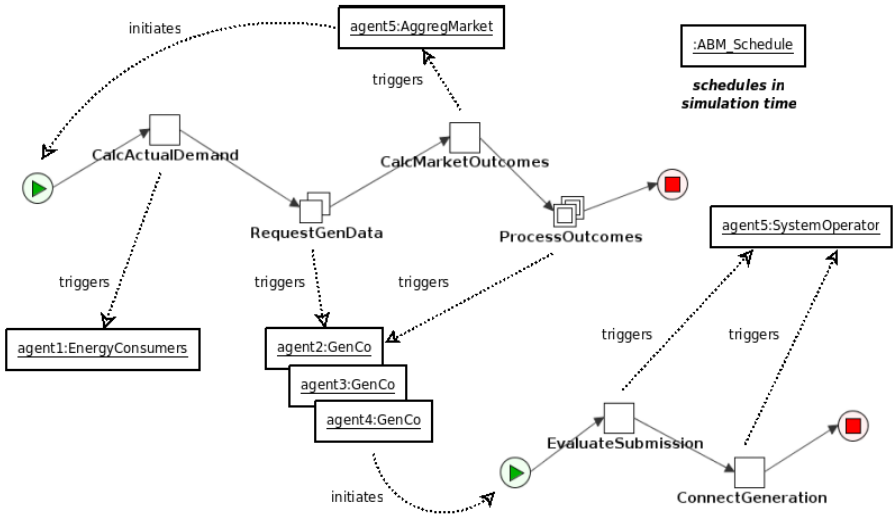
Trained, experienced and knowledgeable people are required to achieve the ambitious agenda for operation of the European electricity supply networks in the future. Meeting the target will require collaboration between academia and industry and people able to do creative research who are also trained to convert the technologies into industrial systems and products. The changed operating, business and technical environment in the industry requires new ways to monitor and manage system stability security and reliability. This proposal presents a balanced programme of applied R&D to address measurement-based monitoring and management of the high voltage transmission grid.</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>7</td><td>-10</td><td>17</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">For very low cost National Grid can have exposure to the latest thinking surrounding how infrastructure should be best reinforced and advances in control technology, as well as being kept informed on the important area of measurement-based technology enabling stability and security of the AC transmission system in an increasingly complex environment.</td></tr>
</table>

	The three research themes of this project align with National Grid's views and concerns of the future. Providing knowledge in these areas can assist in avoiding misinformed investments resulting in stranded assets. Also ensuring the correct measures are taken to enable the continuing security of supply that the UK currently experiences.		
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-9k
Potential for achieving expected benefits	Due to the large numbers of partners in the consortium and the quality of the academic institutes involved, there is a high likelihood of success for this project which will then need implementing in partner states.		
Project progress **[Year to End of March 2011]**	Two international academic researchers have spent 3-month placements at the ENCC. Jukka Turunen from Aalto University, Helsinki, Finland was in Wokingham from January to March and was applying the power-system oscillation analysis techniques he had developed as part of his PhD on both historic and current National Grid data. During the placement, he briefly returned to Finland and successfully completed his viva exam and was awarded his PhD. Prof Herwig Renner from Technical University Graz, Austria was in Wokingham from February to April and was investigating the modelling of oscillation and stability phenomena on the National Grid system. He developed a simplified power system model based on Seven Year Statement and other publically available data and compared this with the full National Grid model. Having both secondees on site proved invaluable in being able to compare historic and current measurements and the corresponding analysis techniques with modelled results. It also gave a useful overview of the real system issues and has provided a very useful start to the project.		
Collaborative partners	European wide collaboration (FP7)		
R&D provider	Imperial		

<table>
<tr><td>Project title</td><td colspan="4">Reducing Climate Change Impacts</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Shanti Majithia</td></tr>
<tr><td>Description of project</td><td colspan="4">In order to meet some of our Strategic Goals set out in our R & D strategy in Jan 2007, this project on Climate Change tries to address various adaptation and mitigation issues within National Grid.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £4k
External £11k
Total £15k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £20k
External £47k
Total £67k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£132k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£ 0k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Given the potentially increasing levels of extreme weather events, this project addresses issues related to National Grid’s adaptation to climate change strategy.</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>6</td><td>-4</td><td>10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">In order to mitigate the Climate related risk on our transmission System this work will provide information on possible extreme weather events. Recent extreme events have lead to loss of supply to customers which has a cost associated with reputation and security of supply – full costs not known at this time however potential avoidance of extreme event costs will give financial benefit in addition to the strategic objective of addressing climate change issue, indeed the Executive identified that the costs cannot be underestimated.</td></tr>
<tr><td>Expected timescale of project</td><td>2 years</td><td>Duration of benefit once achieved</td><td colspan="2">Ongoing</td></tr>
<tr><td>Probability of success</td><td>70%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">-£97k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Good. This projects results will be communicated via four lunch time presentations.</td></tr>
<tr><td>Project progress
[Year to End of March 2011]</td><td colspan="4">The project has completed and the reports on baseline climate hazards have been issued.
The analysis of the data showed a correlation between faults and weather conditions. This was then used to calculate the potential increase in faults that may occur with climate change using UKCP09 data. (Lightning is not included in UKCP09 data so instead convective available potential energy (CAPE) was used as a proxy for the number of lightning strikes per day.) The report was accompanied with a web page that allowed users to use a raphical information system to view the results and show any areas of concern.
The difficulties in the statistical analysis (Bootstrapping) of the weather types and the work itself have merited a paper that has been produced by the Met</td></tr>
</table>

	Office. This work has provided a useful independent review of the faults and scientifically proved that the fault types occurring on the grid can be directly linked to the different types of weather. Most weather related faults on the transmission system are related to wind, snow and lightning.
Collaborative partners	ENA
R&D provider	Met Office

Project title	**SuperGUM**			
Project Engineer	Derek Young/Janet Coley			
Description of project	Development of a prototype software analysis program by the University of Strathclyde for probabilistic generation planning, for eventual use by National Grid.			
Expenditure for financial year	Internal £3k External £-7k Total £-4k	**Expenditure in previous (IFI) financial years**	Internal £5k External £20k Total £25k	
Total project costs (collaborative + external + [company])	£27k	**Projected [next year] costs for [company]**	£6k	
Technological area and/or issue addressed by project	Probabilistic generation analysis and network planning.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		6	-9	15
Expected benefits of project	The software developed will be available as a prototype analysis tool, and National Grid will benefit form the knowledge gained during the project. The software could be developed into a production tool used in gaining a greater understanding of the generation market, and in the assessment of risk in load-related capital planning.			
Expected timescale of project	4 years	**Duration of benefit once achieved:**	could be used over a 5-year regulatory review period and possibly beyond	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£7k	
Potential for achieving expected benefits	The transmission network is currently planned using deterministic security standards. However, a major issue in identifying appropriate load-related capital expenditure is the uncertain nature of the 'generation background' against which those standards are applied. That is, a transmission planner cannot currently know the complete future mix of generation capacities and locations with any certainty. This is a particular problem when lead times for major transmission reinforcements are very long and when different future scenarios would, if known with certainty, lead to different transmission development plans and different levels of load-related Capex and consequential levels of cost of operating the system. The intention behind this work is to have a more objective and testable basis on which to develop future generation scenarios in order that (a) transmission development plans can be articulated that are more robust against uncertainty and (b) greater confidence in those plans can be given to stakeholders.			

Project progress **[Year to End of March 2011]**	In late 2008, the student attended a weeklong discussion and workshop period with interested parties at the National Grid Warwick office, and produced a technical progress report concentrating on an analysis of GUM and methodological issues in the modelling literature. In late 2009, an interim report was produced, followed up by a presentation and discussion in early 2010 at National Grid Warwick. A novel software framework has been written which combines elements of agent-based and workflow systems (reusing robust, open source software). This allows GUM to be repositioned using agent-based technology, and separates out the core business processes (market protocols and the connection application process) from agent behavioural modelling. This provides an advanced modelling process including visual development and data standardisation / visualisation. A set of models (using this framework) have been designed which take an analogue of the GUM model and explore the effects of adding various 'more realistic' structural features. In particular, and in contrast to many such models in the literature, it looks at sensitivities to various degrees of heterogeneity amongst market participant behaviour (which an agent-based approach facilitates). This should provide useful insight into the types of model changes, which National Grid might consider, their potential effects on system dynamics, and where real-world variability in behaviour is important. As of March 2011 when funding for the work concluded, a final framework has been developed which allows a number of different approaches to modelling of generation markets to be represented. In so doing, one of its major benefits is to highlight key design issues for a modelling tool and force a tool's users and designers to identify the critical phenomena to be modelled and the data on which they depend.  Example of representation of the process by which a generator applies for and obtains a connection to the transmission system and, by so doing, becomes part of the generation background. As noted above, by being based on workflow models, actual business processes can be represented; this includes those that exist across multiple companies. One of the key issues in design of the framework was resolution of how different time dependencies within the business processes can be represented. In addition, for the purposes of testing the model, manual interventions can be carried out to explore different model states and responses or, alternatively, to allow particular business processes that are not conducive to software representation to be modelled by manual intervention. A high-level view of the kind of process that can be represented in the framework, and which has been implemented as part of the demonstration

	prototype, is show in the figure below.
Collaborative partners	Possible interest was expressed by SPT (Scottish Power Transmission), but no formal agreement was reached
R&D provider	University of Strathclyde: Keith Bell (Senior Lecturer, Institute for Energy and Environment, Department of Electronic and Electrical Engineering), Stuart Rossiter (Research Student)

Project title	**Supergen 1 – FlexNet**		
Project Engineer	Ray Zhang		
Description of project	FlexNet is a four year (2007-11) programme focused on seven themes. Of these "Intermittency", "System Operation" and "Multi-terminal High Voltage Direct Current (HVDC) Systems" are particular challenges for the UK Government's 2020 Low Carbon Transition Plan (LCTP). The other themes: "A More Electric Future", "Visions and Scenario", "Customer Participation" and "Active Distribution" are topics that prepare for the 2030 onwards agenda. The uncertainty of the future means that flexibility continues to be an important objective. The programme aims, where possible, to showcase its insights and achievements so that these can be taken up by the commercial sector, government and regulators for practical implementation.		
Expenditure for financial year	Internal £7k External £25k Total £32k	**Expenditure in previous (IFI) financial years**	Internal £16k External £75k Total £91k
Total project costs (collaborative + external + [company])	£625k	**Projected [next year] costs for [company]**	£3k
Technological area and/or issue addressed by project	The issues being addressed by the work-streams and reported under each of the themes are as follows: • Intermittency - The 40% renewable electricity target will be met mainly by wind energy (intermittent generation). This creates challenges for system balancing and security of supply. This research aims to ensure that cost-effective integration of wind generation is achieved. • System Operation - FlexNet's planned research in system operation is proving well-aligned with the Electricity Networks Strategy Group (ENSG) and Energy Technologies Institute (ETI) reports. The work is focused on building a modelling and analysis base for testing increased boundary transfer limits and of corrective post-fault control. The planning of strategic network investment beyond 2020 is key topics currently being pursued. • Multi-Terminal HVDC Systems - This theme re-focuses on power systems electronics in response to the growing development of offshore renewable generation exploitation of which will require a departure from conventional AC-based transmission. To date, HVDC deployment has been limited to point-to-point connections; realisation of DC networks will require significant research into both control methodologies and underlying hardware. • More Electric Futures - The dramatic cuts in CO_2 in the electricity sector require radical changes. This work investigates these changes and examines the implications for the energy networks through five projects. The first project addresses the demand placed on the electricity system in GB from the increased use of electricity as the vector for energy transmission and distribution. The second project looks at how significantly increased electricity use should be accommodated within the GB power system. • Visions and Scenarios - The work carried out for FlexNet supported the 'Long-term Electricity Network Scenarios (LENS) project. • Customer Participation - The emphasis here is on the end use of electricity in economic, technical and human sense. Work is being undertaken on engaging consumers about the necessary transition towards the 2020 objectives. This is focused on understanding how people view the electricity supply system and their flexibility in interfacing with it.		

<table>
<tr><td></td><td colspan="4">• Active Distribution – The work examines the distribution planning problem as a stochastic maths programme. Work is underway on control room interfaces for active networks, and on an active power distribution network and data acquisition simulator/emulator.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>13</td><td>2</td><td>11</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Each area of FlexNet's work is delivering benefits and expected to deliver further benefits as highlighted below:-

• System Operation – Insights gained will be showcased through grid models, flexible protection and control platforms including WAMS, and demand-side data sets.

• Multi-Terminal HVDC Systems - Control system designs for power flow regulation in MT-HVDC have been established and tested in standard power system simulators.

• More Electric Futures –This theme has already contributed evidence for policy development through the LENS project.

• Visions and Scenarios – The outputs of the LENS scenario have been used in various responses for the fifth Distribution Price Control Review; the OFGEM 'RPI-X@20' project; National Grid in their 'Operating the Electricity Transmission Networks in 2020' consultation (June 2009); the Gone Green scenario (Nov 2008); as well as a joint Electricity Networks Futures Group (ENFG) and Energy Networks Association (ENA) project which is seeking to understand the long term (2020-2030) requirements for distribution systems.

• Customer Participation – To achieve the envisaged decarbonisation of the electricity sector beyond 2030, most of the demand for electricity will need to be able to align itself with the availability of carbon-free generation, The work programme across FlexNet is developing some of the key enablers for this objective including self-regulating buildings, electricity market designs catering for flexible demand.</td></tr>
<tr><td>Expected timescale of project</td><td>4 years</td><td>Duration of benefit once achieved</td><td colspan="2">5 Years</td></tr>
<tr><td>Probability of success</td><td>25%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£77k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The new concepts, techniques, prototypes and demonstrations will inform network operators of the options that could become available in the next few years. FlexNet will produce a number of PhD graduates who will be familiar with issues associated with distribution and transmission networks.</td></tr>
<tr><td>Project progress

[Year to End of March 2011]</td><td colspan="4">The project has completed 3.5 years of its 4 year programme and most work has reached the stage of producing conclusions on the basis of its simulation models and experimental tests. The training programme is also nearly complete with a series of discipline crossing training courses and industrial placements undertaken for researchers.

The progress reported here concentrates on tasks completed in the last 12 months.

• Intermittency – New techniques and algorithms have been used to assess the ability of demand side flexibility and interconnections to.

(i) "Firm up" intermittent renewables, hence increasing the capacity</td></tr>
</table>

	value of intermittent generation and reduce backup requirements (ii) To reduce the need for operating reserves and flexible generation, enhancing the operating efficiency of the system and the ability of the system to absorb intermittent generation. An approach to bidding wind power in a competitive market has been produced. • System Operation – a WAMS demonstration platform has been completed and proposals made for the use of corrective control options. The operation of a system with series compensation and HVDC bootstraps has been modelled and the provision of damping in such as system investigated. An adaptive auto-re-closer scheme has been demonstrated. • Multi-Terminal HVDC Systems – Laboratory demonstration of multi-terminal operation has been achieved. Detailed control schemes have been established for multi-module power converters and tools produced for assessing the power loss of these structures. Some specific proposals have been made for control and operation through AC- and DC-side faults. • Customer Participation – Demonstrations have been completed on frequency responsive home appliances and of building energy management systems that respond to local network conditions and energy prices. A study of deliberative engagement taking an example at Nailsea on the reinforcement route from Hinckley Point has led to conclusions on how a community perceives the information present on route options. • More Electric Future – The linkages between electricity and heat distribution systems have been explored using a case study in Ebbw Vale. • Active Distribution Networks – Experimental evidence has now been provided that the hybrid tap changer extends contact life into millions of operations and a fast switch actuator has been prototyped. The soft-open-point has been assessed in simulations of 12 example networks and the control system is also being tested in a laboratory example. Fault current analysis of inverter distributed generation (DG) has been experimentally verified and a procedure for calculating such fault currents established. Existing protection policies have been tested against a large number DG scenarios to established where and when such policies may need revision. Proposals have been made for adaptive protection regimes. A demonstration of a control room display incorporating active management schemes has been completed.
Collaborative partners	EPSRC and the following industrialists: CE Electric UK, Central Networks, UK Power Networks. Scottish Power Energy Networks and Scottish and Southern Energy.
R&D provider	University of Bath, University of Birmingham, University of Cambridge, Cardiff University, University of Durham, University of Edinburgh, University of Exeter, University of Manchester, University of Strathclyde and Imperial College London.

Project title	**Harmonic data gathering project organised by ENA**			
Project Engineer	Forooz Ghassemi			
Description of project	Organised by the Energy Network Association (ENA), National Grid is in collaboration with DNO companies to conduct a system wide survey on the existing harmonic distortion on the electricity supply system in the U.K. The survey has been conducted since February 2005. The key objectives of this survey are as follows: Increasing Flexibility • To determine the harmonic voltage levels during the defined 5 years, • To obtain the trend of harmonic distortion for the period of survey, • To investigate any correlation in harmonic voltages on transmission and distribution systems at the measured sites, and • Verify whether or not the existing control measures are sufficient to meet the needs of a society with an ever appetites for equipment that generates harmonic current.			
Expenditure for financial year	Internal £3k External £1k Total £4k	**Expenditure in previous financial years**	Internal £16k External £1k Total £17k	
Total project costs (collaborative + external + [company])	£21k	**Projected 2010/11 costs**	£0	
Technological area and/or issue addressed by project	To have the harmonic voltage measurements at 6 National Grid substations. To determine the trend of the harmonic voltage levels over the period of 5 years of survey. To work with DNO companies and ENA on the issue of harmonic variations, harmonic flow and excessive harmonic voltage levels. in G514- 1.			
Type(s) of innovation involved	Tech Transfer	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	0	9
Expected benefits of project	With uncertainties of background system harmonic voltages, larger design margin of harmonic equipment will be required and the additional cost could add up to a million pounds in an EHV project. For example, it had caused an addition of 3 million pounds on HVDC filters on the Chandrapur (Indian) project as the harmonic problem at the design stage of the project was not identified. A similar cost impact could apply in the UK. If a life time of a 240MVA 40011 32kV transformer is reduced to 30 years from 40 years due to the electrical overstress of harmonics, it is equivalent to £750,000 approximately at today's price.			
Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£64k	

Potential for achieving expected benefits	UK harmonic level profile for the last few years for EHV, HV and MV voltage levels has been established. Reports have been prepared for presentation to Engineering Committee.
Project progress **March 2011**	Measurements up to winter 2009/2010 have been obtained. Coordination with some DNOs was completed to do measurements at selected sites. No measurements were able to be completed during the 2010/11 winter season.
Collaborative partners	DNOs, ENA, Harmonic Group (ENA)
R&D provider	DNOs, ENA, Harmonic Group (ENA)

Project title	**Voltage transducers for power quality measurements**			
Project Engineer	Forooz Ghassemi			
Description of project	The aims of this proposal are : • To devise test procedures for determining HV and EHV voltage transducer frequency response. This can be incorporated in international standards such as IEC. • To determine frequency characteristic of typical wound voltage transformers (WVTs) in National Grid's network and hence assess the accuracy of the historical data. • To examine the frequency response of residual current devices (RCDs). • To examine the use of capacitor voltage transformers (CVTs) for power quality measurements by considering the use of a new add-on device, the PQSensor, to a standard CVT. The device response and capability would be examined. Key Deliverables 1:Specification for source, test rig and procedure (4 Months) 2:Design, build and commissioning of source and test (12 months) 3:Specification for reference measurement system.(1 months) 4:Design and build of reference measurement system (4 months) 5:Review and update of test specification (2 months) 6:Review and update of specification for reference measurement system (1 months) 7:Test on different type of Wound VTs (2 months) 8:Test on different type of RCDs (2 months) 9:Test on CVTs with new sensors.(2 months) 10: Analysis of data and reporting (6 months)			
Expenditure for financial year	Internal £11k External £11k Total £22k	**Expenditure in previous (IFI) financial years**	Internal £11k External £175k Total £186k	
Total project costs (collaborative + external + [company])	£208k	**Projected 2010/11 costs**	£0	
Technological area and/or issue addressed by project	To assess the suitability and accuracy of voltage transducers for power quality and wide band measurement.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		6	-1	7

Expected benefits of project	This project will result in a saving of almost £500k considering just wind farm connections and HVDC schemes currently planned. 1. WVTs have been used by National Grid as the acceptable transducer for power quality measurements. This is because of their wider bandwidth. 2. Power quality measurements are limited to sites with WVTs, which are not available at all substations because of their costs and size. 3. When considered for substations, due to their costs and space requirements, only a single unit has been used, usually connected to the yellow phase. 4. Accuracy of measurements taken so far and are being taken through WVTs are not known. Recent comparative measurements have indicated discrepancies in measurements even at low order harmonics. 5. WVTs are expensive and not being used as standard transducers in schemes. They have to be specified on a project by project basis. 6. RCDs are required to be specified in schemes related to tractions, HVDC and other polluting loads. 7. RCDs must be used in parallel with CVTs, nearly doubling the cost of the installation. 8. WVTs and RCDs require additional substation space. 9. Instead of WVTs or RCDs, CVTs together with new accessory, the PQSensor, can be used in power quality monitoring, which in turn will reduce cost and save space, outage time and civil work. 10. PQSensor can be ordered with the new CVTs or retrofitted to the in-service units. 11. CVT and its add-on also make it possible to readily carry out power quality monitoring at all substations as CVTs are present in all EHV substations. 12. IEC standards for instrument transformers need be reviewed so far as power quality requirements are concerned. There is no reference to power quality measurement capability in present IEC standards. 13. At National Grid, a new policy paper for monitoring requirement is in preparation. The project's results will help to incorporate voltage transducer requirements into the paper. 14. The project outcome shows that the cost of voltage transducers can be reduced in schemes.		
Expected timescale of project	3 years	**Duration of benefit once achieved**	Permanent
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£47k
Potential for achieving expected benefits	The project is slightly behind due to the delay in finding a suitable reference transducer and difficulty in design of isolation between high voltage 50Hz and harmonic sources. The project is getting back on track.		

Project progress **[Year to End of March 2011]**	A transducer to be used as reference measurement transducer has been located and procured. This is a device suitable for use in a laboratory with a controlled environment and will be used for voltages up to 240kV. Voltage and current injection methods are being both considered to superimpose harmonic signals on to the high 50Hz voltage to be applied on the device under test. Theoretical models for each element within the source has been determined that will be used to design and test the high voltage multi-frequency source.
Collaborative partners	
R&D provider	Areva, ABB , University of Manchester

Project title	**Improve reliability of future system by enabling integration of new generation**			
Project Engineer	Tarek Ismail			
Description of project	Collaboration projects with developers and manufacturers of power plant to ensure that design of new low carbon plant (CCGT,Clean Coal, Nuclear) meets minimum technical system requirements.			
Expenditure for financial year	Internal £7K External £0k Total £7k	**Expenditure in previous (IFI) financial years**	Internal £39K External £0k Total £39k	
Total project costs (collaborative + external + [company])	£145K	**Projected [next year] costs for [company]**	£50k	
Technological area and/or issue addressed by project	Frequency response capability, load rejection and operation under power system split situation, Black start capability, reactive capability and control system stability.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		11	-5	16
Expected benefits of project	Provide NGET with a timely and efficient means of understanding new generation technology limitation. Reduce the impact of the new generation technology on power system security by the timely development necessary codes and standards evolved from technical knowledge.			
Expected timescale of project	6 Years	**Duration of benefit once achieved**	For the life time of the generation plant which is between 20 and 60 Years	
Probability of success	70%	**Project NPV = (PV benefits – PV costs) x probability of success**	£28k	
Potential for achieving expected benefits	Very good			
Project progress 31st March 2010	In September 2010 funds were approved to allow for extending the project to 2013 for the inclusion of environmental controls. The high level of power station commissioning and associated site work meant that during the year there was a lower level of activity than anticipated. However the manufacturer interface continued plus the inclusion of Pratt & Whitney as a new manufacturer entering the GB market. This year saw a visit to Alstom in Baden to discuss development in CCS systems associated with CCGT and Coal plants. Key objectives of this project continue to be met through collaborative work with power plant manufacturers and developers.			

Collaborative partners	Including Alstom, GE. Areva, Siemens, Pratt & Whitney
R&D provider	Work supported within ENI

Overhead Lines

<table>
<tr><td>Project title</td><td colspan="3">Scheme 20448 Development of a Live Wrap Replacement techniques for OHLs Using a Modified SCC System</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Oliver Aries</td></tr>
<tr><td>Description of project</td><td colspan="3">Develop a new technique and associated equipment which will allow National Grid's overhead lines (OHL) suppliers to replace fibre optic cable wrapped on the earthwire with an optical ground wire (OPGW) using a live technique (i.e both circuits live). This technique will eliminate the need for installing temporary fibre diversions (needed to keep telecoms services going during the work) and the need for transmission outages as the work can be carried out live. The process will reduce scheme costs, reduce the requirement for optical and transmission outages, enable the work to be carried out in all environments and be less damaging to the environment. Capital works will also benefit because the method will lower the risks which normally have to be mitigated in the larger capital scheme ultimately lowering overall scheme costs..</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £14k
External £5k
Total £19k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £42k
External £128k
Total £170k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£189k</td><td>Projected 2011/12 costs for national Grid</td><td>£0k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Replacement of wrapped earthwire without use of temporary bypasses.
System can be deployed without requiring transmission outages (i.e. with the HV circuits live).
Significant reduction in the number of optical outages (reducing risk to customers).
Can be deployed over difficult terrains where there is no method at present.
  </td></tr>
<tr><td>Type(s) of innovation involved</td><td>Incremental</td><td colspan="2"><table><tr><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td>10</td><td>0</td><td>10</td></tr></table></td></tr>
</table>

Expected benefits of project	Removal of the need to install temporary diversions should save National Grid ~£3m between 2008/9 and 2011/12. The method can be used without the need for transmission outages. The method will significantly reduce the number of optical outages, which will benefit C&W and their customers and reduce National Grid's project risks. The procedure can be used to replace the wrapped fibre across all terrains and environments, which is not possible at present.		
Expected timescale of project	3 years	**Duration of benefit once achieved**	Ongoing
Probability of success	80%	**Project NPV = (PV benefits – PV costs) x probability of success**	£1,577k
Potential for achieving expected benefits	The project has had a number of delays due mainly to technical and system access problems to trial new OHL process. It is expected the technique will be available for commercial use from end of 2011/12 after the system has gone through a final live trial. However, the system has been rolled out to all 3 main OHL suppliers. It is expected that post the live trial the system will be moved into production status. Its use should provide a net benefit of around ~£3m by end of 2018. However, one of its key benefits will be in its use to enable fibre wrap replacement work to be carried out over difficult crossings and in built up areas which presently cannot be achieved by other methods. It is expected that this system will achieve its objectives and will be in use in time to meet the peak volume of work expected beyond 2012.		
Project progress **[Year to End of March 2011]**	In Sept 2008 a full live trial was carried out on a 3km section of overhead line near Tilbury. This was very successful but exposed some minor technical issues and has also driven further improvements in equipment design. Since this trial the equipment has been modified to overcome some of the installation issues raised in the trial. A small training and trial was carried out at Eakring in early 2010 to handover the method to the 3 overhead line suppliers. The next step is to carry out a further live trial to prove new process and modified equipment on a longer run and across different OHL environments. Access to obtain this trial has been difficult to accommodate within the capex work and is still outstanding. However, it is expected a route will be defined in due course and the trial carried out as part of the capex works. In summary the R&D has concluded on this work but outstanding areas to resolve are: Acceptance of the system by Network Rail – requires an external Network rail consultant to review the research specifications. Acceptance of the system by C&W – This is low risk.		
Collaborative partners			
R&D provider	BBPNL (East OHL Alliance)		

Project title	**Earthwire Platform**			
Project Engineer	Martin Wilson			
Description of project	A lightweight platform, which will give access for one linesperson to the earth wire span. The platform must be quick and easy to install on all tower types and will extend approximately 2.5m out from the tower into the span.			
Expenditure for financial year	Internal £2k External £10k Total £12k	**Expenditure in previous (IFI) financial years**	Internal £13k External £26k Total £39k	
Total project costs (collaborative + external + [company])	£51k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Health & Safety			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		5	-5	10
Expected benefits of project	This project will provide a system which is user friendly, very effective and will ensure we give our Lines persons the best working environment to eliminate the risk to their health. The long term occupational health benefits to the company will mean less man hours lost due to lower back and muscular injuries sustained during the routine maintenance activities. The reduction in long term occupational health issues is unquantifiable but the reduction of injuries we cause to our staff undertaking their routine duties cannot be underestimated.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	20 Years	
Probability of success	75%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£17k	
Potential for achieving expected benefits	The work completed to date has indicated there is good potential to achieve the benefits as detailed above.			

Project progress **[Year to End of March 2011]**	2008 – 2009 First prototype trialled, this identified a change to the specification and design parameters. Second prototype manufactured and tested, field trials to be completed to ascertain the suitability of current design and any required design changes. 2009 – 2010 A number of field trials have been completed and further modifications have been identified and installed. Further field trials now required to enable the effectiveness and suitability of the current specification to be confirmed.  2010 – 2011 During the last year it has proved very difficult to complete the required field trials to enable the current specification to be evaluated. In principle the design has been well received however without the confirmation of this with practical trials further progress cannot be made. The requirement to complete these trials has been highlighted to the OHL management team and the expectation is that these will be completed in the near future.
Collaborative partners	
R&D provider	Spondon Engineering

<table>
<tr><td>Project title</td><td colspan="5">Development of Multi response Stockbridge Damper at 400kV</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Dave Bedford / Martin Wilson</td></tr>
<tr><td>Description of project</td><td colspan="5">The project is proposed to :
Meet all requirements of TS 3.4.7 on Zebra and Araucaria conductors.
Design attributes to ensure approval for future high temperature conductors.
More conductor friendly than current designs, expected to reduce damage and mechanical stresses at attachment points.
Improved damping efficiency - multi response as opposed to current twin response for increased conductor life.</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £7k
External £37k
Total £44k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £5k
External £30k
Total £35k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td colspan="2">£147k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£68k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">National Grid currently uses a range of twin response dampers with bolted clamp attachment based upon optimum performance based on corona performance and mid range damping qualities. These generic designs are between 20 & 30 years old, with the improvements in analytical design tools National Grid are seeking to develop a damper that has acceptable corona performance at 400kV, increased reliability of attachment points, minimised conductor damage & improved damping efficiency.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>9</td><td>-2</td><td colspan="2">11</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">Reduced number of instances of inner layer damage caused by aeolian vibration, - therefore offering an extended life for conductors.
Reduction of damages to outer layers of alloy conductors, minimising the risk of conductor failures. The recent ZPA conductor failure cost in the region of £24K to recover not including constraint costs.
Removal of installation errors, impossible to over torque and can be reapplied more times than current guidance suggests for bolted attachments.
Compatible with AGS / HSU applications.</td></tr>
<tr><td>Expected timescale of project</td><td>4 years</td><td>Duration of benefit once achieved</td><td colspan="3">5 Years</td></tr>
<tr><td>Probability of success</td><td>60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="3">-£157k</td></tr>
</table>

Potential for achieving expected benefits	The supplier has already proved a number of the different concepts in various products in use in other parts of the world. The largest threat to the project is corona performance of the unit. It is anticipated that with the joint knowledge of PLP & National Grid experience of corona testing this can be overcome. The potential for success of this project is deemed to be good.
Project progress **[Year to End of March 2011]**	This project has reached the first milestone with Conceptual Design – Design Drawings & Proof of Concept all being completed. The required testing has been completed by March 2011 and the project has progressed to the stage where a line trial is to be completed to enable the effectiveness of the proposed solution to be verified. A trial location has been identified and the trials are planned to be completed between July & September 2011. A set of Vibrec monitors are being installed to benchmark the current solution before the new dampers are installed following, which a further period of monitoring is to be completed. Following the site trials the information downloaded from the Vibrec monitors will be analysed and the effectiveness of the new dampers can be determined.
Collaborative partners	N/A
R&D provider	Preformed Line Products GB

<table>
<tr><td>Project title</td><td colspan="4">Remote control of bird scarers</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Mark Winters</td></tr>
<tr><td>Description of project</td><td colspan="4">At present, our bird scarers [20 off] do not have a remote control or indication capability. This project will deliver remote control and indication economically, simply and efficiently by means of SMS from any mobile phone. This functionality is urgently required for several key reasons. Providing the platform to mute the equipment opens up other exciting functionality options, and will dramatically minimise the number of times a tower has to be climbed. Running costs will be negligible, as “pay as you talk” SIM cards will be used, costing around 10p per call.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £5k
External £11k
Total £16k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £13k
External £20k
Total £33k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£49k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Functionality improvements to existing bird distress call bird scarers. Benefits include minimising habituation of birds, minimising noise nuisance to neighbours and almost eliminating expensive visits to site to adjust settings or investigate faults.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>15</td><td>-4</td><td>19</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">When deployed, the remote controlled bird scarer would be seen as a reassuring demonstration of our professionalism and capability to what may be very irate grantors or neighbours. The option for complainants [in appropriate circumstances only] to “self manage” their scarer and hence their problem.

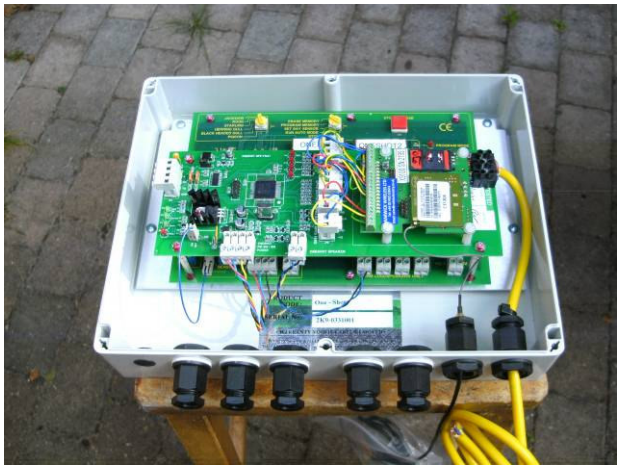
Rapid reaction times to turn units on or off as dictated by birds or noise complaints. Rapid reaction times to switch the operating mode from normal to reinforce or to intense if birds are stubborn.

Fast diagnosis of the most likely faults without having to climb a tower.

Without remote control, a tower would need climbing at least four times per annum to effectively but basically manage the scarer “On” and Off” cycles. The number of visits can quickly ramp up if the mode needs changing or if there are concerns about integrity that can only be confirmed by physical inspection. The cost of one “quick” visit is no less than £800 and probably in excess of £1K. Then there remains the problem of resourcing an appropriately skilled linesman.

There is a very real risk of birds habituating if units are left on permanently. Once that happens, life becomes very difficult for our neighbours and then for us.

Being able to manage the units means that the scenario of the unit being removed for deployment elsewhere can be easily tested. The units are meant to be a temporary expedient for a transient problem in most cases. In reality, we tend to leave them on their first deployment until we have desperate need of a unit elsewhere. At present, we have no spare units available.</td></tr>
</table>

Expected timescale of project	2 years	Duration of benefit once achieved	5 Years
Probability of success	60%	Project NPV = (PV benefits – PV costs) x probability of success	£175k
Potential for achieving expected benefits	The entire R&D funded scarer units [now 7 units] are working to Version 2 which delivers all of the original benefits of v1but now with the required level of power economy. On v1 the GPS worked 24/7 and the main scarer board was powered 24/7, with power consumption around 300mA for 24/7. Now the GPS only powers up for about 5-minutes twice/day and the main scarer board is switched off during the hours of darkness. Power consumption now is acceptable and much improved; daytime is 170mA and nighttime is 75mA. This benefit is most useful during winter months when daylight hours are shortest, the available energy in the sun is less and the amount of cloudy weather is much more than in summer.		
Project progress **[Year to End of March 2011]**	Project complete; all R&D scarer units have been recovered from service, upgraded, bench tested and re-deployed successfully [to time, cost and quality]. Many thanks to the willing participation of field staff and planning, who managed to get the units down and back up again during an otherwise busy time. 		
Collaborative partners	N/A		
R&D provider	Adaptive Wireless Solutions Ltd		

Project title	**Acoustic Emissions from HV Overhead Conductors**
Project Engineer	Richard Morris
Description of project	The key objective of the proposed research is aimed at understanding the causes of excessive noise from overhead line conductors and how this might be alleviated. The aims of the project are as follows. Characterise the surface ageing processes, including corrosion, on conductors including GAP, AAAC and solid aluminium: • The deposition of species (e.g. sea salt, dust, soot, pollutants, etc.) from the atmospheric environment onto the conductor surface and how these influence local processes such as pitting corrosion and hydrophobicity. • Determination of initial surface chemical state for the conductor, including hydrophobicity; how this chemistry changes as a function of environmental stresses, including: moisture, atmospheric deposition, high voltage, etc. • Determination of initial surface physical state for the conductor, this being predominantly surface roughness; the progression of roughness as a function of environmental stresses (i.e. as above) • Study interactions (if any) within the conductor, including effect of internal moisture, greasing and galvanic corrosion between steel core and aluminium conductor. • Identification of the key factors involved in physico-chemical deterioration of the surface and, hence, development of a model of surface damage with time. Characterise the corona discharge activities resulting from wet high voltage surfaces: • Audible discharge activity will be characterised in terms of volume and frequency content as a function of surface hydrophobicity, surface conductivity, surface roughness, and moisture conductivity • The impact of the physical form of the substrate (conductor) will be determined, including conductor geometry strand size and shape and pitch • The way in which moisture behaves macroscopically on a conductor will be determined including the impact of wind, inclination, geometry and hydrophobicity • Measurements of force generated by discharges will also be determined • Provide a model showing the causes of excessive corona discharge leading to noise and radio frequency interference (RFI) from ‘gap’ type conductors: • The way in which complete spans of conductor might be excited to generate excessive corona discharge, noise and radio discharge from discharge activity will be modelled • Electrodynamic behaviour resulting from the novel conductor structure will also be considered as a potential cause of the noise and radio discharge. • Generate at least one solution for to the problem of excessive corona discharge producing noise (considering requirements for existing and new installations)

<table>
<tr><td></td><td colspan="4">Working with National Grid engineers, potential remedial solutions will be identified.
Information will be supplied in a form suitable for inclusion in future National Grid specification to minimise future exposure.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £7k
External £555k
Total £562k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £9k
External £62k
Total £71k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£870k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£224k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The environmental impact of assets is a key concern to the community and National Grid. One key aspect of this is the audible noise produced by plant. Noise resulting from high voltage overhead lines is well studied, and models exist for traditional conductors and conductor bundles. However recent experience of Matthew GAP conductor has demanded a rethink of the fundamental, largely empirical models used.

This work will challenge existing models and create data on which to base new models suitable for application on any form of conductor. This will allow novel conductors to be deployed with a clear understanding of their acoustic and electromagnetic noise emission characteristics.

The corrosion characteristics of new conductor materials will allow improved asset management, and the implications of ageing on acoustic noise to be determined.</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>7</td><td>3</td><td>4</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">National Grid has already spent £1.35M reconductoring just a few spans at one location on the ZO route, costs such as this could easily escalate should National Grid begin to receive more complaints from members of the public following reconductoring with Matthew Gap conductor. The avoidance of only one repeat event of this type would save £1.35m and more than repay the project costs

The avoidance of costs associated with conductor cleaning or inspection. The cleaning of conductor on only one span of the ZDA cost in the region of £25k for direct expenditure only, so future annual savings can be in the region of £12.5k per annum if one intervention can be avoided every two years, plus savings in outage planning and project management time.

Avoidance of staff time taken up in managing complaints, both in liaising directly with complainants and local Environmental Health Officers, and undertaking monitoring visits. This is estimated to be in the region of £20k per annum, suggesting potential savings of £20k per annum if a doubling in the number of problem areas is avoided.

There are no clear mitigation measures available at present, so the avoidance of costs and extended time scales associated with having to resort to presently available alternatives, for example the use of triple instead of twin bundles, requiring the diverting of routes and/or rebuilding of towers, and the potential requirement to apply for Section 37 consents. The savings here can be considerable.

Better specification for conductors on future schemes will reduce the need to respond reactively following complaints and so there are considerable resource</td></tr>
</table>

	savings to be made in future years. Additional business benefits include: • A greater understanding of the processes resulting in excessive corona discharge leading to conductor noise and radio interference • Better modelling of conductor noise for planning and selection of appropriate conductor types and specification • Reduction in the number of complaints from members of public, leading to a positive public image. • Better understanding of the causes of noise and radio interference and therefore more ability to respond effectively and efficiently • Less man hours required for responding to complaints • Reduction in the number or outages (for example to carry out conductor cleaning); this may in itself generate more outage opportunities • Alleviate existing H&S concerns by reducing future need for manual intervention • A more professional approach and better understanding of the issues will improve our reputation with our complainants and other stake holders		
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£34k
Potential for achieving expected benefits	Developing background knowledge to support the application of existing and new conductor technologies will be supportive of improving transmission capability and managing the environmental impact of our overhead line infrastructure. In addition this will rebuild a core competence for National Grid and its partner in the University of Manchester. It will also leave a legacy capability of laboratory-based noise and corrosion measurement on HV equipment for further work.		
Project progress **[Year to End of March 2011]**	The three strands of work: studying corrosion processes, modelling electric fields and acoustic energy, and measuring acoustic emission have come together over the last six months to show this comprehensive approach was correct, and will yield a holistic view of the processes not previously achieved. The project continues broadly to plan, with the theoretical side in advance of expectation and the experimental some what slower. It is expected that over the next six months the experimental work will have caught up with the original plan. Such deviations for the original plan are not unexpected. Corrosion Processes: • Research continues on increasing our understanding of the potential corrosion processes that may give rise to changes in the surface morphology, roughness and surface chemistry of conductors during atmospheric exposure. • Controlled experiments have been conducted by collecting residues from ultrasonic cleaning, and re-applying these. • Sample conditions investigated include as received, ultrasonically cleaned, steam treated and washed in acetone and ethanol.		

- Salt fog tests have been used to simulated industrial conditions
- Contaminated samples exhibit higher hydrophobicity than relatively cleaner ones, as evidenced by droplets retained on sample surfaces (below) and a longer time-of-wetness.

- Quantified measurements include surface roughness, contact angle and weight-loss.

The present conclusions of this work are that hydrophobicity is increased after corrosion; more significantly for contaminated samples. An Increase in corrosion rate is linked to the presence of contaminants. Surface roughness also increased after exposure to salt spray and weight loss is significantly increased by presence of surface contaminants

Field Modelling:

- A review of existing commercial packages for predicting noise has been completed. The data on which these models have been based has also been reviewed.
- The FEA modelling has shown the limitations of conventional approaches. An improved product, Ansys, has been ordered which can couple three physics fields: Electromagnetic, Multi-phase fluid flow, and Acoustic. This will be used to develop the final models for the project.
- Models of field over the whole conductor are being used to determine potential acoustic power development.

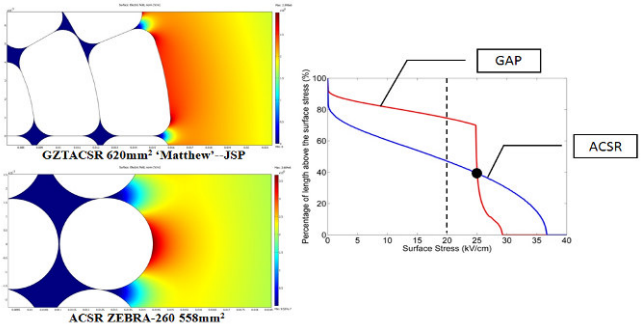
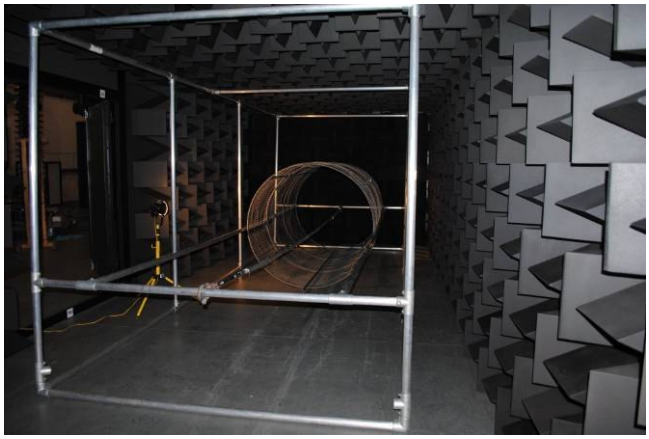


Figure : 400kV Overhead Conductor Surface Field Comparison: GAP -- ACSR

Acoustic experimentation:

- The smaller test rig has been completed. This is now being used to characterise the behaviour of individual droplets, on controlled surfaces. A new partial discharge set from Omicron has been ordered to further improve data acquisition and interpretation.
- The large chamber is complete, but for the HV bushing which is on order. A direct feed via the open doors has allowed experimentation to proceed, verifying the theory and design of the rig, shown below.

	 International Liaison: A key commitment of this project is to gather the world's knowledge and make it available to National Grid. As part of this, a Seminar is being arranged in Manchester with an attempt to pull together representatives from the other three most active research groups in the world. This will take place in Manchester and it is hoped to have representation from Eskom, Tsinghua University, and The Swiss Fed. Inst. of Technol.. So far two of these groups have committed to attend.
Collaborative partners	N/A
R&D provider	University of Manchester

<table>
<tr><td>Project title</td><td colspan="4">Live Line working Equipment</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Matthew Grey</td></tr>
<tr><td>Description of project</td><td colspan="4">Live Line working was initially introduced in the 1960s and actively utilised in the 1990s. This was a high profile project and an example of how an integrated Transmission Company can use innovative Transmission Owner techniques to manage defects in a timely manner and also deliver benefits to the System Operator. These benefits are primarily around access to the system in order to ensure OHL defects are rectified also increasing minimising system outages to carry out work and so increasing system security. There are also maintenance activities that can only be undertaken using Live Line techniques. Since the introduction of Live Line in the 1990s, the system has been less constrained and deadline access more easily available (hence the decline in use). However the Transmission System is likely to become increasingly constrained over the next 5-10 years, based on forecast constraint costs, new access arrangements, continued asset investment requirements and new generation connections. Live Line Working offers significant opportunities in enabling maintenance and defect OHL work to be carried out against this background; however significant investment and commitment is required in order to re-establish previous Live Line capability.

