Innovation Funding Incentive Transmission Annual Report 2007/2008

nationalgrid

Operating safely, efficiently, reliably and responsibly

Introduction by Nick Winser, Executive Director, Transmission

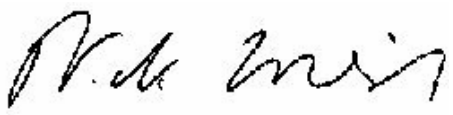
Welcome to this report presenting the steps we have taken in the initial year of the Innovation Funding Incentive. This Incentive, agreed with Ofgem as part of the 5 year Transmission Price Control Review, represents a welcome initiative to stimulate R & D in the energy sector.

It is of course no coincidence that we are stepping up our R&D activities at a time when we are facing significant global challenges. As a company we have set a challenging target for carbon reductions by 2050 and are engaged in research looking at mitigating climate change and reducing the carbon footprint of our operations. R&D can help us to achieve our carbon reduction target. This report also outlines projects we have in place to ensure we are utilising our assets to their maximum capability as we operate, rebuild and replace them.

Specific challenges facing electricity transmission, which will require an innovative approach, include facilitating the connection of new low carbon generation and overcoming capacity constraints on the network whilst enabling Smart technology to optimise network and customer choices at all levels. For gas transmission we have to accommodate the changing pattern of energy supplies, with new LNG coming on line and the UK Continental Shelf gas declining. All this requires new solutions to be delivered through R&D, some of which will be easy wins, whilst others will require longer term programmes stretching over a number of years.

I hope that this foreword gives a useful insight into the value of IFI from a National Grid transmission perspective and that the report illustrates the steps we are taking to tackle the challenges of the future.

Nick Winser



Executive Director, Transmission

Document Structure

This document has been designed in order to comply with the Innovation Good Practice Guide for Energy Networks (ENA Engineering Recommendation G85 Issue2*)* and the contents of this document are listed below.

- Introduction from Nick Winser, Executive Director Transmission
- Document Structure
- Overview of 2007/2008 R&D Activities
- R&D Focus Areas and Successes
- Case Studies
- Finance Overview & Benefits of Programme
- Looking Forward
- National Grid Electricity Transmission - R&D Detailed Reports
- National Grid Gas Transmission - R&D Detailed Reports

Overview of 2007/08 Activities.

Our approach for this first year of the Innovation Funding Incentive (IFI) has been one of collaboration and active discussion with all our stakeholders. Since the introduction of this incentive we have worked with Ofgem, ENA, Distribution Network Operators and the Scottish Transmission owners to put in place an Innovation Good Practice Guide for Energy Networks (ENA Engineering Recommendation G85 Issue2*)*. Issue 2 of this document was published in December 2007 and sets out guidelines for undertaking transmission R&D in compliance with the Incentive.

Wherever practicable we have sponsored collaborative R&D with other organisations who share common objectives as well as maximising the benefit of IFI money for UK consumers through working with Scottish Power, Northern Ireland Electric and Scottish and Southern Energy.

We have in place collaboration agreements with Manchester, Southampton, Strathclyde and Cardiff universities as well as Advantica to aid in the delivery of R&D .These arrangements give us cost effective access to high quality research resources and National Grid is currently looking to expand these arrangements to help us meet the challenges we face going forward.

National Grid currently sponsors the US based Electric Power Research Institute for specific projects, which give the UK electricity transmission business highly leveraged access to US utility research (access to $17.5 million of research for $683,000 expenditure). We are working closely with our key equipment suppliers to ensure their own R&D programmes are geared to delivering products which will meet the challenges we face. We are also looking further afield to find new solutions for the energy sector such as initiating a structured programme with QinetiQ, the government defence research organisation, seeking opportunities to transfer military research outputs into the energy sector.

Example of facilities at Manchester University - one of our Collaborative partners.
(Pictures Courtesy of Manchester University)

Focus Areas and Successes

After the first year of IFI funding, there are already some key focus areas emerging as well as some successful achievements, which we are pleased to share with you over the coming pages.

- Use of mineral insulating oil has potential disadvantages in terms of environmental compatibility, fire safety and sustainability. The use of other fluids particularly vegetable based products gives a sustainable alternative to solve environmental or supply risks associated with existing products. Work undertaken previously showed that there were no fundamental problems with the use of alternative fluids for dielectric strength, ageing diagnostics and dielectric properties at medium voltage. National Grid is now implementing a follow up project looking into 275kV & 400kV applications.

- National Grid has worked with Qinetiq to develop a road map looking at replacing some of our helicopter inspections of overhead line routes and possibly gas pipelines with Unmanned Aerial Vehicles. A more detailed feasibility study and trial will now be initiated. Benefits of this work include significant CO_2 emissions reduction, improved personnel safety and the ability to survey areas, which were previously difficult to survey due to flight restrictions being imposed.

- Composite materials have been a key component of this R&D programme with work being completed on ageing mechanisms in composite insulators (see photos below) as well as further work being undertaken on access and egress to composite insulators given their differing physical properties to conventional insulators. National Grid has also scoped a feasibility study to look at composite cross arms on transmission towers, which commenced in April 2008.

Pictures of AC flashover of field-aged composite insulators
(Pictures Courtesy of Manchester University)

- There is an increasing focus on the use of SF_6 in the electricity industry due to its high global warming potential. National Grid is committed to a Climate Change Strategy that aims to achieve a target of an 80% reduction in emissions of greenhouse gases by 2050 and R&D has been initiated identifying acceptable alternatives to SF_6, as well as working with suppliers to develop SF_6 equipment that has lower leak rates.

- National Grid has continued development of Maintenance Delivery Tools two of which are reported here. The Pladder (PLatform LADDER), which is a lightweight, versatile working platform , which allows Overhead Lines staff to complete required maintenance activities on tension insulators, and the Powered Ladder Access Basket which has been developed in conjunction with the Pladder. Both provide many benefits, the primary one being the avoidance of occupational health issues associated with maintenance activities. Both pieces of apparatus can be seen below.

Pladder

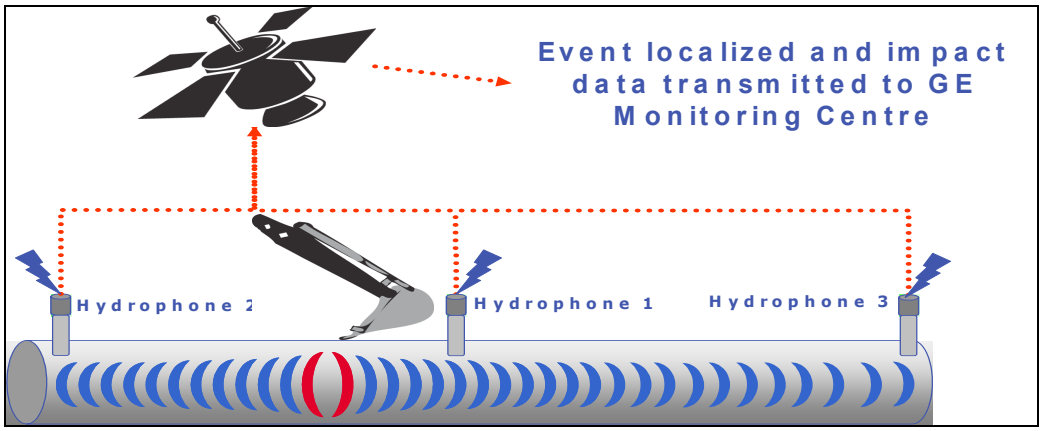
Powered Ladder Access Basket

- As one part of a larger, integrated approach to climate change, National Grid commissioned Weather Intelligence to undertake an assessment of the climate change challenges presented to its UK Transmission business and its organisational readiness for those challenges. This culminated in the initiation of a series of R&D projects looking at asset resilience and security of supply at times of severe climate and weather events.

- National Grid is keen to ensure that any physical impact or third party damage to its high pressure gas network is detected and located to ensure the integrity of the network is preserved and an incident prevented. With this in mind National Grid is currently trialling a rapid detection system, which picks up vibration along a pipeline to determine threats. This

information is quickly relayed so that appropriate actions can be taken. Progress to date has been good and the trial system is currently being installed.

Diagram of basic principle of gas pipeline impact detections system (Picture Courtesy of GE)



- National Grid's electricity assets - overhead power lines, underground cables, and substations - all produce electric and magnetic fields (EMF). At high levels EMFs have established effects on the human body; at lower levels they may or may not have effects with the scientific evidence being ambiguous. In both situations, continued operation of our assets, safely, in compliance with relevant limits and guidelines, and commanding public acceptance, requires a good scientific understanding of the issues and new research into key areas.

- Part of our research on EMFs is focussed on understanding the issues around exposure limits, to enable us better to comply with appropriate regulations and to operate without harming the public or our staff, but also without incurring unnecessary restrictions or cost. Hence we research both the biological basis of the limits themselves and also the numerical calculations necessary to implement them. The other part of our research focuses on the possibility that lower-level EMFs may cause cancer or other diseases.

- Through our involvement in the international scientific community and through key contacts and committees, we target specific pieces of high-quality work that are aimed at key gaps in the current knowledge base, for example, looking directly at cancer rates round power lines using study designs free from the bias that has plagued previous studies; a programme of testing key reported biological results in independent laboratories; and work designed to understand the relevance of key proposed biophysical mechanisms. The aim is not just to contribute generally to the worldwide knowledge base, but to focus on specific aspects of the issue that could have an impact on running an electricity system in a democratic society.

Case Studies

The following case studies are illustrative of projects which have been initiated as research into proof of concept of a technology and are developing into initiatives that have direct impact/benefit on the business.

Case Study 1- Antenna Arrays

Antenna arrays continuously monitor an entire substation and pinpoint partial discharge signals from failing equipment without the need to add sensors to individual devices.

National Grid and EPRI are leading an international collaborative research project demonstrating successfully a radio-frequency early warning system that uses an array of antennas to detect and accurately locate partial discharge (PD) signals from failing equipment throughout a substation. Prototype systems are deployed at 4 sites in National Grid in the UK; TVA, Tri-State, SCANA Corporation, and Southern Company in the United States and Powerlink in Australia. The EPRI trials are built on techniques originally funded by National Grid and EPSRC at the Universities of Bath and Strathclyde.

Even though this technology is in the research phase, reports from National Grid and EPRI show that field deployments have already begun to identify failing equipment and results have allowed users including National Grid to take preventive action before a failure. Specific deteriorating assets identified this year include a current transformer and supergrid transformer bushing, both of which would have failed unexpectedly.

Partial discharge is a symptom of insulation degeneration that often precedes substation equipment failures. PD generates radio frequency interference, which can be used for non-invasive monitoring and early warning of incipient problems. The system consists of a four-antenna array connected to a fast sampling acquisition unit that uses time-of-flight data captured by the array to locate discharge sources in three dimensions.

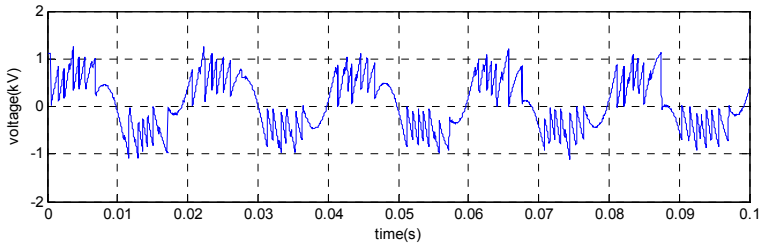
Further work will result in a fully developed online system that will continuously monitor and automatically report (via a web-based portal) the occurrence and location of potential insulation defects.

Case Study 2 - Improving Working Conditions for Linesmen

Linesmen working on towers occasionally report unpleasant discharges on their finger tips. These discharges occur in the form of sparks when there is a small gap between the finger and the tower. The resulting sensation is known as microshocks. Often this is just an annoyance, but the levels can become such that work has to cease to avoid potential risk. Microshocks are unpredictable and therefore planning maintenance work around them has not yet become possible.

National Grid has sponsored a project at The University of Manchester that aims to enhance the understanding of this phenomenon and develop methods to improve working conditions through the implementation of mitigation techniques that will reduce the impact of microshocks during working activities. Experimental activities in the National Grid High Voltage Laboratory at the University and in one of our Substations, together with a software model, have been used to study the process.

Yasir Ahmed, a sponsored EngD student, has also carried out a survey of 102 transmission line workers from England and Wales to further understand their view of the issue. Survey results were presented during the “Overhead Line Senior Authorised Person stand-down day” in April 2008. Currently, mitigation techniques are being developed at the University of Manchester and trials with National Grid linesmen are soon to follow.



A model man producing microshocks in a substation, and the resulting voltage trace showing discharges.

Case Study 3 - SUPERGEN – AMPerES (http://supergen-amperes.org)

National Grid works closely with the Research Council’s Energy Programme (RCEP). SUPERGEN (Towards Sustainable Power Generation and Supply) is a key RCEP initiative to support strategically important research in power engineering. It aims to help the UK meet its environmental emissions targets through a radical improvement in the sustainability of power generation and supply. The Energy Infrastructure Programme, one of 14 within SUPERGEN, is known as AMPerES (Asset Management and Performance of Electrical Systems).

All the major UK Electricity network operators are involved in the project and in addition to their technical knowledge and network data, are contributing financial support. The Universities involved are Manchester, Southampton, Edinburgh, Liverpool, Strathclyde and Queens University Belfast. The four-year project started in 2006 and is now fully resourced in all the universities. The high quality

PHD students and Research Assistants are naturally gaining relevant knowledge and experience which will eventually make them highly employable in our industry.

The two key aims of the project are firstly to provide platform technologies and tools for integrated network planning and asset management (condition monitoring and assessment), and secondly to identify methods to develop and implement networks with reduced environmental impact.

Core to the structure of this project is the integrated use of demonstration sites and activities. This provides vertical integration through the project, bringing together the people working on the areas of material ageing, plant modelling, data acquisition with those working on interpretation and optimal decision making. These demonstrators will pull together the world class research being carried out in the laboratories and allow the value of condition monitoring techniques to be identified, enabling appropriate business decisions on adoption of technologies. The first demonstration project involves the instrumentation of two National Grid transformers to assess condition based performance.

Finance Overview and Benefits of the Programme.

The table below indicates the financial overview of the National Grid Transmission R&D programme, shown individually for gas and electricity transmission and combined as UK Transmission. Over this financial year the number of proposals for innovative research, development and demonstration has steadily increased with the consequent ramping up of expenditure both in current and future years. It is expected to increased the IFI programme funding significantly next year in line with the allowance and carry over. The R&D outputs form an integral part of National Grid's core asset management activities – finding solutions to technical problems and managing risk. Benefits are achieved as a result of the overall R&D programme with multiple projects contributing to a single asset area or issue.

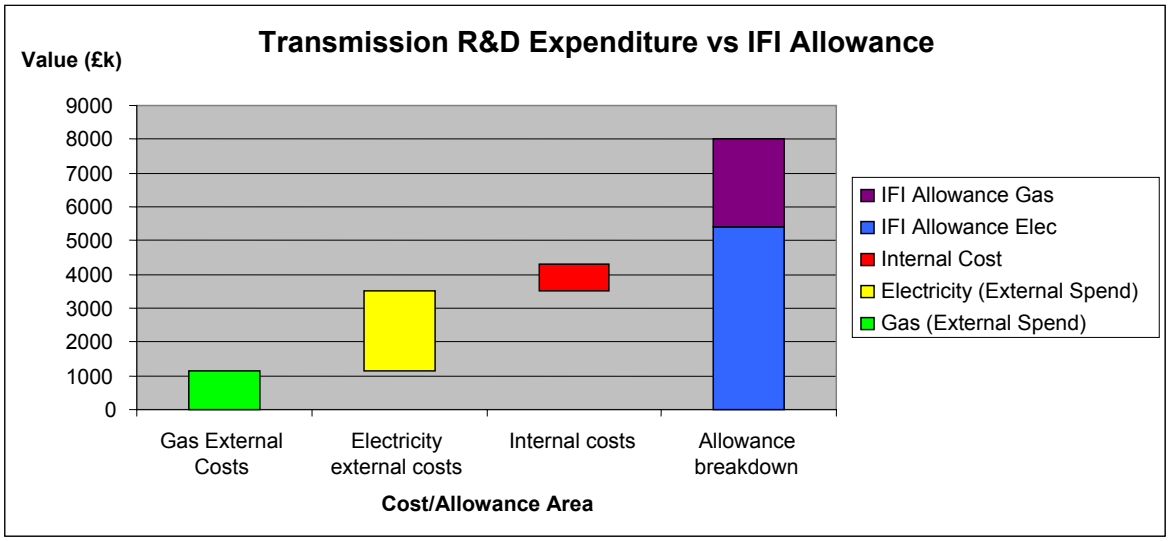
Benefits are achieved in the form of:
Direct costs e.g. through reduced planned capital expenditure or refurbishment
Avoided costs e.g. deferred investment, reduced failures, establishing condition of equipment to feed in to capital or maintenance plans and improved ratings
Managing risk e.g. understanding the application of new technology, understanding the impact of changing generation and minimising the impact of our networks on the environment
Strategic direction e.g. working with others to address sustainability in the energy industry, developing new engineers and scientists, maintaining awareness of new technology in the industry including direct involvement in directing energy R&D in the UK.

The benefits from the 2007/8 programme will be predominately achieved through avoided costs and risk mitigation (passed on to the customer via efficient operation) with an element being direct costs savings. Typical financial benefits are estimated based on implementation of the R&D for a 5 year period (N.B. time to achievement of benefits depends on the project and implementation timescales, varying from one to ten years). These benefits are factored into our Opex and Capex plans and contribute to the efficiency challenges under the current Price Review. The portfolio of projects also delivers a series of non financial benefits such as Safety, Health & Environmental benefits and security of supply benefits. Some of the projects undertaken in the financial year 2007/2008 show minimal or negative financial benefit but have been instigated due to their impact in other key areas of benefit to the UK consumer such as Safety, Health or Environmental benefits or will be used to assess benefit for future innovation.

Specific project benefits are identified where applicable in the detailed reports.

IFI Allowance - Spend shown by individual License and as National Grid UK Transmission

	NGET	NGG	COMBINED
Network Revenue	£1081M	£506M	£1587M
IFI Allowance	£5.405M	£2.529M	£7.934M
Number of Active projects	76	24	100
External expenditure	£2.360M	£1.133M	£3.493M
Internal Expenditure	£0.652M	£0.141M	£0.793M
Total Expenditure	**£3.012M**	**£1.273M**	**£4.286M**
Unused IFI Allowance carried forward to 2008/2009	£2.393M	£1.256M	£3.649M



Looking Forward

As well as reflecting on the work completed in the last financial year National Grid would also like to take this opportunity to focus on the continuing challenges we face going forward. National Grid expects to develop its R&D programme with the IFI incentive in the following areas:-

- Facilitating the connection of renewable (e.g. wind) generation with different performance characteristics
- Improved understanding of end of life mechanisms for compressors, pipelines, etc.
- Providing means of enhancing network capacity through ratings and technology advances including utilising solid state technology
- Replacing conventional SF_6 components and transformers
- Reducing energy losses associated with gas/electricity transport
- Enhanced diagnostics and decision support tools to enable better maintenance management and just in time replacement decisions
- Flexible network technologies, e.g. to facilitate SMART grids at both transmission and distribution, and which enable greater choice by the end customer
- Energy storage mechanisms to enhance network resilience
- Wide area monitoring, protection and control systems aimed at reducing complexity and providing more flexible options.
- Resilience against third party interference
- Deployment of new materials, nanotechnology, composites, e.g. for transmission towers, self healing pipes and insulation.

National Grid Electricity Transmission R&D Programme Detailed Report

During the financial year 2007/2008 National Grid Electricity Transmission utilised the Innovation Funding Incentive across a number of projects. In accordance with Innovation Good Practice Guide for Energy Networks (ENA Engineering Recommendation G85 Issue2) projects under £80,000 annual spend have been combined into programme areas. These projects and programme areas are reported as follows:

National Grid Electricity Transmission R&D Programme areas

1 Strategic Asset Management Capability
2 Electric and Magnetic Fields & Health
3 Dynamic Resistance of Transmission Tower Footings (Phase 111)
4 EPRI (Power Delivery)
5 Transformer Life Management
6 Current and Earth potential at Substations
7 Ratings
8 Conductor Cleaning
9 Ageing Mechanisms in Composite Insulators
10 Cable Oil Leaks and Thermal Data Analysis
11 Oil Technology
12 Condition & Life Extension of Substation Assets
13 River Crossing Dampers
14 Effective Protective Coatings for OHL Towers
15 Development to Upgrade Digital Control System
16 Portable Earthing
17 Alternative Technologies
18 Supergen V – AMPerES (Asset Management and Performance of Energy Systems) & Advanced Real-time Monitoring and Data Analysis (ARMADA)
19 Substation Design
20 Cable Asset Life
21 Efficient incorporation of Intermittent Generation considerations in Network Design (SQSS)
22 Maintenance Delivery Tools
23 New Technology to enable Connection of Low Carbon Generation
24 Flexnet
25 Vegetation Management
26 Climate Change
27 Flooding Risk Reduction
28 Investigation of Network Resilience to Weather Events
29 Network Design (System Stability)
30 Network Design (New Generation)
31 Developments in Protection & Control
32 Measurement of third party Exposure Rise of Earth Potential
33 Understanding & Mitigation of Hazards related to Earthing of Transmission Tower Bases
34 Understanding Conduction Mechanisms in Earthing Systems
35 Substation Compaction
36 Composite Technology
37 Development of Toolkit for the Remediation of Oil-Contaminated Soils
38 Collapse Prediction on Transmission Networks

1) Strategic Asset Management Capability

Project title	Enhancing Strategic Asset Management Capability		
Project Engineer	Jenny Cooper		
Description of project	This project is a combination of more strategic projects being carried out largely by university groups or major strategic collaborations. Projects supported under EU funding and ESR funding are included in this project together with CASE awards focussed on understanding the potential of techniques or technologies to impact the transmission business. Also included are initial scoping studies on new technology in the future transmission network. Flexible Electricity Networks to Integrate the expected Energy Evolution (FENIX) is about harnessing distributed generation and demand response into virtual power plants for the benefits of Suppliers, DSOs and TSOs (this project is mentioned in the "Towards Smart Power Networks" http://ec.europa.eu/research/energy/pdf/towards_smartpower_en.pdf). National Grid's role in this is advisory (e.g. with Poyry concerning regulation and ancillary service contracting) and also as a participant in a systems trial with EdF Energy Networks, Imperial College and Woking Council. Also included in this combined project is the proof of concept project covering the evaluation of electrical properties of ester based transformer oils in the use in large power transformers. Oil and paper are the liquid and solid insulation materials commonly used in transformers. The project compares the electrical properties of Midel/vegetable oil-paper insulation systems with those of mineral oil–paper insulation systems existing in large power transformers. Electrical stresses experienced by the oil-paper insulation under AC and Impulse voltages will be examined with the insulation electrical strengths. Breakdown voltages in large oil gaps will be one of the focuses of the research areas. Insulation degradation in the main insulation structures of windings is the other area the research will focus on. Charge build up on insulating surfaces in high voltage electrical equipment is a real and significant problem that can lead to catastrophic electrical failures. Such events can occur on the surfaces of porcelain bushings in air-insulated substations and internal barriers of SF_6 insulated switchgear. This project develops novel sensing systems that will enable static charge distributions to be imaged in real time and with high resolution. The intention is to develop systems that can be exploited both in the laboratory, to provide novel perspectives on the basic physics of charge transport on insulators, and in the field both to study charging processes and to provide early warning of charge build up in potentially hazardous circumstances. The system will be based on the Pockels effect, but using novel nanocomposite optical devices. Transmission losses are a significant area for study but it is not currently straightforward how these could be significantly reduced. This contrasts with the perception in the global power system community that state-of-the-art optimisers can have a significant effect on the reduction of losses - for this reason part of this project looks at the potential of such techniques with regard to the transmission system.		
Expenditure for financial year	Internal £31k External £51k Total **£85k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**Estimated £6m from EU and EPSRC projects**	Projected 08/09 costs for National Grid	**TBC** (Given new projects being initiated)

<table>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">This project addresses strategic issues including proof of concept of potential loss minimisation, characterisation of partial discharges, condition monitoring techniques and the impact of distributed generation.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Potentially radical but uncertain</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>8</td><td>3</td><td>5</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The likelihood of success is uncertain due to the strategic nature of these projects however, due to contributions and collaborations from EPSRC and the EU, the likelihood of benefit is good – in particular the students on these project spend time working with or being guided by National Grid engineers and will therefore have a significantly enhanced knowledge of the company and therefore be able to steer and deliver the project accordingly.</td></tr>
<tr><td>Expected timescale of project</td><td>3 Years per project (typically PhD students)</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
<tr><td>Probability of success</td><td>10%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">Unable to calculate based on speculative nature of work, high leverage.</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The areas covered in this combined project are more speculative and uncertain with respect to achieving benefit at the end of the project. If these projects are successful, they will be taken forward on an individual basis to develop technology or knowledge with direct benefit eg the trial of a supergrid transformer with alternative oil, the implementation of learning from FENIX to the wider network or an alternative space charge assessment technique based on optics.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="4">Progress has been achieved in all areas with National Grid engineers engaging with university groups to steer these projects. Specific progress has been:
Alternatives oils: all testing to date has proved successful at low/medium voltage leading to the potential to develop project for high voltage applications.
FENIX is progressing well with particular emphasis from National Grid on the Northern Scenario demonstration to accommodate the virtual power plant vision in a number of test sites in the UK.
Although delayed through resource issues the transmission losses project is highlighting area of further investigation to achieve potential benefits. Losses are increasingly important and the output of the theoretical study gives evidence that voltage profile increase could provide reductions in losses. The output of the project is contributing to enhanced understanding of losses.
A potential study on Fault Current Limiters has been developed into a TSB supported project.
A technology review with respect to 2030 scenarios has been initiated.
Although the optical technique under investigation is proving possible as a viable technique, it is unlikely to be robust enough for application in the field at this time. There are however other potential methodologies with respect to condition assessment that may have potential.
ESR network related projects are delivering on the impact of</td></tr>
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	microgrids, Automation and optimisation of wavelet transform techniques for partial discharge denoising, and pulse shape classification in power plant, Optimisation of network outage schedules and condition monitoring of power electronics for reliability.
Collaborative partners	FENIX partners, ESR Network partners
R&D provider	Warwick University, University of Manchester, Durham University, University of Strathclyde, Glasgow Caledonian University, Southampton University, Brunel University, EU project partners

2) Electric and Magnetic Fields & Health

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 £44k External £239k Total **£283k**	Expenditure in previous (IFI) financial years	Internal £ NA External £ NA Total **£ NA**
Total project costs (collaborative + external + National Grid)	**£2m (based on EPRI, other funding through ENA etc)**	Projected 08/09 costs for National Grid	**£283K**
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	Incremental Significant Radical	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		12	0	12

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.		
Expected timescale of project	Year: Ongoing	Duration of benefit once achieved	40 Years:

Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£2544k
Potential for achieving expected benefits	The EMF issue has existed for some 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 recent conclusions of the WHO Environmental Health Criteria now 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 to March 2008	Brief snapshots of developments of the totality of projects benefiting from this project:		
	RSI Information Project: They continue to provide regular information about new scientific publications, scientific meetings and other developments in the news on ELF and RF EMFs.		
	Stakeholder Advisory Group on EMFs (SAGE) This project contributes approximately one sixth to the cost of this consultation process which deals with the possibility of precautionary approaches to EMFs. This year the Interim Assessment, dealing with exposures from power lines and house wiring was published. The activity has been scaled down for the time being, while it is decided what to do next.		
	Manchester University microshocks PhD This three year funding of a PhD project at the HV Research Centre due to complete during the year. The object as been to improve our understanding of the physical process involved in the spark discharges (ie microshocks) that can occur when people are in elevated electric fields, such as when climbing transmission towers. Regular progress meetings have taken place and we are looking forward to seeing the student's thesis.		
	EPRI EMF and Health Assessment and RF Safety Programme This $4m programme of research, co-funded by US and other international electricity utilities is the most comprehensive ELF EMF research programme at the present time, and for which we provide some support. Progress is reported and the future direction of research are discussed at twice-yearly gatherings of sponsors which we contributed to. For example a replication of the Draper study is being planned in California and we have provided details of the exposure assessment procedures that we specified for the original Draper study. The pilot study has been completed successfully, although they have discovered that they have problems with the accuracy of GIS mapping data that we did not experience in the UK.		
	EMF Biological Research Trust National Grid provides separately funding (not through this project) for the independently managed EMF Biological Research Trust. Progress with projects was reported in January at the annual Royal Society workshop and the standard of the work is as always very high. Completed studies are published in the scientific press in the normal way in the peer reviewed literature.		
	Energy Networks Association EMF Research Through our role on the ENA's EMF Strategy committee we direct their EMF research programme. The focus of this programme is primarily on epidemiological studies, both public and occupational. A study on of the cohort of 86,000 electricity workers of neurodegenerative has been completed and published. Progress is reported at Strategy Committee meetings – the most recent of which was on 11 February, when funding for two new projects was approved; one with Peter Wainwright of HPA-RPD (who advise government on exposure		

	limits) to develop dosimetry of the retina (which is critical to EMF exposure limits); and the other with Leeka Kheifets of UCLA to assess the impact of alternative dose response
	Epidemiological studies of power lines The project funds internal resource to work with the Childhood Cancer Research Group and the Small Area Health Statistics Unit on studies of power lines and childhood and adult cancer respectively. The CCRG work itself is now funded by the charity Children with Leukaemia and we assist them informally in their scientific programme. The SAHSU work is jointly funded by ENA and the Department of Health. Without our input these studies would not be possible and they are key components in understanding any health risks associated with National Grid equipment.
Collaborative partners	Energy Networks Association, Department of Health, EPRI, Children with Leukaemia, Childhood Cancer Research Group
R&D providers	Resource Strategies Inc, Manchester University – 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).

3) Dynamic Resistance of Transmission Tower Footings (Phase 111)

Project title	Dynamic Resistance of Transmission Tower Footings (Phase 111)		
Project Engineer	David Clutterbuck		
Description of project	To carry out enhanced environmental modelling of full Overhead line support system fully via 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 £2k External £36K Total **£38k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£270K**	Projected 08/09 costs for National Grid	**£ NA**
Technological area and/or issue addressed by project	Carry out enhanced environmental modelling of full OHL support system fully instrumenting a short section of line. Carry out centrifuge modelling to expand the range of foundation and soil types currently considered, using the data collected by the environmental modelling. Assess the appropriateness of current British Standard method for determining tower foundation uplift capacity and influence the change of industry design codes.		
Type(s) of innovation involved	Incremental Tech Transfer Significant	Project Benefits Rating 14	Project Residual Risk 2	**Overall Project Score** 12
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 programme.		
Expected timescale of project	3 Years	Duration of benefit once achieved	5 Years
Probability of success	50%	Project NPV = (PV benefits – PV costs) x probability of success	£3398k
Potential for achieving expected benefits	As a direct result of the Dynamic Resistance of Transmission Tower Footings project National Grid are deferring upgrading the majority of for towers foundations. This has resulted (depending on the plan) in a typical cost avoidance of £20million per year.		
Project progress to March 2008	All testing to date has been carried out successfully. The all existing deliverables are complete with the exception of the full size field tests and reporting which is due Sept/Oct 2008. Field Testing: Comparison of conventional field testing methods (BS EN 61773:1997) with rapid testing techniques (Statnamic). Recommendations for field testing/load application. Following publication of a number of Civil & Geotechnical papers on the subject the work including at CIGRE 2006 & 2008. There is a growing awareness of the work in progress and the flaws in current methods of assessing the capacity of existing tower foundations.		
Collaborative partners			
R&D provider	Southampton University		

4) <u>EPRI</u>

Project title	EPRI Power Delivery		
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 £ 26k External £ 250k Total **£ 276k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£ 9m**	Projected 08/09 costs for National Grid	**£280k**

<table>
<tr><td>Technological area and/or issue addressed by project</td><td>Project areas 2007/8:
Conductor and Wire Corrosion Management
Improve Transmission Line Lightning Performance
Polymer and Composite Overhead Transmission Line Components
Transmission Circuit Ratings—Optimization Methodologies
Engineering Guide to Increasing Power Flow in Transmission Circuits
Transformer End-of-Life & Condition Assessment
Transformer Life Extension
Life Extension and Best Practices Guidelines for Substation Equipment
SF6 Environmental Management and Equipment Performance
Solid-State Fault Current Limiter/Circuit Breaker Development
Harmonize UCA/IEC 61850, and CIM/IEC 61970/61968 Standards
Management of Substation Ground
AC/DC Line Conversion
Advanced Communications Assessment
Antenna arrays and wireless mesh sensors for partial discharge location
Technology and Innovation Programme including sustainability</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Mainly incremental and technology transfer with T&I programme being significant<table><tr><th>Project Benefits Rating</th><th>Project Residual Risk</th><th>Overall Project Score</th></tr><tr><td>14</td><td>0</td><td>14</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td>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</td></tr>
</table>

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.

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.

$SF_{6:}$ 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: 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	5 Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£221k
Potential for achieving expected benefits	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% • SF_6 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 L&G 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 fadio 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.
Project progress 2007	Delivered and in progress in Power Delivery Programme • 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 • 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 • 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 • Transformer diagnostic and risk assessment tools and software • Maintenance best practice guidelines • Development of fault current limiters • 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 • Software tools to assist with selection of corona rings for insulators • New Transmission Line Design Workstation • Validation of superconductivity technologies and their values • Increased power throughput in urban corridors by a factor of 3–10 using EPRI research results in superconductivity • Adopting cost-effective, reliable, and secure communication for power systems applications • Reducing the risk of interference issues caused by the application of new technologies to transmission and substation systems • Understanding Transmission Grid Complexity, Information, and Knowledge Sharing delivered through updated information about FACTS technology applications. • 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.

Collaborative partners	World-wide utilities and universities through EPRI collaboration.
R&D provider	Electric Power Research Institute

5) Transformer Life Management

Project title	Transformer Life Management			
Project Engineer	Paul Jarman, Mark Osborne, Dave Woodcock			
Description of project	These projects are combined investigations into the dielectric performance of aged transformer insulation, diagnostic techniques and modelling of anticipated failure rates. Understanding the dielectric behaviour aged transformer insulation at high voltages may allow the better identification of the factors likely to lead to the failure of old transformers. This will allow optimum targeting of the transformer replacement expenditure and the oil and moisture care regime, to ensure system reliability at minimum cost. Transformer failures pose an environmental risk and tend to attract media attention if they involve a fire. One project aims to establish the material impact when power transformers are exposed to ferroresonance and how an improved understanding can affect the detection and asset management of the entire transformer fleet. The work packages concentrate on: a) Characterisation of the degradation and failure mechanism in different designs of power transformers associated with ferroresonance. Establish what effect this has on the useful lifetime for a transformer. b) Identify the design features of transformers which are susceptible to ferroresonance c) Establish a reliable ferroresonance detection technique, which can be incorporated into new transformer protection relays. The final project aims to: 1. Fit a new technology tapchanger (Vacutap) to an existing asset which has a worn out tapchanger on a healthy transformer. 2. Monitor the installation on completion to assess the success of the project in order to aid future strategy on this type of problem. 3. Achieve extended life of an asset with a reduced maintenance requirement which will deliver cost savings.			
Expenditure for financial year	Internal £18k External £154k Total **£172k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£ 885K (additional costs from Areva)**	Projected 08/09 costs for National Grid	**£ 176k**	
Technological area and/or issue addressed by project	Asset management of an ageing transformer fleet including tapchangers and the impact of ferroresonance and other low frequency phenomena (GIC & switching).			
Type(s) of innovation involved	Incremental Significant	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		12	1	11

Expected benefits of project	• Increased knowledge of the end-of-life mechanisms, particularly the effect of ageing and moisture on transformer performance in service and guide the most efficient asset management actions in terms of replacement and refurbishment to maintain system reliability. • Development of a transformer model which can be used to determine how modes and duration of ferroresonance affect different designs of transformer and cause ageing. • Guidance document identifying the key design features susceptible to ferroresonance and a retrospective review of transformer family susceptibility to ferroresonance. • Identify families of transformers at risk from ferroresonance. • Move towards an lifetime asset management tool for transformers • Support the rationalisation of complex circuits and switching programmes. • Method to retrofit worn out tapchangers especially on steel works transformers		
Expected timescale of project	4 Years	Duration of benefit once achieved	5 Years
Probability of success	20% up to 50%	Project NPV = (PV benefits – PV costs) x probability of success	£911k
Potential for achieving expected benefits	Many benefits already achieved as knowledge gained has been used in the recently reissued asset management documents on transformer refurbishment and replacement. Review of asset lives is underway and is very likely to achieve a more refined and academically verified estimate of population lifetime. Knowledge is in regular use in the determination of individual transformer asset health indices.		
Project progress to March 2008	Project on partial discharge location and frequency response analysis completed, with much work published in CIGRE and other journals. Partly as a result of the work the FRA technique is now a firmly established and well understood test widely available to understand the mechanical condition of transformer windings. The aged transformer insulation project is complete with significant published work helping to understand how old/wet transformer insulation performs and the limits of operational safety. In general the work has shown that performance is maintained somewhat longer than previously thought but that dielectric failure is probable at higher voltages under high moisture conditions. The effect of surface contamination of insulation has also been found to be significant. Some experimental work has continued in the new project 'Transformer lifetime modelling' particularly on the now established transformer rig at Southampton University that was commissioned successfully and now forms a valuable resource for future work as representative transformer conditions can be achieved in the laboratory. Recently started work on combining fundamental knowledge of end-of-life mechanisms and historical failure information in a statistical model to predict future reliability is progressing well and should provide a refined transformer lifetime model including a full analysis of uncertainty. A comprehensive report of literature survey including low frequency non-linear transformer magnetic circuit modelling, ferroresonance system circuit modelling techniques, and the research findings on		

	ferroresonance transformer degrading and failure mechanisms and detection methods, an EMTP-based power system circuit + transformer model for ferroresonance study, a detailed transformer model in SLIM finite element modelling (FEM) EM field solver environments to enable magnetic field analysis within a transformer under ferroresonance. Although almost complete limitations with the original software have been revisited with AREVA the software developer. In order to progress the replacement tapchanger trial, a series of tests are required on the nominated super grid transformer. Due to another plant failure during a recent outage to carry out these tests the SGT had to be returned to service. The next available outage is in July 2008 and therefore there is a delay to this project.
Collaborative partners	Areva Transformers
R&D provider	Manchester University, Southampton University

6) Current & Earth Potential at Substations

Project title	Current and Earth potential at Substations		
Project Engineer	Alan Ainsley		
Description of project	This project aims to establish whether a risk exists from the effects of step/touch potentials generated during transient surge conditions		
Expenditure for financial year	Internal £ 6k External £ 87k Total £ 93k	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total £NA
Total project costs (collaborative + external + National Grid)	**£ 214k**	Projected 08/09 costs for National Grid	**£31k**
Technological area and/or issue addressed by project	A major shortfall has been identified with respect to a lack of transient high frequency measurements on substation earthing systems during switching operations, surge arrester operation or during the flow of fault current in practice. In addition, no data on the effect of lightning impulse or tests data within substations exist. In order to verify the simulation models, it is crucial that measurements are undertaken. This R&D proposal addresses these shortfalls		
Type(s) of innovation involved	Incremental	Project Benefits Rating: 12	Project Residual Risk: 0 / Overall Project Score: 12
Expected benefits of project	The work on this scheme will enhance the understanding of fast transient disturbances on substation earthing systems and the associated detrimental effect to the correct operation of modern substation control, measurement and monitoring sub-systems. This research proposal is mainly based around measurements of transients within the earthing system at selected substations. The experimental measurements will help to quantify more accurately the measured current magnitudes and shapes and its potential RoEP at various points within the chosen substations. It is proposed to conduct these transient measurements under two conditions:		

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	£31k
Potential for achieving expected benefits	The potential for achieving expected benefits is relatively high as the work is incremental and is devised to enhance the accuracy of the models currently being used.		
Project progress [date]	Report on earth grid impulse injection tests at Knaresborough substation Characterisation of substation earthing systems under fast impulses Report on switching transient measurements at East Claydon Report on switching transient measurements at Cilfynydd substation		
Collaborative partners			
R&D provider	Cardiff University		

7) Ratings

Project title	Ratings Developments
Project Engineer	David Payne, Dan Morrice
Description of project	The following project address rating issues related to National Grid's cable and overhead line assets. A project has been initiated to improve the delivery of cable ratings calculations through the use of more flexible and accurate Finite Element Analysis (FEA) modelling methods. The project will demonstrate the advantages of finite element analysis of cable rating problems compared to the currently used finite difference method. Analyses performed by BICC (prior to their take over and closure) demonstrated the advantages of this method. FEA is the only readily available method for accurately modelling problems such as cable ratings and can be extended to include phenomena such as thermal dry out. The Auckland black-out demonstrated the need for utilities to understand and be able to model the ratings of their cable systems to avoid thermal runaway and consequent failures. The Elstree – St Johns Wood and Dartford cable tunnels have recently been completed and more tunnels are planned for Croydon and the Olympic site in the next few years. Distributed temperature sensor (DTS) system measurements of the cables in the new Elstree – St Johns Wood and Dartford tunnels are now available. These readings, combined with additional data such as local air velocities, will allow recorded data to be compared with predictions obtained using the standard design procedure, providing an opportunity to optimise the ratings model. Site measurements will also be needed in order to determine the effects of other factors such as water ingress that may also play a significant role in determining actual tunnel temperatures.

<table>
<tr><td></td><td colspan="3">Overhead lines: Installation of “CAT-1” tension monitoring systems has been initiated in order to gather information to allow the assessment of National Grid’s probabilistic approach to overhead line ratings. Conductor tension provides a very reliable indirect measurement of Conductor temperature. By measuring and recording the tension and weather parameters and calculating the conductor temperature, an analysis of the thermal ratings model can be performed. This project aims to gather and analyse data in order to provide an up to date understanding of the risks associated with probabilistic ratings.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £14k
External £114k
Total £128k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£426k</td><td>Projected 08/09 costs for National Grid</td><td>£56k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">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 FEA methods to confirm or otherwise existing methods.

Rating methods employed in the design of both forced cooled and naturally ventilated cable tunnels. The objectives of this project are to:
1. Review the ratings methods used to design cable tunnels.
2. Assess existing operational data from cable tunnels, including Distributed Temperature Sensor (DTS) data.
3. Develop a specification for a rating method for cable tunnels installations with independent cable circuits

Probabilistic overhead line ratings: This project aims to review whether the level of risk that is currently accepted by National Grid’s ratings model is correct. This has not been reviewed for approximately 20 years and with improved instrumentation and measuring methodologies it is thought that the level of risk currently used may be shown to be conservative.</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>9</td><td>0</td><td>9</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">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. A recent review has shown that thermal rating enhancements of plant save National Grid up to £10m per annum, of which £900k is attributable to enhancement of cable ratings.

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.