The re-establishment of Live Line Working within National Grid has already been approved by National Grid's internal governance committees and discussions with OFGEM and the HSE on this matter have already begun. As part of the commitment to re establish Live Line, National Grid has committed £451K for further purchase initial prototype equipment developed, training, safety case review etc.

The costs identified in this paper are purely for the initial development of the live line basket system, live line trolley and the new design of aviation equipment.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £56k
External £7010k
Total £757k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £4k
External £52k
Total £56k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£1,265k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£452k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Live line working in support of improved, more efficient system access in critical system areas.</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>13</td><td>-4</td><td>17</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">1 Benefits of Live Line Working

Live Line working would provide greater flexibility and efficiency in rectifying OHL defects, particularly as we move towards a Dynamic Asset Management model.

Increased System Security due to reduced requirement for system outages.

Elimination of hazards associated with dead line working due to tower climbing and earthing requirements i.e. manual handling, management of induced voltages and</td></tr>
</table>

circulating currents (this risk has significantly increased since Live Line working was first introduced).

Increased maintenance productivity levels when dealing with larger volumes, e.g. de-spacering. Typical rates of de-spacering using traditional techniques are approximately 4 - 6 span per day, whilst at the peak of Live Line use, the team were achieving up to 15 spans per day (and typically 10 spans a day).

Additional contingency providing a further option/method of working when responding to major faults or incidents.

There is some works that can currently only be carried out using helicopter access live line techniques (although the circuit may be de-energised), e.g. high crossing work on XL Severn River Crossing. If National Grid Live Line working is not re introduced we would be reliant on RTE to carry out this work on our behalf.

Reduced estimated return to service time (when using helicopter access on de-energised lines) due to no requirement to isolate and earth and apply double dress earth systems to allow access to the circuits.

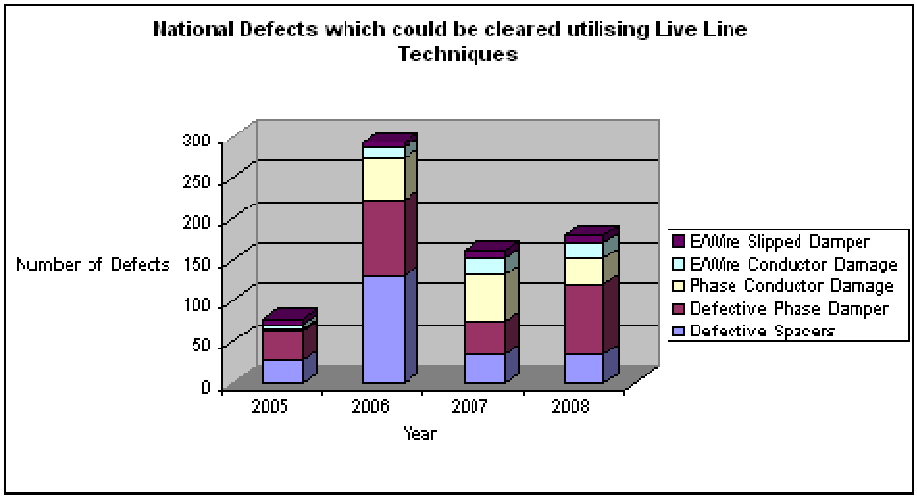
Potential avoidance of System Outage Costs

2 Key Drivers For Increase in Live Line Working

2.1 Current Potential Usage Of Live Line Working

Going forward due to adjustments in our capital plan, aging assets and operating cost pressure, we will increasingly be taking an approach of Dynamic Asset Management. This will require having the capability to respond quickly and effectively to significant defects. Live Line working would strongly support this asset management approach, removing any system access issues, which could otherwise delay defect rectification.

In addition, based on current OHL outage defect levels, approximately £27,600 is spent per annum on monitoring of defects that could be rectified using Live Line techniques.

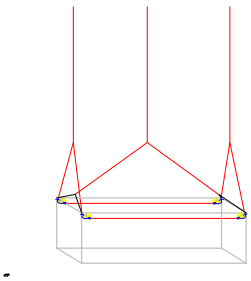


2.2 Short Term Transmission Access Issues

There are a number of longer term drivers that will place an upward pressure on system access:

- Continued high levels of asset replacement on the UK Transmission system
- New Generation
- Development of new Transmission Access arrangements

These system access issues will also be in conjunction with a greater emphasis on a dynamic asset management approach. Furthermore the only feasible provider to National Grid for Live Line work currently is RTE. Development of National Grid capability would introduce competition in this market and potentially allow for the other

	British TOs to make financial savings. **3 Cost Benefits** Over the next five years there are a minimum of three schemes that will require helicopter access work. These include the re-conductoring of the Severn crossing, in 2014/15, which will require the dampers to be removed and then to be replaced (i.e. 2x helicopter access work). In 2011 we will be introducing our first capital scheme which will replace fittings on ACAR (Aluminium Core Alloy reinforced), as the outer aluminium strands are very soft, a trolley will not be used to access the conductor, and helicopter access will be required. If Live Line/helicopter access techniques were developed by National Grid, the in-house cost for this work would be approximately £40K for each scheme involving of Helicopter access work (i.e. £120K). If this work was to be outsourced based on previous RTE contract costs, this would be at least £190K for each scheme (i.e. £570K, £450K more than in- house costs). There is also a significant amount of earthwire repair work that would normally be undertaken using Live Line helicopter techniques. Earthwire damage could be repaired typically within a day using helicopter access techniques (either deadline or live line). If the work had to be carried out using traditional deadline techniques, this would involve earthing (1 day for a simple circuit, 2 days for a complex circuit). It would take 2 - 3 days to lower (and then raise) the earthwire (if crossings are involved this would require the use of scaffolding or skycradle etc.), plus several hours for the actual repair. The work would therefore take anywhere between 3-5 days, depending on the complexity of the circuit, and crossings.		
Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years
Probability of success	55%	**Project NPV = (PV benefits – PV costs) x probability of success**	£190k
Potential for achieving expected benefits	On target to deliver live line working during 2012 and therefore avoiding potential costs to outsource the work to an external contractor. One project already planned in for completion by the National Grid live line team is the Usk river crossing in South Wales.		
Project progress **[Year to End of March 2011]**	Throughout 2010/11 National Grid has been working on a comprehensive R&D programme to facilitate the reintroduction of Live Line working on our overhead line (OHL) network. The main focus was placed on Live Line Work using Helicopter Access Techniques. National Grid has worked closely with an aviation company in producing the design of equipment for Live Line Helicopter Access work. This project also includes development of a new live line insulated rope and all necessary certification and ongoing continuing airworthiness of all the equipment in line with European Aviation Safety Agency (EASA) regulations.   New Design Live Line Basket & Rope System New Live Line Insulated Rope The equipment will include a new rope and rope system, basket and attachment system on the helicopter, a load and visual monitoring system will also be included in		

	the helicopter cockpit, with the aim to make use of new technology and materials to improve the environment in which the pilots and linesmen are subjected to.  Prototype Helicopter Attachment System
Collaborative partners	N/A
R&D provider	Bond Aviation Group, Roblon and English Braids

<table>
<tr><td>Project title</td><td colspan="4">Microshock PPE Development</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Martin Wilson</td></tr>
<tr><td>Description of project</td><td colspan="4">The project will aim to further develop the initial work that has been completed by Yasir Ahmed into the Microshocks received by linesmen. This project will progress the initial studies to produce a harness and lanyard system that will reduce to an acceptable level or totally remove the microshocks that linesmen experience whilst climbing OHL towers with live adjacent circuits.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £15k
External £66k
Total £82</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £4k
External £2k
Total £6k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£102k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£8k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Health and Safety</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>6</td><td>-1</td><td>7</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">To produce a harness and lanyard system that will reduce to an acceptable level or totally remove the microshocks that linesmen experience whilst climbing OHL towers with live adjacent circuits.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
<tr><td>Probability of success</td><td>75%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">-£57k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Work completed to date would indicate there is a good chance of the expected benefits will be achieved.</td></tr>
<tr><td>Project progress
[Year to End of March 2011]</td><td colspan="4"> 
2009 – 2010 The theoretical work previously completed has been progressed into physical equipment. A number of controlled trials measuring the effectiveness of the equipment have been completed. To date trials have consistently seen voltages drop from 2.5kv to 200v thus removing microshocks.

The final production models for field trials are programmed to be available by end of May 2010, field trials are then to be completed to enable the effectiveness of the equipment in the work environment to be documented.</td></tr>
</table>

	2010 – 2011 The field trials commenced in May 2010. A set of 3 controlled trial days were completed with mixed success due to the conditions on the days. Following these trials a more extensive set of trials were commenced which supplied the equipment to approx 10 OHL teams to use for a period of approximately 6 months. The initial feedback from these trials appears to be positive. A trial closure meeting planned for end of March was cancelled and is now planned for the 20th July at which point the feedback from the trial will be received. Following this meeting a review of the feedback will be completed and will allow the effectiveness of the equipment to be evaluated.
Collaborative partners	
R&D provider	Total Access UK, Pammenter & Petrie, The University of Manchester Intellectual Property Limited (UMIP)

<table>
<tr><td>Project title</td><td colspan="4">Development of OHL Hot Joint Monitoring Tool</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Martin Wilson</td></tr>
<tr><td>Description of project</td><td colspan="4">Development of an innovative modelling and monitoring tool for overhead line hot joints that are discovered and reported by the helicopter unit as part of their annual infrared patrols. The model will act as the central repository for all information relating to hot joints on the network (from identification to rectification) and include the deterioration prediction tool currently issued in TGN 200. Implementation via the National Grid SAM platform will allow access to multiple users at the same time and dramatically ease data sharing.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £6k
External £48k
Total £54k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£54k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">National Grid currently complete helicopter borne infra red patrols on an annual basis for 70% of the circuits and every two years for the remaining 30%. Part of this inspection is the search for so called “hot joints”.

The current tool for sharing and recording hot joint data has become inadequate and presently results in long delays in rectifying hot joint problems.

Hot joints can potentially cost the system operator (and thus the consumer if passed through) thousands of pounds as well as possibly reducing system security. This is due to the fact that circuits must be downrated if a hot joint is discovered. Downrating of circuits can then result in constraint costs which can be significant.

As well as cost issues downrating can have a significant impact on the security of the network as circuits cannot be operated as designed.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9</td><td>1</td><td>8</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Development of this modelling tool will greatly enhance the ability of National Grid to manage and monitor hot joints on the network. The new system will ensure that up to date information is made available in a timely manner to all concerned parties.

As well as greatly improving the efficiency of hot joint reporting it will also facilitate faster rectification of hot joint problems as they will be highlighted far sooner than previously possible, thus allowing for quicker defect repair and better planning of the maintenance programme.

This in turn will reduce the potential cost implications of hot joints.

An example of this is that between 7th April and 1st July 2010 the downrating of a single circuit due to a detected hot joint resulted in constraint costs of £625k. It is fair to say that swifter identification and rectification of this issue would have significantly reduced these costs</td></tr>
</table>

	as well as ensured that the network was operating at its optimum. As well as the benefits identified above further benefits will arise from the ability of the model to facilitate trend analysis that will allow a prognostic approach to hot joint monitoring thus allowing for even more efficient maintenance planning and thus a reduction in maintenance costs and a possible reduction in outage requirements for maintenance activities (this in turn may reduce constraint costs).		
Expected timescale of project	1 year	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£98k
Potential for achieving expected benefits	This project has a high chance of being successful due to the previous work that C3 Global have completed for ENI on the SAM platform, it is intended to operate this application via the SAM platform.		
Project progress **[Year to End of March 2011]**	2010 – 2011 – The hot joint model has been developed and is now live on the SAM portal. The model is now actively being used for the monitoring of the OHL hot joints. This has proven to be a useful tool during this short period of time..		
Collaborative partners			
R&D provider	C3 Global		

Project title	**Enhanced Lubrication for National Grid HV maintenance**			
Project Engineer	Pete Denyer			
Description of project	Determine the most effective modern lubricants to ensure enhanced reliability and performance, replacing obsolete, ineffective and possibly environmental harmful lubricants.			
Expenditure for financial year	Internal £13k External £90k Total £103k	**Expenditure in previous (IFI) financial years**	Internal £27k External £79k Total £106k	
Total project costs (collaborative + external + [company])	£258k	**Projected 2011/12 costs for national Grid**	£49k	
Technological area and/or issue addressed by project	Lubrication and maintenance			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		11	-1	12
Expected benefits of project	Extension of maintenance frequencies for a large proportion of National Grid HV equipment. Increased availability and reliability. Rationalisation of existing lubricants.			
Expected timescale of project	3 Years	**Duration of benefit once achieved**	5 years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£412k	
Potential for achieving expected benefits	The expectations are that this project will achieve the benefits expected, as good lubrication is the key to reducing maintenance costs whilst ensuring good availability and reliability. Technology in the tribology field has developed considerably and this project will ensure National Grid will use the most suitable lubricants available.			
Project progress **[Year to End of March 2011]**	An RA was appointed and visited National Grid refurbishment centres and sites. All current and historic lubricants have now been identified and compared based on constituent products. Interim recommendations have been submitted for the bay refurbish program. Extensive aging tests on many greases and oils have been carried out. The aging tests have been along the lines of elevated temperature, intensive UV and water washout. Analysis has been done using an infrared spectrometer and stiction & friction tests. These tests are continuing and the results being analysed and collated into a format that will be useful to field staff. Additional work has been identified for research into spray greases.			
Collaborative partners	None			

R&D provider	Imperial College

Project title	**Vegetation management research**			
Project Engineer	Matthew Murphy			
Description of project	Research into vegetation growth rates.			
Expenditure for financial year	Internal £3k External £76k Total £79k	**Expenditure in previous (IFI) financial years**	Internal £4k External £181k Total £185k	
Total project costs (collaborative + external + [company])	£1,718k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Vegetation growth rates vary across the country, dependent on a variety of climatic factors. Currently we have little research to base these growth rates on. This project aims to provide a growth model, taking these conditions into account.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		8	-1	9
Expected benefits of project	The country can be split into discrete climatic zones; this means that geographical location can have a big effect on growth rate. After the first years research we expect to have a model of vegetation growth rates based on a variety of environmental factors, for many different types and age of tree. This will be refined, based upon additional data obtained over the next 4 years. The result will be a detailed growth model leading to a better understanding of the risks to our system from vegetation. A better understanding of these risks will help us to mitigate them appropriately, and will lead to reduced risk to the system in the future.			
Expected timescale of project	4 Years	**Duration of benefit once achieved**	10 years plus. (results will inform future decisions for many years)	
Probability of success	75 %	**Project NPV = (PV benefits – PV costs) x probability of success**	£131k	
Potential for achieving expected benefits	This project is a collaboration between National Grid and several Distribution Network Operators. These companies fund it jointly. It is in everybody's interest to see a successful conclusion and the potential for achieving the expected benefits is high. The project is due to be completed during June 2011.			

Project progress **[Year to End of March 2011]**	This projects overall goal was to provide an improved understanding of vegetation growth. The project has run successfully for 3 years and although there were substantial delays in making the last measurements in the winter of 2010/2011, due to the adverse weather conditions, however all measurements have now been completed. There was a delay in the production of final reports by approximately 6-8 weeks due to the late measurement. The project is in its final stage, which consists of data analysis, production of a final report and dissemination of results in the form of a national database of vegetation growth. This will be shared with the project partners. ADAS will assist the partners with integration of this database into their vegetation management systems in order to promote efficient management of vegetation.
Collaborative partners	Scottish and Southern Electric (SSE), United Utilities (UU), Scottish Power (SP), EDF Energy (EDFe), Central Networks (CN)
R&D provider	ADAS forest research.

Project title	**Effective Protective Coatings for OHL Towers**			
Project Engineer	David Clutterbuck			
Description of project	A number of tests have been carried out by EA Technology on behalf of a group of ESI companies. This includes the evaluation of a number of new products and special purpose paint systems. Inspections of trial towers painted with a newly developed environmentally friendly water based system have also been carried out. National Grid has requested the opportunity to participate in the final stages of the testing. Participation will ensure access to all test results to date and the final report when complete.			
Expenditure for financial year	Internal £5k External £7k Total £12k	**Expenditure in previous (IFI) financial years**	Internal £16k External £19k Total £35k	
Total project costs (collaborative + external + [company])	£113k	**Projected [next year] costs for [company]**	£8k	
Technological area and/or issue addressed by project	Impending European legislation may restrict further the use of high volatile organic compaound (VOC) paints for any industrial use. The only approved National Grid tower paint product falls into this category. Maintenance policy requires the painting of approximately 1200 towers per year. Predicated ongoing spend on tower painting is £6.85 million per year, hence requirements have been identified for continued research to test and evaluate the performance of alterative paint products to ensure the company is prepared for any changes to legislation.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	0	9
Expected benefits of project	The expected benefits of undertaking this research are as follows. • Compliance with European Law regarding VOC emissions • Reduction to single coat paint systems (two coats currently used). • Reduction of steelwork replacement during OHL refurbishments.			
Expected timescale of project	5 Years	**Duration of benefit once achieved**	5+ Years	
Probability of success	10 %	**Project NPV = (PV benefits – PV costs) x probability of success**	£350k	
Potential for achieving expected benefits	The original alternative epoxy paint proposed has proved problematic and not fully effective during field trials, however significant progress has been made with alternative low VOC and water based coatings. The alternative coatings being tested show good potential for meeting both VOC compliance and performance. The new products are still improving but are already being introduced ahead of European legislation changes.			

Project progress **[Year to End of March 2011]**	A field inspection of the National Grid 4ZC line had been carried out. A report on the previous inspection on the 4ZE line was included in the final report. Results of the tests on insulator samples contaminated with paint have been published. The Prohesion test report on a range of alternative paint products has been completed and report published. The tower paint specification and list of approved suppliers has been published together with the contact details of all the sponsors' representatives. The National Grid specification for the top coat of the modified vinyl system had been changed permanently to allow the use of the lower viscosity version. A new single coat vinyl system has been included in the specification for use on steelwork in good condition, this is still in the trial stage. A list of the toxic constituents of paints currently used for tower painting had been drawn up The approved suppliers of tower paints have been contacted to ensure that they complied with REACH legislation. Improved environmentally friendly versions of the single-coat urethane alkyd and modified vinyl paint systems are still in development. New formulations are likely to be made with low toxicity anti-corrosive pigments, and be based on low aromatic solvents, so that the products will not need to be labelled as 'Dangerous for the environment' or 'Irritant'. It is also possible that they will be cheaper when manufactured in batch quantities.
Collaborative partners	United Utilities, Scottish Power, CE Electric UK (NEDL), Scottish and Southern Energy, Central Networks, EdF Energy
R&D provider	EA Technology

Project title	**Finite element analysis for ratings (FEAR)**			
Project Engineer	David Payne			
Description of project	To improve the delivery of cable ratings calculations through the use of more flexible and accurate finite element analysis (FEA) modelling methods.			
Expenditure for financial year	Internal £3k External £39k Total £42k	**Expenditure in previous (IFI) financial years**	Internal £8k External £59k Total £67k	
Total project costs (collaborative + external + [company])	£114k	**Projected [next year] costs for [company]**	£5k	
Technological area and/or issue addressed by project	Verification of the rating methods used for cable ratings under various laying conditions and considering cable joint rating methods. A review will be carried out using Finite Element Analysis (FEA) methods to confirm or otherwise existing methods.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		8	-3	11
Expected benefits of project	A better understanding of cable ratings and in particular cable joints by analysis using FEA could lead to cable thermal rating enhancements providing more flexible operation of the transmission network, facilitating outage planning and avoiding generation constraints.			
Expected timescale of project	8 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£545k	
Potential for achieving expected benefits	The expected benefits for the original project were achieved and Finite Element Analysis has been adopted as a standard to assess/verify cable ratings under real conditions. The project has been extended to consider the effect on ratings of cables crossing in close proximity.			
Project progress **[Year to End of March 2011]**	The project has clearly demonstrated the use of FEA for providing analysis of complicated cable rating problems. Unfortunately delays have been experienced in this project due to prioritisation of scheme work.			
R&D provider	Southampton University.			

Project title	**Phase III Centrifuge Modelling and Field Monitoring of Wind Induced Loads on Transmission Towers**			
Project Engineer	David Clutterbuck			
Description of project	To carry out enhanced environmental modelling of full OHL support system fully instrumenting a short section of line. To carry out centrifuge modelling to expand the range of foundation and soil types currently considered, using the data collected by the environmental modelling. To assess the appropriateness of current British Standard method for determining tower foundation uplift capacity and influence the change of industry design codes.			
Expenditure for financial year	Internal £6k External £162k Total £168k	**Expenditure in previous (IFI) financial years**	Internal £14k External £32k Total £46k	
Total project costs (collaborative + external + [company])	£214k	**Projected 2011/12 costs for national Grid**	£0k	
Technological area and/or issue addressed by project	The outsourcing of all National Grid Tower design activities for OHL refurbishment using Pre-Sanction Engineering (PSE) has highlighted a difference in approach taken by NGT and its contractors to assess the capacity of existing structures and foundations. Contractors use the current design code BS EN 50341 (normally intended for new build). The contractors' analyses have indicated that tower foundations have a substantially lower capacity to resist uplift forces than previously assumed. To date, foundation-strengthening work identified by PSE has been put on hold pending further R&D by National Grid. These issues have been partially addressed by recent R&D work ref NSETH118. This previous work has successfully established a method of testing 1:50 scale foundation models in centrifuge apparatus capable of giving full-scale results.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	0	9
Expected benefits of project	National Grid will benefit from this research by being able to reliably assess OHL foundation capacity, optimising tower strengthening upgrades, avoiding unnecessary foundation reinforcements The research will contribute to updating to National Grid's Technical Specification for line refurbishment and provide a high level of confidence that National Grid structures are fit for purpose. This research will help significantly reduce the number foundation upgrades required during the planned capital refurbishment program.			
Expected timescale of project	6 years	**Duration of benefit once achieved**	5 years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of**	£3k	

		success	
Potential for achieving expected benefits	High given the initial results and the skills of the university group.		
Project progress **[Year to End of March 2011]**	The field testing element of the work has been expanded to construct 5 new full size L4M type tower foundations and a steel grillage (North American type) foundation at a well characterised clay test site (BRE Chattenden, Kent) and to determine the ultimate vertical uplift capacity when subject to rapid uplift conditions. Foundations installed July/August 2010. A laboratory large scale rapid uplift testing system has been developed to proof of concept and has been demonstrated over a range of conditions. Full scale rapid foundation uplift testing system to be used to load test L4m type foundations installed in clay ground conditions (backfilled with type 2 HA engineered fill) and steel grillage type foundations installed in clay ground conditions. System designed to deliver ~100 tonnes uplift capacity over a vertical displacement of ~130mm in <1 second duration. Test will take place Sept 2011.		
Collaborative partners	EPSRC (to fund a PhD)		
R&D provider	University of Southampton		

Project title	**OHL Conductor Asset Lives**			
Project Engineer	David Clutterbuck			
Description of project	To review the technical asset life for ACSR Conductors			
Expenditure for financial year	Internal £4k External £0k Total £4k	**Expenditure in previous (IFI) financial years**	Internal £8k External £40k Total £48k	
Total project costs (collaborative + external + [company])	£52k	**Projected [next year] costs for [company]**	£0	
Technological area and/or issue addressed by project	Historically, conductors used on the system are aluminium conductors, steel-reinforced (ACSR) of Zebra (400mm2, 54/7, 28.62mm diameter) design, but with different levels of grease protection, and past exposure to environmental conditions that vary widely throughout the UK. Other stresses (e.g. conductor vibration due to subconductor oscillation) may also have a significant influence on remnant life. This project is to determine the condition of conductors, both in service and taken from service, assess the extent and form of any damage and corrosion, and determine the likely remnant life of conductors			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		12	-3	15
Expected benefits of project	There is a requirement to maintain and reliably operate ACSR conductor to end of asset life and produce an optimised plan for replacement. To optimise replacement decisions, an accurate view of remaining life for installed conduction on a range of environmental conditions is required. The OHL asset replacement budget is in excess of £500 million planned for this and future 5 year periods. The work will provide information to feed into a review of ACSR conductor asset lives by enhancing the understanding of corrosion and fatigue as deterioration mechanisms. Confirmation of existing lives with the recent sample data will give confidence that the current asset lives are valid and if possible there may be scope for life extension and replacement deferral. If one 200km scheme is deferred beyond the current price review period as a result of this project, this will lead to deferral of £60m of capex.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£16k	
Potential for achieving expected benefits	End of life for ACSR conductors has historically been taken as a 15% loss of conductor strength. However recent forensic work has found slower rates of loss of strength than previously expected. This work is to better understand the degradation mechanisms. Potential for achieving this goal is high.			

Project progress **[Year to End of March 2011]**	Samples 1 – 188 condition assessed, The generic grease type (i.e. grease or bitumen) established and extent of the grease applied within the conductor (i.e. core-only / all inner-layers /all-layers greased) captured. Tensile measurements completed on 139 samples. Preliminary presentation issued. Approximately 200 additional samples have been collected from across the network. Previous samples were almost all jumper samples but a significant number of the new samples are phase conductor, which is required to give an improved insight into the long term behaviour. Initial results showed the sample number was too small across the various ages and environment types to generate conclusive results. In 2010/11 further in phase, samples have been taken from decommissioned conductor on the major OHL refurbishment schemes. Significant effort has been made to increase the sample size to enhance the quality of the project output. Testing of the new samples is ongoing and once complete full analysis all test data will be compiled and reported on.
Collaborative partners	None.
R&D provider	ERA Technology

Project title	**ACSR Corrosion Research**			
Project Engineer	David Clutterbuck			
Description of project	Phase 1 of Cormon ACSR Equipment replacement. National Grid are seeking a replacement of the existing overhead line corrosiondetector. This project investigates the requirement for a new corrosion detector. This project is a preliminary phase to identify the requirements of National Grid and to understand the costs and timescales that would be involved in developing, testing and trialling an OHL corrosion detector.			
Expenditure for financial year	Internal £4k External £0 Total £4k	**Expenditure in previous (IFI) financial years**	Internal £10k External £17k Total £27k	
Total project costs (collaborative + external + [company])	£31k	**Projected [next year] costs for [company]**	£0	
Technological area and/or issue addressed by project	Internal corrosion is a major factor limiting the life of steel reinforced aluminium conductors (ACSR) and a crucial stage in the corrosion process is the loss of zinc from the central galvanised steel strands. Once this galvanising is lost the aluminium strands are subject to galvanic corrosion and the conductor deteriorates rapidly. The effects of this form of internal corrosion are not visible or detectable by infra-red methods until the conductor is near to failure.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	-4	13
Expected benefits of project	There is a requirement to maintain and reliably operate ACSR conductor to end of asset life. Investment decisions on scope, timing and prioritisation of full refurbishment or fittings only schemes are informed through condition information. The capability to deliver an optimised OHL asset replacement plan relies on the ability to select suitable routes for fittings only schemes. Without ACSR corrosion test equipment, extensive in span destructive sampling would be required leading to additional longer system outages, additional site resources and thus higher costs for collecting the condition information. With an OHL asset replacement budget in excess of £500 million planned for this and future 5 year periods it is essential National Grid can continue to use a non destructive test to measure steel core loss to ensure condition information can be accurately and efficiently collected. Without this equipment it is expected the costs for collecting the condition information will increase from £1500 to £4500 for each section of a route where condition information is collected. This could equate to an additional cost of E600k for the tests which are required to support the plan for this five year period.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£11k	

Potential for achieving expected benefits	The potential for success is high. The basic operating principal is proven. The development is required to enable a modern practical and reliable machine to be developed.
Project progress **[Year to End of March 2011]**	The first 3 stages of work have been completed and the initial agreed funding has been spent Stage 1: Functional Specification Stage 2: System Specification and Detailed Project Plan Stage 3: Options for commercial development arrangements. Commercial discussions are ongoing regarding the significant funding required for the project and how long term support will assured for any new equipment developed. Full scope and final costs for project completion have been agreed. Due to the significant potential project cost discussions are ongoing with other International Transmission Utilities to ensure the development is unique to the market.
Collaborative partners	No Partners at this stage but the options for commercial arrangements include EA Technology as possible partners for future development.
R&D provider	EA Technology

Project title	**Composite Cross Arms study**
Project Engineer	Boud Boumecid
Description of project	**Task 1. Case Study Specification** Upon commencement of the project, National Grid , The University of Manchester (UoM) and EPL Composite Solutions Ltd (EPL) will meet and agree specifications for the L2 and L3 lattice tower cross arms. The specification will include the following. • Current construction details in steel; • Design rules and standards for both structural and electrical performance (these being based on existing cross-arm / insulator standards); • Current weight and installed cost for steel cross arms / insulators, which will be used for benchmark purposes. The specification will also include the required life time, handling techniques, maintenance practices, installation characteristics etc that may be essential or useful to take into account during the design process. This specification will be used as a reference document through the course of this and any future phases of the project to ensure that the final product is fit for purpose and satisfies the requirements of National Grid. **Task 2. Techno-Economic Benefits Of The Case Studies** Given that the uptake of this technology would rely on the development of an economic case, it is essential that this is considered within this phase of work. UoM and EPL will provide to National Grid the benefits that can result from the composite cross-arm. This information will be largely based on work already presented to National Grid with some refinements based on recent work. It is anticipated that while UoM and EPL will contribute to this task with engineering support, the bulk of this work must be undertaken by National Grid who can cost the potential benefits of the technology. **Task 3. Resolution Of Technical Barriers To Composite Cross-Arm Development** This task aims to carry out an initial analysis of the following aspects of the composite cross-arm technology. These specific areas were all identified in the phase 1 report to National Grid as potential barriers to the development of the composite cross-arm technology. • Solution to allow maintenance access to conductor fittings • Selection and test of an appropriate coating technology • Selection of an appropriate pultrusion profile • Identification of a suitable shedding profile for the pultrusions • Design and fabrication of a wet test facility for the prototype • Consideration of failure mechanisms of existing composite insulators in relation to composite cross-arms • Software development for modeling of lateral loading • Development of method to provide co-ordination gaps It is not expected that these phases of work will be fully resolved in terms of defining the final solution by the end of this project phase. However, as a minimum, the challenges will have been more clearly defined and initial developments will have allowed potential final solutions to have been identified. For example, it is highly unlikely that a choice for the optimum silicone rubber coat will be selected in this work but the main challenges will be understood in terms of both manufacturing and electrical performance. The emphasis is

<table>
<tr><td></td><td colspan="4">therefore in the continued reduction of risk associated with the issues presented in the phase 1 report.

At the end of this task, the expectation is that the additional knowledge gained will lead to a review of the three composite cross-arm design options previously presented (fully profiled, flat with insulator or lightly profiled with insulator).

Task 4. Manufacture And Test Of Full-Scale Prototypes

Within this task, a full-scale mechanical prototype (defined in task 1) will be manufactured and tested. EPL will design a structure that can be used to support the cross-arm for the purposes of mechanical testing. A second electrical rig will be developed that will be used in the UoM HV Laboratory for electrical testing only (this rig being relatively light-weight as it will not support significant load). The cross-arm will be designed using software developed in phase 1 of the project which will be updated to include lateral load applications and relevant commercial codes. The testing will be performed according to the specification defined in task 1. However, in terms of mechanical testing, it will check the ability of the prototype to withstand static loads only and not consider long term durability at this stage. Through the mounting of the cross-arm on the test rig (replicating a tower) and by the inclusion of a conductor fitting allowing the installation of a length of conductor, electrical tests will assess the ability of the cross-arm to withstand AC, lightning and switching voltages. An assessment of the levels of visual corona will also be carried out.

Task 5. Development Of Future Project Road Map

At the end of this project phase, the feasibility of a composite cross-arm should be fully established. It is therefore essential to have a future project road-map that builds on the proposal previously presented to National Grid. This task of work will be carried out by EPL and UMIP (the University of Manchester Intellectual Property Company). Ways to include the alliance partners of National Grid and cooperation with other organizations such as Hydro Quebec and EPRI will be discussed in terms of the remaining research and development phases of this work.

Due to the need to develop a full scale prototype within this stage of the work in a short timescale, the spend per month is relatively high owing to the number of people working on the project. This work will also equip EPL and the University of Manchester with many of the hardware and software tools they need for the project going forward. It is intended that future phases of this project will be supported with funds from other sources.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £13k
External £36k
Total £48k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £23k
External £592k
Total £615k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£791k</td><td>Projected [next year] costs for [company]</td><td colspan="2">£67k</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 and the elimination of the insulator strings on other tower types.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Tech Transfer</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>8</td><td>1</td><td>7</td></tr>
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<table>
<tr><td>Expected benefits of project</td><td colspan="3">If it proves feasible to upgrade L3 towers to 400 kV operation there are several areas of the transmission network where future generation connections, that would ordinarily require new overhead line routes to be constructed, could be accommodated by upgrading a 275 kV route to 400 kV operation, increasing its power carrying capability, thereby avoiding the need to construct a new line.</td></tr>
<tr><td>Expected timescale of project</td><td>5 years</td><td>Duration of benefit once achieved</td><td>5 Years</td></tr>
<tr><td>Probability of success</td><td>60 %</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>-£42k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">There is very high potential for realising the above benefits. Work to date has been focusing on studying the feasibility of replacing a steel L3 tower crossarm with an equivalent composite capable of operating at 400kV. Research studies, electrical and mechanical tests have been successfully carried out to confirm this application is feasible.</td></tr>
<tr><td>Project progress
[Year to End of March 2011]</td><td colspan="3"> 
Four prototype cross-arms have been successfully installed at a location in the Cairngorms National Park in Scotland. The cross-arms are placed on a 132kV line in an area where severe environmental conditions are experienced such as high winds and heavy ice. The cross-arms are also being monitored to see how mechanical loads imposed by wind and ice are distributed between the compression members. This trial will also be used to develop a robust data acquisition system to perform satisfactorily under such harsh conditions. Later this year, the cross-arms will be trialled in a coastal location and energised with a 231kV transformer (231kV being the phase to earth voltage of a 400kV system).

A field trial is also planned at National Grid Eakring training facility to develop the required maintenance and access procedures.</td></tr>
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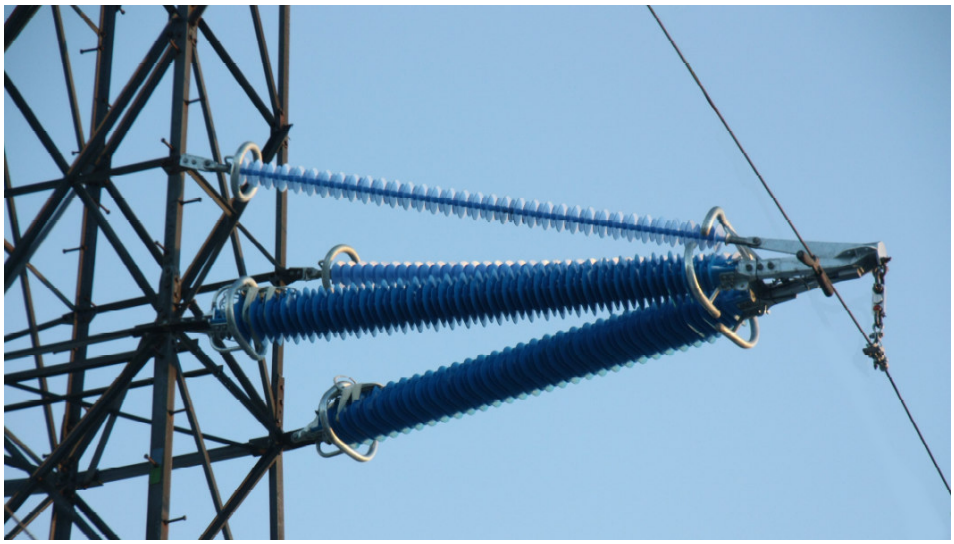
	
Collaborative partners	The field trials in Scotland are funded by SSE
R&D provider	University of Manchester (and EPL composite solutions)

Project title	**Electric Field / Microshock mitigation**			
Project Engineer	Chris Haswell			
Description of project	The key objective of the project is to produce an effective mitigation for severe and painful microshocks being suffered by a grantor and members of the general public. The project will look at a range of effective microshock mitigation measures for the location where a microshock complaint has been received. The team will carry out a feasibility exercise to assess options and develop costings (Part A). Subsequently the team intend to develop, construct and trial an installation at the complainant's property (Part B) subject to the complainant's agreement. This project will be managed independently of the overarching EMF R and D scheme, however will remain mindful of the synergies that may exist.			
Expenditure for financial year	Internal £4k External £0 Total £4k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0	
Total project costs (collaborative + external + [company])	£TBC	**Projected 2010/11 costs for national Grid**	£TBC	
Technological area and/or issue addressed by project	The main driver for this project is that severe and painful microshocks are being experienced by a grantor and members of the public at an aerodrome on the Hoo Peninsular near the Isle of Grain where microlight aircraft taxi under the 4TK20 - 21 Grain – Kingsnorth 400kV overhead line from the hangar / workshop to reach the runway. Aircraft on the taxiway are either being pushed with resulting shocks to the arms and hands or under power resulting in shocks to the thighs and hands of the pilot. The grantor is still allowing access however access may become more difficult if microshocks cannot be mitigated and there is potential for a wayleave challenge.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		13	-2	15
Expected benefits of project	To allow normal access to National Grid towers to be maintained and to prevent members of the public receiving severe and painful microshocks. This will prevent potential wayleave terminations which are each estimated to cost a minimum of £150k and potentially significantly more on a case by case basis.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	ongoing	
Probability of success	60%	Project NPV = (PV benefits – PV costs) x probability of success	£28k	
Potential for achieving expected benefits	High - as some modelling work has been done in this area already and mitigation options are known to work in smaller trials. The feasibility study will provide theoretical evidence that options to minimise micro shocks will work.			

Project progress **[Year to End of March 2011]**	Over the last year this project has started looking at levels of electric field and potential solutions that could be implemented to mitigate the micro shocks that occur in this particular location. The Initial studies have been carried out using software package EFC400. This softwear package will be used to asses the electric fields and the mitigation effect potential solutions have on the electric field prorogation. This project could in future expand to include a feasibility study on the proposed studies that come out of the initial work which is currently being undertaken.
Collaborative partners	
R&D provider	

Cables

Project title	**Severn Cable Tunnel Access / Egress Trolley**			
Project Engineer	Martin Wilson			
Description of project	A powered access / egress trolley for transporting tools / equipment along the access route for the Severn Cable Tunnel. The requirement for rescue will also be accommodated by the inclusion of a stretcher system onto the equipment.			
Expenditure for financial year	Internal £3k External £1k Total £4k	**Expenditure in previous (IFI) financial years**	Internal £7k External £9k Total £16k	
Total project costs (collaborative + external + [company])	£20k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Health & Safety			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		7	-4	11
Expected benefits of project	This trolley is being designed with 2 criteria in mind. Firstly, it will enable tools & equipment to be transported into and out of the tunnel in a safe and efficient manner. Secondly, it will ensure a safe working practice is in place for the evacuation of a casualty from the tunnel. The trolley will enable all required equipment to be transported in one journey with no physical effort from the operator. The main business benefit is both the immediate and long-term welfare of the substation staff carrying out the task and the improvement of the rescue / evacuation provision.			
Expected timescale of project	3 years	**Duration of benefit once achieved**	20 Years	
Probability of success	100%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£11k	
Potential for achieving expected benefits	High likelihood of success due to the good working relationship between Spondon Engineering and National Grid.			

Project progress **[Year to End of March 2011]**	2008 – 2009 - The tunnel trolley was designed and manufactured. Final trials were successfully completed.  2009 – 2010 – Further investigations into other cable tunnels requiring this solution have been completed. No other tunnels have been identified at this time. All drawings to be finalised prior to closure of the project. 2010 – 2011 – All drawings have now been finalised and the tunnel trolley is now in operation.
Collaborative partners	
R&D provider	Spondon Engineering

<table>
<tr><td>Project title</td><td colspan="4">Further Development of PFT in Service Cable Oil Leak Location Technique</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Mike Fairhurst</td></tr>
<tr><td>Description of project</td><td colspan="4">Goal – To provide National Grid with a leak free system oil filled cable system and to preventatively inject all transmission cables with PFT tagged fluid.

PFT in service leak location technique, employing Perflurocarbon tracer (PFT) to “tag” the cable oil. has now been adopted as the main tool in oil leak location which has seen a significant step change in the way in which National Grid responds to oil leaks with improvement to the speed and accuracy of leak location combined with the sensitivity to locate low rate oil leaks, that in the past have been difficult if not impossible to locate with previous techniques, as a result major reduction in outage times to effect repairs (65%) are now being achieved.

Phase 1 & 2 of the original project proved the technique could be used on both 132 & 275kV cables without any detrimental effect to the long term performance of the cable and accessories.

Phase 3 of the project is further develop the technique for use at 400kV and to also reduce outage time by introducing the PFT in to the cable while the cable remains in service, without the need for an outage.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £9k
External £69k
Total £78k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £6k
External £135k
Total £141k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£219k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">High Voltage oil filled cables – Non intrusive cable oil leak detection with the cable in service.</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>0</td><td>14</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Reduction in costs and resources associated with cable oil leak location with potential to give an accuracy of within 2 metres on all cable voltage ranges In 2003/04, 9 cable oil leaks required freezes for leak location, the cost of this work varied between £360k and £720k per leak location. Historically on average, National Grid spent £500k per year on cable oil freezes. Assuming PFT location reduces the requirement to freeze by 50%, this would realise a saving of £250k per year or £1.25 million over a 5 year period.

Following the completion of Stages 1 & 2 a three year contract was let to tag and locate leaks on 20 275 kV cables; contact value £2.3 million or £776k per year. To date 124 cable sections have been, 42 leaks have been located and repaired, with out the need to excavate and freeze for location, thus reducing repair costs by some £2 million over the last 1½ years since contracts were placed. In addition outage and repair times have reduced by 66%, this directly affects the oil loss with regard to moderate and low leaks as the volumes being lost has seen a significant reduction when compared with previous years.

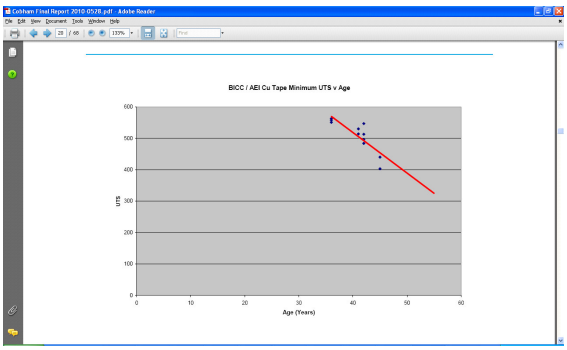
Phase 3 of the project will enable National Grid to extend the benefits on to the 400kV network and in addition improve the flexibility of the tagging process</td></tr>
</table>

	across voltage ranges by enabling the procedure to be carried out without the need for an outage. In summary, potential benefits are : • Improved response times for leak location hence overall repair time • Reduced oil loss resulting from improved response time • Reduced outage times and hence improved circuit availability Improved response to cable oil leaks is an integral part of driving forward improvements in environmental performance and cable circuit availability and is consistent with National Grid's philosophy in promoting the use and development best available practise.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	Years - for the life time of the asset 50+ years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£318k
Potential for achieving expected benefits	Benefits are currently being realised from previous Phase 1 & 2 projects; reduction in OPEX costs, reduced circuit outage time (two thirds) reduction in civil works on roads therefore benefiting road users and local residents. It therefore expected that the benefits will be applicable to National Grids 400kV cable network.		
Project progress **[Year to End of March 2011]**	PFT Technology has carried out site visits to Legacy 400kV Substation (redundant circuit). Some modifications were identified in order to utilise the PFT Technology at 400kV due to the original design. The required modifications are pending a proximity outage causing delay. The Oil Management Unit identified redundant equipment from the Bramley Didcot circuit to be removed and sent to Thorpe Marsh to be used in the feasibility studies. Due to unforeseen circumstances it has not been possible to get back to the site to complete the trial on a dead circuit. A section of the old Beddington Rowdown circuit 275Kv cable is now being lassessed to complete this trail within the next financial year. The hardware and software has all be procured within this financial year and has been tested but needs to be operated in a field trail to prove the techniques will be potentially viable. A paper has been presented to JI cable on National Grid's experience to the international conference on HV cables.		
Collaborative partners	PFT Technology		
R&D provider	Pirelli & PFT Technology inc		

Project title	**Automatic Risk Based Handling of Plant Enquiries Relating to NG Transmission Electricity and Gas Assets**			
Project Engineer	Rob Greaves			
Description of project	The proposed system will determine the appropriate response to enquiries based on querying the asset data directly and through applying an expert system rules-based approach. This intelligent web based enquiry system, incorporating damage prevention management procedures and automated responses, for individuals proposing to carry out third party work in the vicinity of National Grid buried assets resulting in - Less damage to assets. - Reduced consequential loss of supply or service. - Reduced safety risk for those working in or near underground assets. - Reduced safety risk to members of the general public. Resulting in - Reduced direct, third party damage and societal costs. - Improved health and safety. - Reduced congestion.			
Expenditure for financial year	Internal £21k External £66k Total £87k	**Expenditure in previous (IFI) financial years**	Internal £4k External £54K Total £58k	
Total project costs (collaborative + external + [company])	£732k	**Projected 2011/12 costs for national Grid**	£TBC	
Technological area and/or issue addressed by project	Delivery of an automated response system to third parties for National Grid's buried assets. Development of expert system rules based on risk and assets involved. Response will provide with MAPS detailing the assets at risk via Web-based portal.			
Type(s) of innovation involved	Tech Transfer	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		13	-6	19
Expected benefits of project	Improve standards of customer service efficiency & consistency in responding to plant enquiries. The system is designed to mitigate risks of third party damage. Known areas of critical supply and impact on vulnerable customers can be defined and monitored for high risk works.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 years	

Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£175k
Potential for achieving expected benefits	The external trial is nearing completion and there is a high level of confidence in the reliability of the system and the viability of providing an external facing system for use by third parties. The expectation is that the project will realise the intended benefits.		
Project progress **[Year to End of March 2011]**	The adaption of line search to incorporate additional information has in general been a success with this year's trial providing a positive result. This trial has also uncovered some additional enhancements to the system that will be evaluated to see if they are of an innovative nature.		
Collaborative partners	ScottishPower Energy Networks		
R&D provider	University of Strathclyde		

Project title	**Cable asset life project**			
Project Engineer	Michelle Le Blanc			
Description of project	To review and develop our understanding of the factors affecting oil-filled cable asset lives.			
Expenditure for financial year	Internal £4k External £0k Total £4k	**Expenditure in previous (IFI) financial years**	Internal £11k External £83k Total £94k	
Total project costs (collaborative + external + [company])	£98k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	With an ageing population of oil filled cables on the transmission system, National Grid needs to develop its understanding of cable assets particularly with respect to the factors that contribute to cable deterioration.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	-1	10
Expected benefits of project	This project will provide National Grid with a further understanding of the degradation mechanisms and deterioration modes of oil filled cables and develop the ability to understand better the assessment of risks and costs and performance. This will provide National Grid with the means to establish whether cables' anticipated asset lives can be revised. The project will describe practical methods to assess the level of degradation of oil-filled cable systems. This will feed in to the Asset Lives project which is designed to optimise Capex and Opex and will then form the basis of the Capital Plan for replacement of cables.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	Several years and will be subject to constant review	
Probability of success	90 %	**Project NPV = (PV benefits – PV costs) x probability of success**	£207k	
Potential for achieving expected benefits	This work has produced an asset health index, replacement prioritisation and deterioration model for cable systems. The testing and technical analysis of aged cable components has further reinforced the model and confirmed cable asset lives. The output of this work has been implemented in the capital plan by the Asset Investment team and is embedded into the Asset Health process.			