The primary benefit to National Grid with respect to overhead lines will be an up-to-date understanding of the risks associated with probabilistic ratings. There is a possibility that ratings may change for the better. The basis for this expectation is that data monitoring equipment available today is more accurate and reliable, compared</td></tr>
</table>

	to 25 years ago, which would allow tighter margins to be built into the process.		
Expected timescale of project	3 Years	Duration of benefit once achieved	5+ Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£533k
Potential for achieving expected benefits	The potential for better cable enhancements appears to be good based on initial results. This project is in the data gathering stage. It is expected that new/enhanced rating methods will provide the basis for achieving the expected benefits. A verification of the degree of risk that is incorporated in overhead line ratings is expected. It is thought that an increase in overhead line ratings will be achieved but there can be no certainty of this benefit being achieved.		
Project progress to March 2008	The finite element analysis work on cable ratings has progressed well with reports delivered on the initial outputs. Results so provided a better understanding of the rating of cables under various laying conditions and in particular cable joint ratings. Due to both the success of the initial work and the increasing need for information on cable crossings due to IEC60287/3/3, the work is proposed to be extended to allow incorporation of cable crossing ratings into National Grid's Technical Policy. Some work is still required in particular with respect to cooled cable joints. A delay was experienced in the initial stages due to issues with recruiting Research Assistants by Southampton University. This has now been addressed. An initial review of existing rating methods has been carried out and arrangements are underway to gain access to various existing tunnels to gather temperature and air flow data for more in depth analysis. Equipment has been installed for approximately 18months and due to project teething problems and communication issues some data has been lost. A continuous set of data was expected to be recorded for a period of 12months. At present an average of 90% of data over a 12 month period has been recorded. This percentage should increase as time progresses assuming there are no future failures of the communication equipment. One of the three sets of equipment has been taken down due to the line bring reconductored and is currently in storage until a suitable route/tower is found.		
Collaborative partners			
R&D provider	Southampton University, Nexans (formerly The Valley Group)		

8) Conductor Cleaning

<table>
<tr><td>Project title</td><td colspan="3">Greasy Conductor Interstices cleaner</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Mark Winters</td></tr>
<tr><td>Description of project</td><td colspan="3">The key objective of this proposal is to develop simple hardware to be used in advance of other cleaning techniques, to displace and remove the interstices grease.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 6k
External £ 0
Total £ 6k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £ NA
External £ NA
Total £ NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£25k</td><td>Projected 08/09 costs for National Grid</td><td>£5k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Cleaning contaminated conductor to alleviate environmental acoustic noise problems has been effectively demonstrated in the laboratory environment using either water jet washing or pulsed laser cleaning technology. Both methods however struggle to remove thicker clumps of grease which form in the root of the interstices. The same applies for the traditional hand cleaning method! The key objective of this proposal is to develop simple hardware to be used in advance of other cleaning techniques, to displace and remove the interstices grease.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="3"><table><tr><td>Tech Transfer</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td></td><td>8</td><td>-1</td><td>9</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">It takes a group of six linesmen at least one week to manually clean all conductors on an L2 span. This is in excess of 200 man hours. Previous attempts at conductor cleaning by hand have failed to remove all grease. Using a cleaning device that helps remove all grease deposits may result in less man hours cleaning but more importantly would be far more effective. This would reduce or avoid the need for repeat cleaning operations at a later date.

Manual cleaning of conductor may not be a viable option due to existing health and safety. This R&D proposal is the first step in developing an effective cleaning method and is the main obstacle in realising a consistent automated solution. If a cleaning solution is not developed then it is highly likely that conductor replacement will be the only option. A current estimate of reconductoring double circuit twin Rubus for 1km is £250k. If there are any other issues with replacement then this cost could increase. Replacing the conductor is therefore undesirable if other methods of noise control are available.

Other benefits of this project would include or lead toward:

1. Less visible presence hence less advertising of our environmental problems
2. More effective and quicker cleaning times will result in shorter outages
3. Prospect of shorter outages will itself generate more outage opportunities
4. Less likelihood of repeat cleaning in subsequent years
A more professional looking approach to conductor cleaning will improve our reputation with our complainants and other stake holders (and with Linesmen).</td></tr>
</table>

Expected timescale of project	2 Years	Duration of benefit once achieved	3 Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£38k
Potential for achieving expected benefits	There is a high likelihood of success with this relatively simple project. The chosen supplier is an expert in developing cleaning solutions. They have the knowledge and experience of providing customer specific cleaning technologies to many different industries. The required device should not involve a complex design but does require some development time.		
Project progress to March 2008	The start of this project has been delayed due to contractual negotiations with the supplier. The work will now be delivered in 2008; however internal time has been spent identifying potential suppliers and finalising the contract to allow work to start.		
Collaborative partners			
R&D provider	Clean Laser		

9) Ageing Mechanisms in Composite Insulators

Project title	Ageing Mechanisms in Composite Insulators			
Project Engineer	John Hyde			
Description of project	Developing an ageing model for composite insulators and to continue using new techniques to see if these models can be developed further in order to effectively identify and manage any risks associated with their use on the National Grid transmission system			
Expenditure for financial year	Internal £ 5k External £ 98k Total **£103k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£349k**	Projected 08/09 costs for National Grid	**NA**	
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.) Maintenance of these technologies once installed on the system			
Type(s) of innovation involved	Significant	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		10	6	4

Expected benefits of project	The ageing model will, it is hoped, enable National Grid to develop and co-ordinated asset replacement regime for exchanging ceramic insulators with composite ones. Composite insulators are expected to provide the following benefits to the business: • Improved health and safety performance (composite strings at 400 kV are around 15% of the weight of cap and pin ceramic strings) • Reduced installation costs • Faster installation and therefore shorter duration outages • Better pollution performance and therefore increased network reliability		
Expected timescale of project	4 Years	Duration of benefit once achieved	5 Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	-£12k
Potential for achieving expected benefits	This research has allowed National Grid to devise a replacement policy for overhead line insulators that incorporates the use of composite insulators. On the back of this and other research work National Grid is intending to type register and install composite insulators as part of an asset replacement scheme in year 2008/09 with further schemes being identified for subsequent years.		
Project progress to March 2008	The progress has been :- • Characterisation of service aged samples (Saltash) completed • Laboratory aged samples provided by EPRI have been inspected and indicate that the accelerated ageing process does not match that of in service ageing • A comprehensive collection of data on service aged insulators form the testing techniques evaluated (Microscopy, FTIR, EDX and contact angle) ○ A policy document on the application of composite insulators has been produced and validated by the research work.		
Collaborative partners			
R&D provider	Eve Transmission & The University of Manchester		

10) <u>Cable Oil Leaks & Thermal Data Analysis</u>

Project title	Cable Oil Leaks & Thermal Data Analysis
Project Engineer	Caroline Bradley
Description of project	In principle, deterministic algorithms can be used to provide an indication of the leak location. Utilities have had limited success with this method as it requires an accurate knowledge of static oil pressures together with the temperature induced transient pressures. An alternative method is to evaluate data from TOPMOS to obtain the characteristic response of the hydraulic circuit. Using genetic algorithms, data from TOPMOS and from distributed

<table>
<tr><td></td><td colspan="3">temperature sensor (DTS) measurements can be combined to ‘fingerprint’ the hydraulic characteristics of the circuit. Any future departure from this behaviour could be used to estimate the position and magnitude of the oil leak. This will improve cable system availability, reduce maintenance costs and reduce the volume of oil released into the environment.

The DTS data collected to evaluate temperature-induced oil pressure transient along different sections of the route also provide improved methods for evaluating cable ratings. DTS data and cable load history will be examined to provide guidance on enhanced rating methods. This will include an examination of the effectiveness of rate of temperature change alarms for protecting cable from overheating. Techniques for providing early detection of thermal anomalies will be developed. Improved ratings offer savings by reducing thermal constraints on the network, whilst protecting cable assets from overheating.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £1k
External £87k
Total £88k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£225k</td><td>Projected 08/09 costs for National Grid</td><td>£65k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">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.

Oil leaks are damaging both financially and to the reputation of the company. Improved thermal ratings allow more effective use of the transmission network, whilst avoiding overheating.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Significant</td><td colspan="2"><table><tr><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></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">Low-level cable oil contamination of soil is degraded by natural micro-organisms. This project aims to offer a ‘toolkit’ of options, based on the site conditions, to increase the speed and overall effectiveness of this process. This will reduce the chance of leaked oil migrating into the wider environment and minimise the residue left in-situ.

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. Detection of thermal anomalies and efficient alarms prevent cables overheating avoiding expensive damage to the cables and accessories.</td></tr>
</table>

Expected timescale of project	3 years	Duration of benefit once achieved	5+ years
Probability of success	40%	Project NPV = (PV benefits – PV costs) x probability of success	£14k
Potential for achieving expected benefits	Following the research work, the evaluation of oil leaks will not be carried out in real time, but will use data extracted from the TOPMOS database to provide guidance to engineers in Asset Stewardship. The research will include a review of options for raising alarms once the reliability of the method is proven. Enhanced ratings and alarms will initially be evaluated off-line. These can be readily implemented within an updated CTM. DTS alarms can be routed to the NOC, with additional notification to Asset Engineering.		
Project progress March 2008	Thermal data (DTS and load) and pressures recorded by TOPMOS are being gathered and structured to be analysed to obtain the characteristic hydraulic response of a cable circuit. A sample of a suspected leaking cable has been removed from service and an experimental rig is being constructed.		
Collaborative partners			
R&D provider	Southampton University		

11) <u>Oils Technology</u>

Project title	Oils Technology
Project Engineer	Dave Woodcock, Caroline Bradley, Graham Moss
Description of project	This combination of projects addresses the oil technology issues related to sulphur on oil, analysis of small oil volume equipment and the analysis of silicon oil degradation. The objective of the sulphur in oil investigation is to trial on a selection of transformers/reactors the possibility of removing corrosive sulphur through oil reclamation and the addition of inhibitor in the oil. This project will involve a number of external companies (ABB in Sweden, Doble Power Test and Sea Marconi) in order to carry out the testing of the oil during the various stages of reclamation. The reclamation of the oil will be done internally by National Grid's Oil Management Unit (OMU). It is intended to select a number of transformers and reactors to carry out the trial on. Cables represent a significant part of the transmission network. There are 690 route kilometres of cables in service of which 99% are oil-filled. It is estimated that there are about 4 million litres of cable oil in service, a mixture of mineral and synthetic (DDB) oil. Some of these cable circuits have oil samples taken regularly for historic

<table>
<tr><td></td><td colspan="3">reasons, however, not all circuits have been sampled and the data that exists to date is not representative of all cables. In addition, the data cannot be treated in the same way as transformer oil data as there are many differences in the design and construction of the two types of plant. For example, whereas a transformer oil sample is representative of the bulk, a cable oil sample is very localised. The work proposed here aims to develop a better understanding of ageing of cables and how this is reflected in the cable oil sample. This information will then be used either to (1) possibly develop a new test to analyse the condition of the cable or (2) revise the criteria currently used. There are other items of HV plant, such as CT's, that are similar in design and construction to cables, that is, they have an oil/ paper insulation system and contain small oil volumes that are sealed. This work proposed here will be extended to include mineral oils as cables contain a significant proportion (~60%) of mineral oil. This would also provide valuable data for equipment such as CT's , where currently it is not feasible to test frequently, due to the large volumes of oil required, to provide data for trend analysis on such equipment.

The recent introduction of 275 and 400 kV XLPE circuits onto the National Grid system has brought with it a range of new sealing end technologies. Experience of mineral oil-filled sealing ends, in particular the fire risk posed by these, led to a preference for silicone oil-filled cable sealing ends, as a lower risk alternative. However, due to the recent introduction of this new technology, there are at present no accepted International Standards to determine the condition of the silicone oil in cable sealing ends, as there are for other oil filled plant. Although silicone oil-based cable sealing ends have only been implemented for just a short period of time, the technology has resulted in serious problems including a fire and unplanned outages.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £6k
External £68k
Total £74k</td><td>Expenditure for financial year</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£1688k</td><td>Total project costs (collaborative + external + National Grid)</td><td>£1275k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">There have been a number of incidents worldwide where transformers and reactors have failed in service due to corrosive sulphur. This is an emerging problem which is not fully understood and may have implications across National Grid's population of oil filled equipment.

To develop knowledge of the chemical fingerprint of electrical ageing and degradation processes as they apply to small oil volume insulation systems. To use this knowledge to develop novel diagnostic techniques for analysis of oil using millilitre samples, to enable sampling and condition monitoring on a regular basis, such that potential problems can be identified in good time.

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

<table>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental
Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>13</td><td>2</td><td>11</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">If sulphur in oil project is successful then a strategy can be rolled out across National Grid to address potential risk of corrosive sulphur failures leading to avoided costs due to a failure of an estimated minimum replacement cost of £3m.

Current oil analysis for cables requires the removal of at least a litre of oil (and for CT's ~ 50mls). This can limit the number of times that oil can be removed for analysis in the lifetime of some equipment if the system is sealed with no means of top-up. A technique that could allow analysis of the oil using very small oil volumes (a few ml), would allow an increased frequency of sampling such that data can be collected for trend analysis. An improved understanding of the mechanisms through which markers in the oil are generated would give an indication of problems that may arise in the future.

In contrast to mineral oil in transformers, 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 associated with failure, ie fire and failure costs, 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 leading to being able to monitor the condition of silicone oil-filled cable sealing ends, identifying assets in distress and determining appropriate maintenance strategies and minimising unplanned outages through the avoidance of failures.</td></tr>
<tr><td>Expected timescale of project</td><td>3 Years</td><td>Expected timescale of project</td><td colspan="2">5 Years</td></tr>
<tr><td>Probability of success</td><td>20%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£176k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">Establishing the technology for removal of sulphur in oil has increasing priority with the increasing number of worldwide incidents. Given the expertise within National Grid it is expected to achieve a viable technology in collaboration with the selected supplier.

Although it is difficult to extrapolate performance measures and experience between mineral oils and DDB to the new field of silicone oil, the track record of the group at Southampton University leads to the conclusion that it is highly likely that this group will be able to:
• Induce ageing effects in silicone oil in the laboratory.
• Apply appropriate techniques to characterize these.
• Relate observed chemical changes to changes in key electrical properties.
• Identify appropriate routes to implementation.
At present very little is known about the field-ageing behaviour of silicone oils and therefore it is not possible to state that this</td></tr>
</table>

	laboratory work will lead with certainty to a practical testing regime. If successful this work will support failure investigations and will also lead to preventative diagnostic testing of silicone oil cable sealing ends within Asset Engineering.
Project progress to March 2008	The sulphur in oil trial technology is in the process of being scoped. Small volume oil analysis: Laboratory studies of the synthetic cable oil dodecylbenzene (DDB) have yielded a good understanding of the complete ageing process in cable oils. A number of key indicators of oil ageing have been identified, which can be used to assess the condition of National Grid's critical underground cable circuits. There is a strong correlation between some of the ageing indicators and the insulating properties of the oil. In general National Grid's cables contain a mixture of DDB and mineral oil. To date, analysis of field-aged samples has shown that the mineral oil has a 'protective' effect, inhibiting the most destructive degradation processes in the DDB. Although only a limited number of field-aged samples have been tested, early results indicate that the insulation of National Grid's cable assets is generally in a good condition. A rig has been established to simulate intermittent partial discharges in silicon oil terminations.
Collaborative partners	Sea Marconi, DOBLE, ABB
R&D provider	University of Southampton, National Grid's Oil Management Unit

12) <u>Condition and Life Extension of Substation Assets</u>

Project title	Condition and life extension of Substation Assets
Project Engineer	Paul Coventry, Pete Denyer, Andrew Taylor, Kevin Mockeridge
Description of project	The following projects address issues relating to the condition and life extension of substation equipment. Lubrication and maintenance: The study will cover the problems associated with ageing of lubricants, environmental impacts and material / lubricant interference. By using theoretical and practical application and testing, all modern and development products will be considered. It is proposed to use a University to carry out this research as they will provide the level of independence required, will study the latest products available from the major manufacturers and will also be able to consider the latest developments that may not be marketed yet. Internal examination of circuit-breaker voltage grading capacitors removed from service has revealed incipient faults that would certainly have lead to failure but which were not revealed by existing diagnostic checks. The present work is concerned with applying a range of diagnostic techniques to capacitors that have been in service and correlating the indications obtained with the results of internal inspections to identify the techniques most effective in detecting incipient fault conditions. The knowledge obtained will be used to decide whether the capacitors of circuit-breakers undergoing refurbishment are fit for a further 20 years service without risk of disruptive failure or whether they require replacing. The main technical issues with regard to the second refurbishment of Frame r ABCBs are associated with lubrication of the trip latch and trip valves. The operation of the trip valve is critical. A 'stuck

<table>
<tr><td></td><td colspan="3">open' trip valve (which has occurred in service) can cause severe air loss resulting in flash through of the open interrupters. Slow operation and air loss can also result in a severe reduction in Lightning and Switching Impulse Voltage capability. National Grid staff have expressed concerns about the performance of the current recommended trip valve lubrication (Molycote FS 3451) because it is separating in service and losing its oils. The trip valve design relies heavily on regular lubrication to maintain it functionality and the current maintenance regime is inadequate to achieve reliable performance from the valve. Research into the design of the valve is required to alleviate this problem allowing current maintenance intervals to be achieved or improved upon.

The effects of bus transfer duty on the Committee design of disconnectors and the possibility of designing a retro-fit solution to give Committee designed disconnectors an on-load bus transfer rating to modern standards will be investigated.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £16k
External £83k
Total £99k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£416k</td><td>Projected 08/09 costs for National Grid</td><td>£185k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">The project addresses issues related to charge development of GIS spacers, lubrication, grading capacitor condition, bus transfer capability and Frame R maintenance.

Internal examination of circuit-breaker voltage grading capacitors removed from service has revealed incipient faults that would certainly have lead to failure but which were not revealed by existing diagnostic checks. The present work is concerned with applying a range of diagnostic techniques to capacitors that have been in service and correlating the indications obtained with the results of internal inspections to identify the techniques most effective in detecting incipient fault conditions. The knowledge obtained will be used to decide whether the capacitors of circuit-breakers undergoing refurbishment are fit for a further 20 years service without risk of disruptive failure or whether they require replacing.

As a part of the specification development to define the requirements for the second refurbishment of the Frame 'r' circuit breaker to achieve an extra 20 years asset life, it is intended to resolve two design and performance issues associated with the mechanism trip latch & D shaft and the interrupter head trip valve:
• The circuit breaker mechanism trip latch and D shaft has a history of slow trip response due to material hardness variations and resultant poor lubrication performance. The objective is to redesign, re-manufacture and test alternatives designs with a view to resolving the performance issues.
• The interrupter trip valves have a history of sticking in the open position, causing severe air loss, potentially leading to 'flash through' in the interrupters. This problem is caused by a poor valve design and the drying out of the lubricating grease. The objective is to redesign, re-manufacture and test alternatives designs with a view to resolving the performance issues.

Committee designed disconnectors do not have any proven on-load bus transfer rating but they are expected to perform this duty in their</td></tr>
</table>

<table>
<tr><td></td><td colspan="4">locations on the electrical transmission system. Their design is based on requirements dating back some 40 years and they do not fulfil the performance requirements of modern day specifications. There are Technical Limitations (TL) applied to some of these disconnectors to prevent them from being operated while on-load. When Technical Limitations are applied to this equipment this gives rise to operational inflexibility as the circuit has to be made dead before it can be transferred from one busbar to another. In some cases the assets are operated beyond their design capability which leads to damage to the equipment and therefore associated costs for repairs. Damage incurred through operating the assets beyond their design capability has been found and significant work has been required to repair the 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>10</td><td>1</td><td>9</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Extension of maintenance frequencies for a large proportion of National Grid HV equipment. Increased availability and reliability. Rationalisation of existing lubricants.

National Grid is exploring the feasibility of refurbishing some of its air-blast circuit-breakers with the intention of achieving an additional 20 years life beyond anticipated asset life. It is known that some of the voltage grading capacitors in the population to be refurbished may be exhibiting incipient failure and will not be capable of achieving a further 20 years life. If the capacitors exhibiting incipient failure cannot be identified with confidence, it will be necessary to replace all capacitors irrespective of their condition at a cost of around £1 - £1.5 k per capacitor. A reliable diagnostic technique would minimise the risk of in service failures while avoiding the unnecessary replacement of healthy capacitors. If it was found that, say, 50% of the capacitors need not be replaced, savings of the order of £2.5 m could be accrued in the period to 2020.

This work if successful, will improve the reliability of the Frame ‘r‘ circuit breaker for the proposed life extension period of 20 years. Both design modifications will also reduce the maintenance requirements. Currently the trip valves require greasing at 6 yearly maintenance intervals and refurbishment/exchange on a 9 yearly interval. The redesigned trip valve requires no greasing and it is expected to be maintenance free for the remaining life of the circuit breaker 20 years. Either of these failure modes can result in back-trip of the busbar, which may lead to loss of supply. It is estimated that 1-2 system events might be avoided through the successful implementation of this modification over the life-extension of the circuit breaker population (20 years) assuming a typical loss of supply of 300MW in the range 30mins – 1 hour, a value of £33k/MWhr in line with TNRI scheme costs.

Modifying the design of Committee designed disconnectors 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 400kV and 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. Examples of damaged disconnectors show</td></tr>
</table>

	there is no guarantee these new contacts will not need to be replaced at the next maintenance interval due to recurring damage from on-load bus transfer duties. With committee design 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 minimum expenditure of £18k per annum. This excludes any costs 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 these fixed contacts again within their lifetime.		
Expected timescale of project	1 to 3 years depending on results	Duration of benefit once achieved	5+ Years
Probability of success	35%	Project NPV = (PV benefits – PV costs) x probability of success	£939k
Potential for achieving expected benefits	The results from these projects will increase awareness of the condition of the relevant substation assets and potential improved maintenance. Further work is necessary to estimate potential for achieving benefits.		
Project progress to March 2008	The lubrication project has been delayed due to contractual issues, it is hoped to fully start the project in June 08. These projects are in the initial stages with contracts just being in place and only initial work in progress. Projects are progressing with delivery of Frame R trials and grading capacitor testing are expected early in the next year but there is no report to date.		
Collaborative partners			
R&D provider	Imperial College, The University of Manchester, ERA, Southampton University		

13) <u>River Crossing Dampers</u>

Project title	River Crossing Dampers		
Project Engineer	Dave Bedford		
Description of project	Monitoring levels of vibration across three large river spans on the National Grid network, and implementing an innovative solution to manage the vibration		
Expenditure for financial year	Internal £ 10k External £ 77k Total **£ 87k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**TBC (Project variation currently being considered)**	Projected 08/09 costs for National Grid	**TBC (Project variation currently being considered)**
Technological area and/or issue addressed by project	Monitoring levels of vibration across three large river spans on the National Grid network, and implementing an innovative solution to manage the vibration.		

Type(s) of innovation involved	Significant	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		11	0	11
Expected benefits of project	Development of a new vibration damper for National Grid and reduction of vibration levels across three large river spans. Extension of the life of the three crossing beyond the current expected life.			
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	£132k	
Potential for achieving expected benefits	There is a good chance that this project will achieve the expected benefits and progress to date would back this up.			
Project progress to March 2008	River Usk – Initial vibration monitoring complete and dampers installed on one circuit. Further vibration monitoring required to ensure the installation has been successful. River Severn – First installation of vibration monitors completed and data analysed, Further studies are required and will be completed by the end of March 2008. Recommendations implemented by the end of May 2008. Final monitoring of installation expected to be completed by the end of July 2008. River Thames - – First installation of vibration monitors completed and data analysed, Further studies are required and will be completed by the end of June 2008.			
Collaborative partners	Preformed Line Products (GB)			
R&D provider	National Grid			

14) Effective Protective Coatings for OHL Towers

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.