Project progress **[Year to End of March 2011]**	The Cable Asset Life project has completed the following deliverables: • Review and development of our understanding of the life limiting factors for each element of anoil filled cable system. • Develop a cable health scoring system • Develop a deterioration model to represent the degradation mechanisms of oil-filled cable systems. • Testing of aged cable samples to understand the remaining useful life of cable components, including the papers, lead/Al sheaths, reinforcing tapes and PVC/PE oversheaths. This project has now concluded. The final stage of the project, that is, the testing of the cable components, has confirmed the asset lives of the cables based on the samples received. The results of the analysis of the components - papers, lead/Al sheaths and oversheaths - have given National Grid confidence in our cable asset lives. The deterioration mechanism that is currently of most concern to National Grid is associated with cables of a particular family that are vulnerable to reinforcing tape corrosion. An interesting element that emerged from the testing is that there appears to be a link between loss of tensile strength in the reinforcing tapes as they age.  There is a potential for further work to be undertaken to broaden our understanding of this deterioration mechanism and to model this. It is intended that National Grid continues to ensure that as cables are decommissioned from the system, samples are sent for analysis to further reinforce our understanding of cable deterioration.
Collaborative partners	
R&D provider	Energyline – Denis Procter ERA Technology – Ray Houlgate

Project title	**SODA**			
Project Engineer	Graham Moss			
Description of project	To simulate, in the laboratory, the degradation processes seen in silicone oil insulated cable sealing ends and to develop a sufficient understanding of these processes to facilitate the analysis of samples taken from the field in order to provide a measure of asset health.			
Expenditure for financial year	Internal £3k External £63k Total £66k	**Expenditure in previous (IFI) financial years**	Internal £5k External £118k Total £123k	
Total project costs (collaborative + external + [company])	£189k	**Projected [next year] costs for [company]**	£0	
Technological area and/or issue addressed by project	The breakdown pathways and kinetics of poly-dimethylsiloxane (PDMS) insulating fluids are not fully understood, and the study and deeper understanding of how these fluids behave under electrical stress may lead to the identification of significant components which may be used to determine the early determination of fault activity within silicone fluid filled terminations. It is envisaged that with the chemistry fully understood, a much greater appreciation of fault level and time to failure will be derived. Furthermore, the identification of selective analytical markers of fault activity will allow simple routine testing methods to be migrated to the contract oil laboratory, enabling National Grid to look for fault symptoms in a similar way to that already practiced for instrument transformers and bushings			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		13	3	10
Expected benefits of project	Oil-based insulation systems have been used for many decades and, consequently, a number of techniques have been devised to monitor the condition of a range of critical assets. Dissolved gas analysis, for example, has a long and successful history in identifying issues with transformers. In contrast, no comparable testing methodologies exist for silicone oil and, even if testing methodologies were to be borrowed from other oil-based systems, at present it would not be possible to interpret the results. Since silicone oil is already being used on the transmission system and is giving problems of the type described above, our current inability to monitor the condition of silicone oil-based cable sealing ends renders National Grid susceptible to further unplanned outages and the loss of critical circuits. This project sets out to address this issue. In Stage 1 this project will examine field aged samples of silicone-oil and examine the feasibility of simulating, in the laboratory, equivalent time dependent degradation processes by thermal and electrical means and explore a range of potential analytical tools capable of being used to quantify degradation. If it can be shown that appropriate accelerated ageing methodologies can be developed and the degradation detected in the oil, then Stage 2 will: • Examine the effect on silicone oil of a broad the range of ageing parameters, including both electrical and thermal factors. As well as identify physical and chemical indicators of ageing and relate these to			

	changes in key electrical properties. • Compare these with changes seen in field-aged samples. • Seek to determine end-of-life indicators. The above will bring the following business benefits, for the first time, National Grid will be able to monitor the condition of silicone oil-filled cable sealing ends. This will enable National Grid to identify assets in distress. From this information, it will be possible to determine appropriate maintenance strategies and to minimise unplanned outages through the avoidance of failures.		
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 Years
Probability of success	50%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£25k
Potential for achieving expected benefits	From the work performed previously by Southampton University on Cable fluid degradation, this work should have an excellent chance of producing the answers National Grid need to manage the silicone fluid filled assets in the same way we manage bushings and instrument transformers.		
Project progress **[Year to End of March 2011]**	The project was slightly delayed due to Southampton having to re-build their treeing rig and develop the imaging technologies to look at the effect of viscosity interfaces on treeing. This work is important to National Grid as suppliers are often unable to match the grade of fluid already in use, but mainly that high viscosity oil is heated to enable pouring. I believe that the initial oil entering the sealing end will effectively solidify and become mobile in a large volume of liquid. Due to the nature of the silicon oil and the ways that they are transported in large oil drums getting the relevant samples to the university was an issue and the trials although completed did not take a wide enough sample of oil to prove conclusive for the purpose that the trail was started. The structural, elemental analysis and imaging of the samples that were delivered was completed and all reports are due to be passed to National Grid in May 2011. Further work would be needed to determine the possibility of using any mixed silicon oils during sealing end refill as this project did not manage to sample enough oil types.		
Collaborative partners			
R&D provider	Southampton University		

Project title	**Ratings of cables in tunnels (ROCIT)**			
Project Engineer	David Payne			
Description of project	The objectives of this project are to: • Review the ratings methods used to design cable tunnels. • Assess existing operational data from cable tunnels, including Distributed Temperature Sensor (DTS) data. • Develop a specification for a rating method for cable tunnels installations with independent cable circuits.			
Expenditure for financial year	Internal £4k External £58 Total £62k	**Expenditure in previous (IFI) financial years**	Internal £12k External £79k Total £91k	
Total project costs (collaborative + external + [company])	£162k	**Projected [next year] costs for [company]**	£9k	
Technological area and/or issue addressed by project	Rating methods employed in the design of both forced cooled and naturally ventilated cable tunnels.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		4	-3	7
Expected benefits of project	A better understanding of rating of cables in tunnels would lead to: (1) Increased use of existing tunnels for new cable installations (2) Potential use of smaller cables for a given rating through understanding the true rating capability of cables. (3) Optimisation of tunnel cooling systems or in some cases removing the need for any cooling system from better understanding of natural ventilation effects.			
Expected timescale of project	5 years	**Duration of benefit once achieved**	2 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£32k	
Potential for achieving expected benefits	Very High. Algorithms developed under the forced ventilation stages of the project have already been used to assess cable ratings for at least two tunnel schemes.			

Project progress **[Year to End of March 2011]**	A review of existing rating methods has been carried out. Several tunnels have been visited and data gathered for further analysis. Algorithms have been developed to consider tunnels with more than one type of cable construction with forced ventilation tunnels. Further data is being gathered to further verify models. Progress to consideration of naturally ventilated tunnels has been delayed due to urgent requirement to assess ratings for live schemes.
Collaborative partners	None
R&D provider	Southampton University.

Project title	**Cable oil leaks & thermal data analysis**			
Project Engineer	Caroline Bradley			
Description of project	This project is to examine data currently logged by National Grid and develop analysis methods to provide: • An estimate of the position and magnitude of oil leaks. • Guidance on enhanced rating methods • Techniques for the early detection of thermal anomalies and overheating.			
Expenditure for financial year	Internal £4k External £8k Total £12k	**Expenditure in previous (IFI) financial years**	Internal £6k External £73k Total £79k	
Total project costs (collaborative + external + [company])	£91k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Oil leaks from underground cables are damaging both environmentally and financially which impacts on the reputation of National Grid. The ability to identify oil leaks as they develop will allow National Grid to manage and predict leaks more effectively avoiding both damage to the environment and unplanned unavailability of the network. Also improved thermal ratings techniques may allow more effective use of the transmission network, whilst avoiding overheating.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		12	-2	14
Expected benefits of project	The early detection of oil leaks reduces their environmental impact. A method for locating leaks without digging sequential holes will improve cable system availability by reducing outage times, reduce repair costs and minimise the disruption to traffic. Improved understanding of DTS data can enhance cable ratings, reducing costs associated with thermal constraints. Additionally it should prevent an Auckland-style blackout on the National Grid system through the early detection of thermal anomalies and prevent cables overheating avoiding expensive damage to the cables and accessories.			
Expected timescale of project	3 Years	**Duration of benefit once achieved**	Ongoing	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£207k	

Potential for achieving expected benefits	Possible, however the quality of National Grid source data is poor and this may not be rectified before the project is completed.
Project progress **[Year to End of March 2011]**	Initial data has been collected and analysed. From this data a predictive model of cable pressure variation with load has been built. Also tests have been carried out to simulate and aid understanding of how Aluminium sheathed cables corrode. An interim report has been received on progress to date. Further refinement of the model is required in the next year. Initial results are promising but difficulties are being experienced in obtaining data and the quality of the data is poor. Project progress is currently limited, as National Grid cannot provide the required data at this time. Project is a year behind schedule due to the difficulty in recruiting a PhD Student.
Collaborative partners	n/a
R&D provider	University of Southampton

Project title	**Recovery of cable core**			
Project Engineer	Francis Waite			
Description of project	Development of a technique to remove the core of an oil filled cable while the cable is still buried in the ground. This will allow the copper conductor to be recovered and leave an unfilled duct that can be re-used.			
Expenditure for financial year	Internal £3k External £0k Total £3k	**Expenditure in previous (IFI) financial years**	Internal £8k External £126k Total £134k	
Total project costs (collaborative + external + [company])	£138k	**Projected [next year] costs for [company]**	£0	
Technological area and/or issue addressed by project	Current best practice for decommissioning oil filled lead sheathed cables is to remove as much oil from the cable as possible and then leave the cables in the ground or alternatively excavate the cable route to extract the cable (although this is costly). The proposal is to pump biological agents into the out of service cable that would degrade the oil impregnated insulation sufficiently to allow the cable core to be extracted from the cable at joint positions. This would reduce the environmental risk of the cable system, allow recovery of valuable materials reducing waste and allow recovery of the cost of the material (generally copper) and leave a conduit for future use.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		13	2	11
Expected benefits of project	The removal of an environmental risk (oil leaks from decommissioned cables). The environmental benefit of recycling of the cable conductor. The financial benefit of the value of the cable conductor (assuming copper is £3000 per tonne -1 km circuit of 2000 mm2 cable would have around f 150,000 of copper). Turning the decommissioned route into an asset (unfilled conduit for reuse by communications cables).			
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£10k	
Potential for achieving expected benefits	The original estimated success was 30%. The project was completed and it was shown that it was not possible to remove the copper core from the cable.			

Project progress **[Year to End of March 2011]**	The project has demonstrated that there are active agents that are capable of speedily breaking down paper and in theory allowing the cable core to be pulled out of the cable. However the hydrogel process to remove the oil has not been as effective as anticipated and additionally the penetration of active agent into the cable was more difficult than anticipated. Efforts were made to improve the hydrogel process and additionally hydrogel was used to carry the active agent into the papers but this did not improve the results. An alternative method of removing the cable core by mechanical means was attempted but this only removed a limited amount of cable core and was judged not to be economic for general use.
Collaborative partners	None
R&D provider	AES and AGT Sciences

<table>
<tr><td>Project title</td><td colspan="4">Power Cable Materials Related TSB Project: Sustainable Power Cable Materials Technologies with Improved Whole Life Performance</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Mike Fairhurst</td></tr>
<tr><td>Description of project</td><td colspan="4">This project seeks to develop a new generation of polymeric power cable materials which are required to address the growing medium voltage (MV) and high voltage (HV) power utility markets in the UK and the rest of the world. This is driven by replacement of existing aged HVAC systems, new power system connections, especially for renewable (HVDC), and for infrastructure development. Current polymeric cable materials based on cross linked polyethylene do not provide adequate high temperature performance, neither do they offer low environmental impact over their service lives and at end of life. This proposal seeks to remove these limitations by developing and assessing new high-temperature low-loss, recyclable polymeric materials, evaluating their performance in cable designs and by developing and applying a whole-life assessment tool to quantify the whole life benefits.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £23k
External £4k
Total £27k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £35k
External £151k
Total £186k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£278k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The project addresses a new generation of polymeric high voltage cables with higher thermal rating performance than conventional polymeric cables for medium and high voltage applications. It addresses development of the materials and model cables and life cycle economic-environmental tools which account for the full life cycle performance including cable deployment and operation.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9</td><td>-2</td><td>11</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This project contains an element of basic research which involves the development of thermoplastic materials having low electrical losses, high thermo-mechanical stability and good voltage endurance characteristics require for high voltage (HV) cable operation. The immediate market opportunity relates to the HV power cable market in the UK, Europe and globally. .However, the application of the materials technologies developed is expected to extend to the global medium voltage (MV) cable market and beyond.

The proposed new generation of polymeric power cables will address the large and growing HV and MV power utility and distribution markets in the UK, Europe and the rest of the world. It will also address the largely MV cable requirements of large energy users such as metal processors and the chemical and petrochemical industries all of whom have aging power systems in addition to new plant requirements both on shore and off shore. The utility market is driven by new power systems in developed countries including the UK.

Western Europe including the UK have the greatest forecast growth rates for MV cable deployment, with HV cables second, both in the range 2 to 3% p.a. in contrast to Eastern Europe which has a forecast rate of 5% p.a. for MV cables and 7% p.a. for HV cables.</td></tr>
</table>

	This initial project is strategic for National Grid with benefits likely to accrue in the long term. Over the coming 5 years National Grid is to invest £750 million per annum in the electricity infrastructure of England and Wales. This investment is based on both growing demand and the need to replace high voltage equipment at the end of its life. The need for investment will likely continue at this level well beyond the current Ofgem price review period. Of the total, £500million will be invested in cable related projects. This situation is not unique to the UK, with networks across Europe all experiencing the same drivers to invest in new cables to reinforce the electricity supply infrastructure in major cities.		
Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£768k
Potential for achieving expected benefits	Successful evaluation of the both the first and second thermoplastic blend based minicables have shown that the both cable significantly outperforms existing cable materials technologies based on XLPE. The second blend materials formulation has been shown to provide even higher performance thermally, electrically and mechanically. Both variants of the new generation of polymeric materials meet the higher cable operating temperatures which are the goal of the project. Thermal rating and system studies have advanced significantly and the life cycle assessment model has been completed to evaluate the operational and whole life benefits of these new cable materials technologies. These show that the greatest benefits are associated manufacturing energy and process cost reduction and in operation with emergency ratings which far exceed those of existing cable technology. The project has concluded and it has achieved all of the original project objectives and exceeded them in regard to the very high electrical performance that has been found. The expected benefits are very high and may exceed the original expectations although there is some project risk/uncertainty if distribution companies and suppliers do not get involved in the next stage of the project.		
Project progress **[Year to End of March 2011]**	In the work to date, two strong candidate polymeric materials have been identified and variants produced and measured showing that they meet the original objectives for the materials. The first minicable based on the first formulation has also met expectations and the second minicable based on the second formulation has also exceeded expectations. The first materials formulation is the subject of a patent application and the second formulation is at the invention disclosure stage. Some delays occurred in compounding the materials for cable manufacture and this led to a request being made to the TSB for a 6 month extension of the project. This has been approved and the project was completed at the end of December 2010 with full reporting completed by the end of January 2011. This includes 2 TSB Case Studies reports. Also, 6 conference papers based on this work will also be presented at major international conferences during 2011. Journal publications are also planned. In parallel with the materials developments, the thermal rating studies have been completed for cables deployed in underground and tunnel environments. These have shown that the greatest benefits are achieved for emergency rating conditions which are significantly higher than conventional cables. The rating models used have also generated new understanding of the thermal limits of underground systems which are strongly influenced by ground drying and in cable tunnels by acceptable maximum air cooling speeds. This has highlighted the potential to introduce water pipe cooling to further extend operational performance. The completed life cycle model, including an active interface with existing LCA		

	databases, has been used to assess the manufacturing phase of HV cables and the deployment of the cable system in a variety of cable tunnel, cable trough and underground deployments. This has included the assessment of the impact of cable system losses and embedded carbon on the overall environmental performance of the cable system. This has shown that there are significant manufacturing benefits arising from lower energy use during the production of the cables. Transmission network system constraints and deployment opportunities relevant to the new cable technology have also been defined and a series of deployment and operating profiles defined to enable further life cycle modelling of the cable during the operational phase in addition to end of life management, including recycling. Significant interest continues to be shown in the project in the UK and internationally and a new consortium of companies has been formed, including cable manufacturers, to undertake the next phase of development which will design and produce prototype MV cables and establish designs for HV and EHV cables.
Collaborative partners	
R&D providers	GnoSys, Dow Chemicals, University of Southampton.

Materials

<table>
<tr><td>Project title</td><td colspan="3">Bolney 400kV MSCDN insulation co-ordination studies and measurements</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Mark Osborne</td></tr>
<tr><td>Description of project</td><td colspan="3">An investigation into the switching transient voltages / currents occurring in the damping network components of Bolney 400kV MSCDN both by simulation and on site measurement to assist in determination of recent (2004 and 2007) catastrophic component failures.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £37k
Total £40k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£40k</td><td>Projected 2011/12 costs for national Grid</td><td>£0k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Air-cored reactors are used extensively in Reactive Compensation equipment and HVDC converter stations. National Grid has only one Type Registered supplier of air-cored reactors, Trench. The majority of the reactors used by National Grid have been manufactured at their factory in Toronto, Canada. Various problems have been experienced with Trench reactors in a variety of applications over the last 20 years. In October 2004, one of three air-cored reactors at Bolney 225Mvar, 400kV Mechanically Switched Capacitor Bank (supplied by ABB in 1997) caught fire and was destroyed. The reactor was 7 years old. Although the reactor was shipped back to Canada for investigation, no definite cause for the failure was found. In July 2007, the second of the three reactors also caught fire. This reactor was also shipped back to Canada, along with the third reactor which so far had suffered no damage. Following further investigative work by Trench in June 2008, including repetition of various tests and dissection of these two latter mentioned reactors, some possible conclusions as to their failure mode were identified. However Trench have requested National Grid to investigate the routine switching transient overvoltages / overcurrents occurring in this reactor, both by detailed computer simulation and to compare such results with site measurements. It is proposed that both the required simulation and measurements are performed by the High Voltage Energy Systems Group at Cardiff University.</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>8</td><td>-1</td><td>9</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">For the Bolney MSCDN it will confirm or otherwise whether the replacement reactors installed following the two recent failures are adequately specified in terms of their insulation characteristics and / or whether changes in associated surge arrester characteristics are required. The conclusions reached from this study will also determine whether other similar MSCDN installations (eg Willington 400kV MSCDN) are also at risk from premature failure.</td></tr>
</table>

Expected timescale of project	3 years	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£18k
Potential for achieving expected benefits	In terms of the simulation part of the studies the chances of delivering the stated objectives are high, in respect of the site measurements the chances depend on sufficient site resource being available. However this latter requirement has been confirmed subject to timing (it is preferable that this work is carried out during the winter /spring period).		
Project progress **[Year to End of March 2011]**	1- Simulation of switching transients in MSCDN networks: Significant modelling progress was made. The MSDN configuration was simulated including the presence of surge arresters. These simulations have shown that extremely fast transient voltages are developed across the reactor. The detailed modelling of the reactor structure was then undertaken, and a circuit model was developed which accounts for the inter-turn RLC parameters as well as the stray capacitances to ground. By subdividing the reactor height into a number of sections, it was demonstrated that the top coil turns of the reactor experience very high voltages which, in turn, generate excessive electric field stresses on the inter-turn insulation. The combination of high field magnitude and fast rate of rise of voltage constitutes and extreme stress on the inter-turn insulation; this is thought to be the source of degradation for the air cored reactor. The follow-on system voltage application will then cause further damage through thermal effects. This work has led to two generic publications at two international conferences: UPEC 2010 and ISH2011. 2- Transient measurements during switching operations Plans/preparation for Measurement and recording of transient voltages were completed. These will need to be finalised depending on access and space availability. 3- Summary of progress/findings: A mechanism for the failure of air-cored reactors, as used on the 400kV MSCDNs, is proposed and investigated using simulations of the switching operations and a detailed model of the reactor. It is shown that high magnitude voltages with fast rise times are developed across the inter-turn insulation located at the top of the reactor (HV side). Such transient stresses, followed by steady state thermal effects, may initiate the failure process in the reactors as experienced in the field. The next stage of the project is to conduct transient measurements on in-service reactors during switching operations.		
Collaborative partners	None		
R&D provider	Cardiff University		

<table>
<tr><td>Project title</td><td colspan="4">Investigation into the performance of a nano coating for High Voltage substation insulation</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Tony Westmorland</td></tr>
<tr><td>Description of project</td><td colspan="4">To evaluate the electrical and pollution performance of a nano coating, Voltshield, manufactured by RITEC International ltd, for application to substation ceramic insulator systems (such as CT & VT weather shields, circuit breaker bushings, substation post insulators etc.)

To understand the life expectancy of the product.

To understand the application issues of the product.

To provide an alternative solution to grease/washing of insulators to manage pollution related flashovers.

To estimate the comparative costs of greasing and/or live washing systems and the application of Voltshield as an alternative, through the case study of a site/location.

To identify a suitable site and apply the first application (trial) of the product.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £6k
External £0k
Total £6k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £5k
External £73k
Total £78k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£88k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£4k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Pollution performance of substation insulators</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Tech Transfer</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>13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Successful completion of the project will;
• Remove the need to regularly remove old grease and apply fresh grease to insulator systems at defined substations.
• Remove the need for/reduce the frequency of live washing systems at defined substations.
• Make on going Opex savings associated with the above tasks.
• Provide an alternative to greasing/ washing to reduce pollution related flash overs.

To remove and reapply grease to a 275kV post insulator costs on average £233. By comparison, cleaning and applying Volt-shield to a 400kV post insulator costs approximately £100. These costs only include labour and product and do not take access and site engineer costs into consideration as these costs should be the same for both applications. In conclusion Volt-shield will enable National Grid to save up to 57% per insulator on product and labour. Based on an estimate of 50 sites with 200 insulators per site should reduce the cost by £1.3m over 6 years.</td></tr>
</table>

Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£10k
Potential for achieving expected benefits	The first phase has been completed successfully and confidence is high that the expected benefits can be achieved.		
Project progress **[Year to End of March 2011]**	Salt Fog testing of insulators treated with Voltshield has been completed. The tests successfully demonstrated that Voltshield significantly improves the pollution performance of ceramic insulators and would be a viable alternative to greasing and washing. The second phase of the project to determine the life expectancy of the treatment has been significantly delayed. On further discussion with the coating supplier and the testing agency, it now appears that the proposed environmental test specification is too severe and would not produce realistic results. It has been decided therefore to seek guidance on the testing with an external consultancy before proceeding further. Once a suitable specification is agreed testing will commence. Until this is resolved, it is not possible to give any accurate dates but it is hoped that the project can be completed by the end of 2011.		
Collaborative partners	N/A		
R&D provider	RITEC for coating FGH Test Lab for Pollution and Electrical Testing Cardiff University for Accelerated Environmental test		

<table>
<tr><td>Project title</td><td colspan="4">Development and Approval of 190KN Extra Creepage Length (ECL) Suspension and Tension Insulators</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Martin Wilson</td></tr>
<tr><td>Description of project</td><td colspan="4">To design and develop a fully type registered suspension and tension extra creepage length insulator to conform to TS 3.4.17. This will offer an alternative insulator for areas of high industrial or salt pollution on L2/U routes where the nominal size of insulator is 190kN.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £2K
External £39k
Total £41K</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 + [company])</td><td>£43k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£1k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">L2 towers are designed to operate at 275kV but have been uprated to operate at 400kV, in order to do this the insulator strings are shorter than L6 towers in order to maintain clearances and the creepage is little above the minimum required by the current National Grid Technical Specification 3.4.1. ECL units offer an increased creepage distance without increasing the string length. National Grid does not currently have an extra creepage length insulator approved to the Technical Specification. Policy Statement PS (T) 80 states that ‘In coastal areas and/or areas of high pollution ceramic ECL insulators shall be deployed’. In the past this policy has not been adhered to and the only solution has been to use insulators that have been dipped in a coating which bonds to the surface of the unit to assist the run off of rain and pollution through natural washing, It is unlikely that this application will be suitable for prolonged use in dry wind blown areas such as coastal zones.

National Grid currently has approximately 530 L2 structures that are within 5km of the coast or estuaries.</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>15</td><td>-3</td><td>18</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Reduced risk of flashover on coastal routes due to pollution, Many of the nuclear generation sites are in coastal locations and faults and short notice outages incur high constraint costs. Approval of the insulator will add an alternative solution to the components available to MDE and also allow National Grid to conform to current OHL policy. Traditional cap and pin ceramic insulators are given a life of forty years and the ECL unit shall be designed to offer a similar lifetime, It is accepted that standard insulators in high pollution areas have a reduced life of around ten years, use of an ECL unit will help bring the expected life of the unit to a lifetime in excess of thirty years. An added benefit may be to use this insulator to clear ground infringements and therefore minimising the duration of outages and the risk to National Grid when employing current methods of overtension works.

The cost of an ECL unit is expected to be around 60% more than a standard unit, this will be offset by the fact that insulator replacement works every ten years will not be required. ECL unit will cost £29, there are 1920 ECL units used over a span of 10 towers costing £56K in comparison to standard units costing £35K this is an extra expense of £21K per span of 10 towers. An initial stock of 4000 will be purchased to have readily available spares others will be</td></tr>
</table>

	ordered for when the outage plan requires them. Each time a span of 10 towers of insulators is changed the costs are estimated at around £280 – £300K for OMGS and labour, this will be saved twice over as the replacements should no longer happen every 10 years but once every 30 years. National Grid is unique within the electricity supply industry (ESI) with regard to the enhanced specifications it operates and many of the other utilities within the ESI do not accept the need for the enhanced specifications and policies, With this in mind none of the current insulator manufacturers have the demand from the worldwide market to enable them to justify funding the development of these units; if National Grid wishes to procure these then funding will have to be made available for this design of insulator.		
Expected timescale of project	1 year	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£6k
Potential for achieving expected benefits	Dalian is a recognized manufacturer in the insulator market, the tension insulator will require little in the way of changes to the current design. The main concerns that they have are over the electrical stresses present around the cap of the suspension unit but are confidant they can work a design around this issue and produce a product that will meet all the TR requirements. This project should be authorised to fund four attempts at getting the correct design with regular reviews after each attempt in order to maintain control of the direction the project takes		
Project progress **[Year to End of March 2011]**	2010 – 2011 Dalian have produced and tested a number of different options but to date have not been able to pass the 'Steep-fronted Wave Test' as required by TS 3.04.04 This issue has been discussed with ENI Asset Policy and it has been agreed that a derogation may be given to allow a lower pass criteria. Mosdorfer have been tasked with defining the values that Dalian believe the insulator will pass, this will then be discussed in more detail with Asset Policy to agree the derogation. To date Mosdorfer have not been able to identify the figure at which Dalian believe the insulator will pass. Further discussions have been held with Mosdorfer and we are currently awaiting their response.		
Collaborative partners			
R&D provider			

<table>
<tr><td>Project title</td><td colspan="3">Polymeric Insulation - Evaluation</td></tr>
<tr><td>Project Engineer</td><td colspan="3">John Fitch</td></tr>
<tr><td>Description of project</td><td colspan="3">This R&D Project aims to gain an understanding of the technical performance and market experience of the material compounds available, preferred manufacturing process and optimum choice of shed profiles for polymeric insulation systems. This will enable clear policy and specifications to be established for the future application of polymeric insulation in substation applications such as Instrument Transformers. This will form part of the risk management process for the introduction of this new technology into replacement and new build substation projects.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3K
External £10K
Total £13K</td><td>Expenditure in previous (IFI) financial years</td><td>£0k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£51K</td><td>Projected 2010/11 costs for national Grid</td><td>£38K</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Traditionally ceramic insulation has been used for all substation devices required to provide HV conductor to ground insulation clearance. Examples are CTs, VTs, Bushings and Post Insulators which use a special shed profile to optimise on size, strength, creepage and provide weather and pollution resilience. This technology is well proven, reliable with a predictable life and has been used for over 50 years. However these devices can fail catastrophically and unexpectedly and cause serious injury and collateral damage to other plant and equipment. In addition they are heavy and susceptible to damage during manufacture, transport and installation phases and require larger civil foundations and structures to support them than those made from lighter materials.

Polymeric insulation is now a viable alternative to ceramic insulation and there is growing adoption and experience in other utilities. However there are a number of choices on the market, particularly relating to material, shed profile and manufacturing processes. There is also uncertainty over the mechanical strength, proven life, maintenance needs and performance over time.

This project will engage NAREC (NDSL) to carry out a technical survey, evaluate and report on the choices available and provide recommendations for optimum selection. This will enable National Grid to risk manage the introduction of polymeric insulation into main projects. This work will also include a market study to examine the worldwide experience of major utilities in the use or trial of polymeric insulators on post type current transformers in substation applications.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>-1</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">The output from this project will enable policy and specifications (based on IEC standards) to be established for the future procurement of polymeric insulation in devices, initially post CTs (e.g. FMJL replacement).

The benefits will include the following: -
• Non explosive – safer in service for people and adjacent plant
• Lighter devices – reducing the need for machines and man handling</td></tr>
</table>

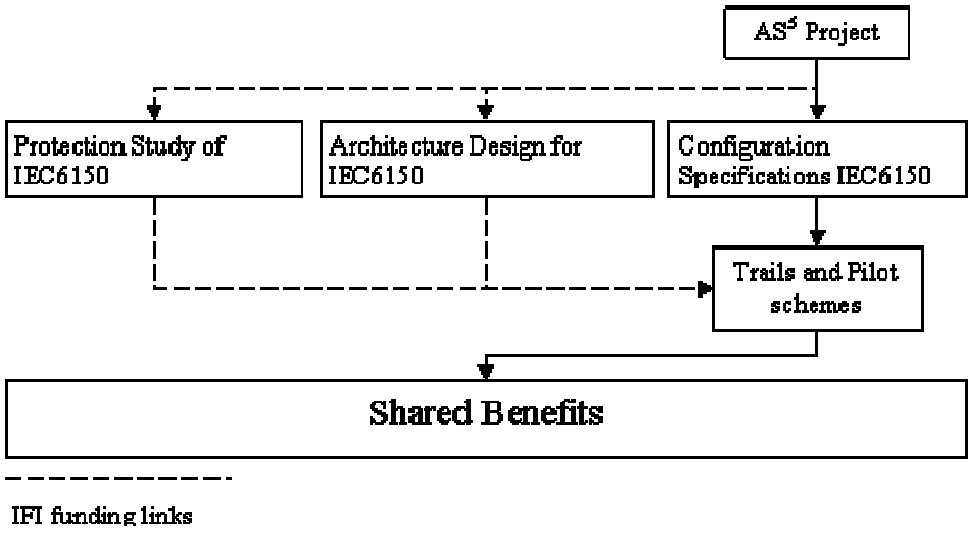
	requirements • More robust – less likely to damage, reduce wastage • Sustainability– potential to reduce the carbon costs due to material extraction, manufacture and transport • Standardised approach – reduce range of spares • Disposal and environmental impact – to be determined • Compact – reduced installation foot print and smaller supporting structures/		
Expected timescale of project	2 year	**Duration of benefit once achieved**	5 years
Probability of success	95%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£45K
Potential for achieving expected benefits	This project will engage NAREC (NDSL) to produce a market survey, evaluation and recommendations of the optimum choices for polymeric insulation for application by National Grid and has a high likelihood of success.		
Project progress **[Year to End of March 2011]**	Work has started on this project and the initial results are proving promising from discussions however there are no deliverables to note at this time.		
Collaborative partners			
R&D provider	NAREC (NDSL)		

Project title	**Long term performance of silicone based composite Insulators**			
Project Engineer	Boud Boumecid			
Description of project	The key objective of this project is to advance the ageing model for composite insulators in order to maximise the return on previous research work in identifying and managing any risks associated with their use on the National Grid electricity transmission system			
Expenditure for financial year	Internal £4k External £70k Total £74k	**Expenditure in previous (IFI) financial years**	Internal £10k External £247k Total £257k	
Total project costs (collaborative + external + [company])	£409k	**Projected [next year] costs for [company]**	£26k	
Technological area and/or issue addressed by project	Overhead line insulation systems/asset management implications of using new technology (principally life expectancy and associated ageing mechanisms).			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		12	3	9
Expected benefits of project	The further development of the ageing model will provide National Grid with an asset management tool that enables cost-effective management of composite insulators used on the transmission network. This could lead to significant mid-life refurbishment savings, improved health and safety performance and improved grantor relations. Furthermore, composite insulators are proving to provide better pollution performance than ceramic insulators with a resultant increase in network reliability.			
Expected timescale of project	7 years	**Duration of benefit once achieved**	Ongoing	
Probability of success	60 %	**Project NPV = (PV benefits – PV costs) x probability of success**	-£356k	
Potential for achieving expected benefits	Based on the research studies carried out to date, including the fundamental study of the nature of low current discharges on surface insulation, allowing a better understanding of the low level long term damage caused during the service life of insulators. Also, the work funded by Scottish and Southern Energy on some ex-service insulators has been fed into this project and enabled study of insulators with more advanced ageing. This has shown the importance of the geography of installations and also, because of particular physical features of the insulators, the way in which water movement controls discharge and biofilm development. The above work has favourably contributed to the increased confidence and high potential in achieving the expected benefits.			
Project progress **[Year to End of March**	Two models have been built and published which show the energy developed in low current arcs on the surface of insulators. It is the energy from these arcs which leads to long term damage of polymeric insulator surfaces. In particular			

2011]	these models show the importance of water movement on the surfaces, a feature not recognised previously and also the change in energy as a discharge develops into an arc and is eventually extinguished. The key challenge now is to understand better the transfer of energy from the arc to the surface of the material. We are developing experimental techniques to measure the temperature of the non-equilibrium arcs (i.e. the electronic temperature is higher than the gas temperature) using spectroscopy. This is in collaboration with the University's School of Chemistry. The generalised asset management tool generated within the Supergen Amperes Consortium has been specialised for overhead line insulation management, and this will also be published externally shortly. The work has also been used to support the development of the Composite Cross Arm technology.
Collaborative partners	National Grid is currently exploring possible collaborative funding of this project with Scottish Power and Scottish and Southern Energy. Should they agree to support this project it is anticipated that the funding split would be 80%/10%/10% National Grid, Scottish Power and Scottish and Southern respectively.
R&D provider	The University of Manchester

Protection

Project title	**Architecture for Substation Secondary System (AS3) Project**			
Project Engineer	Ray Zhang			
Description of project	To develop knowledge to enable a new policy for substation light current systems aimed at maintaining high availability and reliability of the transmission network by balancing the whole life-cycle risk, performance and cost of assets. To develop a new architecture for substation secondary system by introducing new technologies, targeting on a quicker and easier approach for the installation and replacement of protection and control equipment beyond 2011. **Review of current policy and practice** To identity and understand the whole life cycle issues for the existing protection and control systems. **Strategy document for substation secondary systems** To develop a road map to show the strategy for the application of protection and control new technology in the short, medium and long term. **Feasibility Study** • To investigate new technologies • To collaborate with major suppliers/Alliances to share information. • To standardise Substation primary and secondary system interface • To benchmark with leading utilities. **Trials and Pilot schemes** • To try the new approach in parallel with existing systems with outputs disabled -"Piggy-back" trials • To apply the new approach to some real projects as pilot schemes (Min 2) **New Policy** • To develop a new policy for the substation secondary system, • To develop associated technical specifications.			
Expenditure for financial year	Internal £36k External £295k Total £331k	**Expenditure in previous (IFI) financial years**	Internal £121k External £240k Total £361k	
Total project costs (collaborative + external + [company])	£692k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	A new architecture for substation secondary systems/substation light current systems.			
Type(s) of innovation	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**

involved		10	3	7
Expected benefits of project	This project (AS3) is to identify and understand the potential benefits and risks associated with designing and implementing new substation secondary system architecture. It will do this by deploying new technology/developments such as standard interface modules, bay process bus and IEC61850 communication protocol. It is important the National Grid take a leading role in this area so we can provide manufacturers with specification as to what is needed rather than being led into this system by the manufacturers. AS3 has linked IFI projects that contribute to the overall shared benefits of the project increasing the likelihood of success as the project progresses as shown below.  The benefits expected from this project will not be appreciated until the AS3 system has been implemented. The full benefit of the project will only be seen when all AS3 systems have gone through a complete life cycle estimated to be roughly 20 years. This project will investigate the possibility of this new architecture which will have a long lasting interface to the primary plant, which should not have to be altered or replaced should the secondary systems need to be replaced. This project is investigating the feasibility of achieving whole life cycle benefits, so that the asset life of light current system in a substation can be optimised. The project will investigate benefits in the following areas: • The design and development potentially can be standardised at all levels (station, bay and interfaces) within a substation. This will allow proven solutions be used repeatedly for different projects/sites, thus the project risks and resources will be minimised saving time and money. • The installation and commissioning will be much safer and quicker than traditional approaches. The “plug and play” will be possible for the installation and replacement due to use of IEC61850 based fibre optical bus and standardised interfaces. Therefore the required outages of primary system will be significantly reduced ensuring availability is maintained. Safety, health and environment are improved by reducing the need for cross-site secondary circuit cabling migrating associated risks. • The operation and maintenance could greatly benefit from the new approach. Full deployment of digital technology and removal of copper wirings should make the operation of the secondary system more reliable as faults can be more easily recognised and replaced. This would also challenge the traditional concept/requirements for maintenance. The new technology will enhance functions such as condition monitoring and remote			

	access, which should further improve the operation and maintenance by providing real time information to enable the operator to take the best-informed action. Also this process will be safer as the new secondary systems transmit data of CT and VT analogue signals via bay process bus. This poses no safety risks of opening CT circuits, and hence improving the safety when the protection replacement is carried out with primary circuit in service. • The replacement and de-commissioning can be achieved in a quick "plug and play" manner. Components used will no longer be limited to a specific manufacturer due to Inter-operability/Inter-changeability facilitated by the IEC61850 protocol. This will significantly reduce the requirements and costs for the Post Delivery Support Agreement (PDSA). By enabling any unit to be replaced by any other IEC61850 machine therefore not tying National Grid into uncompetitive PDSA's The new technology using IEC 61850 communication protocol will enable vendor interoperability and easier modification and extension of the secondary schemes, particularly allowing reconfiguration and feature enhancement by software means, rather than the modification of hardwiring as would have been the case in the past. • The fully digitised fibre optical architecture will also form an additional "isolation layer" for the electromagnetic noises from primary system. This will significantly improve the reliability of secondary systems and consequently reduce the requirements for the costly Electro-Magnetic Compatibility (EMC) for the protection and control devices. A similar pilot scheme by GE has reported potential savings of 25% in the installation of secondary systems using a plug in and play system of installation. Estimating a saving of approximately £50K (5%) per substation with AS3 implemented. With an expected roll out rate of approximately 50% of substations refurbished or newly built to have AS3 each year. Making a total saving of approximately £500K per year.		
Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£19k
Potential for achieving expected benefits	Technically, it has a good potential to achieve expected benefits as • International committees such as IEC and CIGRE have set up working groups to carry out studies on relevant technical subjects; some standards and application guides have been published. National Grid is participating most of the working groups directly or indirectly. • All the major suppliers have been working in this area for more than 10 years, product prototypes are being produced and tried. Some trials and pilot schemes with leading suppliers are planned within this project. • Some leading utilities such RWE, Tennet have started some pilot schemes. Benchmark with those utilities is one of the key feasibility studies within this project. • This project is governed and managed with a hierarchical structure including a sponsor, project board, project manager and working groups, to ensure that all the planned activities will be properly delivered. However due to market readiness and resource seconded to support System Strategy (ENSG Vision 2020), it is expected that the AS3 project will be delayed for a period of 12-18 months		

Project progress **[Year to End of March 2011]**	• The project continued to progress well in the first half of the 2nd year, and some key deliverables were successfully completed. However with consideration of the market readiness and urgent resource needs to support System Strategy (ENSG Vision 2020), the AS3 project has been consolidated into 4 work streams (WS) from 09/2009 to 04/2010, consequently the key deliverables have been re-focused on: • WS1: R&D project for AS3 Architecture & Reliability analysis • WS2: R&D project for Protection Performance Study with AS3 architecture, • WS3: IEC61850 Configuration Guideline/Merging Unit Guideline • WS4: Siemens Process bus trial at Radcliff substation with Switchbox (SB) development. With the revised programme, it is expected that AS3 project will be delayed for 12 – 18 months. The progress to date of all the planned activities under original 5 key deliverables are: **1. Review of current policy and practice** AS3 Working Group 1 has successfully completed this key deliverable. Seminars and workshops were held with NG internal departments and external suppliers to identify the whole life-cycle issues regarding protection and control systems. Some high level policy and specifications were also reviewed. **2. Strategy for the development of substation secondary systems** Strategy Document SD(T)012 has been produced by AS3 Working Group 2. This document specifies the strategy (road map) for the application of new technology in the development of the substation secondary system in the short, medium and long term. **3. Feasibility Studies** The draft documents for Testing & commissioning philosophy and Scheme Implementation Strategy have been produced by WG8 and WG3 respectively. And a high level specification for Switch Box was drafted by Safety & Operation working group (WG9). **WS1: AS3 Architecture & Reliability analysis,** Produced proposal for the optimal AS3 architectures Developed methodology for reliability/cost analysis to identify optimal architectures Establishing testing facilities for the IEC61850 9-2 process bus products For the detailed progress of WS1, see separate IFI annual report for “TAOOL146 AMRDE1044 10-11 Evaluation of process bus…” **WS2: Protection performance study** All the planned activities within WS2 are under R&D project “the Protection Performance Study with AS3 architecture”. The project is co-founded by Areva which jointly delivering some process bus systems/equipment with University of Manchester and bath for the testing. For the detailed progress, see separate IFI annual report for TAO/20627 the Protection Performance Study with AS3 architecture. 3.2. WS3 has finalised the draft document “IEC61850 Configuration Guideline” with participation and contribution from all NG alliances/suppliers. Using the same set-up, the working group was also assigned with a new task to explore the requirement for the merging units to meet the needs for all the protection and control functions/devices on the process bus as well as their interoperability and interchange ability. A “Merging Unit guideline” has been successfully drafted by the Working Group, which has also been forwarded to IEC TC38 as a reference for developing international standards.

3.3 AS a UK regular member, National Grid participates the following CIGRE working groups which are directly beneficial to this project

- B3-10 Primary / Secondary system interface modelling (Standardisation I/O signals), which is in the final stage of preparing a technical brochure.
- B5-27 Implications and Benefits of Standardised Protection Schemes
- B5-24 Protection Requirements on Transient Response of Voltage and Current Digital Acquisition Chain

3.4. Benchmark took place with Tenet (Dutch) and RWE (German) for their pilot projects using Locamation and Siemens systems respectively.

4. Trials and Pilot Schemes

Dedicated working groups were set up with Areva/SE alliance, ABB/central alliance, Mitsubishi/SW alliance, Siemens/North alliance, to pursue the collaborations and "Piggy-back" trials.

Linked to WS2, Areva is upgrading their existing trial at NG Osbaldwick substation to further develop it into a feeder bay trial with the AS3 Architecture

Under WS4, Siemens has installed and commissioned a Process bus trial with "conceptual units" of Switchbox (SB) at NG Radcliff substation. This WS is aimed to

- Finalise Technical specification for the Switchbox
- Examine the philosophy for installation, tests & commission
- Trial with Siemens process bus technology at Radcliff substation

Now all the planned activities under WS4 have been completed. Siemens has produced a final report to summarise the experiences/results from the site trial. The Switch Box Technical Specification TS 3.24.89 and Technical Guidance Note TGN (E) 241 have also been drafted for final approval.

5. New Policy Statement and Associated Engineering Documents

Some high level strategy analyses have been performed on the management of technologies, risk assessment, long term costs/benefits. A business case interim report has been produced to summarise the study result to date.