<table>
<tr><td>Expenditure for financial year</td><td>Internal £ 7k
External £ 6k
Total £13k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £
External £
Total £</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£366k</td><td>Projected 08/09 costs for National Grid</td><td>£8k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Impending European legislation will electively ban the use of high 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.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Significant</td><td colspan="2"><table><tr><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td>9</td><td>0</td><td>9</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">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.</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>10%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>£350k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">A full scale change to the originally proposed epoxy paint is unlikely in the near future but in the medium term a change to one of the alternative coatings being tested is almost certain as impending European legislation on VOC’s will mean the current vinyl paints can no longer be used.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="3">Field inspections have so far been carried out in three of the sponsoring companies.
A Prohesion test has been completed to compare the protective performance of several samples of epoxy paints and other paint systems
Investigations into resolving Algae Removal / Growth Prevention problems are ongoing.
A review of Environmental legislation was presented in a report EATL/85510/7.</td></tr>
<tr><td>Collaborative partners</td><td colspan="3">United Utilities, Scottish Power, CE Electric UK (NEDL), Scottish and Southern Energy, Central Networks</td></tr>
<tr><td>R&D provider</td><td colspan="3">EA Technology</td></tr>
</table>

15) Development to Upgrade Digital Control System

Project title	Development to upgrade Digital control system		
Project Engineer	Mark Illsley		
Description of project	Develop FE Control System replacement control system solutions		
Expenditure for financial year	Internal £ 9k External £ 45k Total **£ 54K**	Expenditure in previous (IFI) financial years	Internal £ External £ Total **£**
Total project costs (collaborative + external + National Grid)	**£290k**	Projected 08/09 costs for National Grid	**201k**
Technological area and/or issue addressed by project	There are a number of variants of the FE control system. These variants are fitted to FE2 300kV, FE2 400kV, FEX2 400kV, MFE2 400kV and MFEX2 400kV. Each of these circuit breakers is different in design and application. It is therefore necessary to develop a replacement for each version prior to embarking on a large volume replacement programme.		
Type(s) of innovation involved	Tech Transfer	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		7	-3	10
Expected benefits of project	This project will enable National Grid to develop a replacement control system solution for a family of approximately 300 circuit breakers. This will enable the circuit breakers to achieve a anticipated technical life of approximately 50 years instead of a potential reduced life of 25 to 30 years.		
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	£ 220k
Potential for achieving expected benefits	There is a high potential for achieving the expected benefits as the development work is mainly incremental.		
Project progress to March 2008	To date, a modular replacement has been developed at the factory. This is awaiting installation on a 300kv FE2 CB. The project has encountered difficulty in obtaining a candidate for a suitable outage period corresponding with a suitable return to service duration. .		
Collaborative partners			
R&D provider	Areva T&D		

16) Portable Earthing

Project title	Portable Earthing			
Project Engineer	Martin Wilson, Alan Ainsley			
Description of project	The purpose of this project is two fold firstly work is being undertaken to gain an understanding of how substation Portable Primary Earths perform over extended application periods and to declare a maximum continuous current rating of substation PPE's under induced current conditions Secondly work is ongoing to develop a machine to enable the installation / removal of substation portable earths to be completed in a controlled and safe manner.			
Expenditure for financial year	Internal £ 7k External £ 24k Total **£ 31k**	Expenditure in previous (IFI) financial years	Internal £ NA External £ NA Total **£ NA**	
Total project costs (collaborative + external + National Grid)	**£97k**	Projected 08/09 costs for National Grid	**£63k**	
Technological area and/or issue addressed by project	Health & Safety			
Type(s) of innovation involved	Tech Transfer	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		12	-3	15
Expected benefits of project	The benefits from phase 1 of the project are to define a definitive number of PPE's required to ensure that excess manual handling is not occurring, the work will also look at compliance with the specification ENATS41-21. This second part of 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.			
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	£170k	
Potential for achieving expected benefits	For phase one there is a high risk of success as the nature of the work is gaining readings and undertaking scientific tests. For the second part of this project the technology already exists although it doesn't meet our specific requirements and has never been used on our system. Therefore there is high potential to achieve expected benefits.			

Project progress to March 2008	For phase one the project has been completed and the results of the work are currently being used within National Grid to see if current technical specifications are correct. For part two of this project a prototype design has been agreed with manufacturer and currently in production. Project currently on programme, the majority of the work to be completed 2008 – 2009.
Collaborative partners	None (potential collaboration in 2008 – 2009 with P&B Weir).
R&D provider	ERM Ltd., P&B Weir.

17) <u>Alternative Technologies</u>

<table>
<tr><td>Project title</td><td colspan="3">Alternative Technologies</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Paul Coventry & Ian Welch</td></tr>
<tr><td>Description of project</td><td colspan="3">This project incorporates a knowledge and innovation search with QinetiQ which looks external to existing energy providers with a view to provide technological substitution. The project specific target being reducing energy losses, seeking alternatives to SF6 gas and reducing environmental impacts. There is also a further project with Manchester University & Liverpool University which focuses in more detail on alternatives to SF6.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £10k
External £78k
Total £88k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£393k</td><td>Projected 08/09 costs for National Grid</td><td>£184k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">This area of work looks to search for and import technology propositions and solutions from non energy related R&D sectors (ie in this case the major UK provider for defence) which have potential for electricity (and gas) transmission with a particular focus on SF6.

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 and its use raises concerns on environmental grounds.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Tech Transfer
Significant
Radical</td><td>Project Benefits Rating
10</td><td>Project Residual Risk
7</td><td>Overall Project Score
3</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">Written evidence submitted for the Stern Review on the Economics of Climate Change estimated the social cost of SF_6 emissions to be $800 000 per tonne (www.hm-treasury.gov.uk). It is foreseeable that, as pressure increases to improve environmental performance, taxes on greenhouse gas emissions in addition to existing carbon trading arrangements will be introduced.

In the first instance, the outcome of the project will reduce SF_6 gas emissions from new equipment installed on the transmission network. If the project reduces the leakage rate of new equipment by 0.25 percentage points, it is estimated that savings may be accrued increasing at a rate of around £5.5 k per year, i.e. increasing from £5.5 k in the first year after the project to £55k in the tenth year, and so forth, based on the Stern Review figures.</td></tr>
</table>

	The project will have a greater impact a few years into the future as the first generation of SF_6 filled equipment on the transmission network reaches its end of life and 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 savings may be accrued at a rate of the order of £200 k per year, depending on the volumes replaced. The consequential benefit to the environment are additional to these financial benefits		
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	£-210k (benefits to be established as project progresses
Potential for achieving expected benefits	At present there is no obvious alternative to SF_6 in transmission applications and it is difficult to envisage what technology or technologies might replace it. Consequently, the proposed work takes the form of a scoping study the purpose of which is to identify and perform a preliminary evaluation of the widest range of potential alternatives and to make recommendations for the subsequent development of the most promising candidates. It is envisaged that further R&D investment will be required beyond the end of the project to develop, test and implement any promising alternative technology to SF_6 identified in the course of the present work. In the event of successful development of a viable alternative technology, there will be considerable pressure to implement a solution. In the area of technological substitution there is a fair chance that some technologies from other areas can be substitutes into the energy sector.		
Project progress to March 2008	The work with QinetiQ looking at knowledge and innovation search external to the existing energy providers has reached the following stage Project scoping, and workshops to assess key issues have been held. Specific technology solutions available within QinetiQ have been identified and reviewed on an application by application basis. Other work areas under assessment include recovery of waste heat from substation equipment, use of unmanned aircraft to replace helicopter surveys and optical intruder detection equipment The project with Manchester University & Liverpool University looking at alternatives to SF_6 has recently started and work is at an early stage.		
Collaborative partners			
R&D provider	The University of Manchester, Liverpool University & Qinetiq		

18) Supergen V – AMPerES (Asset Management and Performance of Energy Systems) & Advanced Real-time Monitoring and Data Analysis (ARMADA)

<table>
<tr><td>Project title</td><td colspan="4">Supergen V – AMPerES (Asset Management and Performance of Energy Systems) & Advanced Real-time Monitoring and Data Analysis (ARMADA)</td></tr>
<tr><td>Project Engineer</td><td colspan="4">Jenny Cooper</td></tr>
<tr><td>Description of project</td><td colspan="4">This is a 4 year major multi party collaborative project. The research programme is split into 6 work packages & 25 activities. Most of the research will be carried out by the universities. A National Grid representative has been identified for the Steering Group and each work package so that research and demonstration projects can be identified. The two key aims of the project are; firstly to provide platform technologies and tools for integrated network planning and asset management; and secondly to identify methods to develop and implement networks with reduced environmental impact.

Work Package 6 of the Amperes programme is focussed on developing advanced condition monitoring techniques including data management and analysis. To demonstrate the capabilities of WP6, real world data and experience is required. To this end, National Grid have been installing an agreed set of sensors to 2 Supergrid transformers (one fully, one partially) at a single site. The sensor list has been developed using National Grid's engineering experience and the combined AMPerES team to maximise the possible benefit from the project. This will allow data analysis algorithms and knowledge extraction techniques to be developed by Strathclyde University which extract the most benefit from the available data. Additionally by comparing the fully instrumented transformer with the unit with less monitoring it will be possible to determine the most effective solution for future installations. Moreover, this will help to determine the limits to which information about the performance of one unit can be inferred from the behaviour of another unit.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £11k
External £44k
Total £55k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£2,800k (plus additional demonstrator costs)</td><td>Projected 08/09 costs for National Grid</td><td colspan="2">£30k (plus additional demonstrator costs)</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">WP 1: Programme delivery, outreach and implementation
WP 2: Enhanced network performance and planning
WP 3: New protection and control techniques that adapt to changing networks
WP 4: Infrastructure for reducing environmental impact
WP 5: Ageing mechanisms
WP 6: Condition monitoring techniques including instrumentation of 2 supergrid transformers at a single site to demonstrate the benefits of analysing the combined outputs from a variety of simple sensors.</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>
</table>

<table>
<tr><td>Expected benefits of project</td><td colspan="3">The expected aims of the project are:
• To deliver a suite of intelligent diagnostic tools for plant
• To provide platform technologies for integrated network planning and asset management
• To progress plans to develop and implement improved and reduced environmental impact networks
• To develop models and recommendations for network operation and management

ARMADA further leverages National Grid's involvement in the Supergen 5 programme; by offering these transformers as a trial facility National Grid gains directly from the outputs of WP6. The knowledge gained from this work will also allow National Grid's monitoring policies to be further developed and implemented. Key benefits from the work will include:
1. The extent to which data from one transformer can be used to infer condition information about a similar unit.
2. Understanding how data fusion from several simple sensors can give additional information beyond treating each individually.
3. Test the transformer thermal model previously developed by Liverpool university.
4. Look for correlations in the data that have not been previously observed due to never having had such a heavily instrumented transformer.

In addition to the Supergen work it is proposed to undertake a test of wireless sensor networks in collaboration with the National Physical Laboratory (NPL). This work will only require the provision of some manpower since NPL already have funding for the sensors. However the knowledge gained from trialling these new advanced data communication systems within a substation environment will allow National Grid to (1) understand the influence of electromagnetic interference on performance, (2) assess the battery performance and (3) evaluate the embedded intelligence within the motes.</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>25%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>£150k (based on demonstrators)</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">Asset management is core to the business. The appropriate use of the emerging opportunities for condition monitoring is key to optimising performance, both financially and in quality of supply. Some of the technologies being developed in this programme are likely to be utilised, however much more important is the broader window this work gives to the global research community. Through demonstration sites the true value of condition monitoring will be identified, enabling appropriate business decisions on adoption of technologies.

If ARMADA is successful, the work will be implemented through changes to condition monitoring policy and application within Asset Management.</td></tr>
</table>

Project progress to March 2008	The project is now fully resourced in all the universities (PhD and RAs). A number of demonstrators have been identified and are being implemented ahead of schedule. The high-level work to develop optimal asset replacement and network expansion methodologies is progressing well, and it has been agreed that this project should become a demonstrator, the form of which is being agreed by the Steering Group. More physical demonstrators are being built at both distribution and transmission substations. The initial evaluation of techniques is complete and machine learning techniques have been selected for implementation. The more fundamental work on ageing of plant which is necessary to underpin the more applied activities is also progressing according to plan, with development of methods to characterise ageing plants being developed. To date 14 reports and 38 publications have arisen from this work. <u>Technical documents produced</u>: • Loss of Mains Detection and Amelioration on Networks • Loss-of-Mains detection by differential ROCOF Protection using internet protocol. • Interim report on protection and control of distribution networks with synchronous islands. • Reducing the Environmental Impact of Electrical Plant - Annual report • First report on use of high temperature conductors on distribution networks. • Final report on high temperature low sag conductors. • Report on ICSD 2007 • Report on literature on non-power frequency ageing in dielectrics • Condition monitoring -State of the art report version 2 27 technical publications have been submitted or published since in the last year. <u>Technology & trials</u>: The following demonstrator projects are presently being implemented in both Transmission (due to finish mid-June) and Distribution substations: • Monitoring of two 275/132kV National Grid transformers. • Monitoring of 6 Scottish Power Substations. • Processing of Partial discharge data from EDF Energy substations. These will be used to prove data acquisition technology and develop interpretation tools.
Collaborative partners	Scottish Power, Scottish and Southern, United Utilities, Western Power Distribution, Central Networks, CE Electric, NIE, Advantica & EDF Energy Networks.
R&D provider	Universities of Manchester, Southampton, Edinburgh, Liverpool, Strathclyde, Queens (Belfast), Integrated Data Logging Solutions

19) Substation Design

Project title	Substation Design		
Project Engineer	Mark Osborne		
Description of project	The purpose of this work is to establish a generic assessment model to compare performance and reliability between different substation configurations under various fault and operational contingencies.		
Expenditure for financial year	Internal £ 6k External £ 0 Total **£ 6k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£50k**	Projected 08/09 costs for National Grid	**£44k**
Technological area and/or issue addressed by project	The project will compare the reliability and availability for different substation arrangements based on historical switchgear and protection performance. The impact of various fault scenarios will be examined, to identify the appropriateness of substations for extensions or development. This will form a strategy for new connections, extensions or asset replacement decisions. This will also be used to examine alternative substation configurations (double breaker or one and a half breaker systems) and new technologies such as integrated or hybrid switchgear (such as disconnecting circuit breakers or compact units) can be used to make the network more effective.		

Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		9	0	9

Expected benefits of project	This work will be used to support scheme decisions which underpin the long term impact on design reliability when extending substations to meet additional demand. This work will save costs through reducing some of the substation design feasibility work carried out on schemes prior to sanction. On large schemes this can be up to £100k. It is envisaged potential savings could be in excess of £300k over the review period. This tool will also aid with decision support on asset management issues such as maintenance strategies and operational contingencies. This is also an evaluation exercise to determine the capability of this tool to provide further decision support on asset management decisions.		
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	£99k
Potential for achieving expected benefits	Likely at this stage		

Project progress	Project just started.
Collaborative partners	None
R&D provider	Troll Power Consultants, Norway

20) Cable Asset Life

Project title	Cable Asset Life			
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 £ 15k Total **£ 19k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£70k**	Projected 08/09 costs for National Grid	**£51k**	
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	0	9
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 into the Asset Lives project 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	5+ Years	
Probability of success	60%	Project NPV = (PV benefits – PV costs) x probability of success	£207k	
Potential for achieving expected benefits	This work will produce an asset health index and deterioration model for cable systems. Once available, the outputs of this project will feed into the capital plan and will form part of our Asset Health process. This will be implemented in the capital plan by the Asset Investment team.			

Project progress to March 2008	The project started in January and has completed an extensive literature review. A draft deterioration model is expected by the end of March. Further research work will commence looking in detail at the various elements of the oil filled cable system assessing the asset life and modelling the deterioration mechanisms. The final output is expected to be a full review of an oil filled cable's degradation mechanisms.
Collaborative partners	
R&D provider	Energyline – Denis Procter

21) Efficient incorporation of Intermittent Generation considerations in Network Design

Project title	Efficient incorporation of Intermittent Generation considerations in Network Design			
Project Engineer	Bless Kuri			
Description of project	Development of a methodology for determining the optimum required capability for the main interconnected transmission system with significant intermittent generation.			
Expenditure for financial year	Internal £87k External£19k Total **£106k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£144k**	Projected 08/09 costs for National Grid	**NA**	
Technological area and/or issue addressed by project	Integration of renewable generation into the grid. Reliability of electricity supply. Network investment.			
Type(s) of innovation involved	Significant	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		2	3	9
Expected benefits of project	An efficient methodology to determine transmission capability requirements with significant intermittent generation will address the following: (a) Optimum balance between investment costs, operational costs and reliability of supply (b) Promotion of integration of renewable generation into the transmission grid hence reducing CO_2 emissions			
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	£28k	
Potential for achieving expected benefits	High. Key approaches have been identified from the work done so far. The approaches are based on sound engineering principles and further work has been identified to further develop the principles Feedback from industry indicates a significant interest in the			

	outcome.
Project progress to 28 March 2008	Approximately 70% – 80% complete Six approaches were identified, explored and consulted upon. Approaches were ranked according to predetermined criteria. Initial results are promising but further work is required to develop approach into a practical application.
Collaborative partners	Scottish Power and Scottish and Southern Energy.
R&D provider	TNEI Consultancy in collaboration with Strathclyde University

22) Maintenance Delivery Tools

Project title	Maintenance Delivery Tools		
Project Engineer	Martin Wilson		
Description of project	To produce a lightweight, versatile access system for access/egress to and working on suspension & tension insulator strings.		
Expenditure for financial year	Internal £ 16k External £ 33k Total **£ 49k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£49k**	Projected 08/09 costs for National Grid	**NA**
Technological area and/or issue addressed by project	• Health & Safety (occupational Health) • Environmental • System Availability • Productivity		
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		12	-5	17
Expected benefits of project	This project will provide two systems, which are user friendly, and will ensure we give our lines persons the best working environment. Both systems give benefits in health and safety. 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. In addition the Pladder system for working on tension insulators also provides other additional benefits on top of the obvious occupational health benefits including:- **Environmental -** the system reduces the impact on the environment by removing the potential requirement to take heavy goods vehicles into OHL towers. The system can be transported into towers using current OHL ATV's and trailer. In the winter period, in some areas, work would not be possible due to the land damage caused by taking HGVs onto the land. By using the Pladder work is now		

	possible in these areas in the winter. The avoidance of land damage is an obvious financial benefit to the company as Trackway used in the winter period costs approx £1200 per tower. Use of the Pladder allows winter work avoiding the cost of £1200 per tower. **System Availability –** the Pladder system allows the return to service times on circuits to be substantially lower as it only takes a short time to remove the equipment from the tower compared to the time taken to de-rig a 19m platform. **Productivity –** the Pladder system removes the requirement for a day of set up time/tower which needs to be built into the work plan when using a 19m platform. This equates to a saving approx £1200 per tower where the Pladder is used instead of the 19m platform.		
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	£244k
Potential for achieving expected benefits	Pladder equipment has been trialled using this fund, all trials have been successful and currently expected to achieve benefits. On the powered ladder basket a number of trials have successfully been completed in different environments and there is a high expectancy for delivering expected benefits.		
Project progress to March 2008	The Pladder equipment has been trialled, all trials have been successful and R&D element of project complete. The manufacture and roll out is now being progressed and will be completed by end June 08. For the Powered ladder access basket a number of trials have been successfully completed. Further trials are programmed to ensure suitability in all environments. To ensure compliance with legislation a 'drop test, is to be completed. The outcome of the test may mean further work is required.		
Collaborative Partners	None		
R&D provider	Spondon Engineering		

23) New Technology to enable Connection of Low Carbon Generation

Project title	New Technology to enable Connection of Low Carbon Generation
Project Engineer	Zia Emin, F Ghassemi, Mark Perry, Ben Marshall
Description of project	The need to enable connection of low carbon generation to the transmission grid is a priority for National Grid – this project looks to scope technologies and knowledge to allow the connections. It is likely that viable technologies will be developed into major projects. Issues under investigation are: • Looking at the various scenarios to establish any stability issues with large generation plant that may be part of future nuclear or any other power plant. • Accurate models of the excitation control systems on existing power stations giving improved assessment of system stability hence optimising network capacity • Investigating harmonic voltage levels and potential impact on control systems • Development of a software analysis program by Strathclyde

<table>
<tr><td></td><td colspan="3">University for probabilistic generation planning, for eventual use by National Grid</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £40k
External £57k
Total £97k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£786k</td><td>Projected 08/09 costs for National Grid</td><td>£310k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">• Impact of future generation plant on system stability and frequency control - stability of large generation plant.
• Voltage transducers for power quality measurements. To assess the suitability and accuracy of voltage transducers for power quality and wide band measurement.
• Model development for new HVDC plant. The development of models for new types of HVDC links that are connecting to the GB system and that may provide an option for re-enforcement within the system.
• Risk Managed Corrective Control of Electricity Transmission The co-ordinated use of Quadrature Boosters following a fault, to allow greater use of existing transmission assets.
• Probabilistic generation analysis and network planning.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Significant</td><td colspan="2"><table><tr><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td>13</td><td>4</td><td>9</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">The project will enable us to know whether it is safe in terms of stability to connect large generation plant to the system.

Optimisation of network capacity will reduce the need to upgrade transmission lines, minimising necessary investment to achieve increased capacity.

The software developed will be available as an analysis tool, and National Grid will benefit form the knowledge gained during the project. The software could be used to develop a greater understanding of the generation market and in the assessment of risk in load-related capital planning.</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>35 %</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>£110k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">Early identification of any potential issues and technologies associated with the connection of new types of generation will ensure that system planning issues can be addressed to ensure that the generation can be connected without reducing system security. Any requirements to review Grid Code or SQSS requirements resulting from new generation proposals need to be addressed at an early stage, to benefit the whole industry.