Based on the first two year's project progress as well as the development of IEC61850 technology and NG internal business, a strategic direction paper of the AS3 project was produced and approved by the project board to

- summarise the achievement to date,
- identify some earlier applications/benefits,
- confirm the further developments:

ACHIEVEMENTS TO DATE:

Policy & Practice Review

SD(T) 012 Strategy Document for Substation Secondary Systems

AS3 Generic Architecture – 4 key elements identified

IEC61850 NG configuration Guideline (final draft)

IEC61850 Merging Unit (MU) Guideline (draft)

Strategy for AS3 Scheme Implementation (draft)

Philosophy for AS3 installation, testing & commission (draft)

Switch Box TS 3.24.89 and TGN(E) 241(draft)

Cigre B3-10 "interface model" Brochure (standard I/Os, primary)

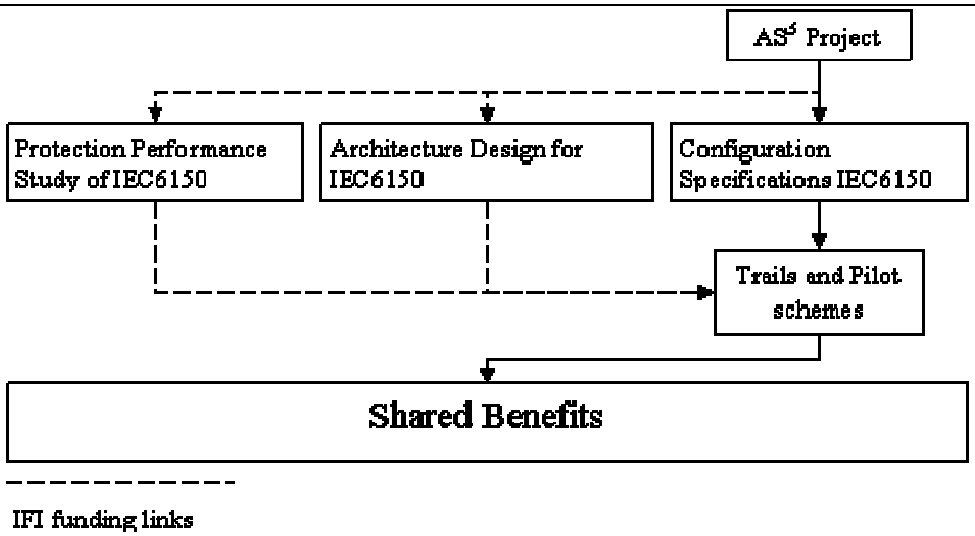
AS3 "Business Case" Interim Report

Areva feeder unit protection trial at Osbaldwich Substation

	Siemens' trial (process bus + Switch box) at Radcliffe Substation **STRATEGIC DIRECTIONS** The key drivers and business needs for AS3 project have not changed. The 4 key elements based AS3 Architecture will provide a sustainable solution to the whole life cycle of light current assets, which can be implemented in stage approach: IEC61850 station bus o Ready for single vender applications, o Need pilot schemes for vender interoperability using the NG IEC61850 configuration specification(draft) Standard Bay Solutions(SBS) remain largely the same as SICAP Switch box for the I/O interface should be deployed as soon as practically possible o Technical Specification finalised, low risks o "Quick-win" benefits both SICAP and future AS3 architecture o covers all application scenarios-current, future & changeover Further R&D: IEC61850 Process Bus o MU Specification (draft) to be finalised o Hybrid technology for feeder bay solution (one end process bus and other ends conventional), a potential replacement scenario. o I/O standardisation (P&C alarms and events)
Collaborative partners	A potential collaboration with NGUS and PG&E from the west coast of US are under discussion/preparation.
R&D provider	ABB, Areva, Mitsubishi, Siemens, Univ. of Manchester, Univ. of Bath

<table>
<tr><td>Project title</td><td colspan="4">Protection Performance Study for IEC61850 Process Bus Architecture of Substation Secondary Systems (AS3)</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Wen An</td></tr>
<tr><td>Description of project</td><td colspan="4">Maximising economic and effective utilisation of the transmission asset and network is the key objective. The deployment of the technology advocated for this IFI project will allow ongoing substation secondary equipment retrofitting (refurbishment) projects to proceed whilst limiting the duration and frequency of circuit outages, required to facilitate the work. Once the new technology is installed, secondary equipment renewals occurring mid-life in the primary plant lifecycle can be undertaken in a safer, quicker and easier way with much reduced outages of primary systems. At any time, secondary system upgrades and modifications can be undertaken without a primary circuit outage. This will also significantly reduce the outage period required for substation extensions.

In order to pursue this strategy, sufficient confidence must be demonstrated in the philosophy and the new technology, hence the need for the IFI research. The work is thus strategic, aligned to the AS3 project and is designed to understand the impact of the emerging technology of process bus architecture on the performance of protection and control equipments.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £7k
External £76k
Total £83k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £21k
External £98k
Total £119k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£396k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£54k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The key objective of this project is to investigate, quantify and optimise the level of security, dependability and operating speed in secondary schemes using IEC 61850. As a precursor to wide deployment of the philosophy in AS3 project, it must be ensured that the performance of the protection and control scheme meets or exceeds that of its hardwired predecessors.</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>2</td><td>6</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This project is linked to the AS3 project contributing to increased likelihood of success of the project and therefore has shared benefits with AS3.</td></tr>
</table>



The separate business benefits of the project are:

Understanding the impact of emerging technologies on the future protection and control systems to support National Grid's decision-making.

Taking full advantage of the emerging technologies while identifying and minimising potential risks. Providing a proper basis for the development of future protection systems based on the experience of the protection schemes being studied. Less site commissioning required for the new protection systems. Most of the tests can be carried out in factory by software simulation using the IEC61850 process bus. Much reduced outage required for the future replacement of the new protection and control equipments. Maximising economic and effective utilisation of the transmission asset and network.

Safety, health and the environment is improved by reducing the need for cross-site secondary circuit cabling, mitigating the associated risks.

Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£219k
Potential for achieving expected benefits	Following the literature survey and evaluation of possible topologies for bay process bus and station bus architectures, it became apparent that current 100 Mb Ethernet switches and Merging Unit (MU) limit the number of MUs on a process bus to a maximum number of 8 units. This limitation may restrict the application of the IEC61850 architecture depending on the size of a substation. It is anticipated that 1Gb switches and MU will be developed by manufacturers, the full benefits of the project can then be achieved when the 1 Gb units are available. The test on the feeder bay using different manufacturer's merging units revealed some compatibility issues. The test results obtained so far indicate that with current prototype of merging units, the IEC61850 system has some reliability issues, however when manufacturers fully develop their products say in 2 ~ 3 years, the reliability will be improved and the process bus of sampled values can then be implemented.		

Project progress **[Year to End of March 2011]**	The project started in Jan 09, during the first three months, literature survey of the IEC61850 process bus architecture and its impacts on protection performance have been completed. The trial topologies to interconnect the protection relays have been established. The protection panels have been built and delivered to University of Manchester for testing. Relay firmware has been updated. Initial tests on relays using simulation software of IEC61850 data have been completed. Test bench using Omicron test sets has been set up and relays were configured for the stage 1 testing. Full stage 1 tests have been completed and have highlighted complications with the merging units. Both the feeder protection and the transformer protection schemes have been tested and reports submitted. These have confirmed the correct operation of these units. Simulation studies have examined the characteristics of the main variants for the process bus topologies and these have been supported by practical implementations. Based on these and practical considerations of the operation objectives of using the IEC61850 system, Star configurations have been chosen for the process buses. Having developed simulation models of the process bus structures, initial studies have been undertaken on the possible failure modes of the IEC 61850 based communications. It has been generally confirmed that the current 100MB communications will handle the communications requirements of the scheme being examined. Further analysis is in progress, using probabilistic studies to better define the 'safety margins' and predict where data congestions may occur and their consequences. The feeder protection panels will soon be moved to Bath, where the RTDS system will facilitate extensive tests on the protection scheme. Several papers have been presented in support of this study.
Collaborative partners	Areva, Scottish Power, Scottish & Southern Energy
R&D provider	University of Manchester, University of Bath

<table>
<tr><td>Project title</td><td colspan="4">Impact of extending operational lifetimes of electromechanical relays</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Wen An</td></tr>
<tr><td>Description of project</td><td colspan="4">To ascertain through detailed scientific analysis and testing, the period of time for which certain models of electromechanical protection relays can remain in operation on the GB Transmission System.

To determine the effects (if any) that the operational lifetime of the electromechanical protection relays has had on the mechanical reliability and anticipated design life of the units.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £6k
External £97k
Total £103k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £7k
External £38k
Total £45k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£196k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£48k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The results of this investigative analysis will feed back into Scheme 15328 – Control & Protection infrastructure replacement scheme.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>12</td><td>-1</td><td>13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">By accurately determining the length of time for which electromechanical protection relays can reliably remain in operation on the GB Transmission system, the financial elements linked to the various replacement options can be deferred to a later date – allowing greater flexibility in the asset investment process.

Examples of these financial elements include;
• Decommissioning & removal costs of the electromechanical protection relays.
• Purchase costs of the replacement protection relays.
• Associated PDSA (Post Delivery Support Agreements) for the replacement NICAP solution
• Installation & Commissioning costs of the replacement protections.

For a typical double busbar substation, the cost of installing a NICAP solution is in the order of £3m - £4m (including protection changes at the remote ends of the circuits).

It is anticipated that significant cost savings will be achieved from the additional flexibility this testing will provide for the asset investment process.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td colspan="2">Duration of benefit once achieved</td><td>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>£239k</td></tr>
</table>

Potential for achieving expected benefits	The project approaches the last stage. The electromechanical relays have been tested. Following the recent review meeting, further repetitive operational tests are being added. Test on solid state relays are to start in the 2nd week of June. The project will conclude by the end of November. Results so far indicate that it is possible to achieve the expected benefits.
Project progress **[Year to End of May 2011]**	Electromechanical relay samples have gone through three types of test: • Artificial (accelerated) aging in cyclic temperature chamber to emulate the natural mechanical stresses due to temperature changes; • Artificial (accelerated) aging in gas chamber to emulate the atmospheric corrosion effect; • Repetitive operational test, over 100 times. The main findings are: Temperature cycling has not caused any working relays to fail, suggesting that the inherent mechanical strength is adequate to tolerate the natural and operational stresses for another 40 to 50 years, based on the results on one sample on each type of relays received. The impact of atmospheric corrosion is to deposit material on the metals in the relay. This can cause the relay to fail due to excessive resistance between contacts. However the deposit can be easily removed during maintenance without causing the metals to lose mass. This is due to the anti-corrosive alloy used for the sensitive parts. The deposit has not caused noticeable effects on the mechanical properties of the springs and bearings. National Grid intends to establish a concept about the speed of corrosion development, to guide their maintenance practice. Durham University are aiding in developing the maintenance procedure in light of the findings of the project so far. Durham University would also try to suggest implementable methods to delay and monitor the aging process, e.g. seal replacement.
Collaborative partners	N/A
R&D provider	University of Durham, GL

<table>
<tr><td>Project title</td><td colspan="3">Alternative Bus Bar Protection Solution</td></tr>
<tr><td>Project Engineer</td><td colspan="3">John Fitch</td></tr>
<tr><td>Description of project</td><td colspan="3">This R&D Project aims to deliver an evaluation and desk top design solution of an alternative digital bus bar solution architecture. This will help formulate a future technical and procurement strategy for bus bar protection, potentially leading to a pilot installation, evaluation and deployment as a replacement (or new) bus bar protection system.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £2k
External £0k
Total £2k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £0k
External £0k
Total £0k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£12K</td><td>Projected 2010/11 costs for national Grid</td><td>£11K</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">A policy for single Digital Bus Bar Protection has been employed on the National Grid UK Transmission network since 2002 either as a replacement system (for duplicated high impedance schemes) or for all new build double bus bar substations. These systems have a distributed architecture with remote bay units (interfacing to the plant) for each protected circuit with ruggedized cross site fibre connections to a central processing unit. Where a substation has a centralised relay room (e.g. GIS) layout, the bay units are co-located in a suite of cubicles and connected with a network of fibre patch cords.

A number of systems and versions have been installed from National Grid's preferred protection suppliers and Alliances over the past 20 years and these have required additional support through contracted PDSAs to provide field staff with the resources to manage faults and defects. A recent protection policy change also requires a second (hot standby) central processing unit to be deployed (with it own dedicated fibre connections) to better manage contingency issues for central processing unit failures.

The systems installed to date have proven to be generally reliable; however each system is bespoke to each supplier with a limited technical life, leading to issues with future substation extensions and potentially the need to consider equipment upgrades and early asset replacement of the complete system. This will have major issues on future system access to carry out this work across a complete substation.

Through work with CIGRE, contacts with other utilities and National Grid US, it has been found that an alternative centralised bus bar protection system may offer greater asset management benefits in the longer term, especially when managed and supported by well trained internal staff.

This project is desk top evaluation of an alternative bus bar protection design and the interface and application on the UK Transmission system.</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>6</td><td>-2</td><td>8</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">The output from this project if successful will feed into a second stage project to establish options for a pilot installation.

The benefits will include the following: -

• Development of Bus Bar Protection Strategy and Policy changes</td></tr>
</table>

	• Standardised plant interface and “one off” standard solution • CAPEX savings (reduced equipment costs) • OPEX savings (train internal staff- reduce PDSA) • Extended Asset Life (elimination of short life components e.g. fibres) • Reduced System Access for extensions and future replacement.		
Expected timescale of project	2 year	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£11k
Potential for achieving expected benefits	This project will review designs and products used by other utilities for adoption on the UK Transmission system. The likelihood of success is high.		
Project progress **[Year to End of March 2011]**	Work has started on this project however it was started very late in the financial year and there are no deliverables to note at this time.		
Collaborative partners			
R&D provider	SEL		

<table>
<tr><td>Project title</td><td colspan="4">Evaluation of the performance and application of process bus</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Wen An / Ray Zhang</td></tr>
<tr><td>Description of project</td><td colspan="4">To evaluate the functionality and performance of IEC61850 process bus based architecture for substation secondary systems</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £51k
Total £54k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £16k
External £89k
Total £105k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£194k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">-Process Bus (IEC61850-9-2)
-Protection and Control systems</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9</td><td>-1</td><td>10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">To establish and validate an IEC61850 based architecture and solution that will significantly optimise the life of new and existing secondary system assets and simplify the methodology for its replacement therefore requiring short or no outages leading to cost savings.</td></tr>
<tr><td>Expected timescale of project</td><td>4 years</td><td colspan="2">Duration of benefit once achieved</td><td>40 Years</td></tr>
<tr><td>Probability of success</td><td>% high</td><td colspan="2">Project NPV = (PV benefits – PV costs) x probability of success</td><td>£4k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Potential for achieving the expected benefits is high. The University of Manchester (UoM) has a very experienced team in the area of power system protection and control led by Prof. P Crossley. His team successfully performed the feasibility study for the SICAP policy which has been deployed within National Grid for nearly a decade. This R&D project is directly managed by Dr. Haiyu Li who is specialised in power system protection and communication systems. He has been working on the IEC61850 standard applications for many years. The PhD student, Miss Uzoamaka Anombem, has been working on this project full time for nearly three years.

The project has completed the design of the substation secondary system architectures based on a set of golden rules for substation protection and control. The assessments of the architectures on the typical double busbar and mesh corner substations have been carried out. Results have confirmed that the designed architectures are practical, reliable and flexible which can minimise the outage times during the maintenance and replacement of the secondary protection and control devices.</td></tr>
</table>

Project progress **[Year to End of May 2011]**	This project has been progressing since kick off at the end of 2007. Once the required research staff had been fully employed and functioning, all the planned activities were confirmed on the programme. The project plan and the Gantt Chart were revised. The survey studies as one of the key milestones was completed in December 2008. The survey covers the topics of the IEC61850 standard, existing applications of the protocol for substation protection and control (P&C) systems, and the methodology of reliability analysis for the P&C systems. The 2nd key milestone was completed in September 2009 and the 3rd key milestone was completed in April 2010. These two milestones cover the substation secondary system architectures designs and their optimality based on the analysis of the architecture reliability and life cycle cost. A set of golden rules for substation protection and control has been agreed on by National Grid experts from the fields of protection, control, equipment commissioning/decommissioning, and by relay manufacturers including Alstom Grid, ABB and Siemens. A flexible Standard Interface for the substation Intelligent Electronic Devices (IEDs), compliant with the golden rules, has been proposed. Based on this standard interface, process bus architectures and their applications to both the double busbar and mesh corner substations have been investigated and discussed. The reliability analyses of these architectures have been carried out, and optimal architectures have been proposed. The 4th stage of the project is the assessment of various CTs and VTs Merging Units performance. The design and development of a Merging Unit (MU) test bed is being carried out. This test bed consists of a Real-Time Digital Simulator (for modelling a substation), an Omicron amplifier (for amplifying the substation CT/VT output), a National Instruments Digital Acquisition System (which serves as a reference), an Endace Network Monitoring Card (for real time stamping the digitized CT/VT output from the MU) and a PC, (for analysing captured data). Tests for the following MU characteristics are being carried out: format of the Ethernet Frames transmitted by the MU, (based on the IEC 61850 9-2 “Light Edition” implementation guideline), MU process delay, and the current/voltage recovery error. Interoperability tests for communication between an Alstom Grid relay and merging units from Alstom Grid, Locamation and Mitsubishi respectively have been carried out. 5 research papers have been produced so far. 15 project-meeting reports have also been produced for this project. The project will produce testing results for various CTs and VTs merging unit performance from Asltom Grid, Siemens, Mitsubishi and Locamation. The final report and the workshop for the results dissemination are expected to be completed in September 2011.
Collaborative partners	Scottish Power, Scottish and Southern Electricity
R&D provider	Univ. of Manchester

Transformers

<table>
<tr><td>Project title</td><td colspan="5">Alternative Fluids for Transformers</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Paul Jarman</td></tr>
<tr><td>Description of project</td><td colspan="5">Evaluate alternative fluids to use as an insulating fluid for transformers to determine if they can be used at voltages of interest to National Grid. Specifically to look at one synthetic ester and two natural ester materials. Particular emphasis will be placed on investigating dielectric performance at high voltages. Ideally the project will enable sufficient confidence to be gained to enable a trial of the fluid in an in service transformer (a trial would not be part of this project).</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £7k
External £49k
Total £56k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £7k
External £37k
Total £44k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td colspan="2">£4k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£1k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">Use of sustainable materials for plant and reduction of potential environmental impact on failure.</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>6</td><td>-4</td><td colspan="2">10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">Use of mineral insulating oil as used in existing transformers has potential disadvantages in terms of environmental compatibility, fire safety and sustainability. The use of other fluids particularly vegetable based products could give an alternative which could prove vital if the environmental or supply situation with existing products became unsustainable. The key environmental benefit with vegetable fluid relates to its biodegradability when compared with mineral oil. Some vegetable fluids also have a higher flash point than mineral oil and have a lower energy density when aflame making them beneficial when where fire risk would have significant consequences (e.g. built up areas). In addition, ageing tests conducted by other researchers have reported that for paper impregnated with vegetable fluids, the paper lifetime could be extended. Use of vegetable oil could also contribute positively to the image of the company and more widely the electricity supply industry in adopting sustainable solutions. At the moment vegetable fluids are more expensive than mineral oil but through this project National Grid will be in a position to evaluate how to take forward if the background changes.</td></tr>
<tr><td>Expected timescale of project</td><td colspan="2">4 Years</td><td>Duration of benefit once achieved</td><td colspan="2">5 Years</td></tr>
<tr><td>Probability of success</td><td colspan="2">60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">-£58k</td></tr>
</table>

Potential for achieving expected benefits	Recent results have started to show that ester oils have different behaviour to mineral oil at high voltages in highly divergent electric fields, typical if the situation where partial discharge has been initiated. This would indicate that special precautions would need to be taken in the design of very high voltage transformers for use with ester liquids. This is an important discovery and could avoid significant costs in terms of unexpected failures if the technology was to be adopted.
Project progress **[Year to End of March 2011]**	A very large number of impulse and AC tests on the alternative liquids and mineral oil have been carried out to plan. The experiments on the alternative oils particularly high voltage impulse tests using a high speed camera to observe results have produced some very interesting results. Most low voltage tests have shown little difference between fluids, but higher voltage tests have revealed differences that may be significant in terms of transformer design at 132kV and above. The prospect for using alternative and natural oils is still positive but it is clear the differences need to be understood to avoid costly mistakes. Further experiments have shown that a pressboard surface has little effect on the breakdown properties of alternative oils, but does have some influence on mineral oil.
Collaborative partners	EdF, Areva, EPSRC, M@I Materials, TJH2B Electricity North west, Scottish Power
R&D provider	Manchester University, Leicester University

Project title	**Oil Level Monitor**			
Project Engineer	Graham Moss			
Description of project	This project will develop and trial an oil level monitoring (OLM) system that can be retrofitted to substation plant in non-outage conditions. The trial will be based at the OMU in Thorpe Marsh and involve attaching a sensor to two Transformer Oil storage tanks. By artificially imposing a leak on either or both of the tanks the sensitivity of the monitoring equipment can be evaluated. The effects of environmental changes on Oil Level will also be evaluated.			
Expenditure for financial year	Internal £3k External £12k Total £15k	**Expenditure in previous (IFI) financial years**	Internal £5k External £6k Total £11k	
Total project costs (collaborative + external + [company])	£26k	**Projected 2010/11 costs**	£0	
Technological area and/or issue addressed by project	National Grid owns and operates large items of primary plant that contain large volumes of Oil. The development of low cost adaptable Oil Level monitors to detect leaks would aid the management of leaks on large plant. It would also ensure they are managed in an efficient manner without the need for a reactive use of resources.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		11	-5	16
Expected benefits of project	This development should play a major role in the risk management of oil containment, removing the need for 'bunding' of at least 450 single-phase oil units. An example case presented by Network Design is for a 6 Bay site, and is approximately £350k. This includes 'bunding' interceptors, project management, etc. The estimated cost of an equivalent monitoring system at a 6 bay substation is estimated to be in the region of £37k. This does not include economy of scales given the larger scheme. If the monitoring scheme proves viable, the stated values could contribute to a saving of £7m over a bunded scheme. Fitting Oil Level Monitors to potentially leaking plant would also enable the issue of oil leaks to be managed in a far more efficient manner. Earlier detection would enable faster response and resolution. Evaluating the leak rate would provide a "line of site" that enables resources to be managed in a proactive rather than a reactive manner. Low oil level alarms triggered by cold snaps could also be assessed and evaluated by the OMU without the need for the reactionary use of manpower and resources.			
Expected timescale of project	2 Years	**Duration of benefit once achieved**	Ongoing	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£17k	

Potential for achieving expected benefits	This project is only concerned with the development and trial of an Oil Level Monitoring system. An initial feasibility study conducted by our contractors provides confidence that reductions in Oil Level can be detected to a useful resolution whilst taking into account environmental fluctuations and potential noise.
Project progress **[Year to End of March 2011]**	The trial system has been installed and run at Thorpe Marsh OMU for a 6 month period in which the oil level inside square section oil tanks were monitored to determine the effect of temperature fluctuation and the limit of detection when oil was drained from the tanks periodically. The preliminary results are very encouraging with the detection of as little as ~20lites being visible. The trial on the OMU tanks is now complete and the system is currently being transferred to a 'live' asset (transformer and OCB) to determine the effectiveness of the detection system on a non-linear oil volume. We are also providing additional funding for a duplicate system for comparative data which will be sent to SAM. This trail has proved to be very successful and proven to operate and provide reliable data. This technology has now been proven to work for Oil monitoring in oil tanks and is now a business decision if the oil monitors are taken up. Due to the sensitivity of this technology it is now being trialled to detected oil loss for fault progression in FMJLs, this work is potentially a very promising area and has only been considered due to this trial taking place. Further work regarding the oil monitors should continue and remain focused on the FMJL application as the application for transformers has been proven.
Collaborative partners	
R&D provider	IDLS

<table>
<tr><td>Project title</td><td colspan="4">Magnetic Models for Transformers Transformer Core Modelling</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Paul Jarman</td></tr>
<tr><td>Description of project</td><td colspan="4">The project will deliver tools to analyse what happens to plant with a magnetic circuit when that circuit starts to become saturated because of extreme operating conditions. Examples of this are transformers under ferroresonant conditions, transformers subject to DC currents such as during geomagnetic (GIC or sun storm) events, series reactors under fault conditions and quadrature boosters (QBs) under high load conditions Failure to properly analyse these conditions leads either to excessive capital cost in increasing core dimensions, or potential failure in service due to the heating of the magnetic circuit and other steel parts in the transformer or reactor.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £4k
External £20k
Total £24k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £7k
External £70k
Total £77k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£217k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£17k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Optimum transformer design and operation within capability to prevent damage.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>-4</td><td>15</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The knowledge generated by this project will improve the modelling of ferroresonance, GIC and QB operation which will help to formulate designs, specifications and policy to mitigate these problems at minimum cost. Improved industry knowledge in this area should also improve designs and help to reduce unexpected operational problems as over fluxing phenomena are not usually tested in the factory.

Quadrature boosters cost approximately £10M and core saturation needs to be modelled in order to optimise their use and avoid failure. One of the most important operating parameters is the point at which the core saturates when the QB is acting to reduce power flow; this parameter is used to set the QB control system which limits tap-changing and therefore utilisation to avoid failure under these conditions. Better knowledge of the core saturation phenomenon will allow the settings to be optimised. Operational savings in increased utilisation are likely but are difficult to estimate, but a QB failure would be very expensive. Reducing the risk of QB failure by 1% will reduced the potential cost of failure over the QB fleet by about £20k per year; similar savings could be expected for increased utilisation.

The need for mitigation measures against ferroresonance partly depends on what damage to transformers may be expected, the project should generate this knowledge and potentially lead to savings of £100k per annum in reduced capital expenditure (where a ferroresonance scheme can be shown not to be required) or avoided failure (if a scheme is shown to be needed). Better knowledge of how series reactor impedance varies with current up to the short circuit current will lead to better calculation of fault levels, the benefit from this is hard to quantify but could avoid uprating of switchgear in certain instances.

Better knowledge of the effect of GIC on transformers which caused two</td></tr>
</table>

	transformer failures in 1989 depends on understanding core saturation. The next GIC activity maximum is expected around 2013, refining operational guidance based on new knowledge could possibly reduce the risk of failure. Reducing the risk of one transformer failure in 2012 by 10% could save £200k in replacement costs alone, consequential costs of such a failure could be higher. Transformer capital costs are significantly influenced by the size of the core required to avoid saturation under certain system conditions, particularly high voltages on the lower voltage windings which might be experienced when local renewable generation is being back-fed into the HV system. Better understanding the limits can avoid over-specification or potential failure. A 1% reduction in the capital cost of transformers represents a saving of around £400k per year. The project will retain a useful modelling capability at the University of Manchester that has been established during the course of the Ferro resonance project and has been used directly by National Grid in failure investigations and capital project evaluation. This resource is not presently available elsewhere.		
Expected timescale of project	3 Years	**Duration of benefit once achieved**	Indefinite
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£7k
Potential for achieving expected benefits	The project has experienced delays due to staff changes and a delay in the contribution from Areva T&D. The modelling capability at Manchester and the understanding of transformer magnetic phenomenon has already been used in a study of a voltage dip caused by transformer inrush. The potential for achieving the benefits are still good with an increased emphasis on understanding the impact of solar storms on transformers.		
Project progress **[Year to End of March 2011]**	The finite element modelling (FEM) modelling aspect from Areva has not progressed but is expected to resume. This means that no further progress has been made on the computer models and their relation to experimental results. Delays have occurred due to staff changes at Manchester, but the planning for bench-top experiments to determine material properties is now complete and results are expected in the next quarter.		
Collaborative partners	Areva transformers and T&D are expected to resume funding a parallel linked project to improve their modelling techniques.		
R&D provider	University of Manchester		

<table>
<tr><td>Project title</td><td colspan="4">Feasibility Study into production mechanisms of corrosive sulphur</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Gordon Wilson/Paul Jarman</td></tr>
<tr><td>Description of project</td><td colspan="4">This project will investigate further the mechanism of copper sulphide formation and whether there is a risk that the passivation strategy is ineffective or only partially effective. A number of specific issues raised by the initial studies will be answered as part of this study.

What corrosive gases are being generated thermally during the heating studies? Are they still produced in the absence of any form of copper in the oil? Could copper corrosion/copper sulphide formation in transformers be resulting from corrosive gases?

What role does Dibenzyl Disulphide (DBDS) play in the production of corrosive sulphur?

In the presence of paper and copper, is it possible to detect corrosive species in the oil? In the case of current experiments, why does repeated thermal cycling appear to reduce the amount of detectable sulphide?

These questions may not be fully answered but on completion of this piece of work it should be evident whether there is an alternative mechanism involved in the production of copper sulphide to the one put forward by CIGRE and whether passivation is an effective mitigation strategy.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £7k
External £59k
Total £66k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£66k</td><td>Projected 2010/11 costs for national Grid</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">National Grid suffered a transformer failure due to the effects of copper sulphide deposition in 2007. The risk of further failures has been mitigated through correction of cooler control temperature settings (OESB 14/09) and passivation of transformers at risk (OESB 9/08). The passivation strategy is dependent on the mechanism of copper sulphide formation as proposed by CIGRE that requires copper-catalysed corrosive sulphur formation in oil. Southampton University recently published a paper at ISEI that suggested that the mechanism might proceed in the absence of copper and that volatile corrosive compounds are formed rather than large soluble corrosive molecules as suggested by CIGRE.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10</td><td>1</td><td>9</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">A large proportion of National Grid’s transformers are affected by corrosive sulphur to some extent because of the long period during which the problem oil was available and the relatively low concentration of corrosive molecules required to make an oil corrosive. There are approximately 30 transformers considered to be at high risk because they are of a design which means they operate at higher temperatures than typical transformers. A small subset of these will likely experience reduced asset life because of the operating conditions and it is essential the correct mitigation strategy is adopted for these units to minimise this reduction. Around 175 other transformers are known to contain oil with the potential to become corrosive because of their age and the remainder of the population (around 700 transformers) are being</td></tr>
</table>

	tested for potential corrosivity resulting from top-ups and maintenance activity. The mitigation strategy for most transformers is to add passivator to the oil on the basis that this will coat all copper surfaces and prevent catalytic conversion of DBDS and other sulphur molecules into a more reactive form. Although this is the most widely used mitigation strategy its effectiveness is not fully known and whether there is a need to add more passivator after it has been consumed is open to question. This study should help us to at least understand whether a suggested alternative mechanism that might undermine the current strategy is credible. Further work would be required to identify an effective mitigation strategy if this is the case.		
Expected timescale of project	1 year	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£50k
Potential for achieving expected benefits	The original work carried out in the School of Electronics and Computer Science has demonstrated their understanding of the subject, they will be supported in this work by the chemistry department. Some of the issues identified will not be explored fully by this study as they are quite open-ended. The more tightly bounded parts of the study that will answer the fundamental question as to whether there is a copper sulphide formation mechanism involving corrosive gases has a high likelihood of success.		
Project progress **[Year to End of March 2011]**	The project was completed within the 6 month program. The University successfully replicated their previous observations and have been able to explain the results satisfactorily. To some degree it has provided new evidence in favour of the widely accepted mechanism and has shown that the main corrosive element in the oil is more volatile than previously thought. The work has furthered our understanding of corrosive sulphur mechanisms but there are still many questions around the efficacy of mitigation. An alternative methodology for the detection of corrosive sulphur species was suggested which merits further investigation and there is still a need to develop a technique for identifying where corrosive sulphur deposition is occurring and to what stage it has advanced. The two departments have worked very effectively with each other offering the opportunity to conduct further work involving engineering and chemistry elements.		
Collaborative partners			
R&D provider	Southampton University		

Project title	**Improved Transformer Thermal Monitoring**		
Project Engineer	Gordon Wilson		
Description of project	This project will deliver an improved transformer thermal model that enables accurate ratings to be calculated. A method for determining thermal parameters for those transformers without test certificates will be developed. The project will specifically address the effects of ambient conditions, changes in cooling state and the influences of the transformer surroundings, of particular interest in built-up locations. Met Office data from a previous scheme will be used to assess the effects of 'heat-wave' conditions, of especial importance in the South-East.		
Expenditure for financial year	Internal £4k External £20k Total £24k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£186k	**Projected 2010/11 costs for national Grid**	£106k
Technological area and/or issue addressed by project	National Grid uses transformer thermal ratings for planning purposes and day-to-day operation of the transmission system. The thermal ratings use transformer models based on IEC methods that are known to have shortcomings, particularly with oil temperature behaviour and where changes of cooling state occur. National Grid is now acquiring transformers cooled only by natural circulation or by three-stage cooling and these require modifications to the existing ratings process to be modelled properly. Transformer thermal capability is calculated from known test certificate data. However, some older transformers in key locations do not have test certificate data, resulting in the use of conservative ratings that will be restrictive. The relevant thermal parameters could be determined by the application of appropriate models to the measured data for these units. An attempt to determine thermal parameters for transformers at New Cross has been made based on long-term monitoring. However, the work at New Cross has highlighted significant shortcomings in the application of existing IEC models to actual data, leading to difficulties in estimating the thermal parameters accurately. The potential influence of ambient conditions and the effects of the environment in which the transformers are installed has also been shown. Measurements of ambient conditions were taken at New Cross that have not yet been incorporated into transformer models. These data will be analysed to assess the influence of the environment on transformer ratings. A transformer with known thermal parameters (and ideally with fibre-optic temperature sensors installed) will be fully instrumented at another location to enable an accurate model of transformer thermal behaviour, as installed at site, to be developed. Since the thermal and electrical parameters will be known beforehand (unlike at New Cross), the success of various methods in obtaining these values from the logged temperatures and loading data can be assessed, for application elsewhere. Particular attention will be given to the behaviour of the oil flow which is known to be quite complex. The effects of ambient conditions can be compared with those at New Cross. The resulting thermal models will be useable in the transformer rating program TRALC, and also for real-time rating estimates by the CTM. The thermal ageing of transformer windings is governed by the detailed nature of the winding construction and oil flow rates, although average values for winding and oil temperatures can be obtained by factory test measurements. The TEFLOW program has been used for such detailed calculations in the past. It has proved valuable in the assessment of failures where the necessary		

<table>
<tr><td></td><td colspan="4">detailed winding measurements can be obtained by inspection. Support will be provided to the University of Manchester in improving the TEFLOW thermal model and further developing the TEFLOW program.

The existing transformer loading program TRALC is used for calculating transformer ratings. Improvements to the thermal model derived under parts of this project described above will need to be incorporated in TRALC. In addition, the electrical model in TRALC will be re-assessed for its suitability in modelling load flow in either direction (HV to LV or LV to HV) and for estimating core flux more accurately. If necessary, the existing electrical model will be improved. A new specification for TRALC v3 incorporating the required changes will be produced. The EPRI transformer loading program PTLOAD will be assessed to ensure that National Grid follows best practice in transformer rating calculations.</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>15</td><td>0</td><td>15</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The provision of enhanced ratings through calculation of potential enhancements provides large cost savings for National Grid and increases flexibility in placing outages. In recent times the potential for granting enhancements has been employed in evaluating load related schemes and deferrals have been possible. In some cases it has not been possible to provide enhancements because of the lack of a test certificate, for example upratings at Ninfield and North Hyde could not be modelled and Cowley, Kingsnorth and Mannington are affected by the same transformers; there are around 100 transformers for which models cannot be produced. This project will result in a method for accurately determining the potential enhancement of such transformers allowing deferral of capital investment at a moderate cost.

TRALC v2 has been revised and updated on a number of occasions since it was first developed; the software developers have suggested that further updates will become increasingly difficult (and more expensive) thus a new version will be required to allow inclusion of three stage cooling and ONAN transformers. It would also allow these transformers to be modelled correctly in the new version of CTM.

System Development are supportive of the research and have produced a model showing how deferrals might be possible depending on demand growth rate at GSPs and potential uprating resulting from more accurate models. Based on recent years the average number of new transformers installed for system development each year is six. Assuming relatively modest cyclic upratings and a moderate view of growth rate the potential to defer half of the annual load related transformer installations for 3 years seems reasonable. Given that many of these sites have transformers that can already be modelled a modest assumption would be that three transformers could be deferred for 3 years in the first 5 years of implementation The unit cost of a GSP transformer is approximately £4m. For NPV calculations a three year deferral would be worth £300k. Given that implementation costs may be of the same order as this project then NPV would be positive in the first 5 years.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td>Duration of benefit once achieved</td><td colspan="2"></td></tr>
<tr><td>Probability of success</td><td>60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£78k</td></tr>
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Potential for achieving expected benefits	Some of the development work will be carried out within CIGRE A2.38, a group that National Grid (Gordon Wilson) is already involved with. The collaborative output of this group will form a part of the deliverables and will ensure that National Grid's transformer ratings program remains state of the art.
Project progress **[Year to End of March 2011]**	This project was late starting and little progress was made prior to March 2011. A candidate transformer has been selected for enhanced monitoring to provide data for the work. A specification for the monitoring required has been developed and instrumentation requirements have been identified and evaluated. The overall timescales of the project should not be affected by the late start.
Collaborative partners	
R&D provider	Southampton Dielectric consultants IDLS Doble Power Test

Project title	**Oil/paper insulation HVDC performance**			
Project Engineer	Gordon Wilson/Paul Jarman			
Description of project	The project will investigate the performance of the oil-paper insulation system used in HVDC transformers under a variety of electrical stress conditions. It will attempt to determine the effects of oil resistivity and other insulation condition parameters on the capability of the insulation to withstand the electrical stresses seen within HVDC transformers particularly during polarity reversal or other changes in stress.			
Expenditure for financial year	Internal £3k External £71k Total £74k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0	
Total project costs (collaborative + external + [company])	£322k	**Projected 2010/11 costs for national Grid**	£99k	
Technological area and/or issue addressed by project	Recent work in CIGRE has highlighted that oil resistivity can greatly influence the stress distribution within an oil-paper insulation system in a DC stress environment especially during voltage changes such as polarity reversals. There have been several failures of bushings at Sellindge during or shortly after polarity reversals and there is evidence that the factory testing of DC transformers is inadequate to cover service conditions. A new CIGRE group is being established to look at this further and this work could usefully link to this group. The measurement of the DC conductivity of oil is not routine and a repeatable method needs to be established. This project will provide the knowledge to specify appropriate tests on new transformers and make sure that oil quality in service is maintained to suitable levels.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		20	3	17
Expected benefits of project	Given the likely investment in DC technology planned in the next decade it is important to have up-to-date knowledge and independent research to ensure that correct specification and operational choices are made to ensure long-term reliability. This project addresses the most likely cause of unreliability in HVDC transformers, the change in insulation condition between factory test and service and its interaction with the time/stress relationship of the polarity reversal. DC transformers cost in the region of £5M per phase and failures have significant outage costs. If this research can indicate how to manage the oil in these transformers or influence design and testing of transformers to improve reliability then significant savings may be possible. The HVDC transformer failure rate is historically about 5-10 times worse that normal transmission units based in international figures. If we have a population of 30-50 units which seems possible with strategic investment plans, then a failure every 1-2 years is expected unless the rate can be reduced.			
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	270k	

Potential for achieving expected benefits	Southampton University has significant expertise in measuring space charge distribution in polymer insulation systems and has recently demonstrated the technique in paper systems. They also have experience in more general measurements of the dielectric properties of oil-paper systems. It is very likely (80%) that useable results will be obtained that support the specification and operation of HVDC equipment.
Project progress **[Year to End of March 2011]**	One PhD student was successfully appointed from overseas; no applications were received from suitably qualified UK candidates. Owing to visa complications the student was only in the UK in late March. A second suitable student is still to be placed. A change control form is being prepared to account for the delays estimated at 3 months.
Collaborative partners	
R&D provider	Southampton University

<table>
<tr><td>Project title</td><td colspan="5">Transformer and system reliability</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Paul Jarman</td></tr>
<tr><td>Description of project</td><td colspan="5">This project will deliver a methodology for assessing the maintenance and replacement strategies for transformers against system reliability requirements. In particular the derivation of transformer replacement priority from asset health index and perceived system criticality can be greatly refined using a detailed knowledge of transformer failure modes (common mode, sympathetic and hidden failures). The availability of such a methodology will ensure an optimum and justifiable prioritisation of transformer replacement and maintenance.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £67k
Total £70k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£295k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td colspan="2">£75k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">At present the risk and criticality approach to transformer maintenance and replacement is based on a relatively crude 3 point scale of criticality and a matrix. This method may be capable of improvement if a real network model is used together with an understanding of possible interactions between failures. Generally a transformer outage is of little consequence, but two or more simultaneous outages on certain parts of the network could have severe consequences. Identifying these situations and the sensitivity to linked failures is important for the correct and timely replacement of the most critical units. As far as can be determined there is nothing significant published on the interaction of transformer reliability and overall system reliability. One of the final parts of the transformer lifetime project which is in progress was to look at this area but it is unlikely that there will be time on this project to start this work.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>8</td><td>0</td><td colspan="2">8</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">Transformer replacement is worth some £20-£40M per year for many years to come, optimising this expenditure and reducing the likelihood of a costly system failure due to late replacement depends on the correct and timely identification of replacement candidates. This project will make a small but significant contribution to this process.</td></tr>
<tr><td>Expected timescale of project</td><td>4 years</td><td colspan="2">Duration of benefit once achieved</td><td colspan="2"></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 colspan="2">-£86k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="5">The project will use the combined expertise of the Transformer and System research groups at the University of Manchester. There is therefore a significant background of knowledge that will be used. The probability of making progress towards a useable failure criticality model is high. It is possible that the problem will have to be simplified to make progress. This</td></tr>
</table>

	should however still result in useful results.
Project progress **[Year to End of March 2011]**	Two students have been recruited and are now making progress on the project. The modelling software will be PowerFactory and a network model has been given to the University of Manchester to start work on. Simple networks have been investigated and preliminary feedback given. Work is progressing on the transformer model.
Collaborative partners	
R&D provider	University of Manchester

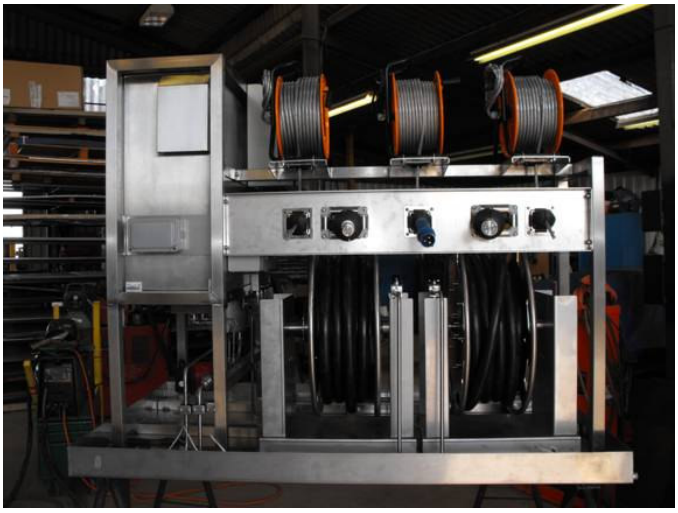
Project title	**Oil-less DGA Sampling (Prospective Trial)**			
Project Engineer	Graham Moss			
Description of project	This is a prospective trial to test the effectiveness of direct oil-gas separation across high surface area ceramic membranes coated with hydrophilic membranes. The aim is to prove the functionality of membrane extraction to be used on oil filled transmission assets where the oil content is of very low volume and successive sampling results in the requirement to 'top-up'. The end of trial will deliver quantitative data concerning extraction efficiency and most suitable membranes to use in the construction of a field worthy sampling system. It is expected that the trial will deliver as far as a proposed technical drawing of the field trial system, if not a working prototype to demonstrate the technology. The second part of this work is to look at key molecular species which can identify winding faults, generated when copper in contact with oil pushes upwards to temperatures of 600 DegC and above. Identifying a key marker species may assist in distinguishing transformers suffering from winding faults from those suffering from non-critical overheating faults such as core-frame circulating currents.			
Expenditure for financial year	Internal £3k External £16k Total £19k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0	
Total project costs (collaborative + external + [company])	£22k	**Projected 2010/11 costs for national Grid**	£3k	
Technological area and/or issue addressed by project	According to theory, with the oil being exposed to a very large surface area membrane, the gas contained within the oil will transfer to the low concentration gas space on the far side of the membrane to achieve equilibrium. This process will be faster and more efficient with the greatest surface area profile. Ceramic membranes offer this property. It is expected the membranes will be formed from aluminium nitride and coated with a 5µm layer of various polymers. The choice of polymer is a major goal of this trial. The final field device will be a steel cylinder containing a series of very strong aluminium nitride tubes which give a potential surface area for the oil to act on of some 20m^2 or above. The device will be designed to gently circulate oil to and from the same sample valve. The surrounding container (purged on delivery with argon) will begin to assimilate diagnostic gases from the oil. Diagnostic gas will be removed from the sampling system by syringe and analysed by a laboratory. To reach a field test device, this project will be moved to a full R&D project. The copper species marker for winding fault identification will be carried out using a series of high-end analytical tools to primarily discover the abundance of such markers directly through bench-top experimentation.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**

		11	1	10
Expected benefits of project	Sampling low volume oil assets for DGA without removing any dielectric fluid, thus avoiding top-ups and risk of internal flash-over. Oil-free DGA sampling also offers an environmental saving in not handling or transporting oil. The ability to pinpoint a winding fault progression would ultimately help in avoiding the complete loss of a transformer when allied to on-line DGA analysis.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years	
Probability of success	50%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£19k	
Potential for achieving expected benefits	This is a prospective trial to discover how efficient the extraction process is. The extraction system will definitely work, the question is “How well?” This small trial will give us quantitative data concerning the realistic timescales between samples, differences in gas ratios and the best polymers to use for highest extraction efficiency. The presence of unusual copper species in oil from the high temperatures associated with winding faults would not be unusual. The experiment is to discover how abundant they become and can they provide enough advance warning of future failure.			
Project progress **[Year to End of March 2011]**	The sampling cell has now been constructed and the ceramic membranes have been selected as have the floro-polymer coatings. The efficiency trails on the gas extraction should be completed by the end of September 2011.			
Collaborative partners				
R&D provider	Nynas AB IOM			

Project title	**Transformer lifetime modelling**			
Project Engineer	Paul Jarman			
Description of project	Optimising capital investment in replacement transformers. For long term replacement planning purposes transformers have been given asset lifetimes of 40 to 80 years based on experience and engineering judgement. Actual replacements are based on condition, using several assessment methods which have been successfully developed and applied. There is however a gap in the knowledge of transformer end-of-life modelling linking the probabilistic and deterministic approaches of the long and short term plans. This project has the objective of building on existing knowledge of ageing mechanisms to provide a model to bridge the gap and provide credible predictions of medium term (4-10 year ahead) requirements for transformer replacement volumes. The basis for the plan would be the existing policy of maintaining system reliability and unplanned transformer replacements at existing levels. The dependence of system reliability on plant reliability would be part of the study. Transformer replacements will cost between £10M and £30M per year for the foreseeable future, failure to plan effectively could have significant implications for regulatory review and system reliability.			
Expenditure for financial year	Internal £9k External £25k Total £34k	**Expenditure in previous (IFI) financial years**	Internal £17k External £195k Total £212k	
Total project costs (collaborative + external + [company])	£247k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Optimising modelling techniques to support capital replacement planning for transformers.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		6	-1	7
Expected benefits of project	Being able to accurately predict transformer replacement numbers, and justify those predictions to the regulator will optimise capital expenditure and allowable income. The expenditure is likely to be in the range £10M to &30M over the next 20 years or more. Conservatively assuming that the accuracy of the investment in new transformers could be increased by about 1% as a result of the knowledge gained, would lead to a saving of about £15Ok per annum either in the capital programme or in the costs associated with reducing system reliability.			
Expected timescale of project	3 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£4k	

Potential for achieving expected benefits	As original plan. Some very interesting results on the effect of cooler thermostat setting temperatures on lifetime have resulted in a program to lower them on some units with expected additional benefits in extending lifetimes. Expected transformer lifetimes have been revised partly based on this work to optimise the replacement plan.
Project progress **[Year to End of March 2011]**	Thermal modelling aspects of the project have been very successful and highlight the importance of good thermal design in the life of a transformer, this knowledge is being used in the assessment of new transformer designs. The statistical analysis of transformer failure data has validated the early end of the lifetime model. The work together with some other inputs has been used to review asset lifetimes. The thermal modelling aspect of the project is running to plan and has highlighted deficiencies in existing calculation methods that could well be important for assessing transformer designs for long lifetimes. Experiments on aged transformer insulation at Southampton University have been delayed by equipment failure but are now expected to resume.
Collaborative partners	
R&D provider	University of Manchester, Southampton University

Project title	**Mobile Transformer Assessment Clinic**			
Project Engineer	Graham Moss			
Description of project	The Mobile Transformer Assessment Clinic (MTAC) is designed to offer a finely engineered solution to the fundamental problem of the need to administer expensive and complex on-line dissolved gas analysis systems to oil filled transmission assets that are exhibiting divergence from ideal behaviour.			
Expenditure for financial year	Internal £3k External £19k Total £22k	**Expenditure in previous (IFI) financial years**	Internal £4 External £154k Total £159k	
Total project costs (collaborative + external + [company])	£281k	**Projected [next year] costs for [company]**	£100k	
Technological area and/or issue addressed by project	Currently, on-line DGA systems are a 'fixed' solution, whereby to install an instrument which will take a measurement of the dissolved diagnostic gas profile from a transformer on an hourly basis. Typically this installation totals approximately £26k and takes a team of 3-4 engineers 2 days to complete. In many situations this is not possible. For reasons of health and safety, system stability and security, there may be restrictions on working time within the locale of the asset, reducing contact time per person to 2hrs per 14 days. This means that without outage, we cannot install these instruments. Also, in many instances, there is simply not enough evidence to support the expenditure of a fixed instrument. In order to overcome both these fundamental problems, the mobile system has been designed to allow full on-line DGA monitoring to be brought to site and connected (if required) within a 2hr timeframe. More over, the system is completely trailer-based, allowing for complete freedom of transport.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		15	-2	17
Expected benefits of project	Once tested and found to be functional in all aspects of its design, it is expected each unit will be deployed to at least 4 separate assets each per year, saving the cost of a fixed asset installation each time (£26k). More importantly, they will give us the ability both financially and technically, to administer high resolution, high cost on-line DGA monitoring to any asset on the system without having to raise funding to do so. The cost of deployment of the MTAC system to any asset in the UK is typically going to be £2k.			
Expected timescale of project	3 years	**Duration of benefit once achieved**	Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£1k	

Potential for achieving expected benefits	The probability of achieving the expected benefits stated is exceptionally high. The design and functional specification of the deployment solution has been meticulously researched and built up by the field experience of the last 3 years of actual physical installation of some 24 fixed DGA systems. This experience has led us to a solution that will be able to rise to the challenges that it was designed to overcome. Grahame Barker (Doble Power-Test Engineer in charge of Project Delivery) has an unsurpassed knowledge and working experience of these issues and the problems surrounding the successful deployment of a mobile oil-handling unit for use on HV transmission assets.
Project progress **[Year to End of March 2011]**	As of Late December 2009 MTAC02 was completed. This design incorporated an improved primary pump design which has proven to be invaluable in circulating cool oil which has a significant increased viscosity and has caused problems with MTAC01, the upgraded MTAC01 to the new pump design in July 10. Both mobile systems have proven to be extremely effective and have, since commissioning, been key in several risk mitigation issues for major capital build projects, risk mitigation tasks for transformers under hazard management and unknown fault diagnostic tasks. The cost of these units has already been recovered in operational savings. The latest addition to both units will be solid-state high durability weather stations which will assist ratings engineers to determine the thermal liability to fault gas generation caused by local weather conditions. This data is now feed back live into SAM. The MTAC is operational and creating benefit where it is operational. An additional unit has been built and paid for by asset engineering and is currently operational. This product, although successful, could be developed further so the project was extended to include an alternative analyser for MTAC and to look into the possibility of a miniaturised version of MTAC which is easier to deploy (micro MTAC). Micro MTAC is due to be constructed by November 2011. With trials in the first quarter of 2012. The following photo shows the internal gas analysis and deployment assembly during final stages of construction. The sensor and power line cable reels sit at the top of the main frame, oil supply lines are on deployment drums below these. The main dissolved gas analyser sits to the left. 