Models of any plant connected to or within the transmission system are essential to ensure efficient development of a secure system. The use of HVDC links within the system may provide lower cost developments to facilitate the connection of large amounts of new, renewable generation.</td></tr>
</table>

	The transmission network is currently planned using deterministic security standards, so a probabilistic analysis tool could complement that approach.
Project progress to March 2008	Building a model and simulating various generation/technology scenarios and producing a report. To date, the model has been built and tested and its operation is verified. Part of the studies were run and completed. Voltage transducers for power quality measurement: 1) First report by University of Manchester has been prepared. 2) A device for test has been shipped to the University of Manchester. 3) A 400 kV VT has been located. Plan in progress to ship the VT to the University of Manchester. 4) Work is being done to design a HV variable frequency source. Discussions have been held with a manufacturer for their provision of information necessary to develop models for and assess the performance of HVDC links. A Research Student has been familiarising himself with the GB electricity market and energy economics, and with principles of simulation, with a view to selecting appropriate methods for the SuperGUM project. He has written a discussion paper on his findings to date.
Collaborative partners	Areva, ABB
R&D provider	University of Manchester , Strathclyde University

24) <u>Flexnet</u>

Project title	FlexNet		
Project Engineer	Ray Zhang		
Description of project	FlexNet will put in place a substantial body of work that will build on the achievements of FutureNet and lay out the major steps, technical, economic, market design, public acceptance and others, that will lead to flexible networks, including starting to showcase these so that they can be taken up by the commercial sector, Government and Regulators for practical implementation.		
Expenditure for financial year	Internal £5k External £17k Total **£22k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£509k**	Projected 08/09 costs for National Grid	**£30k**
Technological area and/or issue addressed by project	Some key questions to be addressed are: • How can we judge the degree of flexibility needed? • How can flexibility be achieved? • How much flexibility should come from primary plant giving margin and how much from secondary plant giving enhanced controllability? • What constrains or encourages flexibility, what technologies are acceptable and what economic frameworks and public policies provide flexibility at the least overall long term cost?		

<table>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Significant
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 work stream is expected to deliver benefits.
• Shape & Size of Future Electricity Networks will continue to build on the FutureNet scenarios.
• Markets & Investments will investigate some of the economic issues of the electricity market.
- Power System Electronics will investigate why capital cost, cost of power losses and concerns over local network integration result in power electronic systems currently being restricted to voltage control.
- Smart, Flexible Controls will help network operators to understand the benefits of changing the network operation philosophy and the requirements for its implementation.
• Customers, Citizens & Loads will analyse potential contributions that customers and responsive demand can make towards enabling a more flexible energy system, to identify barriers to this participation and their possible remedies, and to analyse the place-related factors shaping public acceptance of a more flexible network infrastructure.
• Validation and Showcase will provide the basis for testing the research outcomes in a representative environment and demonstrating their effectiveness in addressing problems central to the realisation of flexible power networks.
• Future Energy Mix will consider possible changes in (UK) energy systems to 2050 and examine the impact of these changes on energy transportation networks.
• Future LV Networks will investigate losses through auditing and analysing the relative impact of load-profile, sharing, imbalance and sag on losses.
• Education, Deliberative Engagement and Public Acceptance of Future Network will inform many of the social issues and engagement.
•</td></tr>
<tr><td>Expected timescale of project</td><td>5 Years</td><td>Duration of benefit once achieved</td><td colspan="2">5+ Years</td></tr>
<tr><td>Probability of success</td><td>10%</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">Some of the consortium members who produced the results of Supergen I - FutureNet are continuing to participate in FlexNet. It is expected that the quality of work will continue. The input of the industrial partners will be able to enrich the research with their own experiences.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="4">The project started on the 1 October 2007. Since then the academic partners have recruited PhD students and research assistants to undertake the research.
The project management and steering groups have been established to manage and govern the progress of the project. Some of the work-streams are already producing some useful results.</td></tr>
</table>

Collaborative partners	EPSRC, National Grid, Scottish and Southern Energy, Central Networks, EDF Energy Networks, Scottish Power, CE Electric UK, Electricity North West and Rolls-Royce plc.
R&D provider	Universities of Bath, Birmingham, Cambridge, Cardiff, Edinburgh, Manchester, Strathclyde and Imperial College London.

25) <u>Vegetation Management</u>

Project title	Vegetation Management Research		
Project Engineer	Matthew Murphy		
Description of project	Research into vegetation growth rates. This project proposes to • Monitor vegetation growth at 1650 sites across the UK network; Develop a software model which will take into account factors such as tree species, bioclimatic area, and the effect of climate change, in order to estimate the speed of vegetation growth at different sites.		
Expenditure for financial year	Internal £ 2k External £ 40k Total £ 42k	Expenditure in previous (IFI) financial years	Internal £ N/A External £ N/A Total £ N/A
Total project costs (collaborative + external + National Grid)	**£1740k**	Projected 08/09 costs for National Grid	**£41k**
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. Failure to control growth can result in unexpected circuit tripping with consequent impact on security of supply - tree growth was the initiator of the major US shutdown five years ago.		
Type(s) of innovation involved	Incremental	Project Benefits Rating: 8	Project Residual Risk: -1 / **Overall Project Score**: 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	5+ Years
Probability of success	50%	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. It is funded jointly by these companies. It is in everybody's interest to see a successful conclusion and the potential for achieving the expected benefits is high.
Project progress to March 2008	The project is currently in its early stages. The spans to be cut and monitored have been identified, and ADAS are in negotiations with grantors to obtain the consents required.
Collaborative partners	DNO's
R&D provider	ADAS forest research.

26) <u>Climate Change</u>

<table>
<tr><td>Project title</td><td colspan="5">Climate Change Work</td></tr>
<tr><td>Project Engineer</td><td colspan="5">Shanti Majithia</td></tr>
<tr><td>Description of project</td><td colspan="5">National Grid has undertaken two projects this year with the sole of aim of looking at the impacts of climate change on the transmission system.
[Note this research fits alongside two other programmes covering Flooding Risk Reduction and Investigation of Network Resilience to Weather Events which are reported separately]</td></tr>
<tr><td>Expenditure for financial year</td><td colspan="2">Internal £ 19k
External £ 30k
Total £ 49k</td><td>Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td colspan="2">£463k</td><td>Projected 08/09 costs for National Grid</td><td colspan="2">£38k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">National Grid commissioned Weather Intelligence to undertake an assessment of the climate change challenges and opportunities presented to its UK Transmission business and its organisational readiness for those challenges.

In addition to this work National Grid has also been working with the Meteorological Office to use real climate data to develop models of how changes in climate will affect the assets of energy networks.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td colspan="2">Overall Project Score</td></tr>
<tr><td>8</td><td>1</td><td colspan="2">7</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">The expected benefits of the Weather Intelligence work cover three areas:
• Identification of specific current and future climate change challenges and responses, which supports UK Transmission's work to coordinate, resource and prioritise the key climate change-related work streams.
• A clearer understanding of the future weather data (from climate scenarios) needed to address the technical requirements of a number of asset classes (e.g. cable ratings for overhead lines, transformers, underground temperatures and soil moisture).
• Recommendations for the enhancement of key organisational capabilities. These included further work on the understanding of carbon costing and the development of indicators of changes to asset resilience.

The expected benefits of work with the Met Office is to be able to</td></tr>
</table>

	use real weather data to develop models to help predict how assets may be affect by changes in climate and changes in energy patterns.		
Expected timescale of project	4 Years	Duration of benefit once achieved	5+ Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£-114k
Potential for achieving expected benefits	Project deliverables are on target – potential of adapting to or mitigating climate related issues high given National Grid's priority in achieving ambitious environmental targets.		
Project progress [date]	The work with Weather Intelligence has been completed and a series of presentations made to help determine the next steps required to prepare National Grid's networks for changes in climate. Along side this the project with the Met Office delivered the following during 07/08:- • Developed innovative new techniques that apply climate models to energy applications so that the industry is better placed to adapt to climate change. • Investigated future wind resource, enabling the industry to understand the continued uncertainty of future wind power. This will assist risk management and investment decisions. • Modelled future soil conditions and their impact on cables so that Companies can understand the cost and benefits of installing cables for a more resilient future network. • Built a tool to enable UK coastal and marine sites of interest to be screened to assess if sea level rise should be considered in more detail. • Investigated how the urban heat island effect may change in the future so that Networks can develop plans for their infrastructure in cities		
Collaborative partners	UK Network Operators		
R&D provider	Met Office, Weather Intelligence		

27) <u>Flooding Risk Reduction</u>

Project title	Flooding Risk Reduction		
Project Engineer	Doug Dodds		
Description of project	National Grid has undertaken two projects on researching the risks of flooding at substations in order to ensure economic investment takes place to protect these substations.		
Expenditure for financial year	Internal £ 39k External £ 0k Total **£ 39k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£60k**	Projected 08/09 costs for National Grid	**TBC**

<table>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="4">The first of these projects has been initiated to:-

• Research the level of current and projected risk to substations posed by flooding and a comparison of these risks with the levels of security provided under The Electricity Safety, Quality and Continuity Regulations 2002 (ESQCR).
• To develop Generic solutions and indicative costs to mitigate the risk of flooding should be identified. These may be permanent or temporary and appropriate for new substations or retrofitting to existing substations. It is envisaged that solutions may be site specific, or involve wider flood protection provided by the Environment Agency.

The second scheme will engage Mott Mac Donald to carry out a desktop flood assessment of sites identified as being at Significant and Moderate risk of flooding to establish what projected depth of water can be expected from 1:100, 1:200 and 1:1000 flood events. This data will be used to determine what defence strategy can best be employed at each site –

a. With sufficient warning the use of mobile flood defences (Geo Design flood barrier system)
b. Investment to remove the risk (where the risk and consequence is deemed unacceptable)
c. Where projected depths are shallow determining if site is actually at risk.
d. Identify areas of sites which may flood and relate this to vulnerable plant items.</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>13</td><td>0</td><td>13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">We need to operate the system with the minimum of disruption to service with any preventable losses due to flooding being mitigated through appraisal management and reduction of the risks associated with flooding.

By obtaining and retaining flood data electronically it will contribute to a mechanism, which can be utilised regularly to reassess any changes in flooding risk from Environmental change mitigating the need to establish a flood assessment project after each incident.

In order to reduce the requirements to initiate an assessment of all sites after each high profile flooding event it is envisaged that a robust strategic solution will be flexible enough that in depth site assessments will not be necessary and data is retained and made available for future use mitigating the need to employ resources.</td></tr>
<tr><td>Expected timescale of project</td><td>2 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">£231k</td></tr>
</table>

Potential for achieving expected benefits	The project has a good change to achieve expected benefits.
Project progress to March 2008	The progress of these projects to date is:- Data has been received in DVD disk format from supplier and has allowed a clearer picture of the risks posed by flooding to be gained resulting in the removal of 22 sites from the at risk list and the regarding of 70% of the remainder to a more accurate level. This will contribute to give a clearer risk management and investment strategy. A clearer picture of the sites deemed to be at risk has now been gained this is contributing to a more robust and cost effective flood risk mitigation investment strategy based on prioritisation of the most vulnerable sites. Procedures are currently being developed for the monitoring of flood risk and in the event of the temporary flood barrier being required a deployment procedure along with site specific flood plans are being developed with a trial of the deployment being planned for Mid July 2008
Collaborative partners	
R&D provider	Mott MacDonald,

28) Investigation of Network Resilience to Weather Events

Project title	Investigation to network resilience to weather events		
Project Engineer	Shanti Majithia		
Description of project	This area of research incorporates two projects designed to study and enhance network resilience to severe weather events.		
Expenditure for financial year	Internal £ 14k External £ 33k Total £ 47k	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total £NA
Total project costs (collaborative + external + National Grid)	**£100k**	Projected 08/09 costs for National Grid	**£3k**
Technological area and/or issue addressed by project	The first of these projects studies the use of observations in transmission operations, asset management and resilience to severe weather as it is collected. It will complement the current system and this feasibility study will establish whether enhanced provision of data actually delivers benefits in practice and will highlight relevant issues with equipment. The project will deliver high quality observation using up-to-date technology to be accessible as live data as it becomes available. The second project is to trial a Web Based service to deliver information of anticipated heavy rainfall likely to have an impact on National Grid sub stations. Issued daily this will provide a Traffic Light Approach advising National Grid of potential flooding risk (fluvial and pluvial) through heavy rainfall events. This is designed to be specific to substation sites provided by National Grid and Phase 1 of a longer term collaboration between National Grid and other Network operators, EA, and the Met Office.		

Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		10	2	8
Expected benefits of project	The first project is expected to clarify current use of weather data, highlight core requirements and examine options for the future. With a number of partners it will promote a common solution, which is likely to enhance the security and effectiveness of the observing network, lower costs and improve service delivery. The magnitude of financial benefits will be the reduction in costs from more accurate data is likely to be considerably more than the costs of this project. The second project is being instigated to enhance risk mitigation for substation so that forward planning for flood defences can be carried out.			
Expected timescale of project	3 Years	Duration of benefit once achieved	5+ Years	
Probability of success	35%	Project NPV = (PV benefits – PV costs) x probability of success	£67k	
Potential for achieving expected benefits	Co-funded with other Energy Partners the likely success is very good in delivering the stated objectives and experience on other work with Weather Intelligence reinforces this expectation. The project will deliver improved data although the quality of the data is as yet uncertain.			
Project progress [date]	The progress of these projects is still in an early stage with instrumentation delivered for installation at St.John's Wood substation in July 08. A prototype of the web based service is being tested currently with the possibility of adding substation details on the system.			
Collaborative partners	Centrica, SSE, Eon, and EDF			
R&D provider	Weather Intelligence			

29) <u>Network Design - System Stability</u>

Project title	Network Design - System Stability		
Project Engineer	Mark Perry		
Description of project	• Impact of series capacitors on transmission system performance. • Review of low voltage demand disconnection schemes. • Assessment of SVCs for use in Constant MVAr mode.		
Expenditure for financial year	Internal £16k External £31k Total **£47k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£117k**	Projected 08/09 costs for National Grid	**£69k**
Technological area and/or issue addressed by project	The use of series capacitors on the transmission system has been proposed as an economic means of allowing increased connection of renewable generation in Scotland. Series capacitors can introduce the risk of damage to generating units. This project is to investigate		

<table>
<tr><td></td><td colspan="4">whether such risks would be introduced to the GB system by their use.

The performance of the transmission system following a severe disturbance, and measures to reduce the impact of the disturbance.

The use of SVCs in an alternative control mode that potentially reduces the noise generated and the amount of control room action needed.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>13</td><td>2</td><td>11</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Benefits may accrue from:

• Avoided construction of new 400kV MSCDN devices with average cost of £5-6 million each.
• Minimisation of early write off costs of MSCDN equipment upon their relocation from a 275kV substation to a 400kV substation saving on average £5-6 million each.
• For those substations where the MSCDN could remain in the same physical location there would also be a significant reduction in associated civil costs from retaining a high proportion of the equipment unaltered saving £1.5 million.
• The use of series capacitors will allow increased transfers from Scotland without the need to build additional interconnecting circuits. This will reduce constraint costs and require less investment and have less environmental impact than alternatives such as the construction of new lines. The cost of enhancing the network could be in the range of £100m/100km and this project could contribute 10% towards cost saving through increased knowledge in this area.
• The cost of a total GB blackout has been conservatively estimated at over £1 billion and if the knowledge gained through this project helps to reduce the black out cost risk by 1%, this corresponds to £10m.</td></tr>
<tr><td>Expected timescale of project</td><td>2 Years</td><td>Duration of benefit once achieved</td><td colspan="2">5+ Years</td></tr>
<tr><td>Probability of success</td><td>35%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£689k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">If it can be shown that there are no risks or that they can be mitigated it will mean additional economic re-enforcement options will be available to system designers.

Based on progress to date, there is a high potential that alternative control modes may be used as an alternative to providing physical noise barriers and to reduce control room workload.</td></tr>
</table>

Project progress to March 2008	An initial set of analysis studies have been completed and indicated that there is not likely to be a problem with series capacitors on the UK transmission network. Further, more detailed studies, have been specified and costed and they are expected to be undertaken in the near future. An initial report has been delivered to OFGEM for it to consider whether it would support the principle of a low voltage demand disconnection scheme. Mannington SVC is currently operating in Constant MVAr Mode in direct response to requests from the local environmental health officer to consider noise mitigation measures. A model representing the control system of a different manufacturer will be developed to allow the assessment of all of the SVCs on the system.
Collaborative partners	Siemens, Industry working group
R&D provider	Siemens

30) <u>Network Design - New Generation</u>

Project title	Network Design - New Generation			
Project Engineer	Jonathan Horne, Tarik Ismail			
Description of project	Developing generic methods for developing plant and determining grid code compliance for renewable generation on a type basis directly with the manufacturer. Collaboration projects with developers and manufacturers of power plant to ensure that design of new low carbon plant (Clean Coal, Nuclear) meets minimum technical system requirements.			
Expenditure for financial year	Internal £50k External £43k Total **£93k**	Expenditure in previous (IFI) financial years	Internal £ External £ Total **£**	
Total project costs (collaborative + external + National Grid)	**£385k**	Projected 08/09 costs for National Grid	**£143k**	
Technological area and/or issue addressed by project	Development of renewable plant to provide the best services for the GB transmission system. 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**
		10	2	8
Expected benefits of project	Benefits include: • Developing a direct relationship with the equipment manufacturer in order to help shape development of future plant to provide a GB grid compatible solution. • The project will result in a more streamlined project specific compliance process for developers and National Grid. • Provide NGET with a timely and efficient means of understanding new generation technology characteristics. • 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	3 Years	Duration of benefit once achieved	5+ Years
Probability of success	35%	Project NPV = (PV benefits – PV costs) x probability of success	£214k
Potential for achieving expected benefits	There is a high probability that this project will achieve a successful outcome.		
Project progress to March 2008	The project is progressing well with numerous relationships developing with the major wind turbine manufacturers. Several of the project aims are progressing in parallel with numerous sets of generic modelling data having been received and many of these models under development within National Grid. In addition development of frequency response from wind turbines and fault ride through testing are ongoing for a number of turbine types. Several technical papers have been produced to highlight the main aims of this project to a wider technical audience. Prepared and will be delivering a paper to the industry covering the capability of new low carbon generation technology (excluding renewables). So far this covers super critical coal and nuclear plant. This is expected to lead to changes in the framework for Grid Code and Balancing Services. Progress also made on High Frequency and island mode operation.		
Collaborative partners	Including Alstom, GE. Areva, Siemens		
R&D provider	ISET		

31) <u>Developments in Protection & Control</u>

Project title	Developments in Protection and Control
Project Engineer	Ray Zhang, Alex Carter
Description of project	This combined project covers developments on protection and control in three main areas: To evaluate the technology, functionality, performance, interoperability and application of Phasor Measurement Units (PMUs). This will involve laboratory scenario testing against a system model and pilot deployment on transmission systems in UK and Ireland to baseline and track current and emerging network stability issues. Units will be supplied and installed by Alliance partners (Areva, Siemens and ABB) at agreed strategic points on National Grid, SP, SSE, NIE and ESBI transmission networks. The data will be collected for research purposes and validated against systems models. The work will support the development of next generation data and communications infrastructures for smart applications. To evaluate the functionality and performance of IEC61850 process bus based architecture for substation secondary systems To improve existing power oscillation detection and give additional oscillation source location information to enable the transmission

<table>
<tr><td></td><td colspan="3">network to be operated securely at high utilisation. Additional knowledge on windfarm related oscillations.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £14k
External £75k
Total £89k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£685k</td><td>Projected 08/09 costs for National Grid</td><td>£130k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Market driven grid management has increased the number of renewable/distributed generation sources, introduced complexities to address reactive support and progressively stress transmission networks. This has increased the complexity of operation, monitoring, control and protection of large interconnected electric power systems considerably. The penetration of renewable generation is increasing and there are targets set for connection of future renewable sources. At the same time is the asset owner is faced with increasing maintenance and existing asset replacement which will result in reduced circuit availability. These factors will lead to much less predictable operating scenarios and therefore greater dependence on real-time support tools to observe and manage the condition of the network.

Specific issues for investigation: Synchronized Measurement Technology (SMT), including Phasor Measurement Units (PMUs) and its applications as an important element and enabler of WAMPAC, voltage instability. Process Bus (IEC61850-9-2) and oscillatory stability.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Significant</td><td colspan="2"><table><tr><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td>12</td><td>3</td><td>9</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">The Business Benefits of these projects are as a safety net for the management of future uncertainties in system stability particularly on the England-Scotland interface. This is achieved by better understanding of the current capability and stability of the GB and Irish transmission networks, considering constraints, intermittent generation and changing generation and demand patterns.

Knowledge of the current network conditions will allow future development of smart protection, control and automation applications and will ensure the network is ready and able to accommodate new generation in line with SmartGrid and Intelligrid initiatives.

The projects support the system reinforcement programme, ensuring better use of existing assets and providing an alternative to Operational Tripping and Remedial Action schemes, which are required to manage thermal and stability constraints.

Typically the Financial Benefits will be achieved through avoided investment in infrastructure reinforcement and replacement as part of the current Capital programme. Typically this benefit will be realised if one substation bay extension is deferred. Examples of the potential for savings are:

New Typical Operational Tripping solution current cost £1.5m,
New 400kV AIS Bay current cost £1.5m including Switchgear and Protection
New 400kV GIS Bay current cost £2.7m including switchgear and Protection
New 400/132kV SGT current cost £2.3m</td></tr>
</table>

	New 400kV SVC current cost range £8m to £14m. Any Circuit (OHL, Cable, Tunnel) costs would be in addition to this)		
Expected timescale of project	3 years	Duration of benefit once achieved	5+ Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£2,188k
Potential for achieving expected benefits	The project has a good chance of success due to the current availability of technologies from all main suppliers. Participation and experience with other utilities experiences in Europe and US will be a major factor in ensuring the efficient application and deployment in terms of architecture and applications. The University of Manchester (UoM) has a very experienced team in the area of power system protection, control An important factor is ensuring our main suppliers (through Alliances) are fully involved in this project to enable smooth implementation.		
Project progress March 2008	The majority of the projects have just started with the detailed research proposal and project plan finalised and agreed among all the collaborative partners. Understanding of windfarm issues progressing well. Modelling is showing some of the issues but still needs some refinement. Some techniques for damping control at windfarms are being identified. The project has made good progress in understanding the causes of observed oscillation problems at windfarms and the knowledge gained will help to improve our understanding of current and future windfarm connections. Development of additional analysis tools of network oscillations is progressing well. One new method is ready to be implemented in the next StormMinder release and two others are being developed.		
Collaborative partners	Scottish Power, Scottish and Southern Energy, Psymetrix; Northern Ireland Electricity plc; University of Edinburgh and Queens University Belfast.		
R&D provider	University of Manchester, Psymetrix		

32) Measurement of 3rd Party Exposure to Rise of Earth Potential

Project title	Measurement of 3rd Party Exposure to Rise of Earth Potential ROEP		
Project Engineer	Alan Ainsley		
Description of project	This project is propose to determine the hot zones and transferred potentials in electrical installations and establishes better procedures for a full risk assessment using probabilistic methods.		
Expenditure for financial year	Internal £ 6k External £ 45k Total £ 51k	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total £NA
Total project costs (collaborative + external + National Grid)	**£170k**	Projected 08/09 costs for National Grid	**£21k**

Technological area and/or issue addressed by project	The ROEP at a number of our sites exceeds 650 V (Hot Sites), creating a possible transferred potential hazard to third parties in the vicinity of the site, as a consequence of metallic services to properties e.g. telephone, LVAC, gas, water etc. The transferred potential hazard may result in personal injury and/or damage to electrical equipment, in particular telecommunications equipment.			
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	Overall Project Score
		10	1	9
Expected benefits of project	The work of this scheme will enhance risk assessment techniques already developed allowing National Grid to more effectively target resources for mitigation and minimising the risk.			
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	£85k	
Potential for achieving expected benefits	One of the outturns from the project has allowed us to approach GEL600 with a proposal to consider the inclusion of risk assessment within BS7430. The resultant risk based targeting of spend will enable efficient spend.			
Project progress to March 2008	During the current financial year progress on this project has been the development of a computer-procedure for Stage I risk assessment using BS specifications.			
Collaborative partners				
R&D provider	Cardiff University			

33) <u>Understanding and mitigation of hazards related to Transmission Tower bases</u>

Project title	Understanding and mitigation of hazards related to TT bases		
Project Engineer	Alan Ainsley		
Description of project	The project is to enhance risk assessment methods from the effects of step/touch potentials generated during transient surge conditions. This will allow National Grid to more effectively target resource for mitigation, avoiding unnecessary expenditure and, more significantly, approaches from third parties.		
Expenditure for financial year	Internal £5k External £89k Total **£94k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£385k**	Projected 08/09 costs for National Grid	**£78k**
Technological area and/or issue addressed by project	Increasingly, Rise of Earth Potential issues are being considered both by National Grid and residents alike from legacy and new build sites. Current and previous research programmes on the characterisation of tower base earthing has revealed that the step and touch voltages and the rise of earth potential can be significant		

<table>
<tr><td></td><td colspan="4">under fault and surge conditions. These potentials are shown to be affected by the geometry of the tower structure and the soil properties. Investigations have also demonstrated that the magnitude of these hazardous potentials can be reduced by introducing control measures such as modifying the earthing system of the tower base or on the earthing wire arrangement. On the other hand, it was found that there is a shortfall in the understanding of the dynamic behaviour of tower base earthing which is essential for the accurate prediction of potential distribution and hazard assessment around the tower base.</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="4">The benefits from this project are in particular:
Better understanding of current distribution on tower lines under fault and surge conditions
Accurate quantification of step, touch and hot zones around tower lines under fault and surge conditions
Better identification of earthing hazards related to tower lines and develop mitigation techniques to reduce/eliminate the hazards.
Develop guidelines for safe working practices near tower lines.</td></tr>
<tr><td>Expected timescale of project</td><td>5 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">-£99k plus safety benefit</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">On target based on deliverables to date.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="4">So far the project has delivered the following:-

Report on simulation studies of fault current distribution
Recommendations for working practices near transmission lines
Better understanding of current distribution on tower lines under fault and surge
Report on tower base impulse tests at university test site
Report on tower base step and touch voltage measurements under impulse conditions at university test site.</td></tr>
<tr><td>Collaborative partners</td><td colspan="4"></td></tr>
<tr><td>R&D provider</td><td colspan="4">Cardiff University</td></tr>
</table>

34) Understanding Conduction Mechanisms in Earthing Systems

<table>
<tr><td>Project title</td><td colspan="3">Understanding Conduction Mechanisms in Earthing Systems and optimisation of earth electrode geometries</td></tr>
<tr><td>Project Engineer</td><td colspan="3">Alan Ainsley</td></tr>
<tr><td>Description of project</td><td colspan="3">The proposed programme aims to:

- Understand better the conduction mechanisms following current injection at earth electrodes
- Develop and test new mitigation techniques suitable for the control of safety voltages
- Develop a model for the characterisation of earth electrodes subjected to different magnitudes and shapes of fault current
- Check validity and accuracy of existing earthing designs which were based on most popular computational tools through a comparison of experimental results with predictions.</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 4k
External £126k
Total £ 130k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£260k</td><td>Projected 08/09 costs for National Grid</td><td>£65k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">Previous research efforts have concentrated on the better characterisation of major aspects of practical earthing systems. Both experimental and computer simulation investigations have helped to clarify some performance aspects including determination of safety voltages. However, it is now recognised that little work has been performed to improve the understanding of the conduction mechanisms that control the performance of large/extensive earthing systems. This deficiency in accuracy of knowledge of earthing systems is particularly significant for the control of safety voltages around electrical installations.

Presently, several computation tools exist but their comparison with practical systems is not always possible because the computer models assume uniform layer structures of the soil surrounding the earth electrodes. Therefore, it is proposed to conduct an experimental programme using a large scale test electrode system, and investigate the effects of electrode shape, magnitude and shape of applied voltage/current, and assess the accuracy of existing simulation tools.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Incremental</td><td>Project Benefits Rating
8</td><td>Project Residual Risk
-1</td><td>Overall Project Score
9</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">-Reduce risk of personal injury through better assessment of safety voltages at National Grid installations.
-Assess and develop mitigation techniques to reduce risk of electric shock .
- Enhanced understanding of technical aspects of earthing systems and safety.
-Increase confidence in results obtained with existing computation tools used by the industry.
-Enhance existing earthing and safety practice through better understanding of conduction phenomena around earthing systems under fault conditions.
-Enhanced understanding of issues associated with proposed revision to IEC 61936.</td></tr>
</table>

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	-£30k + safety benefit
Potential for achieving expected benefits	On target given current deliverables.		
Project progress to March 2008	Progress to date on this project includes:- • Laboratory validation of equipment and test rigs. • Initial on-site tests and analysis. • Experiment design and set up. • Computer models of test electrodes and prediction of voltage profiles. • Field tests on experimental electrodes.		
Collaborative partners			
R&D provider	Cardiff University		

35) <u>Substation Compaction</u>

Project title	Substation Compaction		
Project Engineer	Paul Coventry		
Description of project	The project has the key objective of reducing the size of substations using air-insulated switchgear (AIS).		
Expenditure for financial year	Internal £ 6k External £ 68k Total **£ 74k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£225k**	Projected 08/09 costs for National Grid	**£65k**
Technological area and/or issue addressed by project	The project has the key objective of reducing the size of substations using air-insulated switchgear (AIS). A number of factors contribute to the potential for reducing the size: (i) With the use of modern zinc oxide surge arresters, it is possible to reduce the basic insulation level (BIL) of a substation. (ii) Developments such as non-conventional instrument transformers are much reduced in size compared to their conventional counterparts. (iii) Manufacturers are introducing compact, modular types of switchgear where modules are exchanged rather than repaired on site in the event of failure. (iv) AIS substations are designed using conductor clearances that were established in the 1960s and have conservative engineering margins. (v) AIS substations invariably employ an arrangement in which the three phase conductors of each circuit and busbar section are configured in a flat horizontal		

<table>
<tr><td></td><td colspan="4">formation; alternative configurations would allow significant reductions in substation footprint to be achieved.

The conventional solution where land area is limited is the use of gas-insulated switchgear (GIS) using SF_6 as the insulating medium. The use of SF_6 presents concerns on environmental grounds and future legislation restricting or preventing its use cannot be ruled out. The use of a compact AIS substation in such applications would allow National Grid's dependence on SF_6 to be reduced.</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>9</td><td>5</td><td>4</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The main driver for the present work is to reduce the use of GIS in switchgear replacement and hence reduce dependence on sulphur hexafluoride gas, the use of which raises obvious concerns on environmental grounds and entails a legislative risk. It is not possible to quantify the financial benefit of reducing dependence on SF_6. However, a compact AIS design would represent a lower cost technology than GIS and the financial benefits associated with the lower cost can be estimated.

A bay of GIS costs more than an equivalent bay of AIS, typically costing 40% more at 132 kV and more than twice as much at 275 and 400 kV. If the numbers of GIS bays in the switchgear replacement programme were reduced through the use of compact AIS designs, savings in the region of £10 m per year could be envisaged. The potential savings are greater than this, but it would not be reasonable to expect that a compact AIS design could be substituted for GIS in all circumstances.

For the remainder of the switchgear replacements that will be AIS, the use of a compact AIS design would allow reduced expenditure on land and land preparation costs in addition to materials, an estimated saving of around £1-2 m per year.</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>10%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£166k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">There is a high probability that some size reduction will be achievable allowing materials and land take to be reduced. Benefits will become most significant if sufficient size reduction can be achieved that a compact AIS solution can be used in place of a GIS. The implementation of a compact design will require careful risk management and the collaboration of solution providers.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="4">The project is about halfway through its 3-year duration. The main progress to date includes:

• A survey of the available HV plant that allows compact solutions and saving of space.
• Transient studies of overvoltage distribution in large substations following lightning strikes and switching operations including systematic studies of point on wave switching times, and a number of scenarios of lightning and</td></tr>
</table>

	switching overvoltages. • Investigations of overvoltage protection using surge arresters at different locations of the substation to optimise the protection of plant at the substation. • Transient studies for the above substations using reduced clearances in accordance with IEC 71 recommended lightning and switching withstand levels, comparison of the results for the compact versus the existing design. • A feasibility study for a compact air insulated substation at a proposed gas-insulated substation site (case study). • Simulation of new idea of non-horizontal busbar configuration using 3D software. (ongoing).
Collaborative partners	
R&D provider	Cardiff University

36) Composite Technology

Project title	Composite Technology		
Project Engineer	John Hyde		
Description of project	National Grid is engaged in a further two projects to study composite insulators to gain experience in and develop methods and procedures for the handling, installation and maintenance of both Composite Technology Corporation conductor (fibre glass core) and polymeric insulator strings.		
Expenditure for financial year	Internal £5K External £87K Total **£92k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£435k**	Projected 08/09 costs for National Grid	**£139k**
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.) Maintenance of these technologies once installed on the system		
Type(s) of innovation involved	Significant	Project Benefits Rating: 10	Project Residual Risk: 6 / **Overall Project Score**: 4
Expected benefits of project	Further development of the ageing model described previously 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 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. The second project makes use of the overhead line training facility at National Grid's Eakring site. The installation of the new conductor and insulators on equipment that is not part of the energised network gives the following benefits: • The new conductor has specialised jointing equipment; the installation was supervised by the conductor manufacturer and therefore enabled the development of an installation		

	methodology. • The use of polymeric insulators on overhead line tension towers creates a unique issue for maintenance access to the conductor. This is because the insulator cannot be walked on. This project will develop a maintenance access technique for composite insulators use in tension strings. Composite insulators provide several benefits including; improved health and safety during installation, improved pollution performance, reduced electrical noise generation and reduced installation times.		
Expected timescale of project	4 Years	Duration of benefit once achieved	5+ Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	-£354k (part of work is to identify benefit)
Potential for achieving expected benefits	This research form the first project will allow National Grid to hone its asset management of composite insulators. Should the research support the increase in assigned asset life the potential for realising the benefits identified above is very high. In the second project Eve Transmission is producing an installation and handling manual for the conductor system. This will expedite a future requirement to type register this type of conductor. The conductor is high capacity and low weight which makes it suitable for increasing capacity on National Grid's 'smaller' L2 tower types. Potential for achieving benefit is 100% with respect to composite insulator access as safe means of access. Once completed this will allow the type registration of composite insulators for use on both tension and suspension towers. This will allow the realisation of the benefits of using composite insulator. The potential for developing an access method is high.		
Project progress to March 2008	On the ageing project a Research Associate appointed and PhD student in place. Literature review and plan development commenced. On the composite trial project Eve transmission has installed both conductor and insulators. Eve is currently producing installation and handling manuals for the conductor system. National Grid has a draft design for a platform that allows access to the conductors via composite tension insulators. This is being manufactured by a local engineering firm.		
Collaborative partners			
R&D provider	Eve Transmission & The University of Manchester		

37) Development of Toolkit for the Remediation of Oil-Contaminated Soils

Project title	Development of Toolkit for the Remediation of Oil-Contaminated Soils				
Project Engineer	Jeremy Lee				
Description of project	A prototype oil measuring instrument is being produced by Cranfield University as part of the DTI Technology Programme in partnership with Cranfield University and WSP Remediation. The instrument is intended to provide accurate measurements, without the delay and expense of commercial laboratory analysis. It will be small and robust enough to be transported and used at the site where the measurement is required, and will be useable by non-specialist staff. Measurements will be made within minutes to enable decisions to be made quickly. Further development may allow different contaminants to be identified and quantified. National Grid will contribute by providing project management services and by conducting field trials of the equipment.				
Expenditure for financial year	Internal £2k External £6k Total **£8k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**		
Total project costs (collaborative + external + National Grid)	**£29k**	Projected 08/09 costs for National Grid	**£10k**		
Technological area and/or issue addressed by project	Optimisation of the methods available to remediate residual oil left in the ground following repair of a cable oil leak, and make recommendations on how to achieve the best results in different situations.				
Type(s) of innovation involved	Significant	Project Benefits Rating	Project Residual Risk	**Overall Project Score**	
		9	-2	11	
Expected benefits of project	Low-level cable oil contamination of soil is degraded by natural micro-organisms. This project aims to offer a 'toolkit' of options, based on the site conditions, to increase the speed and overall effectiveness of this process. This will reduce the chance of leaked oil migrating into the wider environment and minimise the residue left in-situ.				
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	£207k		
Potential for achieving expected benefits	Foreign micro-organisms and nutrients are currently used in soil clean-up. The results of this project will inform the 'trial-and-error' approach used to date resulting in more effective clean-up and better evidence to present to the Environment Agency.				
Project progress March 2008	A remediation flow-chart has been prepared and the decision making processes are being developed. The researchers have been working with one of National Grid's remediation contractors to investigate commercial products and techniques.				

Collaborative partners	DTI (now TSB), Applied Environmental Solutions.
R&D provider	Lancaster University, Cranfield, WPS Remediation

38) Collapse Prediction on Transmission Networks

Project title	Collapse Prediction on Transmission Networks		
Project Engineer	John Fitch, Kieran French		
Description of project	This project is to test and evaluate the CPR – D collapse prediction relay manufactured by a-eberle and any other devices and/or techniques as they become available. The CPR-D relay is marketed as innovative in the field of network collapse prediction but as yet is unproven and therefore its operation under system stress conditions has not been confirmed. The techniques used by a-eberle in the design of this relay are; • Detection of gradual network breakdowns using the tap/time method. • Evaluation of power frequency and its rate of change. • Measurement of low frequency oscillations and their comparison with a healthy network fingerprint. • Monitoring of voltage drift. • Examination of Lyapunov exponents • Monitoring of damping profile of the network. The project is undertaken in conjunction with Manchester University, Scottish Power, Scottish and Southern Energy with involvement from Northern Ireland Electricity and Eirgrid. The aim of the project is to test the CPR-D relay in both a laboratory and a field environment in order to understand the capabilities and sensitivities of the device and evaluate if it would be a beneficial tool for a system planning/operation during times of system stress. Units will be deployed across networks in order to collect data for research purposes and validating network models.		
Expenditure for financial year	Internal £ 5k External £77k Total **£82k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£251k**	Projected 08/09 costs for National Grid	**£60k**
Technological area and/or issue addressed by project	Power system collapse prediction, voltage instability.		
Type(s) of innovation involved	Significant	Project Benefits Rating 11	Project Residual Risk 3	**Overall Project Score** 8
Expected benefits of project	The Business Benefits of this project contributes to the safety net for the management of future uncertainties in system stability particularly on the England-Scotland interface. This is achieved by better understanding of the current capability and stability of the GB and Irish transmission networks, considering constraints, intermittent generation and changing generation and demand patterns. Typically the Financial Benefits will be achieved through avoided investment in infrastructure reinforcement and replacement as part of the current Capital programme. Typically this benefit will be		

	realised if one substation bay extension is deferred. Examples of the potential for savings are: New Typical Operational Tripping solution current cost £1.5m, New 400kV AIS Bay current cost £1.5m including Switchgear and Protection New 400kV GIS Bay current cost £2.7m including switchgear and Protection New 400/132kV SGT current cost £2.3m New 400kV SVC current cost range £8m to £14m. Any Circuit (OHL, Cable, Tunnel) costs would be in addition to this)		
Expected timescale of project	3 years	Duration of benefit once achieved	5+ Years
Probability of success	20%	Project NPV = (PV benefits – PV costs) x probability of success	£108k
Potential for achieving expected benefits	CPR-D Relay is being installed on a number of Transmission Systems across Europe, following major incidents on their networks. There is great interest in this particular relay and its ability to predict and warn of incipient stability and collapse conditions. The main drive of this project is to evaluate the CPR-D relay and any alternative relays/algorithms (as available) and verify performance in simulation and on line conditions. Benefits will be achieved if it can be clearly demonstrated that a relay of this type can give sufficient early warning for some mitigating actions to be taken in real time or if decision support can be provided to system planning to optimise their planning decisions.		
Project progress March 2008	Specific progress has been made on CPR-D device: • System models evaluated and tested for collapse conditions on a real time digital simulator by Manchester University. • 1 unit delivered to University of Manchester and is currently under evaluation. • Agreement with manufacturer to provide support and assistance in training and application of the CPR-D device. • Plans in place to install units in the field.		
Collaborative partners	Scottish Power, Scottish and Southern Energy.		
R&D provider	University of Manchester		

National Grid Gas Transmission R&D Programme Detailed Report

During the financial year 2007/2008 National Grid Gas Transmission utilised the Innovation Funding Incentive across a number of projects. In accordance with Innovation Good Practice Guide for Energy Networks (ENA Engineering Recommendation G85 Issue2) projects under £80,000 annual spend have been combined into programme areas. These programme areas can be seen below and the progress reports can be seen over the next few pages.

National Grid Gas Transmission R&D Programmes

1 Pipeline Impact Detection System
2 Software Tools for hazard and risk assessment of Major Hazard Gas Pipelines
3 Inspection Techniques
4 PRCI
5 Geotechnics
6 Extending NTS Asset Lives
7 Climate Change
8 Development of connection ability to X80 grade pipe material
9 Research into Meter Assets
10 Feasibility into Technological Substitution
11 Reducing Environmental Impact from Venting
12 Impact of New Gas Sources on Pipelines
13 Study of Pipe Flow Dynamic Loading
14 Gas Leak Detection in Gas Turbine Enclosures

1) Pipeline Impact Detection System

Project title	Pipeline Impact Detection System		
Project Engineer	Aroon Parmar (GNI), Tim Harwood (Construction Phase)		
Description of project	Trial of a system to detect pipeline impacts		
Expenditure for financial year	Internal £ 50K External £290K Total **£340k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£ 500k**	Projected 08/09 costs for National Grid	30K
Technological area and/or issue addressed by project	The objective of the project is to examine the feasibility of an impact detection system for transmission pipelines, GE has developed a solution which has been tested on an operational pipeline in USA and Germany. The impact detection system will be installed on No 7 feeder for trial.		
Type(s) of innovation involved	Tech Transfer	Project Benefits Rating 12	Project Residual Risk -3	**Overall Project Score** 15
Expected benefits of project	Once the system has been installed on No 7 feeder it will enable us to identify location of plant and equipment working in close proximity to the pipeline without physical impact damage taking place. This will allow us to take pro-active precautionary measures to safe-guard the system integrity before damage occurs.		
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	£925k
Potential for achieving expected benefits	GE has developed the system and has been tested on operational pipeline in USA and Germany. The feed back from the pipeline operators is positive. The system has enabled them to take pro-active measures to prevent physical impact damage taking place on their pipelines. This has safe-guarded the system integrity. Based on these on these experiences, the potential for achieving the expected benefits look good.		
Project progress to March 08	Contract Signed:26th September 2007 Equipment purchased and delivered: 14th January 2008 Equipment is currently being installed		
Collaborative partners			
R&D provider	GE, GEL		

2) Software Tools for hazard and risk assessment of Major Gas Hazard installations

Project title	Software Tools for hazard and risk assessment of Major Gas Hazards installations			
Project Engineer	Dave McCollum			
Description of project	Research and development of two Software tools for hazard and risk assessment of Major Hazard, Gas Installations			
Expenditure for financial year	Internal £ 8k External £ 66k Total **£ 74k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£ 320 K**	Projected 08/09 costs for National Grid	**£ 108K**	
Technological area and/or issue addressed by project	Software tools for hazard and risk assessment of Major Hazard Gas Installations			
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		9	0	9
Expected benefits of project	National Grid has to be able to demonstrate that it is meeting regulatory requirements, such as DSEAR and COMAH for its high pressure above ground installations. The first of these projects will develop the methodologies to allow National Grid to manage efficiently the major hazard risks from above ground installations. The project supports National Grid's Major Accident Prevention Policy to increase our knowledge of those aspects of our activities which contribute to major accident scenarios. Current phase is to provide improved method of QRA for AGIs. This second of these projects will support and develop the risk assessments methodologies employed by National Grid to manage the risks from the gas transmission system as required by the Pipelines Safety Regulations. It will provide a demonstration to the HSE that National Grid is continuing to develop more robust and defensible methods of managing the risks from it's transmission system. Through the collaboration National Grid will receive the benefits of work co-funded by the PSG companies and share in world wide safety innovations.			
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	£54k	
Potential for achieving expected benefits	The ORDER tool has proved to be a robust tool in the past and has been accepted by Safety Regulators. With input from the group of worldwide gas companies, this is expected to be maintained. The PIPESAFE tool has proved to be a robust tool in the past and has been accepted by Safety Regulators. With input from the group of worldwide gas companies, this is expected to be maintained			

Project progress to March 2008	The last stage of this phase of the ORDER project delivered an updated approach to the BLEVE methodology for dealing with fire attack on pressurised vessels, a revision of the small leaks methodology to model poorly ventilated regions more effectively and the first stage of an improved methodology for carrying out QRAs of AGIs The last stage of the pipesafe project saw the following research carried out: Variation of pipeline failure frequency investigated with area type Comparison of the HSE PADHI LUP methodology with TD/1 methodology Review of risks for pipelines with multiple infringements to determine appropriate risk criteria to use Review of missile hazards from pipeline failures Feasibility of developing a population database
Collaborative partners	Enagas, Energinet, Fluxys, GasUnie, Gaz de France, Osaka Gas, Tokyo Gas
R&D provider	Advantica

3) Inspection Techniques

Project title	Inspection techniques		
Project Engineer	Joanne Harris, Peter Martin , Duncan Hoyle		
Description of project	This research area encompasses three projects looking at developing or trialling inspections methods to help ensure the integrity of the NTS		
Expenditure for financial year	Internal £ 16k External £ 24k Total **£ 40k**	Expenditure in previous (IFI) financial years	Internal £ NA External £ NA Total **£ NA**
Total project costs (collaborative + external + National Grid)	**£ 235k**	Projected 08/09 costs for National Grid	**£ 67k**
Technological area and/or issue addressed by project	The first of the projects is the On Line Inspection intervals project, which is conducting research into the current methodology used to determine the inspection intervals for in line inspection of pipelines to ensure that an appropriate risk based model is used. This stage is designed to look at the practicalities of applying the new model and the impact of it upon the maintenance regime. The second of the projects will look into the feasibility of alternative inspection techniques to detect third party interference with pipelines. The project will study the feasibility of using other surveillance methods such as unmanned aerial vehicles instead of man helicopter flights. The third project will Identify and evaluate, inspection system's' capable of detecting corrosion under insulation on above ground insulated pipe-work and pipe supports. Having identified suitable inspection system's', Advantica will work with National Grid (NG) to implement a programme of work to inspect the pipe-work considered to be at risk		

Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		12	4	8

<table>
<tr><td>Expected benefits of project</td><td colspan="3">The risk based model being produced from the intervals project will take into account maintenance history and the performance of the asset. This information will lead to changes in maintenance frequencies, and will have the potential to reduce Opex. This stage will prove the validity of the tool and will enable a role out programme to be developed, and an assessment of the cost implications to be made.