	The photograph below shows the first MTAC unit in a completed and deployed state. This deployment was the second stage testing in which the unit was coupled to an out of service reactor to give valuable insight to actual field use.  The unit remained on the primary target for a period of 2 weeks to allow for data collection concerning the dissolved gas analysis (DGA) profile. After this period, MTAC01 was handed over to DoblePT contract management for use as planned as an emergency fast response DGA profiling instrument.
Collaborative partners	
R&D provider	Doble PowerTest LTD, Invisible systems

Substations

Project title	**EPRI Substations**		
Project Engineer	Jenny Cooper		
Description of project	This project encompasses National Grid Electricity Transmission's participation in selected Power Delivery projects from the EPRI (Electric Power Research Institute) R&D Programme. Projects are selected to enable maximum beneficial project interaction and maximum leverage on funds. Additional technical collaborations and access to existing products are included as part of the agreed collaboration at no additional cost together with access to the Technology Innovation Program and participation in the Research Advisory Council.		
Expenditure for financial year	Internal £17k External £469k Total £476k	**Expenditure in previous (IFI) financial years**	Total: £308k
Total project costs (collaborative + external + internal)	£16,214k	**Projected 2010/11 costs for National Grid**	£473k
Technological area and/or issue addressed by project	Project areas: Greenhouse Gas Reductions Options Conductor and Wire Corrosion Management Compression Connnector Management Live Working Research for Overhead lines Ceramic Insulator Integrity Assessment Foundation Analysis and Design Improve Transmission Line Lightning Performance Polymer and Composite Overhead Transmission Line Components Impact of High-Temperature Operation on Conductor Systems Transformer End-of-Life & Condition Assessment Transformer Life Extension Circuit breaker condition assessment and life extension Using relays for circuit breaker diagnostics Fault current management Protection and control Advanced Conductors Assessment & Evaluation of Next Generation HVDC Technologies Life Extension and Best Practices Guidelines for Substation Equipment Improving Overall Substation Maintenance Management SF6 Environmental Management and Equipment Performance Solid-State Fault Current Limiter/Circuit Breaker Development Management of Substation Ground		

<table>
<tr><td></td><td colspan="4">Ground Grid Evaluation, Maintenance Refurbishment
Energy Storage (Transmission)
AC/DC Line Conversion
Antenna arrays and wireless mesh sensors for partial discharge location
Zed meter trial
Technology and Innovation Programme including sustainability.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Tech Transfer, Significant / Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td>0</td><td>14</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">EPRI is probably the largest research organisation in the world with a large-scale interest in the electricity transmission business. The organisation is keen to implement research programmes between suppliers and utilities, thus encouraging innovation and bringing novel ideas closer to the market. National Grid has also been invited to be a member of the Research Advisory Group – the executive level group steering the complete research programme.
The key benefits to National Grid of being involved with such an environment include:
Gain access to a wide range of R&D objectives both underway and planned
Participate in multi-user discussion and networking including setting the direction of applicable EPRI projects
Commercialisation of R&D into products that can be purchased with minimum risk due to knowledge gained in R&D
Trials comparing diagnostic tools – benefit gained from collaboration as National Grid would not support this activity individually
Evaluation of benefit from application of techniques/software currently in development through EPRI projects
Establish further opportunities for tailored collaboration for demonstrations and trials with further shared risk and cost sharing
Access to experts with complimentary skills to in-house specialists
Access to existing products (value up to 10% of contracted costs) – both reports and intellectual property/applicable knowledge
To influence the direction of the EPRI programme to National Grid’s best interests through participation in EPRI project working groups and advisory councils.
Significant leverage on funds estimated to be 50:1 in substations.
Access to EPRI information is open to all National Grid Transmission employees with a password enabling access to the specifically funded projects and the technology innovation projects.
The National Grid selection from the EPRI programme delivers applied research with defined benefit to National Grid’s assets including improved transformer analysis, SF6 leakage recommendations and substation monitoring via antenna array technology based at Strathclyde University.
The total project portfolio for EPRI in the transmission research area is $104million per annum, National Grid’s selection forms part of this total activity giving significant leverage and potential for developing multi utility collaboration on projects leading to networking, cost and risk sharing.</td></tr>
</table>

	Specific benefit areas: Transformers: National Grid has a major transformer replacement programme; understanding the end-of -life processes, condition assessment methods and any possibilities for life extension is required to optimise this expenditure. The EPRI projects provide an international perspective to this activity to supplement the other work, both past and ongoing, that is saving something in the region of £5M per year in capex in terms of avoided replacement and failures if the replacement decision making process was less well informed. Additional incremental benefit from ongoing research is difficult to quantify precisely, but failure to be informed and up to date in a critical asset management area would have a damaging effect on both revenue and reputation. The EPRI work contributes at least 1% of the £5m per annum and is applied via National Grid's transformer specialist. Specific research in EPRI's transformer area cover six main themes that are of benefit to National Grid: Novel sensors: Under this theme, EPRI conducts research on new sensors for assessing transformer condition. The research develops specialized sensor hardware to provide insights into transformer health that are not obtainable using traditional techniques - or provide a step change decrease in overall implementation costs. Research also helps National Grid understand new emerging sensors in the marketplace - both in the utility industry and in other industries where sensor advances could be easily translated to transformers. Training and knowledge transfer: EPRI's flagship guidelines under this important theme is the development of the Copper Book. The Copper Book is a comprehensive transformer reference book that focuses on all aspects of transformer operation, maintenance, procurement, and life-cycle management. It is uniquely written from the perspective of a utility engineer and comprehensively addresses each phase of activity from specifications through to end-of-life. The Copper Book serves as a valuable training aid and guides engineers through case studies of common calculations necessary for transformer specification and management. Transformer Algorithm development: Under this theme, EPRI uses the knowledge and experience gained from years of research to develop actionable information from data gathered from transformer sensors. This topic is growing in importance as more sensors in National Grid send larger volumes of data from transformers in the field. Transformer Aging assessment: Improved estimates of a transformer's remaining life offer significant financial and reliability benefits. EPRI is researching the dynamic behaviour of new chemical markers in the oil that hold the potential for significant improvements in the accuracy of transformer life estimates - possibly even without knowledge of the history of the transformer or the oil. Transformer life extension: New research has demonstrated the possibility for continuous online filtration of oxygen and moisture with new membrane technologies that offer the potential for low cost and minimal maintenance. This would open the door for life-long filtration and corresponding life extension to transformers in National Grid. Transformer forensics - linking diagnostics and maintenance with true internal condition: EPRI research is carefully examining retired or failed transformers and relating the evidence to both transformer operations and diagnostics data. The resulting forensics library provides National Grid with new insights into likely end-of-life scenarios for the increasing population of aging transformers. Circuit breakers: The EPRI project provides an international perspective of risk based asset management, condition assessment methods, guidance on material selection and application, maintenance task and timing and any possibilities for life extension required to optimize expenditure. Benefits come from being able to develop rationale necessary for ongoing and future maintenance and asset management policies and staying abreast of industry maintenance and asset management practices.

	SF6: Strong environmental driver to be involved. Good successes in previous years with benefit achieved through the development of leak sealing technology and partial discharge trials, both leading to implementation on the system. Earthing: The benefits of collaboration on the earthing (grounding) project will allow for alternative methods of test to be examined and validated, resulting in a potential cost saving to National Grid Transmission through efficient incorporation of the techniques into National Grid's operation. Overhead Lines: Specific focus on specific components (e.g., insulators and compression connectors) and issues (e.g., lightning and grounding, and transmission capacity). Inspection and Assessment reference material helps workers keep abreast of new inspection and maintenance practices, tools and issues. Providing corrosion control and management practices for overhead ground wires, phase conductors and hardware can help National Grid reduce unplanned outages, improve reliability, and reduce associated repair Splice failures are expected to increase with increased demand for heavier loading operations. Due to the limitations of existing inspection techniques, isolating the components early enough to avoid failure is a challenge. EPRI's research provides understanding of thermal threshold limits for existing tools and investigates new technologies to improve decision making. Lightning prediction software can be used by National Grids resources to optimize the lightning performance of transmission lines using internal resources. The lightning and grounding reference guide can be used to address the loss of institutional knowledge. Foundation analysis design manual provides designers with most current design approach and this information can be used to fine-tune National Grid's own design. Composite components have certain disadvantages and uncertainties. Concerns include selection, application, and inspection. EPRI's tools and information can increase National Grid's confidence and reliability in using these components, Millions of ceramic insulators are approaching or have exceeded the end of their intended service life. Concerns are growing about the availability of inspection techniques to identify high-risk units prior to failure. A prototype inspection tool was demonstrated at National Grid. The technology is being further developed to be remotely controlled with some automated features. In addition, the technique is being refined to identify cracks in the insulators located underneath the metal cap. The effects of high operating conductor temperature are reduction in conductor ground clearance, loss of conductor strength, and damage to connectors and other overhead line components. EPRI has studied the performance of common compression fittings at various conductor temperatures above 100℃, The benefit of this research can help National Grid increase confidence in operating overhead lines at high temperatures, avoid damage to overhead line components and subsequent line failures and adopt mitigation measures to achieve increased power flows. The long-term in-service performance of Advanced conductors (also known as high-temperature low-sag or HTLS conductors) is unknown. The most immediate need is investigated technologies using a carbon fiber core conductor, which is the least known and most novel of all advanced conductors. The benefit of this work is that it provides information and tools that are currently unavailable to evaluate the performance of various advanced conductors, and provide maintenance procedures and recommend tools to ensure the safety of utility personnel and the reliability of transmission lines. Application of TFlash lightning modelling software to analyse performance of

	current and future assets, also added potential to assess impulse tower footing resistance. Complimentary work to ensure knowledge of asset management of composites in terms of lifetime, handling etc. Facilitating reduced operations and maintenance costs while supporting an aging infrastructure with reduced capital expenditure for new and refurbished equipment. Need to improve reliability and worker safety. Substations: Safety of people and equipment during operations and outages. Enhancing system reliability, performance, and life of equipment on ever-decreasing maintenance budgets has become essential for an infrastructure that has reached its design life of 40 years. Advanced technologies and tools are needed to maintain and operate substation equipment in the increasingly competitive energy marketplace. Transmission System Development: Safeguard, protect, and modernize transmission grids. Increasing transmission capacity utilisation is necessary to ensure grid stability. Need to eliminate or relieve transmission bottlenecks to the market reach of competitive generation. Need to increase the robustness of the transmission grid through use of tools that enhance both steady and dynamic state performance. Sustainability: Understanding implication for National Grid – Model for building sustainability in terms of inputs, operation and delivery of energy. Combined utility view of benefits of sustainability in terms of reduced impact on asset management leading to environmental and cost benefit to the customer.		
Expected timescale of project	5+ Years	**Duration of benefit once achieved**	10+ Years
Probability of success	50%	**Project NPV = (PV benefits – PV costs) x probability of success**	£210k
Potential for achieving expected benefits	Total cost of 2010 EPRI programme that National Grid contributed to in part was $22.2m. EPRI feedback from combined utility membership indicates that with a leverage of up to 50:1, there is potential for achieving benefits through • Maintenance guidelines can extend equipment life by 5–10 years • Condition-based maintenance reduces maintenance costs by up to 30% • SF6 management can reduce losses by up to 50% • Predictive maintenance will reduce maintenance costs by up to 10% • Preventing failure of critical transformers will save £2–5 million per unit • New overhead line design tools that can reduce capital expenditures by up to 5% • Accurate overhead line component condition assessment will be improved to accurately diagnose incipient fault conditions, increasing transmission reliability. • Increased knowledge and understanding of technology-based methods to alleviate transmission capacity constraints and help them optimize use of existing transmission assets • Extending the market reach of competitive generation by eliminating or relieving transmission bottlenecks • Enhanced experience and knowledge about which technologies will increase the robustness and integrity of transmission grids by avoiding or minimizing the impact of cascading failures, voltage collapse, and		

	other major disturbances. Membership of the EPRI Lightning and Grounding Task Force has delivered National Grid guides on the different types of OHL earthing and how to apply them, as well as guidance on the different types of test methods and when to use them. The Task Force is also in the process of delivering a specification for a test meter to allow the earth impedance of individual towers to be measured without removing the earthwire at the peak. This Task Force is also responsible for the development and maintenance of the TFlash software which is used to manage the risks associated with lightning and OHLs, specifically the software allows the probability of an OHL being struck by lightning to be calculated and the potential consequences to be evaluated. Application of the Antenna Array trials have reduced radio frequency interference surveys – removing need for weekly surveys and hence saving manpower directly (estimated as 100 hours minimum per survey). Potential failures avoided this year have been a current transformer and a supergrid transformer due to bushing failure on a supply to a major consumer. The avoided costs from these failures are considerable amounting to an estimated £5m but also avoided potential disruption to customers. The Scope of the project has been increased due to the large variety of partners in the project which has identified additional benefits to the system. Pollution has successfully been monitored and also small cracks in insulations. The project is now looking to find the limitations of the device, the best way of dealing with Noise and how the data can be realistic cleansed. There have been proactive replacements of equipment from partners in this project already in the trial stages cementing the potential benefit this project could have on the network. Work to develop a technique of testing ceramic insulators for defects with the circuit energised has developed to the proof of concept stage. Successful testing at Eakring test facilities has identified the possible best technique which now needs further development. Sunburst – Work is currently ongoing to update the hardware from the late 90's to enable the system to be used inline with SAM and EPRI forecasting studies are to be incorporated into the system. SF6 – Alternatives to SF6 are still being investigated at the moment. There has been a sharing of best practice for leak repair techniques which has been incorporated into SAM. Using relays for circuit breaker diagnostics – There has been a sharing of utility practices to better understand how data in relays is being used for circuit breaker diagnostics and techniques to incorporate this data into SAM using standards based approaches. In coming years, there will be more opportunities to field try EPRI research findings and apply results. Circuit breaker condition assessment and life extension – Application of ongoing EPRI research results enables utilities in improving their maintenance procedures and specification and procurement practices. Specifically for National Grid the progress achieved so far has enable National Grid to define the rationale to standardize products – for example, circuit breaker greases. Prior to engaging in this work National Grid had over 85 products in use for circuit breakers all over the system. Furthermore, the information exchange through a 7 day session with EPRI collaborative utilities in a workshop environment assist in creating further awareness especially in prevalent maintenance practices.
Project progress as of April 2011	Delivered and in progress in EPRI Technology Programme: 2010 Deliverables – EPRI Research – Substations (Program 37) Transformers EPRI Copper Book Development (Power Transformer Guidebook) Novel Sensors for Transformer Diagnosis

	Tools to convert Transformer Data into action
	EPRI Power Transformer Guidebook
	Using forensics to validate transformer life extension and diagnostic tools
	Using forensics to validate transformer life extension and diagnostic tools
	Novel techniques to both estimate and extend transformer life
	Novel online filtration materials and techniques
	Substations Maintenance
	Life Extension Guidelines for Substation Equipment: 2010 Update: Circuit Breakers, Transformers, and Balance of Plant.
	Visual Inspection Guide for Substations
	Equipment Risk and Performance Assessment: A Practical Approach for Substations. Asset Management Best Practices: Assessment of the Implementation for Substation Transformers, Circuit Breakers and Disconnect Switches.
	Assessing Maintenance Effectiveness: Developing a Business Analytics Approach for Substations
	Industry-wide Substation Equipment Performance and Failure Database – Analysis: Electronic Media.
	Industry-wide Substation Equipment Performance and Failure Database: Transformer Data Model and Data Collection.
	Power Transformer Failure Investigation and Root Cause Analysis.
	Balance-of-Substation Equipment: Research Needs Assessment Roadmap.
	Assessment of High Voltage Disconnect Switch Maintenance Practices.
	SF6 Management and Environmental Performance
	Field Guide for SF6 Management in a Substation
	Fault Current Management and Grounding (2010)
	SSFCL Design and Test Document
	SSFCL Prototype Development
	Fault current management guidebook
	2010 Deliverables – EPRI Research – Overhead Transmission (Program 35)
	Inspection and Assessment Guidelines
	Inspection and Assessment Methods (IAM) Reference Guide
	New Set of Pictorial Field Guides
	Online Learning Modules
	Conductor, Shieldwire and Hardware Corrosion Management
	Overhead Shield Wires Management Guide
	Assessment of Shield Wire Inspection Technologies
	Compression Connector Management
	Identification of New Compression Connector Inspection Technologies
	Compression Connector Population Management
	Evaluation of Remediation Techniques.
	Lightning Performance of Transmission Lines
	Alternative Grounding Designs and Materials

	TLSA: Mechanical considerations for installation
	Effect of Seasonal Variations on Transmission Line Grounding
	Lightning prediction modeling software
	Lightning & Grounding Reference Book
	Foundations Analysis and Design
	Guide for Reliability-based Design of Transmission Structure Foundations
	Polymer and Composite Overhead Transmission Line Components
	Short-Term Tests to Evaluate Aging Performance
	Composite Component Failure Database
	E-field Modeling Software
	Interactive Aging Chamber Report
	Ceramic Insulator Integrity Assessment
	Guide to Specifying and Procuring Glass and Porcelain Insulators
	Evaluation of Aged and New Porcelain Insulators
	Impact of High Temperature Operations on Conductor Systems and Thermal and Corona Models
	Guide for Operating Overhead Lines at High-Temperatures
	Impact of High Conductor Temperature on Corona and Thermal Models
	Advanced Conductors
	Methods and Tools for Maintenance of HTLS conductors
	Performance of HTLS Conductors under an Accelerated Aging Test
	AC to DC Power Transmission Line Conversion (09)
	Assessment and Evaluation of Next Generation High-Voltage DC Technologies; Phase 2 (09)
	Touch and Step Voltage Measurements on Field Installed Ground Grid and Concrete Pads (09)
	Field Guide: Smart Ground Meter (09)
	Current Practice for Geotechnical Design of Transmission Line Structure Foundations (09)
	Foundation Design and Analysis for Overhead Line Structures Workshop (09)
	Transmission Efficiency Technology Assessment (09)
	Impacts of Extreme Weather on Power Systems and Components (09)
	Towards a Risk Analysis Framework for Extreme Weather Impacts on Electric Power Systems (09)
	A Novel Method for Circuit Breaker Maintenance Ranking (09)
	Using Relay Data for Circuit Breaker Diagnostics -- Results and Findings of Utility Use Cases (09)
	Field Guide: Lubrication of High-Voltage Circuit Breakers, Version 2.0 (2009)
	SF6 Training Tools (09)
	Development and Demonstration of New Condition Monitoring Sensors and Techniques (09)
	EPRI Transformer Guidebook Development (09)
	Forensics Library: Assessments of Aged Transformers (09)

	Use of Paper Degradation Products for Diagnostics and Condition Assessment (09) Development of Standard Tests to Evaluate Composite Insulators (09) Mechanical and Electrical Testing of Porcelain Insulators (09) Contaminated Outdoor High Voltage Insulators (09) Demonstration of a Tool for Non-Contact Evaluation of Porcelain Disc Insulators (09) Approach to Assess an Aging Population of Polymer Insulators (09) Analysis of the EPRI Transmission Line Polymer Insulator and Fiberglass Component Failure Databases: 2009 Zed-Meter Construction and User Guide (09) Overhead Transmission Line Lightning and Grounding Reference Book (09) Guide for the Application of Transmission Line Surge Arrestors (09) Alternate Ground Electrode Materials (09) An Approach for Using TFlash to Improve the Lightning Performance of Transmission Lines (09) Renewable Energy Technology Guide – status, performance and cost data (09) Conductor and Shield Wire Corrosion Management: Assessment of environmental factors and new and emerging inspection technologies delivered (08). Greenhouse Gas Reductions Options: Launched Global Climate Policy Design Forum Series, communicated the importance of technology innovation in addressing climate change through Global Energy Technology Strategy work (08) Transmission Line Lightning Performance: demonstration of field tool to evaluate Transmission line earthing (including award to Ben Howat for contribution to the project), report on improving lightning performance utilizing TFlash, report on sub-grade corrosion of earth electrodes (08) Overhead Transmission Insulators: Polymer and composite overhead transmission line components – tool for corona ring selection, report assessing a population of polymer insulators and ageing evaluation. Ceramic insulator integrity assessment – assessment of mechanical and electrical strength of porcelain disc insulators. (08) Advanced conductors: reports on maintenance and methodology for HTLS conductors (08) ACDC line conversion, efficient transmission system studies & impact of energy storage on transmission: in progress (08) Transformer end-of-life & condition assessment: delivered demonstrations of individual monitoring techniques including advanced DGA, additional information in transformer guidebook & real time processing of diagnostics (08) Transformer Life Extension: Delivered ageing models of cellulose insulation due to moisture, oxygen and heat, PTLOAD enhancements, a transformer moisture assessment tool and guidance on the effectiveness of transformer life extension through enhances oil filtration (08) Improving Overall Substation Maintenance Management contributes to predictive and condition based approaches to life extension guidelines and risk for transformers and circuit breakers (08) SF6 management and equipment performance: delivered focus on potential current and future issues including potential alternatives (08) Solid state FCL development: reviewed potential for SSCL (08)

	Circuit Breaker Condition Assessment and Life Extension: research on lubrication, life cycle performance and potential technology transfer (08) Ground Grid Evaluation, Maintenance and Refurbishment: progress on condition assessment and performance requirements for a field instrument, review of available staged fault test data (08) Life Extension Guidelines is a web-enabled database and stand-alone guidebook that provides substation engineers and maintenance crews with up-to-date knowledge, data, procedures, and best practices for substation equipment maintenance, condition assessment, and life extension—transferred through knowledge and use of the database and guidebook; can also be transferred through a training course (07) Transformer Expert System V 2.0 (Xvisor) is expert system software intended to help non-experts determine the condition of transformers and components—transferred through a training course (07) Computer-Based Training (CBT) for Overhead Transmission Components or Inspection Techniques is a training tool that utilizes standard CBT protocols to allow members to utilize their in-house training management systems—training is updated on an annual basis with new modules (07) Transformer diagnostic and risk assessment tools and software (07) Maintenance best practice guidelines (07) Development of fault current limiters (07) New SF6 Camera is an SF6 leak detection camera that is smaller and lighter than a prior version, providing a passive method of detecting leaks which eliminates the safety and training issues associated with lasers—expect to transfer this hardware device through EPRI-developed training courses in the field (07) Software tools to assist with selection of corona rings for insulators (07) New Transmission Line Design Workstation (07) Validation of superconductivity technologies and their values (07) Increased power throughput in urban corridors by a factor of 3–10 using EPRI research results in superconductivity (07) Adopting cost-effective, reliable, and secure communication for power systems applications (07) Reducing the risk of interference issues caused by the application of new technologies to transmission and substation systems (07) Understanding Transmission Grid Complexity, Information, and Knowledge Sharing delivered through updated information about FACTS technology applications (07) Common Information Model: The CIM standards, accepted globally, allow replacement of older inefficient energy management systems—transferred through a utility-specific application study or training programme (07)
Collaborative partners	World-wide utilities and universities through EPRI collaboration.
R&D provider	EPRI

<table>
<tr><td>Project title</td><td colspan="3">Feasibility of using Trifluoromethyl Iodide as a replacement for SF_6 in high voltage switchgear</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Paul Coventry</td></tr>
<tr><td>Description of project</td><td colspan="3">The project will establish the feasibility of trifluoromethyl iodide (CF_3I) as an environmentally compatible alternative to sulphur hexafluoride (SF_6) in high voltage switchgear applications and identify those areas which would require further work in order to achieve application.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £4k
External £27k
Total £31k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £5k
External £25k
Total £30k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£61k</td><td>Projected 2011/12 costs for national Grid</td><td>£0k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">The high global warming potential of SF_6 gas has encouraged research for alternative gases and mixtures in order to address the environmental issues. In recent years, several mixtures of SF_6 gas have been the subject of investigations by academics and manufacturers, including a large European project. However, these have led to a mere small incremental progress, and therefore, it is desirable to find an alternative gas to SF_6 and remove it completely from future electrical power applications.

Research work initiated at Tokyo University in Japan has investigated the electrical insulation characteristics of CF_3I gas, a gas which is widely used for fire extinguishing applications. It possesses the important physical and chemical properties of SF_6, but has a much lower global warming potential. The project aims to establish the feasibility of using CF_3I in high voltage switchgear applications and identify those areas which would require further work in order to achieve application.</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>7</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">The proposed work is intended to contribute to a reduction in SF_6 emissions by establishing whether switchgear using an environmentally compatible alternative gas is feasible. DEFRA has adopted a shadow price for carbon (SPC) in 2007 of £25/t CO_2e and, according to its guidance on use of the SPC, a price of 23,900 x £25/t or £597 k /t would be applicable to National Grid's SF_6 losses. The savings would be dependent on the volume of SF_6-based equipment replaced with the environmentally compatible alternative. In the event of a successful outcome, it is conceivable that all SF_6-based equipment on the transmission system would be replaced by 2050, representing a saving of some £ m per year, depending on the residual level of SF_6 losses that would otherwise have been achieved.</td></tr>
<tr><td>Expected timescale of project</td><td>2 Years</td><td>Duration of benefit once achieved</td><td>5 Years</td></tr>
<tr><td>Probability of success</td><td>60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>-£25k</td></tr>
</table>

Potential for achieving expected benefits	With regard to the likelihood of CF_3I being found suitable for use in switchgear applications, initial reports are encouraging. It has already been reported that the gas has a dielectric strength around 20% higher than that of SF_6 and an arc interrupting capability between that of SF_6 and CO_2. On the other hand, it has a boiling point at atmospheric pressure of -22.5℃ and measures would need to be taken to prevent condensation at low temperatures. It has been widely investigated as a fire extinguishing medium and can be produced at a reasonable cost. In the event that CF_3I is found to be suitable for use as an environmentally compatible alternative to SF_6, new designs would need to be developed and type tested by switchgear manufacturers.
Project progress **[Year to End of March 2011]**	Cardiff University have completed the feasibility study into trifluoromethyl iodide (CF_3I) as a replacement for SF_6 in switchgear. The gas has better dielectric strength than SF_6, has environmentally compatible properties, low toxicity, no risk of fire or explosion and no harmful by-products. In its pure form, however, it has a high boiling point (-3 deg C at 0.2 MPa), but may be used in mixtures with CO_2. A mixture of 70% CO_2 and 30% CF_3I presents the best performance with optimal gas phase stability. It therefore appears to have potential as an insulating medium and worthy of further investigation. It also has good properties as an arc interrupting medium but is not as good in this respect as SF_6. CF_3I presents some toxicological issues but these appear to be manageable. Its compatibility with materials of construction is apparently good but the available information is not exhaustive. Areas that would require further work are: • To establish properties of 30% CF_3I + 70% CO_2 gas mixture as an insulating medium • To establish long term stability, particularly in the presence of partial discharge activity • To establish compatibility of by-products with solid insulating materials • To explore whether a small but non-zero ozone depletion potential might be an issue in the long term Application as a replacement for SF_6 would need new equipment design (dielectric clearances, design pressure and possibly solid insulating materials) and a long time to market (design, development, type testing) would be expected. This financial year a small amount of internal time was used to review the final project reports.
Collaborative partners	
R&D provider	Cardiff University

<table>
<tr><td>Project title</td><td colspan="3">Replacement of SF_6 in transmission switchgear</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Paul Coventry / Dongsheng Guo</td></tr>
<tr><td>Description of project</td><td colspan="3">The project will develop an understanding of the fundamental physical mechanisms of arc quenching by chemical components produced from solid particulate material and subsequently deliver a demonstration interrupter unit for transmission applications that does not require SF_6 for its operation.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £90k
Total £93k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £6k
External £20k
Total £26k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£119k</td><td>Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Sulphur Hexafluoride (SF_6) gas has excellent arc interrupting properties which have lead to it being the only commercially available technology for circuit-breakers in electricity transmission applications. It does, however, have an extremely high global warming potential and its use raises questions on environmental grounds. Much work has been done in the search for alternative gases, but candidates having the appropriate chemical and physical properties also tend to exhibit high global warming potentials. Recent work performed at the University of Liverpool has adopted an alternative approach. An arc interruption technique has been demonstrated that uses chemical components produced in the presence of the arc from solid particulate materials. Its basic performance has been assessed with fault currents of up to 60 kA with moderated rates of rise of recovery voltage of up to 1.2 kV/µs. The work is continuing at present as part of AMRDE 1043 ‘Use and management of SF_6’. In the proposed work, the fundamental physical mechanisms of the technique will be studied and the four stages of arc interruption, thermal recovery, dielectric recovery and dielectric withstand will be optimised such that an interrupter unit for transmission applications can be developed. An approach using modelling and experimentation will be adopted and a demonstration unit for transmission usage developed.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>14</td><td>4</td><td>10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">National Grid has committed to reducing its greenhouse gas emissions by 80% in advance of the target date of 2050 set by the UK Government. SF_6 losses from switchgear constitute the third largest source of National Grid’s Baseline emissions in the UK, which highlights the importance of reducing SF_6 losses in order to meet the above greenhouse gas emission target.

The UK Department for Environment, Food and Rural Affairs (DEFRA) has adopted a Shadow Price of Carbon (SPC) in 2007 of £25/tCO_2e. According to DEFRA’s guidance on use of the Shadow Price of Carbon in policy appraisal, SF6 has a global warming potential of 23,900. On this basis, National Grid’s published SF_6 losses in the UK in 2007/08 of 14.53 t represent a cost of £8.7M for the year. A proportion of these losses are associated with SF_6 in interrupting applications.

An interrupter unit for transmission applications that does not require SF_6 for its operation would eliminate a proportion of the losses by displacing SF_6-based interrupters from the inventory, the level of savings depending on the number of units displaced. In the event of a successful outcome, it is credible</td></tr>
</table>

	that all SF_6-based interrupters in air-insulated switchgear (AIS) applications would have been replaced by 2050, eliminating a contribution to National Grid's SF_6 losses of a few tonnes per year representing savings of around £2M to £3M per year. EC Regulation No 842/2006 on Certain Fluorinated Gases which came into force in June 2006 prohibits the use of SF_6 in some applications. If legislation banning the use of SF_6 in switchgear were to be introduced significant other costs would be incurred including replanting of substations, which could be avoided by the timely adoption of a non- SF_6 based interrupter. The public image and reputation impacts would also be significant. By supporting the proposed work, National Grid will be demonstrating a proactive and innovative approach to reducing global warming.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	Years
Probability of success	40%	**Project NPV = (PV benefits – PV costs) x probability of success**	£114k
Potential for achieving expected benefits	Although the technique for interruption without SF_6 has been demonstrated in the laboratory, there is a significant level of risk associated with the project. Out of arc quenching, thermal recovery, dielectric recovery and dielectric withstand, it is the latter that is expected to present the greatest challenge. The likelihood of success is estimated to be medium. Given the current imperative to reduce greenhouse gas emissions, a successful outcome to the research is likely to result in significant pressure for implementation. Production prototype devices will need to be built and type tested at a short circuit test laboratory. The involvement of a switchgear manufacturer will be essential for production of a commercial device. The test at Liverpool are done on a full sized circuit breaker unit and at fault current levels of 63kA and with an injection voltage of 1.2kV/s.		
Project progress **[Year to End of March 2011]**	A non- SF_6 self-blast type interrupter unit has been designed to utilise the accumulated thermal arc energy to build up high pressure in the expansion volume. In the case of a high-current arc interruption, the resultant high pressure gas is released at current zero to help extinguishing the arc. For a low-current operation, the present design mainly exploits the effects of polymer reaction induced pressurisation and arc quenching phenomena to assist arc interruption. The use of polymer materials in the arc discharges currently forms part of the development of new interrupter methodologies for replacing SF_6 in future switchgear systems. The objective of the present work is to focus on optimising and improving the current interruption ability of low-current arcs (i.e. for arc currents with peak magnitude of less than 10 kA). A number of basic tests have been undertaken involving additional design changes being made on the existing test interrupter unit. This is centred on the injection of particulates to promote arc interruption. The schematic diagram of the test interrupter unit is shown on Fig. 1. One of the aims of the experiment is to compare the effects of pressure build-up by introducing additional ablative wall materials and some other micron-size polymer particles within the test unit. It is known that the presence of additional polymer materials can lead to an increase in the pressure build-up inside the expansion volume which subsequently intensifies the gas flow flushing and arc cooling process.		

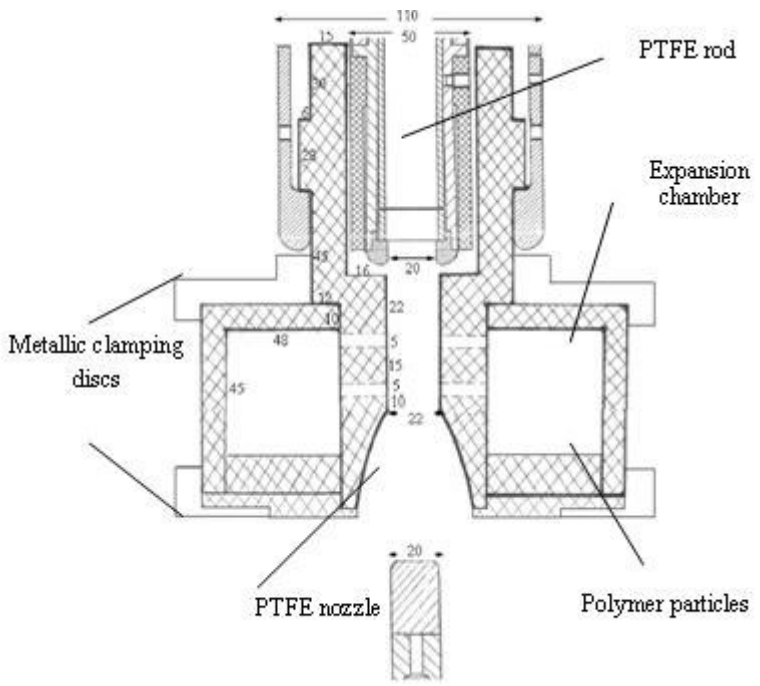


Fig. 1: Test unit with an additional PTFE core inside the hollow fixed contact.

In the current test arrangement, an additional ablation element (PTFE rod) is placed inside the hollow fixed contact. The design modification is aimed at reducing the overall arc-heating volume, as well as increasing the mass ablation, in order to generate a larger pressure build-up inside the expansion volume. Tests are performed on the test unit in Nitrogen and also SF_6 at 1 bar pressure. Their results are first used to establish a benchmark against which the performance of the test unit can be evaluated.

In addition, a polymer injection apparatus (see Fig. 2) will be used to supply a pressurised nitrogen gas flow into the expansion chamber at a certain fixed timing during the arcing event. The external gas flow will make the polymer particles which are pre-loaded inside the expansion chamber become buoyant in the air. Some of the particles may be expelled into the arcing column via the existing vent holes. Overall, this setup increases the surface area of polymers being exposed to the arc plasma, subsequently leading to the increased rate of polymer reaction.

Tests have been carried out on the test unit of Fig. 1. It can be seen in Fig. 3 that the presence of a PTFE rod inside the hollow fixed contact causes significant pressure rise inside the expansion chamber for the high-current arcs. As an example, the results of Fig. 3 has indicated that a maximum pressure rise of approx 18 bar could now be achieved by the 30 kA arc, hence future design should be robust enough to withstand higher pressures. Pressure relief valve may be installed to relieve overpressure in the case of higher arc currents. Overall, the induced pressures are still quite low for the low-current arcs. Fig. 4 shows the comparison between different polymer reactions in some of the previous polymer test setups in order to increase the expansion chamber pressure for the low current arcs. These include pre-loading some micron-size polymer particles inside the expansion chamber and also making them airborne during the tests.

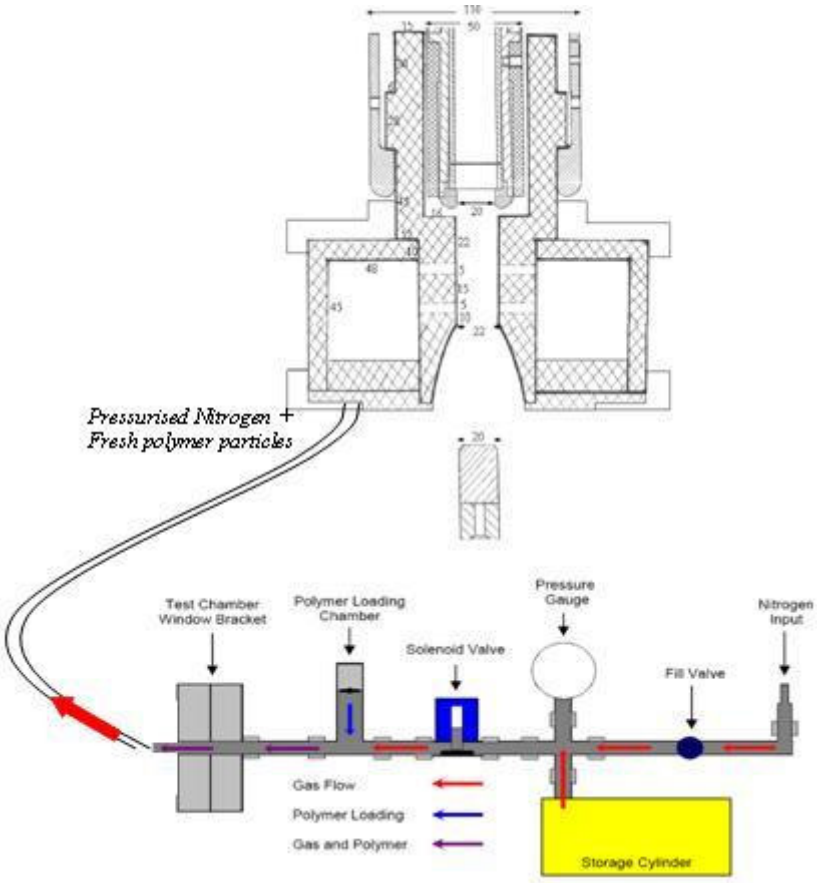


Fig. 2: Polymer injection apparatus to propel pressurised nitrogen and polymer particles.

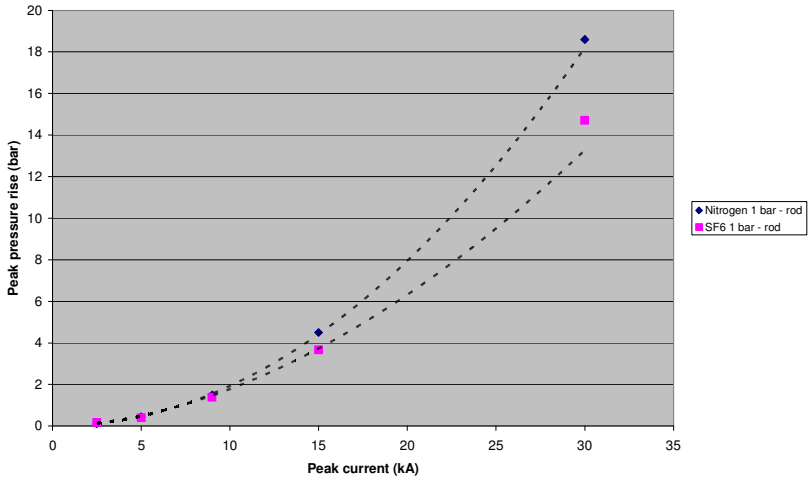
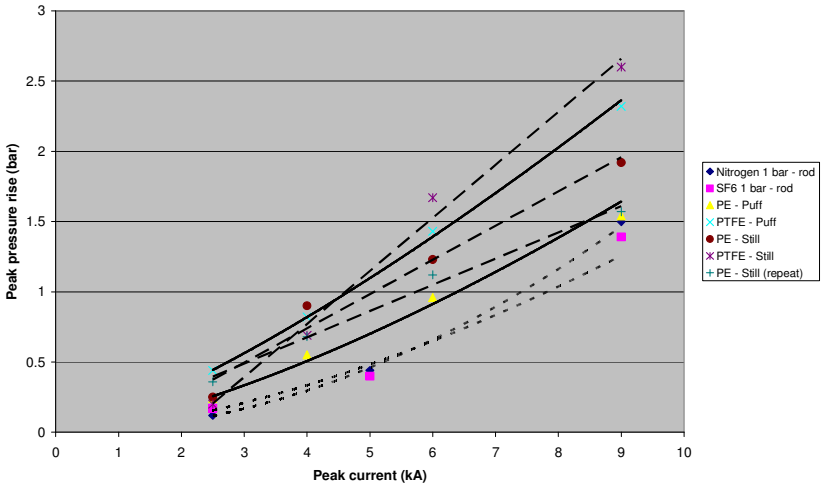


Fig. 3: Maximum pressure rise in expansion volume as a function of peak arc current without the use of polymers.

	 Fig. 4: Influence of polymers on the maximum pressure rise in expansion volume for low-current arc interruptions. The peak currents are less than 10 kA. Polymer particles are present inside the expansion chamber. **Conclusions.** The low current arc / particle interaction and its contribution to the interruption process is been identified. The processes for optimising the low current arc interaction with the polymeric materials is being optimised to produce maximum pressurise in the expansion chamber. A design feature related to the high pressure withstand of the assembly has been identified.
Collaborative partners	Discussions are being held with potential collaborative partners.
R&D provider	University of Liverpool

<table>
<tr><td>Project title</td><td colspan="3">33Kv Voltage Transformer (VT) Shutter Locking Device</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Dave Turnill</td></tr>
<tr><td>Description of project</td><td colspan="3">The development in the short term of an interim solution utilising an approved method to access and apply a locking device to the VT Shutters for safety switching activities. Reduction in the level of exposure to the danger from working at height.

The interim development of a shutter locking device will immediately reduce MDE's exposure to the dangers of working at height. But only when the final solution is developed will the dangers of working at height be reduced to zero.

The development in the long term of a final solution where the VT shutter is modified to provide a locking function at ground level for safety switching activities. It is proposed the final solution will enable the lock to be applied from ground level. As a direct consequence it will reduce to zero the requirement to work above ground level.

The final development of a shutter locking device will take a prolonged time to implement due to the outage constraints the HV system places upon MDE. It is envisaged the final solution will take up to 5 years to implement fully and therefore an interim solution will be necessary to minimise MDE's exposure to the dangers of working at heights.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £6k
Total £9k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£16k</td><td>Projected 2010/11 costs for national Grid</td><td>£7k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">The design of the AEI VSLP15/10 2000A, & VSLP15/15 2500A 33kV OCB has its synchronising VT mounted on top of the switchgear The height of the OCB and VT is 3m from ground level (photo 1). The VT is racked out from ground level which retracts the VT from the spouts and an interlocked cover then automatically drops to cover the 3 spouts (photo 2).

During operational safety switching an Appointed Person (AP) is instructed to "Isolate & Lock VT Shutters" a lock and caution notice have to be applied to the yellow interlocked shutter to prevent accidental operation and reenergisation of the VT. In carrying out his duties the AP has to gain access onto the top of the switchgear to check the shutter has dropped and then apply the lock and caution notice.</td></tr>
</table>

<table>
<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>6</td><td>-6</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This Final solution project will provide a system which is user friendly, very effective and will ensure we give our MDE Appointed Persons the best working environment carry out their duties and eliminate the risk to their health and safety by removing the need to work off ground level.

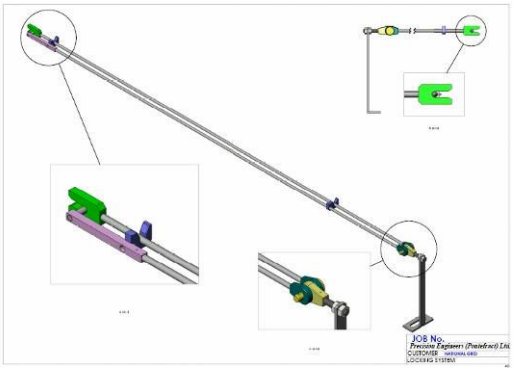
This Interim Solution project will provide a system which is user friendly very effective and can be implemented immediately to all OCB's of this type on completion of the development phase. It will ensure we give our MDE Appointed Persons the best working environment to carry out their duties and eliminate the risk to their health and safety by reducing the need to work at height when accessing the VT shutters.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td colspan="2">Duration of benefit once achieved</td><td>5 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>-£17k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">It is envisaged that there is a very high possibility of success with this project.

Interim Solution: - Although there is currently nothing on the open market that will fulfil our requirements fully, we can utilise a combination of both open market solutions for access to the shutter level which will allow the application of a bespoke solution for the shutter locking device.

Final Solution: - Although there is currently nothing on the open market which will fulfil our requirements, a bespoke solution to extend the shutter locking device to enable ground level locking can be developed.</td></tr>
<tr><td>Project progress

[Year to End of March 2011]</td><td colspan="4">Interim Solution: This period has seen very good progress with this project. Several field trials have now been held and the concept has proved very successful over several sites Having designed built and trialled both the access podium and locking device this project is now reaching its conclusion.

Access Podium
 
Locking Device
  </td></tr>
</table>

	 Final solution After consultation in the field whilst carrying out interim field trials it is now considered not necessary.
Collaborative partners	
R&D provider	Parkway Sheetmetal Bratts Ladders

Project title	**Air System Conditioning Monitoring**		
Project Engineer	Martin Dimmock		
Description of project	This project will develop and trial a remote access condition based monitoring system that can be retro fitted to substation air systems. The objective of this trial is to confirm the feasibility to take data wirelessly from National Grid compressors located at sites throughout the UK for display on the National Grid Condition Monitoring website called 'SAM' (Smart Asset Management). The members of the consortium (shown below) will all work together under the project coordination of Adaptive Wireless Solutions Limited. The ultimate objectives are to more efficiently manage the air system fleet by: • Proactively give an early warning of asset failure. • Optimising running regimes to balance compressor running hours against maintenance & energy costs so more effectively applying maintenance policy. • Reduced operational costs due to remote dew point monitoring. • Providing measurement of energy consumption & subsequent CO2 footprint data. • Potentially provide data for use in air leak detection using "Fuzzy logic". The following suppliers will be involved in the trial: • Gardner Denver are a supplier of compressors to the National Grid and will generate data from their compressors for the trial • CompAir are a supplier of compressors to the National Grid and will generate data from their compressors for the trial (Merged with Gardner Denver Dec 2009) • Adaptive Wireless Solutions are providers of wireless data acquisition technology who will collect and transmit the compressor data to C3 Amulet • C3 Amulet will manage all aspects of the data from decoding and upload through to calculations, analysis and presentation. The trial is split into two phases: Phase 1 – This is a 3 month proof of concept to show that the end to end wireless monitoring of compressors can be achieved via the C3 Amulet website. A working system will be created on one test compressor from each manufacturer and this will form the test bed for the suite of monitoring. Sensors will be added and data will be generated. During this phase the C3 Amulet website will be developed to meet the project outputs and displays required. Phase 2 – Once phase 1 is completed successfully a 2 year trial will commence on two National Grid sites where each manufacturer has installations of their compressors running in normal production use. This phase will include all of the compressors at the chosen locations. The website will be configured to display these two sites and the data and outputs will be reviewed over a two year period. The specification has been drawn up and agreed by National Grid Asset Engineering in conjunction with all the suppliers in this paper.		
Expenditure for financial year	Internal £7k External £17k	**Expenditure in previous (IFI) financial years**	Internal £9k External £125k

	Total £24k		Total £134k	
Total project costs (collaborative + external + [company])	£158k	**Projected 2011/12 costs for national Grid**	£0k	
Technological area and/or issue addressed by project	Development of substation compressed air systems condition monitoring.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		12	-1	13
Expected benefits of project	Due to the majority of the costs being software dependant, the site trial costs are high. This being said, a follow up National roll out scheme will benefit from the software already being developed and will be much cheaper based on a per site basis. Following a successful trial and national roll out, the following conservative cost savings could be made. Lowered operational expenditure via improvements in reliability and lowered spares consumption. £100K per year. WSE legal compliance (TGN 77) & (TGN 14) via DEW point monitoring. £60K per year. CO_2 & Energy cost reduction (CO_2 savings based on £17 per tonne of CO_2). £100K per year. Proactive maintenance and oil top up prediction £50K per year. Total annual savings = £310K.			
Expected timescale of project	2 Years	**Duration of benefit once achieved**	Ongoing for the duration of NG air-systems	
Probability of success	98 %	**Project NPV = (PV benefits – PV costs) x probability of success**	£580k	
Potential for achieving expected benefits	Once the development trial is concluded a summary report will be generated to evaluate the viability of a national roll out of the technology on a cost beneficial basis. The potential cost savings will be estimated at that juncture based on analysis of actual data recovered from the trial sites pro-rata across the entire fleet at 220 substations.			
Project progress **[Year to End of March 2011]**	The initial Ipswich test site has been completed and test data collected to prove delivery model viability. This site has since been de-commissioned and the equipment reassigned to progress the East Claydon & Feckenham sites. The East Claydon site is now operational and data is being downloaded to the SAM system. This was initially delayed due to site operational issues which affected the installation time scale. The Feckenham site is now being deployed and test data will be available and viewable on the internet from the end of May 2010. Test data will be collected and analysed until January 2011. The final project report will be available January 2011			

	as stated in the R & D scheme paper. This project is complete and was successful in the trial operation. This system can be easily integrated into the SAM and RAM projects and should not require additional IFI funding to complete. Adaptive solutions have provided a summary and this has been integrated into National Grid's policy.
Collaborative partners	
R&D provider	Adaptive Solutions/C3 AMULET/CompAir/Gardner Denver.

<table>
<tr><td>Project title</td><td colspan="5">Non Conventional Instrument Transformers (NCIT) Pilot Project Closures</td></tr>
<tr><td>Project Engineer</td><td colspan="5">John Fitch</td></tr>
<tr><td>Description of project</td><td colspan="5">This R&D Project aims to deliver closure, reporting on the learning achieved and the potential whole life value benefits of 3 pilot installations of NCITs, which are currently installed as shadow /non operational systems on the National Grid Electricity Transmission System. This will help formulate future strategies and direction for future NCIT trials and implementations.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3K
External £5K
Total £8K</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td colspan="2">£0K</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£27K</td><td colspan="2">Projected 2010/11 costs for national Grid</td><td colspan="2">£18K</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">As part major construction projects in the late 1990s and early 2000s, 3 pilot installations of NCITs were installed as “shadow” systems by substation project companies to help them gain some operational experience with this new technology. These projects have since lacked a focus and any value output, so this R&D project is to manage these trials through to a mutually agreed completion and outcome, with reporting on the lessons learnt and benefits achieved. It will lead to a planned decommissioning, removal and disposal of these non-maintained assets.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>9</td><td>-1</td><td colspan="2">10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">Lessons learnt form these three pilot installations will be documented and recorded and fed into future strategy and policy changes. This will include the following:
Installation Issues
Asset Performance
Asset Reliability and Stability
Maintenance Issues
Health, Safety & Environmental Issues
Asset degradation mechanisms
Decommissioning and Disposal Issues
Risks to the UK Electricity Transmission Network will be reduced by removal of non maintained/non operational assets connected to the HV system and auxiliary supplies.</td></tr>
<tr><td>Expected timescale of project</td><td>2 year</td><td colspan="2">Duration of benefit once achieved</td><td colspan="2">5 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 colspan="2">-£23k</td></tr>
</table>

Potential for achieving expected benefits	With a project focus to manage these 3 off NCITs pilot installations and commitment from product suppliers, the likelihood of success is high.
Project progress **[Year to End of March 2011]**	Work has started on this project however it was started very late in the financial year and there are no deliverables to note at this time.
Collaborative partners	
R&D provider	Alstom GRID & ABB

<table>
<tr><td>Project title</td><td colspan="4">Demountable Flood Barrier Facilitating work Phase 1 and 2 (Flooding)</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Doug Dodds</td></tr>
<tr><td>Description of project</td><td colspan="4">To ascertain what works must be undertaken on flood risk sites to ensure demountable flood defence is best utilised with maximum effectiveness and seek a detailed understanding of the safety issues and practicalities of erecting the Geo-Design demountable barrier including:
Carry out trial deployment of temporary flood barrier system
Carry out 2nd trial deployment of temporary flood barrier system on completed site
Produce flood barrier deployment plans for all of the at risk sites
Produce permanent works plan for at risk sites to facilitate and maximise the effectiveness of the temporary flood barrier and carry out works on trial sites
Develop model deployment plan to maximise the effectiveness of the temporary flood barrier
Develop model permanent works plan for at risk sites to facilitate and maximise the effectiveness of the temporary flood barrier and carry out works on trial sites
Produce permanent solutions options plan to feed into Capital investment schemes
Obtain LIDAR data for 1 in 100 year flood risk sites to give a greater understanding of the flooding profile of a site also to indicate low points on site and show potential flooding routes onto site.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £8k
External £0k
Total £8k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £28k
External £2k
Total £30k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£38k</td><td>Projected [next year] costs for [company]</td><td colspan="2">£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Flooding/risk management</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Tech Transfer</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">Our Transmission licence requires us to operate the system with the minimum of disruption to service with this in mind any preventable losses due to flooding should be mitigated through appraisal management and reduction of the risks associated with flooding.

Climate change is resulting in greater frequency of flood events similar to the flooding experienced in June/July 2007. In order to reduce the requirements to initiate an assessment of all sites after each of these high profile flooding events it is envisaged that a robust strategic solution will be flexible enough</td></tr>
</table>

	that in depth site assessments will not be necessary with data being retained and made available for future use mitigating the need to employ resources. Understanding the complexities, potential limitations and risks associated with deploying the demountable flood defence through study and trials will give visibility to safety and installation problems reducing the need leaning lessons during actual incidents and the potential risks associated with this. Cost effective assessments can be made as to the amount of barrier required to protect a site. Through the innovative combination of flood defence systems together with permanent works will give greater flexibility and cost savings associated with removing the need to purchase extra barrier or the construction of a total flooding protection in the form of permanent works on site.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£320k
Potential for achieving expected benefits	High		
Project progress **[Year to End of March 2011]**	A number of test sites are being assessed for suitability; the detailed site surveys for all 1 in 100 year risk sites were made available by September 09 which will give us a base for costing the permanent fixing works and the deployment routes for the barrier at a test site. There have been further controlled test deployments exercises carried out to better understand the seepage rates we can expect on different ground surfaces. The data from the Environment Agency was successfully challenged by National Grid and the test site has been moved due to the lack of risk to the identified site. The investigative and construction costs associated with this project were transferred into the pre works scheme 21235P with only the internal costs associated with the trial deployment exercise carried out during the national exercise (Watermark) remaining within the IFI scheme. National Grid's participation in exercise watermark was successfully completed with positive feedback on National Grids approach to flooding. More work is continuing in this area under asset scheme as the uncertainty has been removed.		
Collaborative partners	-		
R&D provider			

<table>
<tr><td>Project title</td><td colspan="4">Determine the resilience of GPS Clocks and installations to substation and externally generated radiated interference</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Stuart Mann</td></tr>
<tr><td>Description of project</td><td colspan="4">Determine the resilience of GPS clock synchronisation to substation generated and external interference that shall include :-
An investigation and evaluation into the cause of poor reliability of the time synchronisation of certain GPS clock installation
Recommendation on actions that can be taken to improve reliability particularly if poor installation techniques or location of antenna have caused unreliability.
Investigation into the ongoing suitability of current GPS based clocks to determine if these offer sufficient resilience to radiated interference or whether other time synchronisation systems or methods should be investigated either as an alternative or supplement.
An investigation of alternative causes of GPS Clock time synchronisation unreliability to determine what these are likely to be and whether these are affected by environment or installation.
Produce a strategy, specification and technical guidance on deployment of GPS clocks for protection systems where required.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £8k
Total £11k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £9k
External £15k
Total £24k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£60k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The resilience of GPS clock synchronisation to substation generated and external interference</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9</td><td>-1</td><td>10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Understanding if GPS clocks within substations are susceptible to substation and externally generated radiated interference or if improved installation or antenna location will contribute towards:
Reliability.
Risk avoidance through understanding the impact of these vulnerabilities and what actions to take.
Investigation into alternative or complementing technologies.
Help to prevent against loss of supply reputation and associated costs.
Reduction in the protection mal-operations due to unreliability of GPS based clocks</td></tr>
</table>

	resulting in a cost saving of £46.3k per MWh of lost supply. As an example, using this cost value, a single incident of a 10 minute loss of supply of 50MW average would result in a cost to National Grid of £383k. The cost of each loss of supply would need to be calculated on an individual basis.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years
Probability of success	70%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£33k
Potential for achieving expected benefits	High – The R&D project has now been completed and a report has been delivered and circulated for comment. The outcome of this work requires further investigation by a separate project and collaboration on development of complimentary supporting technology. The outcome of the project may influence future protection or telecoms system design and procurement.		
Project progress **[Year to End of March 2011]**	This project is now complete and the following work has been undertaken • Loan of clocks from 3 of National Grid's protection system vendors • Non destructive testing of these clocks in a laboratory environment • Non destructive testing of one of the clocks in a live substation environment • Production of a report into the findings • Distribution of the report internally for comment • Availability of a sanitised report for protection system vendors or external parties The report has found 2 significant areas of concern Reliability issues could be self inflicted. The site test revealed that a second clock installed on site was interfering with the clock under test by radiating a signal that was jamming the received GPS signal. This fault often leads to alarms from the protection equipment to indicate that the GPS signal has failed. There are significant security concerns with all clocks. The lab and site tests showed that it was possible to jam the GPS signal received by the clock from a variety of distances (depending on the clock make and model). In addition, it is possible to interfere with the time synchronisation of the clock either by gradual or step change. The results of this R&D project could be used to initiate further separate R&D projects. Some recommendations are as follows. For point 2 above, a separate R&D project may to determine how susceptible the related protection systems are to changes in the GPS clock time synch data. A separate R&D project in conjunction with CPNI and an external supplier on the development and trial of a solution to detect or protect against malicious intent.		
Collaborative partners	CPNI		
R&D provider	DSTL		

<table>
<tr><td>Project title</td><td colspan="4">High Contact Resistance on SF_6 Interrupters Associated with Compensation Duty</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Simon Atkin</td></tr>
<tr><td>Description of project</td><td colspan="4">This project aims to carry out research and development into high contact resistance on switches, fitted with sulphur hexafluoride (SF_6) interrupter units, carrying out compensation switching duties in applications where the loads are low.

This high resistance has been attributed to the drying out / decomposition of contact lubricants producing a high resistance layer. It has also been suggested, by the manufacturers of the equipment, that due to the nature of the equipment and lubricants used a chemical reaction may also be occurring causing a build up of silver sulphide (Ag_2S) on the contact surfaces.

Currently it is suspected that this issue is the cause of the high contact resistance evident on the AEG S1 models of switch. Additional issues have been reported implying this issue may also be occurring on the ABB HPL300 switch carrying out the same compensation duty.

It is proposed that this work be undertaken in two stages:
• Research into the circumstances precluding to the production of the high resistance film
• Development of non intrusive diagnostic methods allowing the equipment to be maintained and returned to operational service within the scope of current maintenance policy without safety or operational restrictions.

This paper seeks funds to carry out the first stage of the work research to substantiate the presence and effects of contact film / silver sulphide on contact resistance.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £2k
External £10k
Total £12k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £5k
External £21k
Total £26k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£39k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£1k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Hhigh contact resistance on switches, fitted with sulphur hexafluoride (SF_6) interrupter units, carrying out compensation switching duties in applications where the loads are low.</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>1</td><td>7</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This work will establish the effects Ag_2S has on contact resistance enabling an accurate diagnostic of electrical contact condition to be achieved. This issue is currently manifesting in the AEG S1 models of switch, the current population which may ultimately become affected by this issue is 37 therefore if this issue is not addressed there is a potential resource requirement for thermo vision to be carried out on 37 switches.

Ultimately as the electrical contact condition cannot be fully ascertained the equipment may need to be switched out of service. This will have an effect on</td></tr>
</table>

	the amount of compensation available on the network. Additional benefits from this work may lay in the development of contact measuring means which will give a greater indication of contact condition allowing the content of interrupter maintenance to be reviewed. This has the benefit of reducing outage time and costs.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£53k
Potential for achieving expected benefits	The R&D project is progressing well and there is high expectation that the identified benefits will be achieved. It is still envisaged that the expected outcome will be achieved.		
Project progress **[Year to End of March 2011]**	Investigations into silver sulphide deposits have corroborated initial thoughts on composition. Detailed analysis on longer term effects and potential eradication will be established during a condition assessment which had been programmed for 2009; however this had been initially delayed due to the availability of spares from the manufacturer. The spares have now been sourced and the condition assessment scheduled. Although the paper sought funds for the 1st stage of the proposed work the project has progressed well allowing investigation into a non-intrusive testing and condition assessment methods to be undertaken and 2 types of tests are currently being investigated. Studies in one of the testing methods has identified that slight modification to existing test equipment can achieve the desired results. It has also been identified that this methodology may be employed on a different genre of equipment. Longer term, providing the desired results are obtained, it is probable that the outcome from this R&D project will enable a review of current maintenance policy to be undertaken enabling a condition based approach to be adopted. The R&D into diagnostic testing has been completed and a benefit from this has enabled existing National Grid test equipment to be utilised by means of a patch box. Work into the reason why silver sulphide develops in this type of unit is still ongoing and post discussions with two manufacturers it has been identified that a further development opportunity exists. This additional R&D will enable a more accurate assessment to be made on the condition of the equipment without the need for intrusive investigation. It is recommended that a change request be issued and this work continued.		
Collaborative partners	N/A		
R&D provider	ABB, Areva and Doble		

<table>
<tr><td>Project title</td><td colspan="3">Development of probabilistic risk assessment procedure for earthing systems</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Alan Ainsley</td></tr>
<tr><td>Description of project</td><td colspan="3">Align against recently published safety voltage thresholds and delivering a software tool that helps to manage National Grids risk responsibilities from voltages seen on earth mats within substations under fault conditions and the management of export potentials.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £3k
External £85k
Total £88k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£295k</td><td>Projected 2010/11 costs for national Grid</td><td>£162k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Previous involvement on international committees has resulted in the recognition and acceptance of a probabilistic risk based approach to earthing system design and assessment. The confidence gained from National Grid to support this approach was as a direct result of previous research that reviewed local fault levels and fault clearance times against site earth potential rise seen under fault conditions.

To date success has been seen in;

• Building an interface between the Cardiff Risk Assessment For Transmission Systems (CRAFTS) software and the CDEGS earthing analysis software and implement a fault clearance time database.

• Building a steady-state model of the 400kV/275kV UK transmission system in ‘NEPLAN’ power system design software and calculate the variation in fault current magnitude and its effect on prediction of individual risk.

• Undertaking limited case studies with CRAFTS using data provided by National Grid and Scottish Power.

This project should account for any benefit from supportable historic clearance protection times and actual system fault current magnitudes. Such detail will allow a more precise risk assessment and a relaxation away from worst-case scenarios. In order to gain most benefit from these previous research findings, the future research will focus on four main areas;

• Effect of fault current level on probabilistic risk assessment around substations.

• An interface between the National Grid simplified GB transmission system model, implemented on Power Factory, and the probabilistic earthing risk assessment software developed at Cardiff University (CRAFTS) will be developed. This facility will allow the engineer to assess the level of risk at particular problem sites, by quantifying the effect of fault current variation on risk level. This will require procedures to be developed that compute fault current data for given locations taking into account generation ranking order and load level over an annual cycle.

• CDEGS earthing software interface

• Investigating the probabilistic risk for exported potentials and hot zones.

Currently, hot zones and exported potentials prediction using CDEGS</td></tr>
</table>

<table>
<tr><td></td><td colspan="4">software provides National Grid with useful information for assessing impact on third parties. The research in this area will enhance this information by also including the associated risk level corresponding to the hot zones and exported potentials mapped for a given substation location.

Application of recently updated CENELEC/IEC standards to the developed Cardiff probabilistic software (CRAFTS)

The developed Cardiff software (CRAFTS) uses BS7354 as a working standard. Recent developments in the UK and Europe have resulted in a new set of standards that will be shortly adopted as UK standards in the form of British Standard European Norms (BSENs). These will be therefore adopted by National Grid and other ENA members. It is proposed to adapt the CRAFTS software to include the new standard recommendations which include, inter alia, the revised safety limit threshold values.

Investigation of variability of probabilistic risk at different locations within a substation.

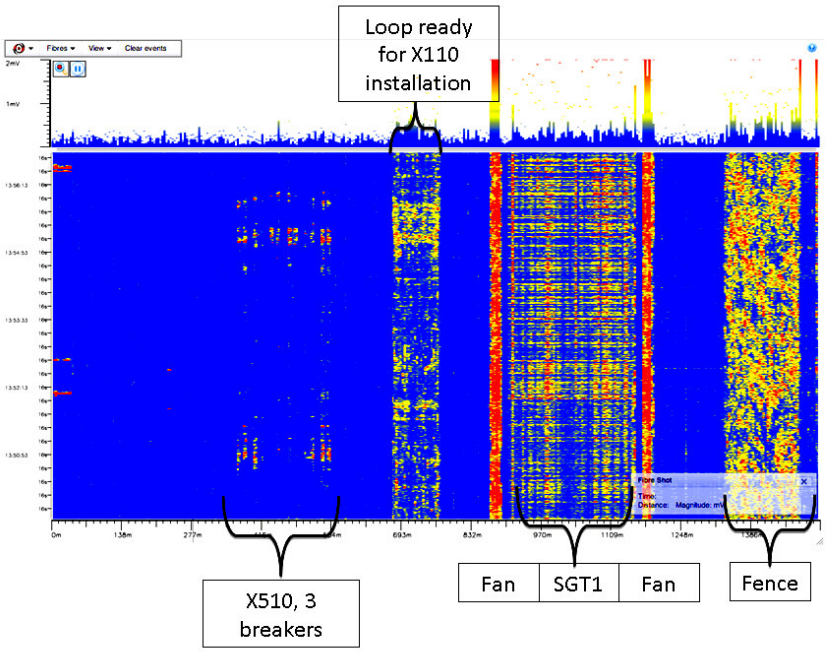
This research will assess whether the currently-used approach of checking the safety voltages at the corner of the substations is the most appropriate method. It is expected that the corners of the substations will have higher probability of higher safety voltage levels compared with other locations in the substations. On the other hand, the presence probability at the corners of the substation is expected to be lower than at the other key-frequented locations within the substation.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>-1</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The four areas above will lead to significant financial benefits due to avoided remedial work on substation earthing systems that would have previously been identified as being of high risk. In 2008 alone three sites were identified where remedial work was not required thus saving between £50k and £100k per site. This procedure will ensure that savings such as this continue to be made routinely in the future.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td colspan="2">Duration of benefit once achieved</td><td>5 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>£154k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Based upon Cardiff universities previous research in this area, and with the change of standards at IEC/CENELEC levels that recognise Risk Assessments within Earthing design and Earthing assessments, the likelihood of success is extremely positive.

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

Project progress **[Year to End of March 2011]**	This project is a new project following on from a recently close IFI project which identified the need for additional work in this area. The research assistant is already in post and available for use on this project. This will mean that this project can start immediately without delay Over the last year the software CRAFTS has been updated to include the findings of the original R&D project and changes in the standards at IEC/CENELEC. This work is due to be presented to National Grid in June 2011.
Collaborative partners	
R&D provider	Cardiff University

Project title	**Use of Fibre Optics in Substations to Detect Noise.**			
Project Engineer	Carl Johnstone (Oliver Aries)			
Description of project	To implement a pilot trial and assess the benefits and limitations of optic fibre sensing in a Substation Environment for asset management and operational needs. This project will deliver a fibre optic cable at Bolney 400kV substation which will be routed around part of the perimeter fence and in the near vicinity of at least one 400/132kV SGT, a 13kV tertiary reactor, a 400kV air blast circuit breaker and other switchgear. This fibre will be lit using a sensor which has been developed by BT which uses the fibre to detect audible sounds. The data from this will be sent across an internet connection back to a BT server to analyse the noise signatures on site. A trial of this system will be carried out over a period of a year to determine its potential. Key benefits will be in the areas of: Condition Monitoring using audible signatures Extension of maintenance regimes of transformers, reactors and switchgear using audible footprints. Detection of imminent equipment failure.			
Expenditure for financial year	Internal £30k External £96k Total £126k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0	
Total project costs (collaborative + external + [company])	£148k	**Projected 2010/11 costs for national Grid**	£22k	
Technological area and/or issue addressed by project	Asset condition assessment in substations through noise detection. BT have used this technique with Network Rail and it is now in production and has proved very useful for the location of Trains by triangulation from the sound source, improving the safety at farm Railway Crossings (determining when next train will be), fault diagnosis of trains whilst running on the track (diction of square wheels by analysing the sound footprint) and detection of Copper Thefts. It is believed this system can be tailored to suite a number of applications some of which may only transpire during the project.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		12	0	12
Expected benefits of project	If successful this system will: Provide a 'two voting system' to minimise false alarms Increase maintenance cycles as detection of wear and faulty parts can be done on equipment in service and before failure occurs. Analysis of a system incident on site to determine more accurately the cause			

	and effect. Single sensor technology that offers a simple yet diverse use, with a closer match in life with our assets It is difficult to put a cost to this but on the first point alone this could save around £400k pa in call out costs.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£7k
Potential for achieving expected benefits	It is predicted that the system should at least detect audible noise along the fibre route and pinpoint noise. BT with Network rail has successfully demonstrated this and its use for capturing a noise footprint. They have also successfully demonstrated its security objective. In the area of noise footprint of National Grid plant its success is less certain because although signatures can be taken for equipment, meaningful diagnosis of this data will be a steep learning curve and may not be possible to take into production during the trial period. However, the system is cheap to install and given time it is believed these applications should also prove to be successful for National Grid. The biggest risk to this project is the background vibration noise from transformers. An aim of this project is to see if this is an issue and, if so, can the 50hertz be filtered out and still give the system's potential benefits.		
Project progress **[Year to End of March 2011]**	Fibre and sensing equipment were installed in Bolney 400kV substation, enabling a sensing loop of fibre to be attached to circuit breakers and tap changer and fans of SGT1. The system was configured to listen to the High Voltage equipment and the cable troughs and fencing along the route. A series of tests were conducted; switching circuit breakers and tapping transformers on and offline, to provide enough audible data to evaluate the capability and potential of the technology. The objectives of the project were considered by engineers in Asset Management and Network Operations to explore the viability of the system as a condition monitoring tool and also as a new strand of thinking developed during the experiment, as a risk management device to give "visibility" of personnel on towers and in tunnels. The project's limited time span did give sufficient information to appreciate that there is potential for a more intense project to explore a system to give Network Operations a device utilising existing fibre on OHL earth fibre, to detect a human presence on towers and alert, and similarly by using DTS fibres in cables there appears to be prospect to use fibre sensing of sound to accurately locate a workforce in a tunnel to support risk management of workers in a cable tunnel. Condition monitoring of assets using sound requires an intimate understanding of the individual noise features of an asset and a profile would probably have to be developed for each asset determine how healthy equipment sounds and a point or points could, perhaps, be defined or sounds identified at which the asset can be said to be ailing. Potential exists for a long term project, possibly in collaboration with manufacturers to develop this condition analysis technique and additional work to develop and research the technique would be of value.		

	 Fig: Sound Picture of the entire length of the FAM fibre at Bolney
Collaborative partners	
R&D provider	MDE / BT

Project title	**High Level Indoor Isolator Access**		
Project Engineer	Dave Turnill		
Description of project	A standardisation of safe working practice and adoption of an interim solution utilising approved methods of accessing both fixed and moving contacts of high level indoor isolators for maintenance activities. An interim solution will reduce the level of exposure to the danger from working at height with the development of a bespoke access podium which can be readily manoeuvred around the existing safe working area. A final solution will remove and replace the current inadequate fixed handrail system and working floor area which has very restrictive access and implement an engineering solution it will necessitate maintaining safety distances. The solution will have to be a readily applied interlocked safety barrier. When the safety barrier is not in use it can be retracted/withdrawn/removed/lowered to be outside safety distances prior to it being returned to service. It will further reduce the level of exposure that MDE to the dangers of working at height. It is envisaged the interim solution will be adopted in the short term and can be developed and finalised in the next 12 months. The long term objective of a final solution to negate the requirement for the interim solutions will take possibly up to 10 year to implement due to system constraints and the restricted access which this allows MDE.		
Expenditure for financial year	Internal £4k External £5k Total £9K	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£43k	**Projected 2010/11 costs for national Grid**	£21k
Technological area and/or issue addressed by project	Within National Grid we have 10 substations on the system which are of an indoor design with both main and reserve busbar isolators located above the circuit breakers on the second floor Photo 1. Historically MDE staff the staff have maintained the rotating centre post isolators which have 6 fixed contacts and 6 moving contacts either by accessing from a ladder or climbing the insulator stack with the assistance of a pole strap. These practices have now been outlawed due to legislation changes and policy changes but no replacement method of accessing the equipment to carry out maintenance or has be highlighted or developed to allow MDE maintenance to continue maintaining the asset. However in the original design all the 9 insulator stacks were not located within the safe working and hand railed area see photo 2 below. The picture is of a Main Bar isolator and it can be seen that both fixed contacts are outside the safe working area. The photograph was taken at Ferrybridge which was the scene of a major incident in the early 1990s. A MDE fitter was accessing the moving contact to carry out maintenance from a ladder stood up against the moving arm of the isolator. Unfortunately the isolator arm moved away and as a consequence he fell on the breaker floor some 8m below severely injuring himself. Also a near miss at Lister Drive in October 2010 was logged after a hand rail gave way no one was injured but the potential of an incident remain very high.		

<table>
<tr><td></td><td colspan="4">  
It is proposed to extend the safe working area to encompass all 9 stacks which make up the isolator.
This will however necessities the need to develop a bespoke hand rail mechanism. In Photo 1 there is a need to maintain the physical separation between the MBB Isolator on the right and the RBB isolator on the left.
At this point the hand rail will be required to be a bespoke engineered solution for the following reasons.
• Maintain the safety distance when in service.
• Maintain the physical separation between bays.
• Not interfere with access or reduce the access capability to the adjacent bay
• Provide adequate fall protection when applied and in position
• Provide interlocking with isolations and earthing so it cannot be returned to service with the hand rail in its deployed position.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>9</td><td>-4</td><td>13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This project will provide a package of solutions and systems which are user friendly, very effective and will ensure our MDE maintenance staff have the best working environment to eliminate their exposure to the dangers of working at height. The final removal of this health, safety and restricted access issue will have other benefits such as cost savings gained from no use of scaffold, tower hire and platform hire. It will reduce the amount of time taken to set up and complete the maintenance.
It is worth noting that the current annual costs of scaffolding, tower and platform hire will cease once the safe working area and hand rail has been extended to encompass all 9 isolator stacks.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td>Duration of benefit once achieved</td><td colspan="2">5 years</td></tr>
<tr><td>Probability of success</td><td>60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£27k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Interim Solution
Having provisionally investigated the interim solution, it appears there is nothing on the open market that suitably fulfils our requirements for an access podium to allow ready access to the 9 stacks This project will utilise modern</td></tr>
</table>

	materials to enable a lightweight platform to be designed and manufactured which would be suitable for accessing to the top of the RCP Isolator tower. Initial investigations indicate a very high chance of success with this project. Final Solution. Having provisionally investigated the final solution it appears there is nothing on the open market that suitably fulfils our requirements. There would however be extensive development in guaranteeing the final solution is both suitable and appropriate to MDE's needs. Initial investigations indicate a high chance of success with this project.
Project progress **[Year to End of March 2011]**	Interim Solution Bratts Ladders have provided suitable drawings for a prototype to be built preliminary drawings proved unsuitable returned with comments after protracted delays the drawings were accepted. A prototype podium has been built and inspected at Bratts Ladders but it was recommended that further mods would be required to Securing/locking device before it will be sent for field trials. Final Solutions. Retractable Handrail. Setting up meeting with Ferrybridge and Precision Eng and Parkway to discuss access to a spare bay with a view to setting up a test bay area. Stage 1 Bay Refurb at Ferrybridge now complete - The handrails and flooring have now been replaced this has been done to give a safe working area during the construction phase of the retractable handrails. Awaiting site meeting with Precision Eng prior to Stage 2 starting. Before  During  After 
Collaborative partners	
R&D provider	Planet Platforms, Bratts Ladders, Parkway Sheetmetal

Project title	**Fixed Maintenance Earth (FME) - Development of Handling Techniques and Tool**s		
Project Engineer	Dave Turnill		
Description of project	This project has several objectives relating to three issues surrounding the continued use of FMEs by National Grid staff. These are: • To implement and standardise the Manual Handling and Working at Height technique to transport/transfer FME's from ground level onto high level working gantries. • To further develop a FME Access Platform for FME Maintenance • To further develop an Extended Hand Railing for FME Maintenance. All 3 key objectives are an effort to reduce the manual handling and working at height requirements for MDE substation staff to complete required safety switching & maintenance activities in a manner which will not place unnecessary stresses on their bodies and thus reduce occupational health issues.		
Expenditure for financial year	Internal £4k External £7k Total £11k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£21k	**Projected 2010/11 costs for national Grid**	£10k
Technological area and/or issue addressed by project	Historically the Reyrolle FME has always been considered the most onerous and difficult type of Fixed Maintenance Earth to apply. This is due mainly to their inherent design, manual handling and working at height issues surrounding the application of FMEs. The FME is a 3 section portable earthing arm weighing 45kg in total, with 1 set of 3 primary earths being made up of 9 sections in total. Many National Grid substations were designed and constructed in an era where health and safety considerations for maintenance staff were less of a concern than they are today. As a result the location of earthing points can be up to 10m above ground level and the ability to apply and maintain FMEs safely in these conditions is extremely restricted. One of the major issues is transporting the FME sections from ground to the required height before application. Historically the methods utilised to perform this task vary from area to area, most of which no longer conform to current legislation. Some sites have tried to utilise the MEWPs available from Nationwide to lift using home made attachments with limited success. Nationwide now have in their extended range the facility to provide a Sky Rak Boom, though this will require a bespoke fitting to specifically suit our needs. It is intended that this technique will be further developed and trialled to suit National Grid requirements.		

	Sky RAK Boom  FME Access Platform  FME Extended Handrail  Another major issue is the maintenance of FMEs at height. This has previously involved utilising a step ladder while already at height. The development and trialling of an access platform and extended handrail system as picture above should reduce the inherent risk of these maintenance activities.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		9	-6	15
Expected benefits of project	This project will provide a system which is user friendly, very effective and will ensure we give our MDE maintenance persons the best working environment to eliminate the risk to their health. The long term occupational health benefits to the company will mean less man hours lost due to lower back and muscular injuries sustained during the routine maintenance activities. The reduction in long term occupational health issues is unquantifiable but the reduction of injuries we cause to our staff undertaking their routine duties cannot be underestimated.			
Expected timescale of project	2 year	**Duration of benefit once achieved**	5 years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£20k	

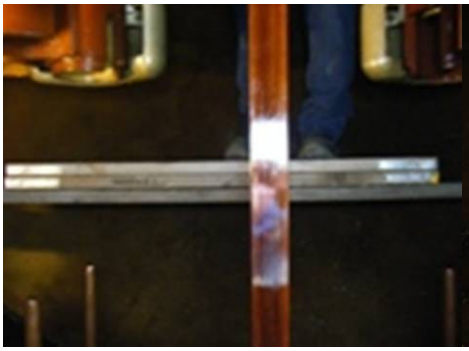
Potential for achieving expected benefits	Although there is currently nothing on the open market which will fulfil our requirements it is envisaged that there is a high possibility of success with this project if we work in partnership with Nationwide. It is expected that the basic design FME Sky Rak Boom lifting device rolled into the provision of single Nationwide MEWP, hence it is expected that this project will have a high possibility of success. A prototype Access platform and hand rail has been constructed therefore making a MKII model incorporating comments and engineering developments would see this project move towards a successful conclusion.
Project progress **[Year to End of March 2011]**	March 2011 - Nationwide FME SkyRak Boom. Unfortunately this project has stalled to Nationwide's lack of input into coming up with a prototype design. March 2011 - Prototype Access Platform. Slow progress has been made on this project due to Bratts Ladders lack of input in producing conceptual drawings. Though we are now awaiting a trial at Wylfa of a MKI prototype staging with integral handrails. MKII Prototype    The original platform and external handrail concept was not considered a viable option due to the very poor condition of handrails at other substations in the country. It was therefore decided to go for a platform with integral handrails.
Collaborative partners	
R&D provider	Nationwide Platforms, Bratts Ladders

Project title	**JW420 - developing improved maintenance tools and techniques**		
Project Engineer	Dave Turnill		
Description of project	The aim of this project is to provide as safe a working environment as possible for maintenance activities carried out on JW420 Bulk Oil circuit breakers. The aim is to ensure the improved maintenance tools and techniques are used across MDE by further developing solutions and techniques that have been partially developed and used locally in the past. These include developing the following: • 2 light weight access benches • A light weight rear access working platform connecting the 2 benches to allow 3 side access to the primary contacts • A temporary 1kg step arrangement to allow access to the top damper plug • Temporary flooring for Basic Maintenance • Temporary platforms for major maintenance • Turbulator Manual Handling Device. • Primary contact closing gag.		
Expenditure for financial year	Internal £6k External £15k Total £21k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£30k	**Projected 2010/11 costs for national Grid**	£9k
Technological area and/or issue addressed by project	The JW420 Bulk Oil Circuit Breaker is likely to see a number of years of further service beyond its original design life due to its Anticipated Asset Life being increased from 45 to 55 years by Asset Policy. There are currently 130 JW420 circuit breakers installed on the system. The JW420 design was originally installed in the 1960s and as such was not designed with modern health and safety requirements in mind. If National Grid intends to maximise the life of these assets then ensuring that they can be maintained in the safest way possible is paramount. There are several issues relating to JW420 maintenance that will be addressed by this project. They are detailed below: JW420 Tank Temporary Flooring Assembly and Working Access Platforms There are a number of maintenance activities that utilise the installation of a temporary access/flooring within the tanks of the JW 420/421 Bulk Oil Circuit Breakers. Once the CB tanks are emptied of oil then access within the contact tank is required to: • Fit the slow closing damper plug which is located in the top of the tank on the mechanism approx 3m from floor level • Carry out internal bushing oil samples. The sample point is located in the top of the tank on the mechanism approx 3m from floor level • Carry out maintenance to the main CB contacts and assembly. The benches currently being utilised were built and supplied on the original build back in the 1960's. Each bench weighs approx 15KG and each tank takes 2 benches. Each bench has to be manually handled through the 600mm port hole on		

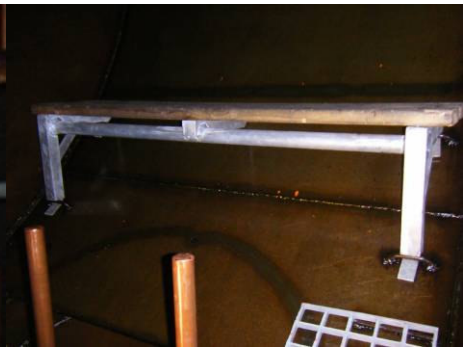
the side of the tank which can be seen below. This is currently the only bespoke aid supplied to give a working platform within. Each area then devises its own solution to access in to top of the tank to fit the damper plug, many of which are not best practice. Due to the environment within the tank, all surfaces are coated in a film of oil and therefore very slippery. In the last picture one team have devised temporary flooring in an effort to reduce risk of a slip hazard.

600mm Entrance Port hole showing Primary contact

JW 420 Bulk Oil CB Tanks



Temporary Work Bench showing Flooring



Temporary Access Platform

JW420 Turbulator Handling Device

In the early 90s during extensive system disturbances the JW420 OCB's at Brinsworth cleared many faults. As a consequence all breakers were entered and the primary fixed contact replaced. This involves the removal of 6 Turbulators. Due to a high number of removals the local team developed a manual handling device to assist in the removal of the Turbulators. The original which was developed weighed 12kg; this added to the 53kg of the Turbulator gives a combined weight of 65kg. A new redesigned and rationalised handling device would weigh in at around 3 to 4Kg therefore reducing the overall weight down to 56 - 57kg. Future development to reduce the profile and structure has also been identified.