The benefits from the aerial surveillance project are a very considerable increase in the safety of the Pipeline Surveillance process, which has a history of fatalities associated with it. The present surveillance routine is fortnightly – it may be possible for this to be continuously monitored which would increase the safety of the Gas Transmission system. This project is complementary to the R&D project looking at Unmanned Aerial Vehicles for electricity applications.

There are several benefits of the corrosion under insulation work including:-

1. The ability to be able to identify on a particular site, which pipes are corroding. Enabling preventative maintenance to be targeted at the problem areas.
2. Improved confidence on the integrity of the pipe-work on NG sites as a result of 100% real coverage of insulated pipe as opposed to targeted sampling.
3. Demonstrating to Certifying Authority (HSE) that NG are using new technology to improve safety on AGI sites.

Impact on Business costs:

1. The ability to identify areas of pipe corrosion will enable effective targeted maintenance and in the medium/long term may reduce maintenance schedules.
2. The ability to identify area of corrosion under pipe supports/insulation will reduce costs of rectification work and costs associated with loss of delivery as corrosion will be identified prior to failure.
Impact on operations:

1. Reduction in onsite maintenance in the medium/long term.
2. Reduction in the likelihood of failure due to 100% coverage of areas under cladding.
3. Improved safety of Gas supply due to assurance of Integrity.
Reduced risk of impact on the environment due to reduced leak likelihood.</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>£520k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">If the model from the intervals project is deemed to be appropriate and the implementation plan is realistic then this project has the potential to deliver the benefits identified.

For the aerial surveillance project the intention of the initial investigation will determine the feasibility of success and if any future</td></tr>
</table>

	work is feasible.
Project progress to March 2008	Current progress on the intervals project is as follows:- The stages of the project completed up to this point had; established a need for developing the existing process; produced a specification for the data requirements; encompassed the development of a software model to evaluate the inspection frequencies. This stage has been carried out as a method to evaluate the model and the data requirements prior to any implementation stage, to see if it is: i) practical to gather the data, ii) to see the impact of missing data and iii) to assess any changes to frequencies of inspection produced by the model to see if they are realistic. Advantica are currently undertaking the feasibility study for the aerial surveillance work and will present the result early in the 08/09 financial year. The work on Corrosion under installation was just commencing at the end of the financial year with kick of meeting held between Advantica and National Grid.
Collaborative partners	UKD
R&D provider	Advantica

4) <u>PRCI</u>

Project title	Pipeline Research Council International - PRCI
Project Engineer	Rob Bood
Description of project	PRCI is USA based pipeline research organisation. National Grid membership is shared between UK Transmission and UK Distribution, with UKT taking the lead. The total PRCI 2007 programme funding is $6.6 million allocated against specific projects. PRCI members allocate their membership fee to specific projects of interest giving member companies more ownership and involvement. Research is concentrated in the following areas: ◆ Design, Materials & Construction ◆◆ Right of Way (ROW), design, materials, welding and construction technologies, and static integrity threat assessment (i.e., weather and outside force, fabrication and construction defects, and equipment failures) ◆ Integrity & Maintenance ◆◆ Time-dependent integrity assessment and management (including inspection and monitoring), repair and remediation (i.e. corrosion, mechanical damage and stress corrosion cracking) ◆ Compressor & Pump Stations ◆◆ Environmental compliance, system efficiency, and O&M cost reduction ◆ Measurement ◆◆ Gas quality measurement, accuracy and measurement O&M costs ◆ Storage ◆◆ Storage safety, reliability, flexibility and cost-effectiveness

<table>
<tr><td></td><td colspan="5">National Grid's main interest and active involvement is in the two pipeline committees, i.e.
◆ Design, Materials & Construction
◆ Integrity & Maintenance</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 11k
External £ 65k
Total £ 76k</td><td colspan="2">Expenditure in previous (IFI) financial years</td><td colspan="2">Internal £ NA
External £ NA
Total £ NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>$9m</td><td colspan="2">Projected 08/09 costs for National Grid</td><td colspan="2">£ 77k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="5">◆ Software Implementation of New Guidance for Assessing the Structural Significance of Corrosion Defects
◆ Determine ILI Tool Performance Characteristics
◆ Direct Examination Techniques for Shorted and Non-Shorted Cased Crossings
◆ Prediction of Pipe Wrinkling Under Ground Movement Conditions
◆ Develop Fracture Initiation Criteria for High-Strength Steel Line Pipe
◆ Development of Alternative Hydrotest Solutions
◆ Understanding MFL Signals from Mechanical Damage in Pipelines
◆ Field Testing and Verification of Existing Tool Capabilities for Mechanical Damage Detection and Characterization
◆ Structural Significance of Mechanical Damage
◆ Measuring the effectiveness of Current ROW Monitoring Techniques/Practices
◆ Development of a Pipeline Encroachment Prediction Model
◆ Extend Solar Turbines DLN Operating Range
◆ Compressor Station Fuel Efficiency
◆ Evaluate Existing Hydrocarbon Dew Point Measurement Equipment
◆ Ultrasonic Meter Recalibration Intervals
◆ Energy Meter Performance Assessment
◆ Clamp-On Ultrasonic Meter to Confirm Conditioned Flow at Primary Meter
◆ Meter Station Measurement Uncertainty Analysis Tool</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Incremental
Significant</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td></td><td></td><td>11</td><td>-2</td><td>13</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">PRCI gives member companies ownership of the R&D programme and is focused on areas of interest.

◆ Main focus for National Grid is assessment, prevention and mitigation of integrity threats, such as mechanical damage.

◆ PRCI membership gives National Grid access to $6.6 million of research per year, with good leverage of about 40:1.

◆ Other benefits – networking, problem sharing, risk spreading, benchmarking.

Management of Mechanical Damage
◆ Assessment
◆ Improved inspection-based tools for locating, sizing and characterizing mechanical damage defects
◆ Tools for ranking and screening of Mechanical</td></tr>
</table>

<table>
<tr><td></td><td colspan="3">Damage Defects
◆ Methods to assess the structural significance of Mechanical Damage defects
◆ Considerations for unpiggable pipelines
◆ Mitigation
◆ Guidelines for repair of Mechanical Damage defects
◆ Prevention
◆ Develop improved technologies for ROW monitoring and damage prevention
◆ Determine current best practices for monitoring the ROW and damage prevention technologies

Management of External Corrosion
◆ Assessment
◆ Provide reliable engineering guidelines for the selection of re-inspection intervals for gas and liquids pipelines
◆ Methods to assess the structural significance of external corrosion
◆ In-ditch and above ground tools to allow identification and accurate mapping of external pipe corrosion
◆ Development of improved technologies to locate and address disbonded and shielding coatings
◆ Above ground and in-ditch tools for detecting defects in unpiggable pipelines (ECDA)
◆ ILI tools for unpiggable pipelines
◆ Mitigation
◆ Guidelines for identifying and mitigating cathodic protection shielding
◆ Interference & CP system integrity
◆ Prevention
◆ Define and catalogue best industry practices with regard to coating selection methodology
◆ Optimize cathodic protection system operation and monitoring to reduce overall maintenance costs</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>% 35</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>£ 124</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">High due to collaborative nature of projects.</td></tr>
</table>

Project progress to March 2008	During 2007/2008 the PRCI programme continued to move forward on many individual project areas, the following highlights the some of this progress in specific project areas.
	
	• Mechanical Damage
	  ○ Research continued into the effects of mechanical damage, and this work will feed into design and construction standards to minimise the risk of these incidents in the future
	
	• Corrosion
	  ○ In the areas of corrosion re-inspection intervals for corroded pipelines have been studied including work on look at the ECDA & RBDA methods.
	  ○ Evaluation of Structural Significance Corrosion is still being studied focussing on leak/rupture boundary conditions.
	  ○ Work on pipeline coatings as well as disbondment of coatings was under taken including work on Cathodic Protection system.
	
	• Design, Materials & Construction
	  ○ $4m jointly funded project on welding of high strength steels was kicked of in autumn 2007 and is expected to complete into 2010
	
	• Stress Corrosion Cracking (SCC)
	  ○ Research in this area consisted of analysis of various factors contributing to the formation of SCC and the development of inspection techniques to detect SCC.
	
	The programme of work also covered several other aspects relating to gas transmission assets including compression and integrity.

Collaborative partners	International gas utilities
R&D provider	PRCI

5) Geotechnics

Project title	Geotechnics		
Project Engineer	Alan Hodder		
Description of project	The project involves 2 areas of work: Soil Restraint to Buried Pipework & Dynamic Behaviour and Soil Damping of Buried Pipework.		
Expenditure for financial year	Internal £ 3k External £115K **Total £118K**	Expenditure in previous (IFI) financial years	Internal £NA External £NA **Total £NA**
Total project costs (collaborative + external + National Grid)	**£ 200k**	Projected 08/09 costs for National Grid	**£ 60k**
Technological area and/or issue addressed by project	A number of areas have been identified as genuinely necessary in relation to ground movement effects on pipeline and pipeline supports this project aims to: 1. To review and update guidance on soil restraint calculation and to provide design guidance for incorporation into all works contracts.		

<table>
<tr><td></td><td colspan="4">2. To develop knowledge and understanding of dynamic behaviour and damping of buried pipework, with regard to the risk of fatigue failure.

3. To assess whether the historic and currently common design practice, consider support settlement effects within stress analysis, which links into IGE/TD/1 and IGE/TD/12 compliance.

4. To provide guidance on tensile strain performance limits for the National Grid high pressure pipeline network for strain based analysis and identify project specific or generic testing requirements to reduce conservatism.</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>7</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">Benefits of this project to NG include reduced costs associated with the assessment, remediation, protection and replacement of steel pipelines, and to maintain safety standards.

Increased knowledge will lead to a greater understanding of buried pipeline and pipe support behaviour for more accurate analysis and a safer high-pressure pipeline system. Consequential benefits include increased scope for uprating, reduced cost of monitoring and less conservative pipeline design on new installations.</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">£5k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The potential for achieving the benefits on this project is good and although project has been affect by changing timescales and deliverables early results have been encouraging.</td></tr>
<tr><td>Project progress 31/03/08</td><td colspan="4">To date the progress of the two projects that make up this programme can be seen below for the Soil Restraint to Buried Pipework project

A Review of available methods and existing knowledge on soil restraint calculation completed and delivered. Furthermore the data analysis of Collaborative Project test results has been completed & the data has been compared with available prediction methods and a set of equations proposed to best fit the pipe loading test results from the Collaborative project on soil/pipe interaction.

However it was decided that the original scope of recommending the new methods that are based on the controlled pipe loading tests alone may not be representative enough. From the earlier and on-going literature searches, some other published data of controlled pipe loading tests have been found to cover the four restraint directions (upward, downward, lateral and axial) and two soil types (sand and clay). It was therefore decided to extend the scope of this</td></tr>
</table>

	works. Following on from this a guidance document and spreadsheet for calculating soil restraints will be produced. For the second project on Dynamic Behaviour and Soil Damping of Buried Pipework a review of existing knowledge on dynamic behaviour and soil damping effect of buried pipework completed and delivered. Finite element analyses and numerical analysis have been carried out. Due to lack of availability of a site for vibration measurements within the original specified timescale, it was agreed that this deliverable would involve in house vibration experiments to investigate the dynamic behaviour and damping effect. The Pipeline Maintenance Centre has been commissioned to build the test rig.
Collaborative partners	Pipeline Maintenance Centre
R&D provider	Advantica

6) Extending National Transmission System Asset Lives

Project title	Extending National Transmission System (NTS) Asset Lives		
Project Engineer	Paul Sinclair, Brian Woodhouse		
Description of project	• Develop an understanding of the mechanisms that cause vibration in strainers at compressor stations, establish the sensitivity of the vibration and pressure drop to key design parameters and identify a preferred configuration of strainer for adoption on the NTS. • To obtain a better understanding of the relationship between compressor operational parameters and the failure mode of the seal and/or lube oils systems, to identify the likely cause of failure and raise awareness and to deliver a modified design of seal oil system, which reduces the frequency of failure to acceptable levels. • A programme of work, aimed at providing additional guidance of the remaining fatigue life of a pipeline containing mechanical damage, and to extend the range of applicability of the procedure to include X80 grade steel. Work is required to resolve outstanding performance issues (the fatigue performance of pipelines containing pitting corrosion, dents, and combined dent plus dressed gouge damage). In addition, although the work undertaken to investigate the applicability of the pressure reduction guidelines to pipelines constructed from X80 grade steel provided confidence that the current guidelines are appropriate, additional testing is required to investigate the influence of more severe damage. • Install Iris separators in the fuel gas supplies of A and B Compressor Units		
Expenditure for financial year 7/8	Internal 13k External 61k Total **74k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£ 437k (awaiting confirmation of future costs)**	Projected 08/09 costs for National Grid	**£ 97k**
Technological area and/or issue addressed by project	It is normal practice for a compressor to employ an in-line strainer in the suction pipework to filter out any large solid items from the gas before compression. Sometimes the strainers are removed after commissioning, but it is more common on the NTS for the strainers to remain in place as a permanent element of the installation.		

<table>
<tr><td></td><td>Reasons for doing this include; a perceived need for permanent filtering (perhaps because the site has no scrubbers), or because of practical difficulties in removing the strainer. The use of a strainer carries a number of risks and uncertainties that are associated with the flow of the gas through the device. These include:

• The risk of vibration failure of the strainer itself or adjacent components including small-bore pipework or the compressor;
• The potential for large pressure drop which will waste fuel and can account for a significant percentage of the whole fuel cost for the site.
• The potential for the strainer to be a major source of noise pollution.

There have been a number of fatigue related failures on seal and lube oil systems at key compressor stations which have lead to significant quantities of pressurised oil being released, substantial repair costs and compressor downtime.

A previous series of ring tension tests on 48” diameter X80 grade linepipe containing simulated dent-gouge defects. The results appear to show that both Ilva and Europipe linepipe exhibit lower than expected failure pressures. One potential cause for this is that ring tension tests, especially when performed with large diameter linepipe, may be overly onerous and may be unrealistic tests. This programme of work is designed to investigate this conjecture.

To trial the use of a rotary separator that will easily remove liquid contaminants form the fuel gas supply, thus increasing the efficiency and life of the gas generators.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Incremental
<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>Fewer failures associated with strainers at compressor stations resulting in reduced costs on repairs of compressors and pipework, less pressure drop across compressor leading to reduced emissions and reduced fuel consumption of compressors due to reduced power dissipation by the strainer.

Safety and environmental benefits will be obtained from the seal oil system investigations. A seal oil system failure normally results in the release of large quantities of oil into the compressor cab. The oil is released as a fine spray/mist and coats all components of the machinery and building. Depending on the design of the cab, the oil may be contained within the cab, or released into pit areas or drains. In either case, this represents a considerable environmental problem, and a considerable clean up operation. There is also a potential fire risk, where at least one fire within the cab has been experienced following a seal oil system failure in the last few years. Loss of systems and fire damage could result in unit unavailability and extensive repairs.

National Grid engineers will be more informed as to the behaviour of X80 grade steel with external interference defects. This will influence our future work programmes in this area and make us better placed at assessing the risk associated with X80 pipeline operation.

To remove liquid contaminants form the gas supply providing the fuel to the gas generators thus increasing the efficiency and life of the gas generators. Monitoring the amount of liquid removed will</td></tr>
</table>

	determine the success of the scheme. Monitoring the amount of liquid removed will determine the success of the scheme.		
Expected timescale of project	3 Years	Duration of benefit once achieved : continuous	5+ Years
Probability of success	60% max	Project NPV = (PV benefits – PV costs) x probability of success	£881k
Potential for achieving expected benefits	Good A comprehensive programme of work was undertaken based on pipeline repairs project to produce National Grid's management procedures, T/PM/P/20 to compliment T/PM/P/11. NB Actual benefits to the gas generators cannot be determined until the next time the gas generators are overhauled.		
Project progress to March 2008	Development of design guidance for the use of suction strainers: Stagegate 1 is complete with the final version of Report 7121 'Review of current understanding of suction strainer vibration at NTS compressor sites' delivered to client representative in December 2007. This report provides an introduction to the pipework vibration problems which are understood to be related to the flow behaviour through suction strainers. To this end, a survey was undertaken of the current situation regarding use of and any issues with strainers across the 26 compressor stations on the NTS. The information obtained has been compiled into a database and reviewed to identify any common issues with the current in-line suction strainers and installation configurations. In parallel an initial study was conducted into the capabilities of computational fluid dynamics (CFD) software for, comprising a review of current capabilities and a preliminary study using a commercial package and a development code. Through this work it was shown to be possible to model flow around the components of the strainer, to examine effects such as turbulence due to the pipework configuration and vortex shedding. Building on the findings of this initial stage, a revised proposal has been submitted to the client representative. This focuses on review of the current design of strainers and the operational requirements for their use. Subsequent work would be based around experimental testing and modelling of the flow behaviour and strainer structure in order to gain understanding of the interaction between the two. This project would ultimately lead to the development of a design specification for strainers, and guidance on their use, location and associated pipework design. Design of seal/lube oil systems at compressor stations on the NTS: Based on the strategy defined in Report R8472 (Strategy for dealing with vibration in seal and lubrication oil systems on the NTS - February 2006), a screening process was applied to all compressor sites on the NTS to identify those most at risk of experiencing an oil system pipework failure. Site visits to review the oil system pipework design were then carried out at the three highest scoring compressor		

	stations, namely King's Lynn, Warrington and Scunthorpe. Recommendations for improvement were compiled and send to the client representative in June 2007. Following implementation of these modifications, it is intended that vibration monitoring will be carried out to validate their effectiveness in reducing the risk of failure to acceptable levels. The findings of these studies will then be used to define modifications to be implemented on other 'at risk' sites. Inspection, assessment and repair of damaged (non-leaking) steel pipelines above 150mm nominal diameter and designed to operate at pressures greater than 2 bar: • Defect acceptance limits for pipelines operating at a design factor of 0.8 (the procedures were previously limited to 0.72) • Defect acceptance limits for pipelines constructed from grade X80 linepipe (the procedures previously only considered pipelines constructed from linepipe up to and including grade X65). This development required extensive experimental testing and numerical and analytical studies, due to there being 10 damage types to consider (arc strikes, general and pitting corrosion, smooth dent, kinked dent, cracking/spalling, gouges, smooth dent plus cracking/spalling, smooth dent plus gouge and stress corrosion cracking). This has led to the development of a new suit of damage acceptance tables being incorporated into the procedures, specifically for grade X80 pipelines. Work is still on-going at Advantica to investigate the integrity of X80 grade pipelines with smooth dent damage. • Fatigue: the defect acceptance limits in the procedures are based on static internal pipe pressure. No consideration is given to the effect of pressure cycling of this damage on the fatigue life of the pipeline. • Extensive experimental testing and numerical and analytical analyses have been undertaken to provide guidance on the effect of each damage type on the fatigue life of the pipeline. • A review was also undertaken to the applicability of the procedures to the inspection, assessment and repair of small diameter (sub 150mm diameter) pipework and pipelines. This review demonstrated the potential for a non-conservative assessment of certain types and sizes of damage, as well as limitations to the applicability of 'then' current repair methods and methods that were used to measure the extent of the damage. IRIS: Pipework Designed, Materials Ordered, PMS have agreed to undertake work. Installation of units is expected in Autumn of 2008
Collaborative partners	
R&D provider	Advantica, IRIS units supplied by Dresser Rand

7) Climate Change

Project title	Climate Change
Project Engineer	Shanti Majithia
Description of project	National Grid has undertaken two projects this year with the sole of aim of looking at the impacts of climate change on the transmission system – this covers the gas component of a joint electricity and gas

<table>
<tr><td></td><td colspan="3">project</td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 11k
External £ 19k
Total £ 30k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£ 463 K</td><td>Projected 08/09 costs for National Grid</td><td>£ 17K</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">National Grid commissioned Weather Intelligence to undertake an assessment of the climate change challenges and opportunities presented to its UK Transmission business and its organisational readiness for those challenges.

In addition to this work National Grid has also been working with the met office to use real climate data to develop models of how changes in climate will affect the assets of energy networks.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="3"><table><tr><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>7</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">The expected benefits of the Weather Intelligence work cover three areas:

• Identification of specific current and future climate change challenges and responses, which supports UK Transmission’s work to coordinate, resource and prioritise the key climate change-related workstreams.

• A clearer understanding of the future weather data (from climate scenarios) needed to address the technical issues potential for ground movement near pipelines

• Recommendations for the enhancement of key organisational capabilities. These included further work on the understanding of carbon costing and the development of indicators of changes to asset resilience.

The expected benefits of work with the Met Office is to be able to use real weather data to develop models to help predict how assets may be affect by changes in climate and changes in energy patterns.</td></tr>
<tr><td>Expected timescale of project</td><td>4 Years</td><td>Duration of benefit once achieved</td><td>5+ Years</td></tr>
<tr><td>Probability of success</td><td>20%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>-£114k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="3">The expected benefits of the Weather Intelligence work cover three areas:

• Identification of specific current and future climate change challenges and responses, which supports UK Transmission’s work to coordinate, resource and prioritise the key climate change-related workstreams.
• A clearer understanding of the future weather data (from climate scenarios) needed to address the technical requirements of a number of asset classes (e.g. underground temperatures and soil moisture).
• Recommendations for the enhancement of key organisational</td></tr>
</table>

	capabilities. These included further work on the understanding of carbon costing and the development of indicators of changes to asset resilience. The expected benefits of work with the Met Office is to be able to use real weather data to develop models to help predict how assets may be affect by changes in climate and changes in energy patterns.
Project progress to March 2008	The work with Weather Intelligence has been completed and a series of presentations made to help determine the next steps required to prepare National Grid's networks for changes in climate. Along side this the project with the met office delivered the following during 07/08:- • Developed innovative new techniques that apply climate models to energy applications so that the industry is better placed to adapt to climate change. • Built a tool to enable UK coastal and marine sites of interest to be screened to assess if sea level rise should be considered in more detail. • Investigated how the urban heat island effect may change in the future so that Networks can develop plans for their infrastructure in cities
Collaborative partners	UK Network Operators
R&D provider	Met Office, Weather Intelligence

8) Development of connection ability to X80 grade pipe material

Project title	Development of connection ability to X80 grade pipe material			
Project Engineer	Richard Wilkinson			
Description of project	To develop a hot tap welding procedure for X80 steel high pressure pipelines			
Expenditure for financial year	Internal £ 4k External £ 154k Total **£ 158k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£ 235 k**	Projected 08/09 costs for National Grid	**£ 77k**	
Technological area and/or issue addressed by project	With the introduction of the new X80 pipelines there is an increasing likelihood that National Grid will be required to carry out a hot tap on X80 pipe. A hot tap maybe required in order to maintain supplies or to connect a third party to the National Transmission System under license condition 4B of the Public Gas Transporters License.			
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		9	1	8
Expected benefits of project	The expected benefits of this project are to:- • Ensure all under pressure connections are undertaken in a safe manner • Ensure National Grid complies with it's obligations under license condition 4B with regards third party connections • Unless the hot tap approach for X80 is validated shut down of pipelines maybe required to facilitate connections • Ensure compliance with statutory requirements i.e. Pipeline safety regulations 1996 • Ensure technical specifications are robust for the full range of pipeline diameters and material grades			

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	£51k
Potential for achieving expected benefits	The project is incremental in nature and has a good chance of achieving the expected benefits.		
Project progress to March 2008	Progress to date is as follows:- Manufacture of the Half shells has been completed. Simulated P9 welding has been completed CTS testing is underway.		
Collaborative partners			
R&D provider	Pipeline Maintenance Centre, Advantica		

9) Research into Meter Assets

Project title	Research into Meter Assets			
Project Engineer	Luke Fieldhouse, Paul Gallagher			
Description of project	Three projects devised to look at metering assets			
Expenditure for financial year	Internal £10k External £63k Total **£73k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**	
Total project costs (collaborative + external + National Grid)	**£ 133K**	Projected 08/09 costs for National Grid	**£ 58 K**	
Technological area and/or issue addressed by project	Assessing lifetime, use, performance and accuracy of metering assets including the affects of drain holes (used to remove contamination from the Meter asset from pipelines) on meter assets, the impacts of localised pressure variables on meter assets and how extremes of temperature will affect metering assets.			
Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		10	0	10
Expected benefits of project	Improved performance of metering assets and an improved understanding of the affects of several criteria on metering assets.			

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	£206k
Potential for achieving expected benefits	The potential for achieving the expected benefits is good given that one project has been completed and the results analysed and the others are currently progressing well.		
Project progress to March 2008	Project progress on the projects so far has been as follows, For the first project Advantica have produced a report identifying that lagging of the pipework prior to meters is not necessary unless extremes of weather are apparent. This information has been presented to all asset owners involved in the project. For the second project NEL have visited a site and produced a report mapping the critical data items in November 2007. Since then a meeting has taken place to scope potential projects for addressing some of the other issues highlighted in the report such as the affects of localised pressure variable on metering assets. On the third project NEL have submitted a report on beta ratios and have delivered a set of initial result on the affects of drain holes on meters.		
Collaborative partners	National Grid Gas Distribution Scotia Gas Networks Northern Gas Networks Wales & West Utilities		
R&D provider	Advantica TUV NEL		

10) <u>Feasibility into Technological Substitution</u>

Project title	Feasibility into Technological Substitution		
Project Engineer	Jenny Cooper		
Description of project	The project is a high-level study to review the inter-relationship and similarities of work practices and systems used within the Medical cardio-vascular and Oil & Gas sector pipeline engineering practices to assess the potential for synergism and 'technology exchange'. Significant work is being carried out in the bio-medical sector by several companies mainly from the academic medical sector. The intention of this study, however, is to consider the engineering perspective, particularly in the light of technological developments in both sectors. It is interesting to note that even within large multi-nationals, eg. Equipment manufacturers with separate operating divisions representing both the medical and engineering sector, there may be little cross-transfer of information. Work practices to be considered will include: in the Medical sector (Body) - veins, arteries, valves, pumps (heart), fluids, etc. and in the Oil & Gas industry (Petrochemical) - pipelines, risers, product flow, controls, pumps, etc.		
Expenditure for financial year	Internal £ 3k	Expenditure in	Internal £NA

<table>
<tr><td></td><td>External £ 9k
Total £12k</td><td>previous (IFI) financial years</td><td>External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£ 30k</td><td>Projected 08/09 costs for National Grid</td><td>NA</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">The techniques used by the engineering industry which could be of interest to this study include:
Fluid monitoring & control - continuous monitoring of product flow to ensure adequate and safe production and to determine chemical dosage requirements
3D finite element analysis
Sonar and seismic techniques for remote visualization
X-Rays, ultrasonic, tomography, various magnetic flux measurements and other non-intrusive techniques - to review defects, anomalies, etc.
Repair - insertion of repair systems either permanent or temporary, eg. lining of pipelines is now routine and remote wellbore patch techniques have been employed for several years
Replacement - valve, pump, pipeline, etc. subject to specification and production constraints; technology for remote replacement and repair are well developed
Booster - pumps and valves used to enhance flow
Tethered systems (pigs, ROVs, etc.) - for inspection & repair
Remote controlled systems (pigs) - for inspection & repair
Autonomous systems for inspection and data collection
Electronic recording of information for comparison purposes.</td></tr>
<tr><td>Type(s) of innovation involved</td><td>Tech Transfer</td><td colspan="2"><table><tr><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr><tr><td>5</td><td>0</td><td>5</td></tr></table></td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">This project addresses the strategic requirement to consider technology transfer between sectors. Potential benefits may accrue through technology transfer between sectors however this is currently indeterminate; the risks of failure are reduced through collaborating on the activity.</td></tr>
<tr><td>Expected timescale of project</td><td>1 Year</td><td>Duration of benefit once achieved</td><td>uncertain</td></tr>
<tr><td>Probability of success</td><td>10%</td><td>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="3">Benefits will ultimately be achieved through follow up work if successful – a project has been scoped out in the area of flow regime with Zentech and the University of Southampton. The project will extend the project into development of pipeline coatings with potential efficiency/loss reduction benefits.</td></tr>
</table>

Project progress to March 2008	The study has shown that there are current medical technologies that could benefit the engineering sector based on transfer of technology and adding value in line with the company objectives. The technologies were ranked based on our combined medical and engineering understanding. The following technologies were identified as having potential transfer potential: • Non-contact ultrasonics – this is an important area with gathering of data • Capsule inspection – the potential is very good but the maturity of the development is not high. • Though medical pumps are of great interest the relevance to the engineering sector is limited, however, the aspect that is of significant interest and potential is that of the 'Flow Regime' where the medical sector has addressed the issue of flow efficiency. Outline Execution Plans for the projects have been identified with key organisations in the areas of non-contact ultrasonics, capsule inspection and flow regime. There are many companies and university departments that could be suitable to assist in the development.
Collaborative partners	BG Group, ConocoPhillips (UK), Harefield Hospital
R&D provider	Zentech

11) <u>Reducing Environmental Impact from Venting</u>

Project title	Reducing Environmental Impact from Venting		
Project Engineer	Lilla Derby-Morris		
Description of project	This programme of works covers two projects looking at measuring fugitive gas from compressors and looking at the impacts of planned venting from National Grid transmission sites.		
Expenditure for financial year	Internal £ 6k External £89k **Total £95k**	Expenditure in previous (IFI) financial years	Internal £ NA External £ NA **Total £ NA**
Total project costs (collaborative + external + National Grid)	**£ 188K**	Projected 08/09 costs for National Grid	**TBC**
Technological area and/or issue addressed by project	The first of these projects will :- • Review and quantify (where possible) existing emissions information. Revisit historical data relating to fugitive emissions as measured using Advantica's FMD or ASV equipment and develop a high level inventory of methane emissions with the aim of targeting key sub-processes or hardware that will provide a "quick-win" in terms of emission reduction. • gain greater understanding of the extent of methane emissions at compressor stations and other Above Ground Installations (AGIs) with a view to improve the overall energy management at the sites. • undertake research into and develop mitigation strategies to reduce the level of methane emissions and thus lower the environmental impact of operations at our compressor stations The second project in this programme will assess the current methods and practices employed for the operational venting of high pressure (HP) gas on National Grid transmission sites including		

<table>
<tr><td></td><td colspan="4">compressor sites, terminals and AGIs.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>11</td><td>2</td><td>9</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">The benefits that are expected from the first of these projects are:-

• reduced energy use at the compressor sites
• improved environmental performance of compressor sites
• detailed understanding of methane emissions with a view to supporting PPC documentation and emissions trading via the EU ETS (stage 2)
• Cost avoidance on an estimated £2m fuel wastage.

From the second project National Grid is hoping that the work will produce a better understanding of the High Pressure venting practice at AGIs. This improved understanding will lead to more detailed knowledge of the noise and methane emissions, and of the environmental impact of these operations. Reduction in noise and emissions will have environmental benefits and will ensure compliance with environmental legislations including PPC, Statutory Nuisance and planning consents.</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>30%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£290k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">This programme of work has good potential for achieving the expected benefits as the work is not radical in nature and is looking for substitution of technology or incremental developments.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="4">For the first of the projects in this programme area, Stage 1 was 65% complete at the end of March 07 and has involved developing the optimum use of three techniques to measure the fugitive methane emissions from compressor station pipework.

The measurements are also being used to validate the modelling assumptions made in the PPC annual reports of fugitive methane tonnage.

Measurements have been undertaken at four compressor stations (Peterborough, Hatton, Wisbech and Huntingdon). The following measurement systems have been employed :

• Mobile laboratory utilising flame ionisation detection (FID) of methane and total hydrocarbons, restricted to making measurements from the roadways

• Handheld portable FID, with lower specification but able to provide better definition away from the roadways
• Fugitive emissions detector (high flow sampler)</td></tr>
</table>

	For the second of these projects Stage 1has been completed and a report on "Optimisation of High Pressure Venting on transmission sites has been issued. Stage 1 of this work involved determination of the quantities of gas vented from various assets (e.g. valves, filters, pigtraps, and compressor units) on the gas transmission system. The report also includes information on current practices, noise calculations and provides an introduction to technologies for gas capture and noise reduction. The report concluded that two or more technologies maybe necessary to cater for the wide range of vented volumes encountered and the geographic spread of the affected assets. The report also concluded that venting of gas, from compressor units in particular, should be given further consideration from an environmental methane emissions perspective.
Collaborative partners	
R&D provider	Advantica

12) <u>Impact of New Gas Sources on Pipelines</u>

Project title	Impact of New Gas Sources on Pipelines		
Project Engineer	Dave Mccollum		
Description of project	▪ To be able to understand fully the implications on pipeline fracture toughness when transporting LNG with high higher hydrocarbon content and to identify what mitigation measures need to be put in place to maintain current risk levels ▪ To be able to understand fully the implications on thermal radiation levels in the event of failure when transporting LNG with high higher hydrocarbon content and to be able to determine whether Building Proximity Distances need to be reset. ▪ To be able to understand fully the implications on LEL levels, gas detection, hazardous area zoning and joint leakage rates when transporting LNG with high higher hydrocarbon content		
Expenditure for financial year	Internal £ 3k External £12k Total **£15**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£ 92k**	Projected 08/09 costs for National Grid	**£ 33k**
Technological area and/or issue addressed by project	Research into fracture toughness of High Pressure pipelines when carrying natural gas with higher proportions of higher hydrocarbons. Gas from the LNG terminals at Milford Haven and Isle of Grain may contain higher levels of higher hydrocarbons (C2 and above) than the natural gas currently transported. Work by Advantica on the potential for fracture propagation has suggested that the presence of higher hydrocarbons can adversely affect fracture propagation in low toughness pipelines i.e. such pipelines may experience long running fractures on failure, which in turn has the potential to affect the safety risks associated with the pipeline. The change in gas composition will also have other effects such as different dispersion and fire characteristics. National Grid needs to understand the implications of these effects to determine whether gas entry specifications need to be changed to reduce risk		

Type(s) of innovation involved	Incremental	Project Benefits Rating	Project Residual Risk	**Overall Project Score**
		10	3	7
Expected benefits of project	Gas from the LNG terminals at Milford Haven or Isle of Grain may contain higher levels of higher hydrocarbons (C2 and above) than the natural gas currently transported. Work by Advantica on the potential for fracture propagation has suggested that the presence of higher hydrocarbons can adversely affect fracture propagation in low toughness pipelines which in turn has the potential to affect the safety risks associated with these pipelines. This initial study will attempt to quantify the potential effects on No 2 Feeder, No 7 Feeder, No 5 Feeder and on a local transmission system pipeline with low toughness properties to indicate whether remedial measures are necessary.			
Expected timescale of project	3 Years	Duration of benefit once achieved	5+ Years	
Probability of success	30%	Project NPV = (PV benefits – PV costs) x probability of success	£108k	
Potential for achieving expected benefits	The research will quantify the risk based on current knowledge and the risk will then be controlled within the boundaries of the ALARP assessment.			
Project progress to March 2008	The first stage of this project has identified a risk to Number 5 Feeder which appears to be not currently ALARP. The second stage of the project is to systematically check all pipelines within the network to check that no others fall within the low toughness category and to recommend a cost effective mitigation process for those pipelines at risk.			
Collaborative partners	Joint Project with National Grid UK Distribution			
R&D provider	Advantica			

13) Study of Pipe Flow Dynamic Loading

Project title	Study of Pipe Flow Dynamic Loading
Project Engineer	Brian Woodhouse
Description of project	The key objectives of this piece of work are: • Quantify vibration level due to turbulence induced vibration by validating experimental test results with in-service pipe line measurements • Assess the impact of turbulence induced vibration on the integrity of the network. • Create Computational Fluid Dynamics (CFD) prediction tool and transfer knowledge from Manchester University to Advantica by means of an Engineering Doctorate

<table>
<tr><td></td><td colspan="3"></td></tr>
<tr><td>Expenditure for financial year</td><td>Internal £ 0k
External £109k
Total £109k</td><td>Expenditure in previous (IFI) financial years</td><td>Internal £NA
External £NA
Total £NA</td></tr>
<tr><td>Total project costs (collaborative + external + National Grid)</td><td>£261k</td><td>Projected 08/09 costs for National Grid</td><td>£15k</td></tr>
<tr><td>Technological area and/or issue addressed by project</td><td colspan="3">There are a number of sites on the National Transmission System (NTS) where the main gas carrier pipe suffers from vibration caused by turbulence in the gas flow. Examples include St Fergus compressor station (Vibration evident at suction and discharge manifolds), Peterborough compressor station and Avonbridge Compressor Station.

In each case the most likely mechanism for the vibration is considered to be turbulence in the gas caused by bends and/or tee connections in the pipe causing dynamic loading on the pipe structure. This dynamic loading has the potential to excite modes of vibration of the pipe system to the extent that fatigue failures are a possibility.

It is known that the dynamic loading is highest at lower frequencies, and therefore it is preferable to make pipe supports stiff, so as to increase the natural frequency of the pipe system to a range where the applied loads are lower. However, very little information is available to the designer to quantify the magnitude of the applied loading and its variation with frequency. Furthermore, the sensitivity of changes to key influential parameters, such as the pipe bend radius and geometry of the tee, are uncertain.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10</td><td>2</td><td>8</td></tr>
<tr><td>Expected benefits of project</td><td colspan="3">Financial and security of supply – The immediate costs of pipe, repair and replacement and possible failure investigation are unknown, but relatively modest. The larger potential threat is the unavailability of the compressor and the associated risk to security of supply.

Safety & Environment – A pipe failure normally results in the release of large quantities of gas or into the compressor cab or atmosphere. Depending on the design of the cab, the gas may be contained within the cab. This represents a considerable environmental and safety problem. There is also a potential fire risk.

Compliance – Transco compliance with regulations such as PSSR and PSR will be improved by demonstrating active measures are being taken to eliminate failures.</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>20%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td>£270k</td></tr>
</table>

Potential for achieving expected benefits	Good
Project progress to March 2008	Report 6484 'Investigation into prediction of turbulent flow in natural gas pipework using CFD' was delivered to the client representative as a draft copy in May 2008. Initial comments have been addressed and awaiting confirmation of acceptance in order to issue final version. The objective of this project is to investigate the prediction of high Reynolds number turbulent flow in natural gas pipework using CFD. This is with the eventual aim of providing guidance for gas transmission installation design in order to reduce turbulence and vibration for critical pipework configurations. The recently completed report summarises the CFD modelling undertaken by University of Manchester to demonstrate the capabilities of the software code selected for simulating turbulent flow, through validation against the testing performed in the previous stage of the project at the Advantica Flow Centre in Bishop Auckland. This study also considered the effect of bend radius on the flow behaviour, and initial models of a pipe tee geometry and a series of closely spaced bends. Preliminary conclusions from this study have provided outline guidance regarding pipework design, and subsequent stages of work will be focused on detailed modelling of pipe tee geometries, coupled with additional experimental work for validation purposes. Techniques for predicting pipework structural dynamic response from calculated turbulence behaviour will then be explored, considering the capabilities of both research-derived codes and recent developments in commercial software. On completion of these activities, these methods will be used as a tool to develop guidance that can be applied during the design of pipework installations.
Collaborative partners	
R&D provider	Advantica

14) Gas Leak Detection in Gas Turbine Enclosures

Project title	Gas Leak Detection in Gas Turbine Enclosures		
Project Engineer	Dave Mccollum		
Description of project	To determine the effectiveness of ultrasonic gas leak detection systems for use in operational gas turbine enclosures. If effective, develop specification for use to improve early detection of gas leaks in compressor cabs.		
Expenditure for financial year	Internal £ 3k External £ 54k Total **£ 57k**	Expenditure in previous (IFI) financial years	Internal £NA External £NA Total **£NA**
Total project costs (collaborative + external + National Grid)	**£ 132k**	Projected 08/09 costs for National Grid	**£59k**
Technological area and/or issue addressed by project	The use of gas detectors based on the ultrasonic principle in gas turbine enclosures: Two current approaches to gas leak detection in National Grid compressor cabs are 'point sampling' and 'line of sight' detection systems. Both of these approaches are dependent on the gas concentration building up to a sufficient level within the detection		

<table>
<tr><td></td><td colspan="4">range of the sensors. Sampling points or sight lines must be numerous enough and carefully positioned if they are to cover all potential leak sites. Even then, cab ventilation patterns can lead to a build-up of gas concentration away from the actual leak site and/or dilute the gas concentration at chosen sampling points / lines of sight.</td></tr>
<tr><td rowspan="2">Type(s) of innovation involved</td><td rowspan="2">Incremental</td><td>Project Benefits Rating</td><td>Project Residual Risk</td><td>Overall Project Score</td></tr>
<tr><td>10</td><td>3</td><td>7</td></tr>
<tr><td>Expected benefits of project</td><td colspan="4">If the project is successful this technology will provide a means of gas detection that will offer operating safety benefits over catalytic or line of sight detectors. Current detectors in some cases cannot detect gas at the low levels now required in highly ventilated enclosures.

Installation of ultrasonic gas leak detection in NG compressor cabs has the potential to improve safety of operations and help to maintain the reputational momentum held by National Grid for using the most appropriate safety systems and processes in the management of natural gas as a fuel for gas turbines. Installation of ultrasonic gas leak detection in gas turbine enclosures on 3rd party power stations has the potential to allow National Grid to decommission odorisation plant that currently costs £250k pa for odorant.</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>35%</td><td>Project NPV = (PV benefits – PV costs) x probability of success</td><td colspan="2">£46k</td></tr>
<tr><td>Potential for achieving expected benefits</td><td colspan="4">The initial equipment trials have demonstrated that the ultrasonic devices have the potential to work in the environment, but it not yet clear their performance in the longer term will be able to discriminate from other noise sources.</td></tr>
<tr><td>Project progress to March 2008</td><td colspan="4">The initial market evaluation and trial of 2 devices has taken place in Peterborough Compressor Station. This proved in principle that the devices could cope with the background noise and were able to pick up the simulated gas leaks. However, further evaluation of the noise characteristics of different turbine types is required to ensure sufficient discrimination.</td></tr>
<tr><td>Collaborative partners</td><td colspan="4">None</td></tr>
<tr><td>R&D provider</td><td colspan="4">Advantica</td></tr>
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