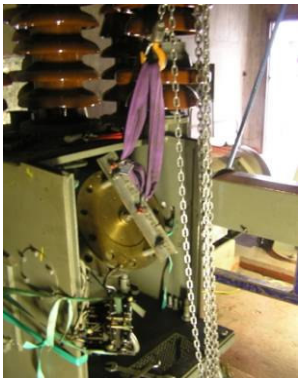
<table>
<tr><td></td><td colspan="4">JW420 Spring closing Gag In order to stop the CB opening when it is in the closed position a gag is fitted under the primary contact cradle. The gag prevents the CB from inadvertently opening when men are at work inside the CB.</td></tr>
<tr><td rowspan="2">Type(s) 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>6</td><td>-5</td><td>11</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Health & Safety - Working at Height, Slips Trips & Falls, Manual Handling– the provision of lightweight benches weight reduced from 15Kg to 4Kg, provision of a bespoke engineered rear access working platform weighing 8kg, provision of a bespoke engineered temporary flooring, a 1Kg step and 4Kg Turbulator manual handling device will provide a pieces of equipment which will reduce the effect of working at heights, the effort required for manual handling and reduce the likelihood of slips trips and falls, all these risks will be reduced to an absolute minimum. Compliance with the Working at Height Regulations at present we don’t comply

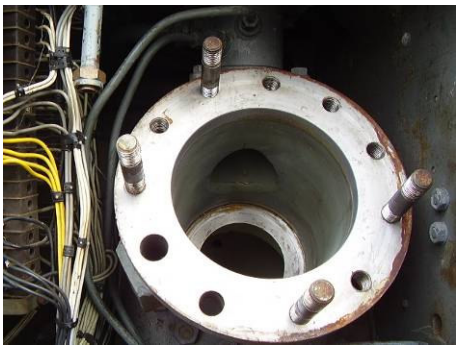
The long / short term health benefits to the company will mean less man hours lost due to lower back and muscular injuries sustained during routine maintenance activities. The reduction in long term occupational health issues is unquantifiable but the reduction of injuries we cause to our staff undertaking their routine duties cannot be underestimated. Secures the companies position by providing current legislation compliance.</td></tr>
<tr><td>Expected timescale of project</td><td>2 year</td><td colspan="2">Duration of benefit once achieved</td><td>Enduring solutions</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>-£27k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The chances of delivering the projects 6 aspects to a satisfactory conclusion are very high.
• Light weight access benches - High
• A light weight rear access working platform connecting the 2 benches to allow 3 side access to the primary contacts - High
• A Temporary 1kg step arrangement to allow access to the top damper plug – High
• Port hole entrance temporary flooring. - High
• Turbulator Manual Handling Device. - High
• Primary contact closing gag – Medium</td></tr>
<tr><td>Project progress

[Year to End of March 2011]</td><td colspan="4">This period has seen significant progress in the development of the benches and staging’s associated with this project. The original designs have been modified in line with comments from MDE Maintenance Staff made during field trials of the apparatus. The Benches and stagings have now had 4 field trials and each has proved very successful. There is a potential issue in funding the implementation of the project due to Opex restrictions.

The final design has now also been proof load tested to a satisfactory safety margin. This project is now reaching its conclusion.</td></tr>
</table>

	Temporary Work Bench showing flooring.  Temporary Access Platform  JW420 Turbulator Handling Device. The Turbulator handling device has now been for field trials and proved very successful; compared to its predecessor. This project is now reaching its conclusion Empty  In Use  JW420 Spring closing Gag. This spring closer gag for the JW420 as mentioned in the maintenance work specification is an urban myth and will have to be developed from first principles. I am currently seeking a JW420 Trip latch mech to assist in the design of through word of mouth I have managed to locate a spring closer gag for the OW410 this is the 132kV version of the 275kV JW420. Through development of the OW410 spring closer gag a solution can be developed for JW420. This project is still in its infancy. 
Collaborative partners	
R&D provider	Spondon Developments

Project title	**OB 14 Blast Valve Lifting Rig**		
Project Engineer	Dave Turnill		
Description of project	The project will deliver a safe method of manual handling the 70kg blast valve and the blast valve cover during its removal for maintenance purposes. The key objective is to safe guard the current workforce. This will be delivered in an effort to reduce the manual handling requirements for MDE Substation staff to complete maintenance activities in a manner which will not place unnecessary stresses on their bodies and thus reduce occupational health issues.		
Expenditure for financial year	Internal £2k External £5k Total £7k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£11k	**Projected 2010/11 costs for national Grid**	£4k
Technological area and/or issue addressed by project	During an outage in November 2009 an MDE maintenance operative sheared off the end of his finger. This was unfortunate incident occurred during the routine major maintenance of the OB14. In order to carry out the maintenance of the CB, the work involves the removal of 3 blast valves, 1 per phase, in order to refurbish the contacts and seals. The CB has to be stripped of various components and a valve cover to expose the blast valve. The blast valve is then extracted by using 2 jacking bolts which lift the blast valve away from its housing (photo3). When you reach the limit of the jacking bolts the valve is manually handled to remove the valve to a barrow to be transported away to a workshop for repair. Once complete the process is reversed and the blast valve replaced in the blast valve housing and the cover replaced. It was during the refitting of the blast valve that the operative had his incident which was attributed to a lack of control on the 70kg blast valve. The proposed development will enable the work to be completed using a bespoke system which will give both excellent control and manual handling capability for completion of the work. Currently MDE staff employ a basic lifting rig (Photo 1) which was developed as direct result of the incident but still has many design flaws. The lifting rig now allows the use of lifting tackle and an A frame (Photo2). There are currently 34 OB14 CB's on the system predominantly in the London area  		

<table>
<tr><td></td><td colspan="4">  </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>6</td><td>-6</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The project will remove unnecessary and undue stress / strain on MDE staff. The long term occupational health benefits to the company will mean less man hours lost due to lower back and muscular injuries sustained during the routine maintenance activities. The reduction in long term occupational health issues is unquantifiable but the reduction of injuries we cause to our staff undertaking their routine duties cannot be underestimated.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td colspan="2">Duration of benefit once achieved</td><td>5years</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>-£11k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">This project is an addition to and development of an existing piece of equipment which is currently in use and is an incremental development to provide and improve safer / efficient working methods.

Although there is currently nothing on the open market which will fulfil our requirements it is envisaged that there is a high possibility of success with this project.</td></tr>
</table>

Project progress **[Year to End of March 2011]**	Proposed Final OB14 Blast Valve Extraction Kit. Which consists of :- 3x Extraction guide rods. 2 x 250mm Extraction Bolts 1x Blast Valve Lifting Rig     March 2011 - Carried out Modifications with Parkway as highlighted in previous trial, control handle fitted and stainless steel guide rods extended. Final visit to Bradwell required prove all modifications now work and finalised latest MkIII prototype. Jan 2011 - Removed from site redundant OB14 Blast valve and taken to Parkway for further assessment and development in line with further site based consult and included 3 stainless steel guides to facilitate the safe controlled removal of the blast valve. Original Design 
Collaborative partners	
R&D provider	Parkway Sheetmetal

Project title	**GA ABCB Slow Closing Device**		
Project Engineer	Dave Turnill		
Description of project	The project will deliver a safe method of manual handling the spring loaded CB mechanism which has to be manually opened and closed during maintenance activities. The key objective is to safe guard the current workforce, This will be delivered in an effort to reduce the manual handling requirements for MDE Substation staff to complete maintenance activities in a manner which will not place unnecessary stresses on their bodies and thus reduce occupational health issues.		
Expenditure for financial year	Internal £3k External £5k Total £8k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£13k	**Projected 2010/11 costs for national Grid**	£5k
Technological area and/or issue addressed by project	During the maintenance of both the GA6 and GA10 ABCBs it is necessary to manually open and close the CB in a controlled manner. Historically since GA6 and GA10 ABCBs were installed on the system in the 1950s the methods utilised by current workforce to slow open and close the CB during maintenance never had any bespoke tools provided by the manufacture to reduce the effect of manual handling. The method employed over the years is to extend a spanner with an extendable pole (Photo 1). This has proved an unsatisfactory solution in the past as the practice has resulted in muscular skeletal injuries. The Pentir team within NW1 have with limited resources been able to develop and manufacture a MKI prototype slow closing device. This solution utilises a torque multiplier in an effort to reduce the manual handling effort required open and close the CB. There are currently 43 GA10s and 19 GA6 ABCB on the system  		

<table>
<tr><td></td><td colspan="4">  </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>6</td><td>-6</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The project will remove unnecessary and undue stress / strain on MDE staff. The long term occupational health benefits to the company will mean less man hours lost due to lower back and muscular injuries sustained during the routine maintenance activities. The reduction in long term occupational health issues is unquantifiable but the reduction of injuries we cause to our staff undertaking their routine duties cannot be underestimated.</td></tr>
<tr><td>Expected timescale of project</td><td>3 years</td><td colspan="2">Duration of benefit once achieved</td><td>5 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>-£13k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Although there is currently nothing on the open market which will fulfil our requirement it is envisaged that there is a high possibility of success with this project.

It is expected that the basic design of the CB slow closing device can be further developed into a successful tool which will assist MDE staff to safely carry out their maintenance, hence it is also expected that this project will have a high possibility of success.</td></tr>
<tr><td>Project progress

[Year to End of March 2011]</td><td colspan="4">Precision Engineering has manufactured a bespoke Male to Female adaptor which now conforms to the Tool BS7794:1995. The original adaptor did not conform. This is now ready for field trials along with a ¾” square drive ratchet. This particular drive has the feature of being able to be locked in the engaged position. This has the effect of being able to totally control the breakers isomaker primary contacts during maintenance activities.

The bespoke Male to Female adaptor and ¾” x 620mm Ratchet drive now on Final trial at Wylfa along with the breaker anchor plate and torque multiplier which makes up the GA ABCB Slow closing Kit.

ENI have been approached and the solution discussed and accepted</td></tr>
</table>

	 It is envisaged this project will be sanctioned in the near future with 100% success.
Collaborative partners	
R&D provider	Precision Engineering & Grays Engineering

<table>
<tr><td>Project title</td><td colspan="5">Tapchanger Spring Measuring Device</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Dave Turnill</td></tr>
<tr><td>Description of project</td><td colspan="5">The project will deliver the ability to measure accurately and consistently both the opening and closing spring pressures on Transformer Tapchangers.
To allow ENI and Asset Policy build a clear picture of the condition of tapchanger spring contacts.</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £2k
External £4k
Total £6k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td colspan="2">£9k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£3k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">Historically MDE’s staff have used a spring balance and piece of nylon line to determine the spring pressure on any single contact in a series of up to 25 contacts. The nylon line was attached to the contact and the spring balance to the line on pulling the balance a reading was taken. This has led to inconsistencies in the measured values obtained over the years. With this method it was also very difficult to build up a historical data base on the condition of springs with a view of determining any gradual degradation in the condition of the spring’s strength.
Both ENI and the transformer asset group are very interested in the project and fully support the imitative.</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 colspan="2">Overall Project Score</td></tr>
<tr><td>6</td><td>-7</td><td colspan="2">13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">With the implementation of the digital spring balance and associated measuring jigs ENI’s Asset Policy will now be able to gain a very accurate picture to the condition of the tapchanger springs which are in service on the system. ENI will then be able to minimise tapchanger gassing and reduce possible downtimes and expensive repairs. This will give both ENI and the transformer asset group the facility of documenting and building a picture of the present condition of the springs within the tapchangers</td></tr>
<tr><td>Expected timescale of project</td><td colspan="2">3 years</td><td>Duration of benefit once achieved</td><td colspan="2">5 years</td></tr>
<tr><td>Probability of success</td><td colspan="2">60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">-£8k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="5">Although there is currently nothing on the open market which will fulfil our requirement it is envisaged that there is a very high possibility of success with this project.
It is expected that the basic design of the Tapchanger Spring Measuring Device can be further developed into a successful tool which will assist MDE staff to safely carry out their maintenance, hence with the support of ENI’s Asset Policy it is expected that this project will have a very high possibility of success.</td></tr>
</table>

Project progress **[Year to End of March 2011]**	Feb 2011 - Precision Engineering have completed now completed the final package With ENI for field trials.  Jan 2011 - Held meeting with Precision Engineering to discuss the final designs, minor modifications to be completed
Collaborative partners	
R&D provider	Precision Engineering & Grays Engineering

<table>
<tr><td>Project title</td><td colspan="4">Portable Earthing Trailer</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Martin Wilson</td></tr>
<tr><td>Description of project</td><td colspan="4">A machine to enable the installation / removal of substation portable earths to be completed in a controlled and safe manner. There are serious manual handling issues with installing portable primary earths within substations this machine will look to address these issues by providing a suitable mechanical aid.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £8k
External £30k
Total £38k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £21k
External £134k
Total £155k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£194k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Health and Safety</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>11</td><td>-4</td><td>15</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">This project will aim to produce a machine which is both easily transportable within the substations and provides a manual aid to enable the portable earths to be both installed and removed in a safe and efficient manner. The main business benefit is both the immediate and long term welfare of the substation staff carrying out the task. In the last 12 months there has been a fatality which has been directly attributed to the removal of portable earthing.</td></tr>
<tr><td>Expected timescale of project</td><td>4 years</td><td colspan="2">Duration of benefit once achieved</td><td>20 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>£170k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The initial prototype is being designed to enable the concept to be proven. Once the prototype is available and trials are completed a more definite idea of the success and achievement of benefits will be available.</td></tr>
<tr><td>Project progress

[Year to End of March 2011]</td><td colspan="4">2007 – 2009 The investigation and evaluation into the possible solutions was completed. A design brief was established and a consultant appointed to progress the design brief to a practical design.

2009 – 2010 The design of the prototype was progressed. The design was viewed by a number of substation staff with positive feedback. Prototype build initiated, some delays were identified due to concerns regarding the estimated build costs. The initial build is being completed to enable the concept to be proven by field trials, this was understood and the build was re-started. The prototype is expected to be complete by June 2010 at which point the concept trials will be completed.

2010 – 2011 The concept trails have been completed and the product has</td></tr>
</table>

	been proven to work successfully. Further work may be needed to assess if the initial build costs can be reduced to build an economically viable production product. The benefits of this project are reduced manual handling and also increased safety due to up to three earths being applied during an earthling procedure.
Collaborative partners	
R&D provider	P&B Weir

Project title	**Bus Transfer Capability**			
Project Engineer	Damien Culley			
Description of project	Investigate the effects of bus transfer duty on the Committee design of disconnectors. Investigate a solution to modify/retro-fit Committee design disconnectors to provide them with a Bus Transfer rating as per current IEC/National Grid standards.			
Expenditure for financial year	Internal £13k External £164k Total £177k	**Expenditure in previous (IFI) financial years**	Internal £11k External £16k Total £27k	
Total project costs (collaborative + external + [company])	£205k	**Projected 2010/11 costs**	£0	
Technological area and/or issue addressed by project	Committee designed disconnectors do not have any on-load bus transfer rating but they are expected to perform this duty in their locations on the electrical transmission system. Their design is based on requirements dating back 30-40 years and they do not fulfil the performance requirements of having an on-load bus transfer capability when compared to modern day specifications. In some cases operation of the assets leads to damage to the equipment and therefore attracts associated OMGS costs for repairs and significant work has been required to repair the damage. These disconnectors will be on the system for a considerable number of years to come and are being re-used in Capital schemes, albeit without having a rated bus transfer duty. As a result National Grid will continue to operate and maintain this equipment with the operational inflexibility and continued damage to the equipment unless a modification/retro-fit option can be developed.			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		10	-3	13
Expected benefits of project	This will remove operational inflexibility by allowing the Committee design disconnectors to be operated in the on-load bus transfer mode which in itself will remove existing longstanding Technical Limitations on some of the disconnectors. By modifying the design of these disconnectors, this should improve their remaining service life and ensure they are used to their full potential when they are retained/reused in Capital schemes. There is a population of approx. 2800 disconnectors (across the 400 KV and the 275KV Transmission system) that may be candidates for this solution although it is not expected all disconnectors will be modified/retro-fitted as a the cost/benefit will need to be assessed based on remaining useful life. If the fixed contacts are replaced on a complete 3 phase disconnector, the cost of the raw materials is estimated to be £3600 (£150 per pair of fixed contacts, 24 pairs required for a full 3 phase disconnector). Examples of damaged disconnectors being on a 9 year maintenance interval (i.e. 311 disconnectors			

	maintained per annum), a conservative estimate of the replacement of fixed contacts equivalent to 5 disconnectors per annum would lead to a minimum expenditure of 18K per annum. This excludes any cost associated with refurbishment of the main blade if this is damaged, or any labour costs to perform the work. However, just replacing these fixed contacts does not eliminate the problem and it can be expected it will be necessary to replace a proportion of the fixed contacts again within their lifetime.		
Expected timescale of project	3 years	**Duration of benefit once achieved**	Remaining lifetime of the equipment (20+ years where solution deployed)
Probability of success	100 %	**Project NPV = (PV benefits – PV costs) x probability of success**	-£15k
Potential for achieving expected benefits	The potential for achieving the expected benefits is very high. The development is complete and long term site trials are now underway.		
Project progress **[Year to End of March 2011]**	The development phase of this project is now complete. Several contacts are currently undergoing field trials and have been a success to date.		
Collaborative partners			
R&D provider	Ruhrtal-Hochspannungsgerate GmbH & Co. OHG		

<table>
<tr><td>Project title</td><td colspan="4">Environmentally acceptable alternatives to SF_6</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Paul Coventry / Dongsheng Guo</td></tr>
<tr><td>Description of project</td><td colspan="4">The key objective of the proposed work is to enable National Grid to achieve the targets set out in its Climate change Strategy by means of the following:
To identify environmentally acceptable alternatives to SF_6 gas
To participate in collaborative efforts to develop alternatives to SF_6 gas</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £9k
External £125k
Total £134k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td>Internal £17k
External £301k
Total £318k</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£452k</td><td colspan="2">Projected 2011/12 costs for national Grid</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">Sulphur hexafluoride (SF_6) is widely used in electric power transmission equipment on account of its excellent properties both as an insulating material and as an arc-interrupting medium. It has become the only commercially available technology for circuit-breakers at transmission voltages. However, it has a high global warming potential approximately 23,000 times that of CO_2, and its use raises concerns on environmental grounds.

Against this background, it is essential that the electricity supply industry should actively consider environmentally more compatible alternatives to SF_6. The proposed work is intended to allow National Grid to identify and evaluate candidate alternative technologies to SF_6 for further development, to drive improvements in containment of SF_6 in equipment, to maintain an awareness of research and development into potential alternatives to SF_6 and to collaborate where appropriate.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>5</td><td>3</td><td>2</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">National Grid is committed to a Climate Change Strategy that aims to achieve a target of a 80% reduction in emissions of greenhouse gases by 2050 from a baseline of 6.6 million tons CO_2 (equivalent). The proposed work is aimed at identifying ways of reducing or eliminating the use of SF_6 in transmission switchgear and reducing leakage rates and is in direct support of the above target.

The cost of SF_6 gas lost to the atmosphere, although significant, is small compared to the cost of the environmental impact of gas leakage. According to DEFRA's guidance on the Shadow Price of Carbon (SPC), the shadow price for SF_6 is given by the SPC of carbon multiplied by 23,900 or £575k per ton at 2007 prices (www.defra.gov.uk). It is foreseeable that, as pressure increases to improve environmental performance, taxes on greenhouse gas emission will be introduced.

The project will accrue benefits few years into the future as the first generation of SF_6 filled equipment on the transmission network reaches its end of life and significant portions of the SF_6 inventory is replaced by equipment having lower leakage rates or not using SF_6 at all. At this stage, if the project reduces the leakage rate of new equipment by 0.25 percentage points, then additional</td></tr>
</table>

	savings on the environmental cost of SF_6 emissions will be accrued at a rate of the order of £200k per year, depending on the volumes replaced. It is envisaged that further R&D investment will be required beyond the end of the project to develop, test and implement any promising alternatives technology to SF_6 identified in the course of the present work. A provisional figure of £150k per year for the following two years is forecast as National Grid's contribution to the further development. It is recommended that this figure be reviewed depending on the outcome of the present work and the level of interest shown by potential collaborating partners.		
Expected timescale of project	4 years	**Duration of benefit once achieved**	20+ Years
Probability of success	10%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£143k+ potentially large environmental benefit
Potential for achieving expected benefits	The development of environmentally acceptable alternatives to SF_6 constitutes a high risk. Any alternative technology would have to be comparable in effectiveness to SF_6 based technology and would have to be economically viable. On successful completion of the present work, a demonstration project or projects will be required to prove any prototype technique or techniques. Manufacturer collaboration will be essential to the development of any commercial product. Application issues will need to be identified and managed.		
Project progress **[Year to End of March 2011]**	Work at Manchester has continued to examine viable alternatives for SF_6 in transmission substation equipment. Work has investigated alternative solutions for switchgear and for GIS. With vacuum switchgear technology now appearing viable at transmission level, work has centred on developing an understanding of the likely impact on transients within substations. Indications from a CIGRE working group are that chopping overvoltages will not be as significant in per-unit terms as they would be at the lower system voltages but this needs careful investigation. There is also a need to find a suitable insulant to surround the vacuum bottles. One possible gas is CF_3I. This may also be usable within GIS but the low boiling point does give rise to some concerns over usability. Calculations have now been carried out to examine the feasibility of CF_3I filled GIS in terms of its size and ampacity when the gas is used at a lower pressure or as part of a mix. The results indicate the equipment of a reasonable size could be developed using CF_3I gas with no deterioration in performance. One question mark that remains over the use of this gas is the long term performance – it is hoped that work being carried out by Cardiff University as part of a PNRA project will examine this aspect of gas performance. The University of Manchester is also investigating the feasibility of solid foam insulation as an option in GIS equipment. The dielectric strength of foam looks reasonable for the application (in terms of AC, LI and PD strength) but maintenance issues may be a concern going forward. The work being carried out in this area is examining substation post insulators as an alternative application that would benefit from foam technology and an MSc project is being tasked with this.		
Collaborative partners	Discussions are ongoing with potential collaborative partners for future work.		
R&D provider	University of Manchester (Liverpool University)		

Project title	**Uneven dynamic voltages**			
Project Engineer	Simon Atkin			
Description of project	This project will demonstrate the uneven dynamic voltage distribution between circuit-breakers interrupters that is believed to be the cause of a number of in-service failures of devices switching shunt reactors. Successful demonstration of the phenomenon will allow design and type test requirements for circuit-breakers and their voltage grading capacitors to be specified, so that in service failures may be eliminated by design.			
Expenditure for financial year	Internal £3k External £4k Total £7k	**Expenditure in previous (IFI) financial years**		Internal £11k External £19k Total £30k
Total project costs (collaborative + external + [company])	£37k	**Projected 2011/12 costs for national Grid**		£0
Technological area and/or issue addressed by project	A number of in-service failures of circuit-breakers switching shunt reactors have occurred both in the UK and elsewhere. A theoretical explanation for the cause of failure has been proposed in collaboration with CIGRE Working Group A3.18 'Operating environment of circuit-breaker voltage grading capacitors'. Due to considerable practical difficulties in performing suitable measurements, it has not been possible to prove the theory experimentally. British Columbia Transmission Corporation (BCTC) has invited National Grid to participate in the proposed research project which aims to address the above shortcoming by performing tests in BCTC's high power laboratory.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		7	-3	10
Expected benefits of project	Experimental proof of the cause of failures associated with shunt reactor switching would allow such failures to be eliminated through the adoption of appropriate specifications and type test procedures. The costs of failures including consequential damage to equipment and repair costs, will be avoided, the impact on the system of non availability of the plant will be minimised and safety risk to personal will be reduced. A single failure requiring replacement of a circuit breaker can result in direct costs exceeding £500k and indirect costs of several £100k if additional generation is required while the shunt reactor is not availed.			
Expected timescale of project	2 years	**Duration of benefit once achieved**		5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**		-£17k
Potential for achieving expected benefits	National Grid is eager to resolve this issue. In the event of a successful outcome, there would be significant potential for achieving the expected benefits. The electrical testing has provided the required evidence therefore it is assumed that the desired effect will be achieved.			

Project progress **[Year to End of March 2011]**	Initial test have been carried out and proved successful however National Grid is proposing to adopt an alternative approach that tests the grading capacitors against the worst case conditions predicted by the theoretical model. These tests will be performed in the high voltage laboratory at the University of Manchester in September 2010. The testing has been completed and the data has been analysed. A report and presentation of the findings is currently being drafted with the recommendation to remove the restrictions associated with these grading capacitors. The report will be presented to appropriate the National Grid board for final approval prior to the restriction on this equipment being revoked nationally.
Collaborative partners	None since cancellation of collaborative project.
R&D provider	British Columbia Transmission Corporation, University of Manchester

<table>
<tr><td>Project title</td><td colspan="3">Improved Life Cycle Costing Methods</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Damien Culley</td></tr>
<tr><td>Description of project</td><td colspan="3">To establish a methodology for evaluating the life cycle costs of transmission system assets and to account for the potential health and safety performance of such assets across their life cycle. The methodology will be used to support the development of asset investment and management policy and will allow optimum solutions to be identified taking into account economic, environmental and social costs. It will also inform health and safety policy and the cost-benefit assessment of risk reduction and improved risk management strategies.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £9k
External £2k
Total £11k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £29k
External £286k
Total £315k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£326k</td><td>Projected [next year] costs for [company]</td><td>£0</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Traditionally, investment decisions have been made on the basis of capital costs of equipment only. This approach has been accepted since the capital costs for electricity transmission assets are large compared to annual operating costs and, being incurred up-front, are dominant in the discounted cash flow. However, it is becoming increasingly important that the whole life cycle be considered when evaluating options, including costs of obtaining raw materials, manufacturing, maintenance, losses and decommissioning/disposal of equipment.

The use of more holistic life cycle costing (LCC) methods are an imperative for companies based on capital intensive assets having long asset lifetimes where the true current and future costs of ownership and operation are to be critically assessed with investment decision criteria that are searching and meaningful. Although the importance of this approach is recognised, its complexity and a lack of meaningful data and appropriate techniques have hindered its implementation.

While health and safety risk assessment is a well established discipline, very little has been done on life cycle assessment of human hazards and risks from plant manufacture, to scheme construction and commissioning, to operation and maintenance through to end of life management. There are significant potential benefits to being able to carry out such assessments in order to quantify the most effective ways to reduce hazards and risks and how to assess the effort and cost required to achieve safety by design for both new and current schemes.</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>11</td><td>1</td><td>10</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">This research will provide a platform for policy decision making to reduce overall project costs while delivering National Grid's stated health and safety and environment performance aspirations in the context of asset investment and design related decisions. It will assist in enumerating potential long term liabilities and provide a rational and transparent assessment of whole life cycle costs. It will enable informed justifiable decisions on health and safety and environmental management to be made and enable the trade-offs between competing and often conflicting criteria to be better and more formally</td></tr>
</table>

	managed. It will provide a knowledge base for improved asset policy and management. The framework will facilitate consistency in asset investment and design related decisions which are of particular importance as National Grid moves towards Alliance ways of working. It will provide a platform to demonstrate the Company's competence in proactively managing the health and safety and environment challenges facing the company. It is clear that the above benefits will result in financial savings. Without a methodology such as the one that forms the subject of this proposal, it is difficult to determine the level of financial benefit of the proposed research. Given the range of policy decisions that may be influenced and the value of National Grid's construction/replacement programme, savings of the order of millions of pounds per year can be envisaged.		
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£233k
Potential for achieving expected benefits	This project has now completed and the results are being incorporated into National Grid's whole life costing strategy.		
Project progress **[Year to End of March 2011]**	This project was completed early in the 2010/11 financial year. All reports on case studies have been submitted and shared with the wider business. The results of the project have been taken into consideration for the development of National Grid investment appraisal techniques such as Whole Life Value.		
Collaborative partners			
R&D provider	Gnosys UK Ltd, University of Surrey Asset Management Consulting Limited (AMCL)		

Strategic

Project title	**Electric and Magnetic Fields and Health**		
Project Engineer	David Renew		
Description of project	The possibility that there may be effects of EMFs on health is an important issue for National Grid. This project will enable National Grid to strengthen its position in the face of the external threat posed by the EMF issue, through helping it to avoid unjustified constraints in its operations while at the same time ensuring that the EMFs associated with the operations are not the cause of any adverse health effects. This is an umbrella project providing resource for a variety of aspects of research on EMFs and Health, including resource directed towards management of projects funded elsewhere.		
Expenditure for financial year	Internal £72k External £344k Total £416k	**Expenditure in previous (IFI) financial years**	Internal £179k External £1,764k Total £1,943k
Total project costs (collaborative + external + [company])	£8,756k	**Projected [next year] costs for [company]**	£398k
Technological area and/or issue addressed by project	Interaction of electric fields and magnetic fields with people, and the assessment of fields associated with the use of electricity.		

Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		11	2	9

Expected benefits of project	While there is not likely to be a direct financial gain from this long-term research, without it there may be considerable additional costs and constraints imposed on the electricity industry operations arising from lengthy and costly debates about EMF and from unwarranted exposure limits or other constraints on operations. For example an assessment provided to the then DTI about the possible cost to National Grid of implementing the EU Recommendation (1999) on public exposure to EMFs included estimates of up to £850M. Another assessment, to the HSE, about the cost to National Grid of implementing an early version of the EU Directive on occupational exposure to EMF identified costs of the order £10-100M per year. In 2005, the Assessment published by the Stakeholder Advisory Group on EMFs estimated compensation costs payable by National Grid to landowners if an EMF risk because established as potentially several hundred £M.		
Expected timescale of project	Year: Ongoing	**Duration of benefit once achieved**	Years: Indefinite
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£2,500k

Potential for achieving expected benefits	The EMF issue has existed for many years, and so has funding of research in this area by National Grid and its predecessors. It is clear that this funding up to now has made real difference in both the lay and scientific arenas – for example the conclusion of the World Health Organisation (WHO) Environmental Health Criteria which focus on childhood leukaemia as opposed to other widespread health outcomes such as breast cancer. Nevertheless the issue is so broad and continuously developing that continued efforts will be needed for the foreseeable future.
Project progress **[Year to End of March 2011]**	The multiple strands of this long-term project progress at different rates, leading towards publication in the scientific literature. The EMF Biological Research Trust, who are funded by National Grid, established and began six new projects this year. These are to study two overall themes, the magnetic field sensitivity of cryptochromes to affect biological functions and the extent, if any, of DNA damage caused by magnetic fields. The projects are as follows. University of Manchester (magnetic field and spin effects in human cryptochromes - 3 years)), University of Leicester (The role of cryptochrome in the detection of electromagnetic fields in drosophilia – 3 years), University of Cambridge (The role for mammalian Cry in proteins in magnetosensation – 3 years), and University Cambridge (EMF effects on light-shock responses in mouse adrenal glands – 1 year). EPRI in the USA (who conduct research for the electricity industry) have continued seeking answers to questions surrounding childhood leukaemia and magnetic field exposure. This has included publication of a study of magnetic field exposures in residential buildings with transformer stations, this time in Switzerland, as part of preparations for an epidemiology study in which exposures are assessed from proximity to the transformer room. Results from the North California Childhood Cancer study testing the earlier hypothesis concerning exposure to elevated contact currents and childhood leukaemia have been published and shows no such association. They have also submitted for publication an analysis of exposure to EMF and neurodegenerative disease, and they have prepared a Job Exposure Matrix to allow the association between electric shocks and neurodegenerative disease to be assessed. A replication in California of the previously published epidemiological study by Draper of proximity to overhead and incidence of childhood leukaemia is in progress. It aims to expand on the body of knowledge arising from the Draper study. Various studies have been conducted or are in progress relating to radio frequency exposures from smart meters. Early work has commenced on investigating new aspects of the microshocks issue. National Grid staff are working directly with the University of Oxford to explore in more detail the implications of the finding from 2005 that childhood leukaemia rates are higher close to power lines. To date the work has fallen on CCRG (at Oxford University), obtaining and organising new data so that new analyses can now be done. National Grid also contributes to the wider electricity industry research on EMFs and, although this strand is not within IFI, it is run as a single integrated programme. Research in this strand includes ongoing work on the health of electricity industry employees, using the database of staff created in the 1970s, which continues to provide reassuring results and is now being expanded to look at incidence of some cancers not just fatalities. The addition of cancer incidence data is complete and allows an analysis of standardised incidence ratios to be prepared for publication. It is also intended to repeat the previous analyses (which used mortality data only) of association between occupational exposure to magnetic fields to leukaemia and to brain cancer.
Collaborative partners	Energy Networks Association, Department of Health, EPRI, Children with Leukaemia, Childhood Cancer Research Group, EMF Biological Research Trust (some of these partners are involved in the components of the research programme which do not come under IFI)

R&D providers	Resource Strategies Inc, University of Manchester – HVRDC, EMF Biological Research Trust and others via collaborative partners including HPA-RPD, UCLA, Microwave Consultants Ltd, SAHSU, Institute of Occupational and Environmental Medicine (University of Birmingham). (Some of these providers are involved in the components of the research programme which do not come under IFI)

<table>
<tr><td>Project title</td><td colspan="5">Energy harvesting technology for self-powering condition monitoring sensors</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Leigh Fraser</td></tr>
<tr><td>Description of project</td><td colspan="5">The aim is to develop the power supply technology for energy harvesting for self-powering condition monitoring sensors.

Investigate and develop energy harvesting devices based on capacitive / inductive coupling with the electromagnetic fields present in electricity transmission substations.

Intention is to produce a generic device capable of powering substation light current equipment such as active sensors that monitor the status, health and condition of electrical plant.

Most likely uses of such power is to enable short-distance wireless data transfer to enable monitoring of a wide range of parameters using safe, low-cost, unobtrusive devices.

Condition monitoring and asset management processes are increasingly capable of being automated through intelligent software. Consequently, it is increasingly necessary to obtain data from more diverse and larger numbers of sensors than has previously been the case. To power those sensors, traditionally DC power supply from substation battery systems has to be connected via cross-site-cables, which often involve significant engineering work, also introduce additional risk of electromagnetic interference.

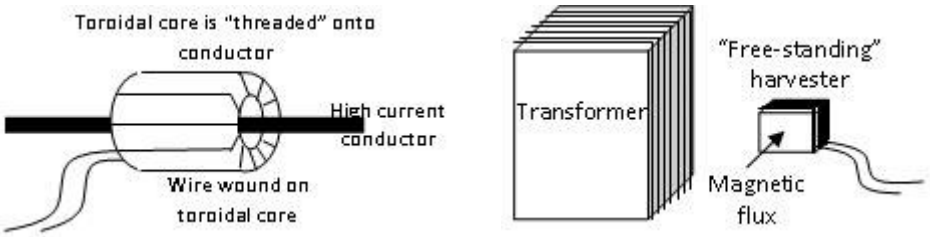
Therefore, installation and maintenance of these sensors must involve the minimum of labour, and removing the need for cables and batteries is a key aspect of “fit and forget” functionality. It is likely that the eventual cost of the sensors (once integrated) will become so low that they become effectively disposable. Robust monitoring will be further bolstered if the sensors are cheap enough to install with a level of redundancy for extra security.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £8k
External £66k
Total £74k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £11k
External £38k
Total £49k</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£135k</td><td colspan="2">Projected 2010/11 costs</td><td colspan="2">£13k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">This project addresses the area of substation data collection systems required for operational and condition monitoring over short range communication links.

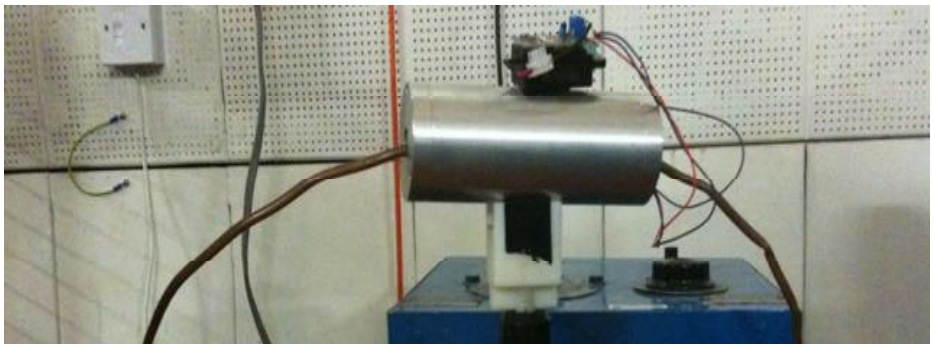
Self powered sensors are required for the deployment of plant and system monitoring functions at remote substation locations. These sensors could simply and efficiently collect data from difficult locations where the value of the data collected does not justify the provisioning of permanent data and power cabling.

The project supports other research and initiatives in energy storage and wireless substation communications to provide an easy to install and low maintenance data collection solution.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Radical</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td colspan="2">Overall Project Score</td></tr>
<tr><td>5</td><td>-1</td><td colspan="2">6</td></tr>
</table>

Expected benefits of project	This project is likely to have medium-term payback (5-10 years). The technology to be developed will enable the deployment of more advanced sensors and monitoring techniques within the electricity transmission system, enabling National Grid to take a world leading position in the management of its plant and capital assets. The research will contribute to the reduction of DC battery and cabling requirements for plant sensors and facilitate the monitoring of hitherto inaccessible information on plant condition. Consequently this will avoid unnecessary site engineering work, minimise the impact of electromagnetic interference, and ultimately enable more efficient operation of the network and give greater confidence in the health of plant in operation. As such, it should eventually lead to reductions in costs associated with unanticipated plant failure and consequent detrimental effects on industrial and domestic consumers. It would be rather difficult to use money terms to value the benefit of this research on reducing the risk of electromagnetic interference and improve reliability of substation secondary systems. However, the potential saving on reduction of battery usage, site cabling and implementation/outage time could lead to substantial savings. In addition, the outcome of this research will also have huge impact on the environment due to reduction of the usage and disposal of DC batteries at substations.		
Expected timescale of project	4 years	Duration of benefit once achieved	5 Years
Probability of success	60%	Project NPV = (PV benefits – PV costs) x probability of success	£13k
Potential for achieving expected benefits	This project provides research into fundamental power harvesting techniques. The potential for achieving overall benefits depends on the outcomes of this research, the techniques developed, successful pilot implementations and the cost effective manufacture of robust sensors. At this stage harvesting energy is achievable but optimisation and efficiency of the technology (e.g. Sensor nodes) and environment are key. Although the project benefits are also linked to other research areas in order to fulfil the expected benefits i.e. Energy Storage, wireless communication, data transmission and infrastructure. Currently the harvesting technology is feasible and lab demonstrated, however current National Grid sensor technology has a too high power requirement and an alternative is required for site based demonstrators to further prove the harvesting potential.		
Project progress **[Year to End of March 2011]**	Project started Sept 2008 and Six project meetings have been held to date (Sept 2008, Feb 2009, Aug 2009, Mar 2010, Aug 2010 and Feb 2011). Two technical reports have been delivered to date with a final report to be collated at the end of the project. Initial research has been completed and the energy harvesting techniques identified have been evaluated. Both Inductive and Capacitive energy harvesting techniques have been investigated, tested and lab demonstrated. The project is currently only looking at deployment in the safe-zone for harvesting not in the HV field, however future work should be considered in this area as the harvesting potential is greatly increased.		

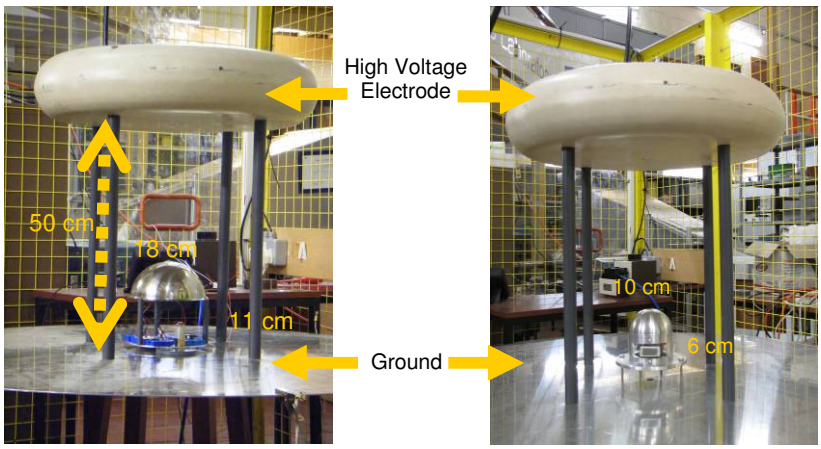
Inductive Harvester Approaches





Inductive Threaded (above) and Free Standing (below) harvesters

Capacitive Harvesters



Large Device (Capacitive)

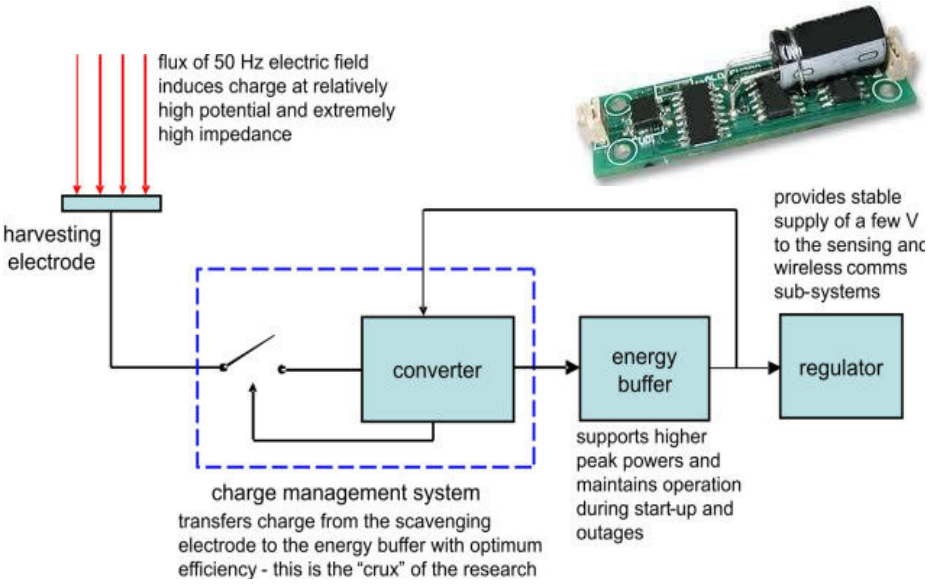
Small Device (Capacitive)

A power budget matrix is being prepared as an ongoing part of the project to match the harvesting technique with potential location and application within substations. From the investigation a focus has been on size and efficiency of the different harvesting technologies which is a key aspect to energy harvesting performance.

Research into existing measured field strength data has been completed but does not serve the purpose for this project. National Grid will be supporting Stathclyde University by planning site surveys at typical substation site's in order to carry out the required electrical and magnetic field strength measurements to assess energy harvesting potential and add to the power potential matrix. This is to be supported locally at Scottish substation sites.

The aim to investigate the typical field strengths within substations, especially at prospective sensing locations and to develop generic devices that are able to harness, store and deliver energy from substation ambient fields.

This technology requires an efficient and optimised conversion circuit to ensure a useful supply.



	The current sensor/transmitter nodes used by National Grid require too high power requirements for these energy harvesting types. Further work planned is to deploy demonstrators of each harvester type with a lower power requirement sensor to record ambient temperature and potentially energy harvested at a substation site.
Collaborative partners	None at present – although activity has begun in seeking potential collaboration as beneficial for DNO. May also be of interest to other infrastructure industries (water rail etc).
R&D provider	University of Strathclyde

Project title	Strategic R&D
Project Engineers	Jenny Cooper
Description of project	This project is a combination of strategic projects being carried out largely by university groups as part of major strategic collaborations. Projects are supported under EU funding, Electricity Supply Research (ESR) network funding and Engineering and Physical Sciences Research Council (EPSRC) funding in conjunction with contributions from international utilities. The projects focus on understanding the potential of techniques or technologies to impact the electricity Transmission network. Electricity Supply Network - A coordinated network of electricity supply companies which combines links to the majority of electricity research related academic institutions and links to current EPSRC funded energy projects. Projects are identified in the current EPSRC portfolio that are of interest to at least one member company and that the academic is willing to share the project progress. Forecasting Average Circuit Reliability (Industrial Mathematics Knowledge Transfer Network) - National Grid has a requirement to understand the unavailability of the electricity transmission system as a result of asset unreliability and has built up a large amount of historical data over several years. The project aims to use this data to forecast anticipated network unavailability for the years ahead. Modelling and control of AC-DC system with significant generation from wind (Imperial) - This PhD project will investigate into the modelling, analysis and control aspects of AC-DC system with synchronous and non synchronous generation. The modelling will be in general multi-machine framework. The expectation is that the HVDC grid side converter control will be supplemented through system level control to mitigate the impact of any time critical dynamic event limiting the transfer capacity of the system. A further research objective is also to see that the undesirable dynamic interaction of the wind generation with a DC link is also controlled through the wind generation side converter system level control. A significant effort in this PhD besides modelling will be concentrated on the control design of these system level controllers for both the converters. The Development of an Equivalent Power Network Model for HVDC Studies (Imperial) – This PhD aims to develop an equivalent network model using the Matlab/Simulink in connection with the Western HVDC project and to run the DC and AC load flows at different conditions to assess the model's robustness. Transmission Tower Field Testing and analysis (Southampton) – An EPSRC CASE award to support the longer term aspects of transmission Tower Field Testing and analysis (Dynamic Resistance of Transmission Tower Footings) by addressing the following: Develop a modern design methodology incorporating field research into rate loading effects and failure mechanisms and to apply these findings in the assessment of existing transmission tower foundations systems. Identify tools and develop a system for recognising locations and conditions where geotechnical uplift and compression issues are present. A Wide-area System for Power Transmission Security Enhancement using a Process System Approach (Imperial) - National Grid and Imperial College London have a long term aim of discovery of new uses for measurements from fast SCADA and Wide-Area Monitoring Systems (WAMS). The long term aim is enhanced operation of power transmission systems where the stability and power security will be threatened in future by generation from renewable resources such as wind power. The collaboration will contribute towards the long

	term aim by providing operational insights into the technical issues and specification of the system requirements.		
Expenditure for financial year	Internal £23k External £85k Total £108k	**Expenditure in previous (IFI) financial years**	Total £268k
Total project costs (collaborative + external + internal)	£12m	**Projected 2010/11 costs for National Grid**	£56k
Technological area and/or issue addressed by project	Electricity Supply Network – Projects areas currently being monitored by National Grid through the network include Knowledge Discovery from On-line Cable Condition Monitoring Systems – Insulation Degradation and Aging Diagnostics (Glasgow Caledonian University and the University of Strathclyde), Energy Efficient Cities (University of Cambridge), Development of Transformer and Fault Current Limiter for High Power DC Networks (University of Aberdeen) and Energy Loss Study for AC Excited Superconducting Coils (University of Cambridge). Forecasting Average Circuit Reliability - One of the key metrics for understanding network unreliability is the Average Circuit Unreliability. It has been reported as in internal KPI for many years and is also fundamental to the annual Regulatory Reporting Pack submission. It describes % network unavailability as a result of asset unreliability (outages related to faults, defects and failures etc). As part of the Network Output Measures methodology there is a requirement to forecast Average Circuit Unreliability. The present techniques are embryonic and limited to just a year's forecast. The KTN for Industrial Mathematics, acting as an agent of EPSRC, receives an annual allocation of funding for Industrial Mathematics Internships for short projects to support postgraduate researchers working on industrial-academic collaborations in mathematics. An Internship involves a high calibre PhD student taking time off from their studies and joining a company for a period of 3 to 6 months to work on a stand-alone project specified by a company. This project is co-funded with EPSRC, who will fund 50% of the student's stipend. The project for National Grid will involve developing a more sophisticated forecast technique for the Average Circuit Unreliability metric. Modelling and control of AC-DC system with significant generation from wind - In 2008 alone 2000 MW of new wind capacity was connected to the UK grid. With further 6000 MW under construction and 10,000 MW under planning stage in the first round, the UK transmission system in the next 5-10 years is going to face unprecedented operational challenges. The challenges are envisaged to be contributed by many factors such as locations, characteristics of new generation and planned retirement of more and more centralised synchronous generations. As majority of the wind uptake is going to be in North West of Scotland and demand growth will still be dominated in the down south in England, secured transfer of the energy is going to be a major problem across the Scotland-England inter connector which is already stability limited. The Development of an Equivalent Power Network Model for HVDC Studies - To assess the performances of the DC system under various operation conditions and assess the influence of the HVDC transmission on system security and AC		

<table>
<tr><td></td><td colspan="4">network performance.

Transmission Tower Field Testing and analysis -Following previous work there is an understanding of the uplift capacity of National Grid's existing transmission tower foundations under steady state and dynamic loading conditions.

A Wide-area System for Power Transmission Security Enhancement using a Process System Approach – Anticipated outputs are the specification for systems for detection and isolation of root causes of disturbances in power transmission systems, power system security enhancements and data sets from fast SCADA and WAMS systems for the testing of research ideas.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Strategic</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>0 to 6</td><td>1 to -2</td><td>4 to 5</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Electricity Supply Network – The outturn from the managed EPSRC projects is an awareness of current research issues and potential to implement via addition IFI projects, for example via application of condition monitoring developments. Through networks such as the Electricity Research Network access is gained to government funded research with potential impact to the networks. Not only is there the potential to be made aware of new knowledge and technology but also the potential for National Grid to inform and influence the research of large collaborative projects leading to more successful transmission research with potential future impact to consumers.

Forecasting Average Circuit Reliability - One of the key requirements of the Network Output Measures work was to understand network reliability, including on a forecast basis. A simple technique to forecast Average Circuit Unreliability was developed and presented as part of the 09/10 Regulatory Reporting pack and rollover TPCR submission. At present the methodology is embryonic, only forecasting for the year ahead and there is scope to develop a more sophisticated model. The methodology can also disaggregate the data to further develop an understanding of and forecast the unreliability of the lead asset groups: overhead lines, cables, switchgear and transformers.

Modelling and control of AC-DC system with significant generation from wind - While the dynamic consequence of Scottish and English interconnected AC system is well understood and can be managed by generator additional control (power system stabilizer) the dynamic performance of the system in the presence of wind generation and HVDC transmission is not well investigated.

Existing research in wind generation modelling addresses the dynamic and control performance of wind generator connected to the AC grid. The modelling details of the grid is neither very comprehensive nor in multi machine small signal stability framework which is often necessary for planning studies for the interconnected utilities. Inclusion of HVDC link adds further complexities giving rise to difficult research issues.

The Development of an Equivalent Power Network Model for HVDC Studies - The work could potentially results in a benchmark model for the National Grid.

Transmission Tower Field Testing and analysis - Assist in the interpretation and</td></tr>
</table>

	implementation of UK and European standards into general National Grid specifications, in particular relating to geotechnical and overhead line foundation design and testing. A Wide-area System for Power Transmission Security Enhancement using a Process System Approach - The benefit to National Grid is that early pre-publication results of the EPSRC project will be available to them on an non-exclusive basis. The benefit to Imperial College London is enhanced understanding of technical and operational issues in power transmission.		
Expected timescale of project	5 Years	**Duration of benefit once achieved**	5+ Years
Probability of success	25%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£319k
Potential for achieving expected benefits	Although speculative or strategic by nature, these projects are expected to feed in to National Grid through knowledge transfer. typically from academics to the relevant specialist engineer. The work is expected to form the basis of further research or developments, most likely as a specific project.		
Project progress as of March 2011	**Electricity Supply Research Network –** Knowledge Discovery from On-line Cable Condition Monitoring Systems – Insulation Degradation and Aging Diagnostics, Prof C Zhou (Glasgow Caledonian University) and Dr M Judd (University of Strathclyde) - a very interesting project, which is progressing well. It has however met difficulties and delays due to changes in support and staff. Reported via condition monitoring engineer. Energy Efficient Cities, Prof I Leslie, University of Cambridge. This very large project is now holding six monthly seminars, which ESR Network are invited to. The individual strands of the project are progressing very well, but the challenge will be to bring them together. Development of transformer and Fault Current Limiter for High Power DC Networks, Dr D Jovcic, University of Aberdeen. This is a new project which has set of extremely well. Three member Companies attended first meeting. Energy Loss Study for AC Excited Superconducting Coils, Dr Tim Coombes, University of Cambridge. A new project which has set off well. Two member Companies attended first meeting. **Forecasting Average Circuit Reliability** - There are a number of mathematical techniques available which could be employed to forecast the Average Circuit Unreliability and these have been be explored in order to develop the best methodology going forward. The intern used the ACU data and supporting information to develop the forecasting technique at a network level and also as an asset level by equipment group. The output is a model from which ACU and other data can be input and which will produce a forecast for future ACU, disaggregated by equipment type. A technical report detailing the modelling has		

	been produced **Modelling and control of an ACDC system -** With significant generation from wind modelling of an AC and an ACDC network with a current source converter link have been conducted in Power Factory and Matlab, for comparison. Some Matlab simulations have been conducted on a DC link with voltage source converts. These simulations were conducted to solve load flows within ACDC networks. Furthermore wake simulations on a wind farm were developed in Matlab. The simulations take the operating regime of the wind turbine into account. Results are shown for each wind turbine and for the whole farm, for 12 sectors of wind directions. The work included the submission of an initial research plan and technical report to Imperial College. **The Development of an Equivalent Power Network Model for HVDC Studies** – From the 21st February to 1st April Jenny Zhang, a PhD student from Strathclyde University, worked on a project of "The development of an equivalent power network model for HVDC studies". She completed the model development in Matlab/Simulink. A report was written for future reference. Jenny expressed that she has gained great experience through this work placement and feels grateful for the NG for providing her with this opportunity which she thoroughly enjoyed. **Transmission Tower Field Testing and analysis** - The design has been completed and a scale model built feeding in to verifying the main project outcome (reported separately). **A Wide-area System for Power Transmission Security Enhancement using a Process System Approach** – The project was completed successfully with PhD awarded earlier on this year. The student had secondment with NG and work at Wokingham to analyse system oscillation incident data to give National Grid confidence on the performance of the Dynamic System Monitors. In addition to the collaborative work with Imperial College, through the project, National Grid has also established good working relationships with ABB, FinGrid and Helsinky University. An IEEE paper on Comparison of electromechnical oscillation damping methods was published. As the result, ABB had improved their alogorithm on their PSGuide WAM based monitor. The success of the project team has a major contributory factor in the EU funded project started this year. The collaboration has extended to include further members (Statnett, GE and Graz University). This latter project has led to two further successful secondments to National Grid (Professor Renner from Graz U and Dr Jukka Turunen from Helsinky U) on analysing system incidents and using Power Factory to replicate the incidents. This will be key to the development of our WAM based system monitor and improvement our our modelling facilities. In summary, the project has been a success in bring the equipment supplier,

	utility companies and academia together to exploit new technology and advance techniques in the hope of helping National Grid to better position ourselves to manage the future challenges.
Collaborative partners	EPSRC, ENW, SSE, EoN, Alstom Grid, Dooson Babcock
R&D providers	University of Manchester / Industrial Mathematics KTN, Imperial College, University of Strathclyde, Southampton University

<table>
<tr><td>Project title</td><td colspan="3">Power Networks Research Academy</td></tr>
<tr><td>Project Engineers</td><td colspan="3">Jenny Cooper,</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.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £6k
External £71k
Total £77k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £6k
External £56k
Total £62k</td></tr>
<tr><td>Total project costs (collaborative + external + internal)</td><td>£1,085k</td><td>Projected 2010/11 costs for National Grid</td><td>£63k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">PhD Award Holders
Details of research projects, the lead academic, the university and the name of the PhD award holder are set out for each of the years below, National Grid supported projects highlighted in bold:
<table>
<tr><th>Project Title</th><th>Lead Academic</th><th>University</th><th>PhD Scholar</th></tr>
<tr><td>Overhead Lines Measurement System (OHMS)</td><td>Manu Haddad</td><td>Cardiff</td><td>Stephen Robson</td></tr>
<tr><td>Application of Artificial Immune System Algorithm to Distribution Networks</td><td>Jovica Milanovic</td><td>Manchester</td><td>Nick Woolley</td></tr>
<tr><td>System Impacts and Opportunities of HVDC Upgrades</td><td>Tim Green</td><td>Imperial College</td><td>Yousef Pipelzadeh</td></tr>
<tr><td>Protection Issues of Inverter-Interfaced DG</td><td>Tim Green</td><td>Imperial</td><td>Nathaniel Bottrell</td></tr>
<tr><td>Electrical Network Fault Level Measurement
For DG and other applications</td><td>Andrew Cruden</td><td>Strathclyde</td><td>Steven Conner</td></tr>
<tr><td>Reactive Power Dispatch for Distributed Generation</td><td>John Morrow</td><td>Queens</td><td>Stephen</td></tr>
</table></td></tr>
</table>

				Abbott
	Protection of future power systems encompassing DG, converter interfaces and energy storage	Campbell Booth	Strathclyde	Kyle Jennett
	Intelligent Insulation Systems	Paul Lewin	Southampton	Alex Holt
	Early Frequency Instability Measurement	**Vladimir Terzija**	**Manchester**	**Peter Wall**
	Protection of Series Compensated Transmission Lines based on synchronised measurement technology	**Vladimir Terzija**	**Manchester**	**Shantanu Padmanabhan**
	Influence of oil contamination on the electrical performance of power transformers	**George Chen**	**Southampton**	**Shekhar Mahmud**
	Alternatives to SF_6 as an insulation medium for distribution equipment	Manu Haddad	Cardiff	Phillip Widger
	Reducing the risk of sub-synchronous resonance in meshed power networks with increased power transfer capabilities	**Jovica Milanovic**	**Manchester**	**Atia Adrees**
	Solid state devices for electrical power distribution	Stephen Finney / Tim Green	Strathclyde Imperial	Gordon Connor April 2011 start

Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		2	-2	4

Expected benefits of project

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; and

<table>
<tr><td></td><td colspan="3">deliver research output that is industrially relevant.
See online for further information at
http://www.theiet.org/about/scholarships-awards/pnra/</td></tr>
<tr><td>Expected timescale of project</td><td>5 Years</td><td>Duration of benefit once achieved</td><td>5+ Years</td></tr>
<tr><td>Probability of success</td><td>60%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>-£172k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">It is expected that the PNRA will achieve its potential benefits with more expertise being produced either as academics or potential recruits for industry. The PNRA is expected to form an important part of the recently announced EPSRC HubNET collaborative project</td></tr>
<tr><td>Project progress as of March 2010</td><td colspan="3">Since 2008 fourteen projects for PNRA scholars have been 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 and a brief summary of the progress on National Grid supported transmission projects achieved to date are detailed below. National Grid also receives benefit from the DNO supported projects, most applicably the Alternatives to SF_6 as an insulation medium for distribution equipment at Cardiff University which will be considered as part of National Grid's review of alternatives to SF_6.

System Impacts and Opportunities of HVDC Upgrades (Imperial College, London)

A major change in generation mix and demand growth is anticipated by 2020 in the GB network, with 35% of total energy demand to be supplied by renewable generation. This includes an additional 45 GW of power generation.

The major generation supply (Wind generation in particular) is in the North, whilst the demand is predominately in the South. The circuits between these regions operate near their maximum transfer stability limit and the prospect of overloading the transmission network in GB demands major transmission network reinforcements to accommodate the anticipated growth. Managing this change will require the electricity industry to tackle new legal, technical, commercial and regulatory challenges.

Its envisaged that the feasible options are first to maximise the utilisation of the existing assets through installation of series compensators within the stressed 275 kV Scottish/English corridors resulting in boundary flows between regions to operate closer to the thermal capacity and second, exploit the latest technological solutions to ensure demand is met with minimal environmental impact. As such High Voltage Direct Current (HVDC) is envisaged to play a vital role to meet this target.

In light of these system reinforcements, the project attempts to address some of the technical challenges in improving the angular stability and system security be means of intelligent supplementary control techniques acting through HVDC devices.

The expected benefits of the project are
Demonstration of the ability to increase the transmission network capacity by developing wide-area power oscillation damping (WAPOD) controllers through HVDC links.</td></tr>
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	• Demonstration of optimal allocation of control duty between the two terminals of a VSC HVDC link to minimize the control effort and hence allow use of less expensive converters. • Development of novel decentralized control scheme for VSC-HVDC links. • Methods for Coordinated Control of Offshore Wind Farms and VSC-HVDC links for Effective Power Oscillation Damping. • Assessment of the Impact of Significant Wind Penetration and HVDC Upgrades on the Stability of Future Grids. • Identification of reinforcement opportunities through coordinated control of Wind-Farms and HVDC, TCSC, etc. in GB network The research underpinning the expected benefits is well advanced. It has not been possible to yet obtain a suitable GB network test model for GB specific studies of the methods developed. Research progress has been good and results have been positive. Relevant control techniques have been successfully applied and adapted for the cases studied. The results have been disseminated through academic publications: Submitted 4 conferences and 2 Journals papers to IEEE/IET. Presented work at an International conference in North America every year. Presented work at U.K conference/events every year. Currently working towards 2 CIGRE conference papers and an IEEE journal paper for July. A 2.5 month industrial placement at National Grid in Warwick was undertaken. Another placement will be considered before completion of the PhD **Early Frequency Instability Predictor Based on Synchronised Wide Area Measurements - E-FIP (Manchester)** The goal of the E-FIP project is development of a new tool that will support frequency control. The tool will provide this support by predicting the post-disturbance frequency behaviour. Where, a disturbance is a significant change in the active power balance of a system. Examples of a disturbance include the disconnection of a generator or a large change in load. This prediction of frequency behaviour should allow the system operator to optimise the actions taken to control any deviation in frequency. The expected benefits of the E-FIP tool are enhanced transmission system performance, in the form of: • Reduced stability margins • A significant reduction in the investments made in procuring frequency response support. The methods currently being considered depend upon the value of system parameters that may be difficult to estimate in the time available after a disturbance. This dependence does cast some doubt on the potential realisation of the expected benefits. Although with the time available it is likely that this problem can be overcome. A model based method for estimating the magnitude of the steady state frequency deviation that will occur after a disturbance has been developed. A literature review of direct methods for stability assessment, based on an energy function, is in progress. Based on the current state of this review it appears possible that a direct method can be employed, if a suitable energy

	function can be produced. Work has continued on inertia estimation. This has focused on dealing with some of the issues that make practical implementation of inertia estimation difficult and has produced some promising, although only initial, results. **Protection of Series Compensated Transmission Lines Based on Synchronised Measurement Technology (Manchester)** Transmission networks across the world face the challenge of increasing electricity demand requiring an increased power transfer capacity for the transmission lines. More specifically to UK, a large amount of distributed generation is expected to be connected to the Great Britain transmission network as a part of vision 2020. The large distances between the distributed generation and the load centres can be met provided the transmission capacity of the system is increased. Series compensation provides an effective solution to this problem and also provides increased transient stability to the system. Series compensation may be in the form of Fixed Series Compensation (FSC) or Thyristor Controlled Series Compensator (TCSC). There are however, a number of problems associated with series compensated lines such as protection and fault location. The changing impedance of the series compensators during the fault makes it very hard for conventional impedance based protection to distinguish the appropriate zone where the fault has occurred. This may cause mal-operation of protection for faults outside its zone. The impedance introduced by the Series Compensator will also cause inaccurate fault location when using conventional fault location algorithms (FLA). As a result, in recent years a number of improved protection systems and FLAs have been developed specifically for Series Compensated lines. Most these algorithms are impedance based and require line parameters. Thus the main aim of this project is to develop a settings free numerical algorithm that does not require any line parameters. This algorithm is required to be based on the Synchronised Measurement Technology (SMT). This technology uses synchronised voltage and current samples from both terminals of the line. This algorithm is later required to be validated using Real Time Digital Simulator (RTDS) at the National Grid Power System Research Centre at the University of Manchester. The expected benefits of this research are: • Numerical algorithm for asynchronous distance protection of series compensated transmission lines (SCTL) • Fault location algorithm for fixed SCTL using SMT • Fault location algorithm for thyristor controlled SCTL using SMT • Asynchronous fault location algorithm for fixed SCTL using SMT. Given the facilities at the University of Manchester and current progress, the potential for achieving the expected benefits is high. It is very likely that these benefits are realised. Targets that had been set at the start of the project have been met. These include: • Literature review of protection and fault location of series compensated transmission lines • Creating a reliable model for thyristor controlled series compensated transmission lines • Creating the appropriate simulation framework for the protection of series compensated transmission lines The progress is ahead of schedule and the student is now working on a robust

	settings free algorithm for fault location of SCTL using SMT. **Influence of oil contamination on the electrical performance of power transformers (Southampton)** In this project, we intend to extend our initial work to consider both metallic and insulating particles under both dc and ac voltages. This is extremely important to power converter transformers which are one of the key components in high voltage dc transmission systems. Power converter transformers experience the combination of dc and ac voltages during operation. To fully understand the characteristics of contaminants under the combined dc and ac voltage, bridging characteristics under dc and ac voltage will be studied separately. In addition to live optical observation and capturing of bridging phenomena between two spherical electrodes in oil under different voltages, contamination levels and oil and paper insulation conditions, electrical conduction currents and partial discharges will also be measured simultaneously during bridging. Finally, the electric breakdown tests of these various contaminated oils will be carried out. To simulate extreme cases of non-uniform electric field and its influence on pre-breakdown characteristics of contaminated transformer oil, a needle-plane electrode system will be further investigated. Similar tests to the two spherical electrodes outlined in the above section can be performed. As the project develops forward, practical application will be considered such as the effects of electrode and temperature. The influence of coated/wrapped electrode on bridging dynamics can be explored. As transformers are typically operated at elevated temperatures, therefore, it is vital to extend the above research to a higher temperature regime. Particle bridging characteristics as a function of oil viscosity will be revealed as oil viscosity changes with temperature. The comprehensive experimental results will allow us to establish a good understanding of contamination and its relation to electrical performance and pre-breakdown phenomena. To aid the understanding of bridging dynamics in the contaminated oil, a numerical model of particle movements and their accumulation at high field regions will be developed. It will be based on the hydrodynamic drift-diffusion approximation for the particles' motion under dielectrophoresis (DEP) forces. Additionally, the effect of particles shape and surface roughness on dust migration will be studied and an average (and easy measurable) parameters to characterise a wide variety of dust particles will be found from the simulation. This will create a link between the simulation and the practice, plus provide a verification tool for the model. The model assumptions will be tested by experiments with variety of dust particle (bunches of different sizes and shapes). By assigning appropriate conductivity values to the oil and contaminant, it is possible to obtain the current that flows during the bridging. It will be compared with the electrical conduction current measured under various conditions. Furthermore particles' percolation as a function of particles geometry and volume fraction will be modelled and the effects of dust accumulation around the electrodes on breakdown initiation will be understood. This step by step approach will provide us with essential knowledge of oil contamination on the electrical performance of power transformers so that a set of criteria about oil contamination levels can be established to reduce potential transformer failures in power systems. The student will be involved in comprehensive experimental work and computer simulation. This will equip the student with a broad range of skills and knowledge for future carrier in either industrial or the academic world. In addition to research specific skills training, the school involved in this project has a large and well-established postgraduate school offering a wide range of (compulsory and optional) courses covering subject specific and generic skills,

	as well as exciting seminar programmes. The student will have regular opportunity for scientific discussion, problem solving and presentation of the work at meetings with the industrial partner and at international conferences. Written skills and report writing are enhanced through the monthly report system, which includes presentation of experimental details and recorded data. The University has a well equipped High Voltage Laboratory to carry out all the experiments for this project. All the necessary software for this project is also provided. Progress to date has included: • Presented current work to National Grid team during a visit at Southampton University • Purchased necessary equipment for experiment • Liaised with HVLAB team to get a place for setting up the experiment • Continuous Learning of COMSOL Multiphysics **Reducing the Risk of Sub-Synchronous Resonance in Meshed Power Networks with Increased Power Transfer Capabilities. (Manchester)** Following the first two reported shaft failures in Mohave power station (USA) in 1970 and 1971 due to torsional oscillations, a number of studies have been carried out to explain the phenomenon and to propose countermeasures. Torsional (mechanical torques) oscillations are usually associated with sub-synchronous resonance phenomenon. Undesirable sub-synchronous oscillations that may lead to SSR (sub-synchronous resonance) and significant increase in mechanical torques, can arise in general in any compensated or uncompensated power system when natural frequency (fm0) of mechanical system is very close or equal to the complement (fc=50-f0) of the natural frequency (f0) of the electrical system. The potential sources of sub-synchronous oscillations can be classified into three categories. • Series capacitance compensation of network • Interactions with series compensators • Interactions with HVDC controllers It is anticipated that in order to increase power transfer between critical areas and accommodate new generation (mainly offshore wind) without building new AC transmission lines, future Great Britain power network and other power networks around the world could include multiple series compensated lines and HVDC lines. These types of lines give rise to SSR under certain conditions. There have been studies related to control of SSR in networks with compensated transmission lines with FACTS devices and very a few with HVDC lines. The SSR phenomenon in meshed power network with multiple, relatively short, series compensated AC lines and HVDC lines operating separately or in parallel as GB transmission network could look in near future has not been investigated in the past at all. The objective of this research is to explore in detail, scenarios which can lead to SSR in meshed power networks with relatively short but heavily compensated AC transmission lines operating in parallel with HVDC lines and to propose, using probabilistic risk based index, adequate AC/HVDC topologies that minimise the exposure to SSR. Expected benefits of this research are summarised below: Clarify significance of SSR studies for future networks considering that type and size of energy generation will change leading to significant changes in

	transmission network. Provide quantitative and qualitative comparison among different transmission network structures with respect to avoidance of SSR. Small and large disturbance studies carried out during this research, under various operating scenarios including multiple uncertainties in electrical and mechanical system parameters will help to establish robustness of different compensation and power transfer technology options and to identify safe operating ranges for each of the feasible solution. Contribute towards the growing research work to meet carbon reduction target of 2020 (EU renewable energy directive) and 2050 vision for UK power systems. Significant progress in the work has been made to date and objectives of this research are realistic. It is expected that all objectives of this research will be fully achieved and benefits will be realised. Progress to date: A literature review has been completed which includes anticipated changes in type and size of power generation due to renewable energy and carbon emission reduction, SSR history, detail explanation of this phenomenon, its potential sources and its counter measure. Gaps are identified in the past work related to SSR and scope of future work is explained. Models of synchronous machine and turbines are also explained. First Bench Mark Model is developed in DigSilent and series compensation is varied to see effect on torques of different turbine sections. A meshed network is also built to compare the torques of different turbine sections against the torques of different turbine sections generated in radial network. A HVDC link is also built and connected in parallel to AC link in meshed power network to analyze the effect of HVDC controllers and this topology on turbine torques.
Collaborative partners	PNRA: EPSRC, National Grid, Scottish and Southern, Central Networks & EDF Energy Networks.
R&D providers	PNRA: Universities of Cardiff, Manchester, Queens (Belfast), Southampton, Strathclyde, and Imperial College London.

Project title	**DD-DSM: Demonstration of Distributed Demand-side Management as a service to the UK grid operator**			
Project Engineer	William Hung			
Description of project	This project will demonstrate the operation of distributed demand side management as a service to the UK grid operator, providing fast response in order to reduce reliance on conventional generation for grid balancing and security and thus permit much greater penetration of renewables and aid in maximising the use of existing assets. The demonstration will focus on the control of commercial air conditioning to provide an aggregated service of some tens of MW. The value and scope for wide scale application of the technology across the UK, and with regard to transmission constraints will be demonstrated through software modelling based on the results of the practical trial.			
Expenditure for financial year	Internal £19k External £-11k Total £8k	**Expenditure in previous (IFI) financial years**	Internal £6k External £0k Total £6	
Total project costs (collaborative + external + [company])	£38k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Improve demand side management technology to allow the commercial building demand in particular air conditioning load to be effectively control to minimise CO2 emissions from power stations and also help to reduce the impact of intermittency of wind generation on system performance.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		7	-2	9
Expected benefits of project	The benefit of the services derived form the project will help to reduce the generation response requirement provided by Generators leading to less plant being deload and hence reduction in CO_2 emission. The service provision from the demand side management helps to increase competition in the frequency response market leading to reduction of frequency response service cost to the GBSO. Given air conditioning load is becoming more significant in recent years (eg summer demand in London is higher than that in Winter), the appropriate management of this type of demand in commercial buildings will help to level out some of the peaks and hence reducing the technical and financial impacts on National Grid.			
Expected timescale of project	2 Years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£19k	
Potential for achieving expected benefits	Significant ground work has been initiated and good progress made in each work stream (5) to contribute to the success of the project. There is a good potential for achieving the objectives set out in the project. The two year effort in demonstrating the feasibility of the project had been successful and more effort will be required in the follow up project to allow more focus on deriving			

	control strategy for the demand control to meet the final objectives.
Project progress **[Year to End of March 2011]**	The project was completed in Dec 2010. The DD-FD project brought together a team of organisations specifically to work on this demonstration: manufacturers, National Grid, leading academics, and E.ON New Build and Technology (providing access to E.ON retail, distribution and trading businesses). The diverse team represents every aspect of the value chain for developing D-FD. Each organisation is highly successful in their field, has demonstrated commitment in energy efficiency and low carbon R&D, and brought value to the team through the exceptional track record of the individuals involved. Together this consortium represents every aspect of the value chain for developing D-FD and all of the entities required to initiate a UK and European-wide D-FD market. By sharing expertise, this consortium has successfully delivered the D-FD project objectives and is well placed to exploit the technology developed. From NGET's perspective, as the demonstration project is to establish Demand Side Management type of Balancing Services and possibly energy trading, our role throughout the project had been making sure the services need by the system is clearly defined to ensure the service to be developed will serve the system in a efficient and cost effective way. Close involvement on the modelling of the system dynamic, response scheduling and load dynamic is critical as accurate modelling is important for the correct assessment of the potential of the service development. Without this involvement, the Grid Operator would not have sufficient confidence in utilizing the service provision for maintaining the security of the system. During the project, contracts were made with 5 commercial buildings in London with the objective of collecting data and try out different control strategy. Given the limited time scale, significant data have been collected but more detailed analysis will be required to allow more effective control strategy to be derived to benefit the system. Given the promising results from the 2-year collaborative work between partners, E.ON agreed to continue to fund the project in the forth coming years. NGET has agreed to continue to support on the development of the service and provide advice on the system needs to allow service to be developed into a form which can be used effectively and efficiently by the System Operator. The service provision is addressed and solution identified to facilitate future service operation. There is a need for accurate modelling of the dynamic demand behaviour including the implemented control functions as the aggregated effect of demand and active DSM could have a significant impact on the Grid performance. The dynamic demand behaviour of different types of buildings and their variations with seasonal and ambient conditions are required to be taken into considerations. This will be required to assess their aggregated effect on the system should there be any extended period of depressed system frequency incident which if not correctly predicted and managed could result in demand disconnection and partially black out the system.

	NGET believes these models are required to be validated with real site data to gain confidence on the accuracy of each of these model types in terms of their demand profile. These demand profiles of each building types are required to be aggregated to simulate the overall system demand behaviour and compare with the demand profile of the GB system. In summary, the 2-yr TSB funded project was a greet success and NGET is looking forward to continue to work with E.ON and other partners to pursue the forward looking project.
Collaborative partners	E.ON, SpaceAir, Daikin, Horstmann, Viessmann, IC, LUT, National Grid
R&D provider	IC and LUT

Project title	**DC Supply Com Air Energy Storage System Pnu Power**			
Project Engineer	Tony Westmorland			
Description of project	The project is to evaluate the dependability, performance and application of the "Pnu Power" DC Supply Compressed Air Energy Storage System. This system offers a promising alternative to a traditional charger and battery system used for substation light current supplies. It could provide an alternative, reliable, low maintenance and environmentally friendly solution, which can provide a scaled and flexible DC output capability. The project will consist of laboratory tests, type tests and a pilot installation and evaluation.			
Expenditure for financial year	Internal £5k External £0k Total £5k	**Expenditure in previous (IFI) financial years**	Internal £5k External £20k Total £25k	
Total project costs (collaborative + external + [company])	£30k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	Alternative to substation batteries			
Type(s) of innovation involved	Significant	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		10	-2	12
Expected benefits of project	The business benefits are that the Pnu Power system will be a more dependable, reliable source of back up DC power. When called upon to provide back up power, it will dependably and reliably provide the supplies for a known and measured time. Without reliable and dependable supplies caused by an aging battery population, a total battery system failure could lead to local black outs and severe penalties for National Grid in excess of £1m. The system is anticipated to have more than 20 years design life, with little maintenance and safety hazards.			
Expected timescale of project	2 years	**Duration of benefit once achieved**	5 Years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£20k	
Potential for achieving expected benefits	Based on the successful testing of the prototype, confidence is high that the expected benefits will be achieved.			

Project progress **[Year to End of March 2011]**	The first installation of the Energetix Pnu Power unit has been operating successfully at Capenhurst substation for the past 18 months and is being supplied with air from the substation ring main. The unit is now permanently supporting both the 48V and 110V dc systems. A second unit is being installed at Pitsmoor (which does not have a site air supply) in August 2011 to prove the alternative solution which has a self contained air system. This is second and final phase of the trial which is expected to demonstrate that the key objective of the project can be achieved i.e. that this technology can provide an alternative to substation batteries. It is anticipated that the project will be completed in the last quarter of 2011. A cost/benefit analysis has being undertaken in parallel with the technical evaluation. The analysis has shown that the Pnu Power compressed air energy storage system is a viable option for substation standby battery systems. A final report will be issued and presented at the end of the project to National Grid's investment governance group where it is anticipated that the technology will be adopted for implementation.
Collaborative partners	N/A
R&D provider	Energetix Pnu Power

Project title	**TSO-DSO Real time data exchange for Smartgrid operation**			
Project Engineer	Alex Carter			
Description of project	The project will assess the requirements for, and demonstrate the viability of enhanced data exchange between National Grid (as Transmission System Operator) and the Distribution Network Operators to facilitate the secure and effective operation of the GB electricity networks following the introduction of Smart Grids.			
Expenditure for financial year	Internal £6k External £47k Total £53k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0	
Total project costs (collaborative + external + [company])	£53k	**Projected 2011/12 costs for national Grid**	£0	
Technological area and/or issue addressed by project	The introduction of SMART Networks within Great Britain will potentially introduce increased uncertainty in the operation of the overall Transmission network, in terms of both the increased level of volatility in demand and the consequent impact on Transmission Network flows. Without adequate data exchange and the development of suitable analysis tools and data visualisation between both the Transmission company and the Distribution Network Operators it will not be possible to ensure that appropriate levels of security are maintained across all networks, ultimately potentially impacting the reliability of supply in Great Britain.			
Type(s) of innovation involved	Incremental	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**
		14	-2	16
Expected benefits of project	HIGH- both WPD and National Grid are highly supportive of taking this work forward.			
Expected timescale of project	1 year	**Duration of benefit once achieved**	Enduring	
Probability of success	80%	**Project NPV = (PV benefits – PV costs) x probability of success**	£482k	
Potential for achieving expected benefits	GE are the established supplier of Transmission and Distribution SCADA systems in GB, the trial will also demonstrate the implications for sharing the data across SO and DO SCADA Systems and help demonstrate the data required both parties in a SMART enabled environment.			
Project progress **[Year to End of March 2011]**	National Grid and WPD have agreed the initial data to be exchanged in the first phase of the trial and the ICCP data link has been established between the two systems, we are awaiting final software update and configuration of the Distribution SCADA System by GE before the data exchange can commence (anticipate for Sep 11) although all of the protocols are established and ready to go.			
Collaborative partners	25% Funding up to a maximum of £33k from DECC SmartGrid funding initiative agreed.			

R&D provider	GE

Project title	**SuperGen – HiDEF (Highly Distributed Energy Future)**			
Project Engineer	Dr William Hung			
Description of project	The Consortium will develop the analytical, sustainability and economic evaluation tools, interface technologies and coordination strategies that are required to demonstrate the credibility, test the feasibility and engineer the integrative solutions of a future power system that delivers sustainability and security through the widespread deployment of distributed energy resources (DERs) and thus contributes to national and international ambition for a low carbon future.			
Expenditure for financial year	Internal £3k External £20k Total £23k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0	
Total project costs (collaborative + external + [company])	£4,597k	**Projected 2011/12 costs for national Grid**	£25k	
Technological area and/or issue addressed by project	The Highly Distributed Power Systems Consortium have developed plans for renewal that will demonstrate a radical vision of a highly distributed energy future that enables all end users to participate in system operation and real time energy markets and thereby more fully exploits the potential of distributed generation and active load resources to deliver a more sustainable and resilient provision of energy for the future. This Highly Distributed Energy Future (HiDEF) programme researches the essential elements of a decentralised system that could be implemented over the period 2025 & 2050, but at the same time has been structured to support the evidence base relating to key questions of current concern within the stakeholder community and in this way its relevance extends beyond the limits of its decentralised system vision. In concept, the research vision is one of decentralised resources, control and market participation extending to include end users at system extremities. This challenges the current fit-and-forget strategies for the incorporation of such small elements within the power system that fails to capture the potential added value of this distributed technology. Furthermore, this approach opens up new opportunities that are not feasible in the conventional centralised structure, such as local heat and cooling grids, or district biogas schemes. In recognising this, the consortium's scope has broadened from electrical power systems to future energy systems. This builds naturally on the extensive device based modelling work and conceptual work conducted under HDPS 1. In particular, the cell concept developed by HDPS 1 becomes the mechanism for localised management of not only electrical energy but also gas/heat/cooling and to extent energy for transportation. The HiDEF project strongly complements the research, development and demonstration activities of TSB, the Carbon Trust, ETI, industry and EPSRC. A cross-cutting systems perspective is taken by the HiDEF team, building from detailed bottom-up modelling and systems level requirements. In this way the consortium is particularly qualified to contribute to an understanding of distributed resources and loads, their optimal coordination, and mechanisms for comprehensive integration.			
Type(s) of innovation involved	Tech Transfer	**Project Benefits Rating**	**Project Residual Risk**	**Overall Project Score**

		5	-4	9
Expected benefits of project	The project will help to deliver efficient highly distributed embedded generation, flexible demand and actively managed network which will improve utilization of generation capacity and optimise balancing services. This will not only optimise system operation cost but reduce CO_2 emission. National Grid's participation in SuperGen HiDEF was planned for £20k pa and 13 man days per year for 4 years.			
Expected timescale of project	4 year	**Duration of benefit once achieved**	5 years	
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	-£86k	
Potential for achieving expected benefits	Medium to high likelihood of success based on current output from the consortium. Success will also depend on National Grid's engagement and direction. NGET has been contributing to the consortium from a Transmission system perspective to ensure any development in this area will be complementary to the Smart Grid Development.			
Project progress **[Year to End of March 2011]**	Attended 2 HiDEF Consortium management meeting and project report workshop in Cardiff (May 2010) and Strathclyde (Sept 2010). The purpose of the meetings are to allow NGET to participate in the £4.5m project supported by Utility companies and 5 universities. The key objective for NGET's involvement is to establish close collaborative work with Industrial and academic partners to steer future changes to deliver efficient highly distributed embedded generation, flexible demand and actively managed network which will improve utilization of generation capacity and optimise balancing services. This will not only optimise system operation cost but reduce CO_2 emission. The HiDEF project strongly complements the research, development and demonstration activities of TSB, the Carbon Trust, ETI, industry and EPSRC. Some of the key issues which NGET have raised are robustness of small embedded generation (eg inconsistent and unstable ROCOF operations), effect of increasing 1320 to 1800 MW contingency loss on ROCOF operation and co-ordinated strategy in smart meter based demand side management. These, if not managed correctly could jeopardise future system supply security and quality of supply. NGET will continue to contribute in the Consortium and the development in the different Work streams.			
Collaborative partners	Approx £4.5m from other sources including EPRSC and Additional Utilities/companies.			
R&D provider	University Consortium Project Manager–Prof Graeme Burt (Strathclyde U) Imperial Collage, Oxford, Cardiff, Bath, Loughborough and Strathclyde universities			

Project title	**PHILON**		
Project Engineer	Mark Perry		
Description of project	Philion is a consortium that will set out to create innovative strategies and tools focused on the reliability of the pan-European electricity Transmission network National Grid is directly involved in these areas listed below O1: To review and analyze the current good practices at assessing and improving transmission network reliability performances on a world wide basis O2: To develop the risk-based criteria able to balance the probability of contingencies occurring against the impacts of such contingencies for the pan European transmission network O5: To assess the above pan European options through cost/benefit analysis.		
Expenditure for financial year	Internal £3k External £0 Total £3k	**Expenditure in previous (IFI) financial years**	Internal £0 External £0 Total £0
Total project costs (collaborative + external + [company])	£10,000k	**Projected 2011/12 costs for national Grid**	£0
Technological area and/or issue addressed by project	In response to the call ENERGY.2011.7.2.2, the overarching goal of the present project is to propose, develop and assess a new set of improved security criteria for the pan European transmission system without jeopardizing its measured present-day reliability levels. The most important principle of transmission network planning and operations in Europe is to guarantee (N-1)1 preventive security stringently and transparently. This criterion aims at providing the survival of the electric system after a single contingency of default of any of its critical elements has occurred (like overhead lines, cables, transformers, capacitors, generation units, HVDC lines, phase shifters, etc). This criterion assumes that the probability of such a single contingency is one order of magnitude higher than the joint probability of two or more simultaneous contingencies. It also implies that no cascading will occur with impacts beyond a TSO border: each TSO must therefore monitor the impacts of the events defined in its own contingency list and is supposed to warn its neighbours when its own system is at risk. This has led TSOs to behave according to three complementary modes: “Be aware of the risks”, even if not sufficiently covered by remedial actions due to too high costs (potential emergency situations), “Implement Best efforts” to set-up remedial actions, which is not anymore always possible or efficient enough when implemented by one single TSO to		

[1] Implemented by UCTE, it states that the network must survive any loss of a power line or a generation unit. In France, the (N-k) rule prevails with k>1 : typically no network loss must occur even if two generation units trip.

<table>
<tr><td></td><td colspan="4">cover extraordinary contingencies,

“Be aware of the resulting impacts” of domestic operational decisions (switching, redispatching, outage planning, capacity assessment) on neighbouring systems.

However, meeting such constraining criteria, and implementing the resulting process management within TSOs planning and operations, will become more and more difficult, since facing several new barriers:

• Public opposition to new overhead transmission infrastructures and environment legislation, which will further constrain power flows all over Europe
• The system uncertainties coming from the generation outputs of RES and the limited controllability of DER units, which will in turn impact the security of the system, since the number of connected DER units will steadily increase
• The growth of a more and more complex pan-European electricity market
• The development of the Smart-(Distribution)-Grids which will further increase uncertainties since making consumption more dynamic through demand side management.
• The still limited potential of massive electricity storage solutions due to environmental, technical, economic and social factors

There is therefore a need to re-evaluate the (N-1)-security approach, i.e. to make it evolve, implementing novel regulatory constraints which should keep the system reliability figures at values similar to the ones encountered to-day. This doctrine evolution must also integrate several change drivers for the pan European electricity system in the next ten to twenty years:</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Tech Transfer</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>7</td><td>-5</td><td>12</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The business will benefit from sharing best practices with other European TSO’s as well as enhancing its knowledge of the implications of a higher level of cross interactions between TSO’s due to the increasing use of renewable generation. Also from knowledge about the higher levels of interaction between TSO’s and DNO enabling smart grids to be fully utilised.</td></tr>
<tr><td>Expected timescale of project</td><td>2 year</td><td colspan="2">Duration of benefit once achieved</td><td>5 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>-£103k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Drawing on expertise from 11 other Europeans TSO’s gives this project a good chance of success at coming up with a series of suggestions. Engagement with ofgem to enable the implementation of this project is key for the success of the project for National Grid.</td></tr>
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Project progress **[Year to End of March 2011]**	This project was unfortunately unsuccessful at the FP7 review panel and therefore will not be continuing. The spend is purely associated with internal time spent preparing the document and contract negotiation.
Collaborative partners	Collaborative project with 11 TSO's (FP7)
R&D provider	

<table>
<tr><td>Project title</td><td colspan="4">SmartZone project</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Mark Osborne</td></tr>
<tr><td>Description of project</td><td colspan="4">The SmartZone project will develop and pilot a range of intelligence based applications to enhance the boundary rating and network utilisation, this includes dynamic rating, new operational tripping and wide area monitoring control and protection (WAMPAC) tools, with the intention to have these production ready for National Grid to deploy where constraints or ‘Connect & Manage’ dictate. The trial will be a staged programme based in the Humber group to develop a ‘fit for purpose’ communications and data management architecture capable of providing Smarter Transmission. The project will commence in 2011 and aims to have production tools by the end of 2014. In summary, the pilot will intend to:
• Install a variety of sensors to collect system and asset data
• Develop a number of applications which enhance asset performance of circuits and transmission boundaries or enable post fault capacity beyond current deterministic levels
• Design the appropriate architecture and identify the upgrades necessary in the IS infrastructure to support these new tools
• Understand the impact these applications will have on existing operation and procedures.
Stage 1 will look at the end to end issue around installing one application (2010-11), while stage 2 will expand the range and scope of applications (2011-13) and stage 3 concentrates on the implementation programme into daily operation (2013-14).</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £21k
External £200k
Total £221k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £0
External £0
Total £0</td></tr>
<tr><td>Total project costs (collaborative + external + [company])</td><td>£640k</td><td>Projected 2011/12 costs for national Grid</td><td colspan="2">£420k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The Humber estuary is going to be a key import/interface region for offshore generation and as such will be a major beneficiary of developments in dynamic rating and congestion management. The ENSG report ‘Our Electricity Transmission Network: a vision for 2020’ provides greater detail on the network expansion.
There are a number of new technologies being considered which can be used to extract or utilise more capacity out of existing assets through better intelligence on the parameters which determine the thermal operating limits of assets.
Overhead line circuits are very dependent on weather conditions, so are obvious candidates for dynamic enhancement, especially since this will be coincident with the peak output for intermittent generation sources like wind.
Improved network data will enable a new breed of automatic control and protection schemes to be developed.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>16</td><td>2</td><td>14</td></tr>
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Expected benefits of project	The strategy documents WAMPAC (SD010) and Smarter Transmission (SD01x) both advocate the need for this trial as an integral part of preparing the network for the future. Under Connect & Manage, constraints costs can definitely be expected to rise, to at least a mean of £50m pa, but most likely higher. It is not unreasonable to expect that basic improvements in dynamic rating, could permit upto a 5% increase in circuit thermal ratings, and in turn would reduce these costs by 10%; thus a £5m pa saving can be reasonably claimed. Although unproven and not integrated at this time, the installation of a dynamic line rating (DLR) system will cost approx £200k-300k/circuit. In terms of constraint saving on a specific circuit this could equate to between £350k & £750k a day. Across the constraint boundary the saving is typically 2-3 times higher so the constraint savings could be in the order of £1m-1.5m. A range of asset awareness tools will be the key to facilitating system access ensuring connections, asset replacement and maintenance can be achieved.		
Expected timescale of project	4 years	**Duration of benefit once achieved**	5 years, until industry confidence is sufficient to revise Energy security policy regarding network design.
Probability of success	60%	**Project NPV = (PV benefits – PV costs) x probability of success**	£519k
Potential for achieving expected benefits	The project will be carried out in a staged manner. Stage 1 involves establishing a dynamic rating pilot in the Humber. Phase 2 will expand this to wide area congestion management and WAMPAC tools, with Stage 3 concentrating on the implementation challenges for production tools. There is a reasonable likelihood of success in developing a working solution. The valuable experience gained during the pilot will help to significantly reduce risks during the enduring project roll out.		
Project progress **[Year to End of March 2011]**	Internal work has focused on the workstreams necessary to take forward the SmartZone Strategy. Comms and data management will be a major part of SmartZone, establishing requirements for the trial and then enduring services with IS. Review of application architectures to integrate monitoring, control and protection systems. Review of sensors to provide awareness to the wide area monitoring (WAM). Network analysis to ascertain the impact of dynamic rating and power flow control on this region (University of Manchester). Technology providers have been selected based on the solutions they can provide. The bulk of the cost (£180k) is to purchase and trial a real time line rating tool (Ampacimon). Delays are delaying implementation and we have missed this year's outage slot. Once this is resolved and the equipment manufactured a short outage will be sought in Q3 of 2011 to install. A review of System Integration Protection Systems (SIPS) to replace our conventional operational tripping schemes (OTS) is underway with a system integrator involved with projects world wide. An initial solution will be proposed Q3 2011		
Collaborative partners	This will be a multiple stage project which will continue on to. Phase 2 this will be approximately £1.86m, Phase 3 £360k. Only 50% of the 2011/12 costs are sanctioned at this time. Leverage will be sought through a number of channels: Pursue funding from bodies like ETI, TSB and EU initiatives		

	We will look to coordinate application development with Scottish Power and SSE. Work with solution providers to develop new tools (Alstom Grid, Siemens, Pysmetrix) Coordinate with parallel NG Strategies SAM, RAMM, IS Smartvision ,etc
R&D provider	Multiple