CE Electric UK

2005/06 IFI Annual Report

July 2006

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Executive summary

1. This report has been prepared by CE Electric UK Funding Company Ltd (CE) to inform interested parties of the activities of its licensees, Yorkshire Electricity Distribution plc (YEDL) and Northern Electric Distribution Ltd (NEDL), on innovation. It has been prepared in accordance with standard condition 51 of the electricity distribution licence, the associated regulatory instructions and guidance (published by Ofgem) and the Energy Networks Association (ENA) Engineering Recommendation (ER) G85 (the Good Practice Guide).

2. The reporting period (1 April 2005 - 31 March 2006) remained dominated by a slow build-up, as we strove to mobilise projects. Specifically, we aim to work collaboratively wherever possible, which has led to inevitable delays relating to the agreement of commercial contracts and project terms of reference.

3. The key projects in CE Electric during the reporting period are:

   - a novel specification to replace Woodhouse steel girder mast overhead lines,
   - an EHV overhead line CBRM survey using new high-resolution digital imaging techniques;
   - trialling fault passage indicators with GSM modems; and
   - the development of a superconducting fault limiter.

4. It is also worth noting that we have committed some £23,375 of engineering resource to support the DTI Technology Programme and the activities of the Electricity Networks Steering Group (ENSG). We hold this work to be of national importance: however, it is equally clear that committing this much resource to developing R&D contracts let directly by us would have led to significantly higher expenditure than reported here.

5. Qualifying spend for the period has been £185,733 and £278,600 for NEDL and YEDL respectively, of which £27,860 and £41,790 relates to internal costs. This total eligible spend of £464,333 compares with £99,588 for the six months to 31 March 2005. Overall, this gives a total for the eighteen months of £563,921, which we shall submit as a claim in our 2005/06 price control revenue return under standard condition 50 of the distribution licence.

6. There remains a delicate balance in taking work forward, between either:

   - exploiting the existing ENA and EATL STP frameworks or alternative collaborative forums, where the need for consensus extends the process but collaborative specification and support will improve the finished product; and
   - proceeding on our own, where we can commission more quickly but would lose some of the up-front benefits of collaboration.

Introduction

7. This report has been prepared by CE Electric UK Funding Company Ltd (CE) to inform interested parties of the activities of its licensees, Yorkshire Electricity Distribution plc (YEDL) and Northern Electric Distribution Ltd (NEDL), on innovation. It covers the period from 1 April 2005 to 31 March 2006.

8. A single report has been prepared because both licensees are operated under common management, sharing best practice across the whole. Research and development is no exception, and we draw no arbitrary distinction between innovation carried out for the two licensees. Projects and programmes are therefore discussed only once. Finally, the report breaks out the relevant expenditure by licensee to support regulatory reporting requirements. This section takes an eighteen-month view, from 1 October 2004.

9. The report focuses upon research and development work eligible for Ofgem's innovation funding incentive (IFI). The IFI is intended to provide funding for projects focused on the technical development of distribution networks, up to and including 132 kV, to deliver value (i.e. financial, supply quality, environmental, safety) to end consumers. IFI projects can embrace any aspect of distribution system asset management from design through to construction, commissioning, operation, maintenance and decommissioning.

10. In this context, 'technical' requires both that there is a significant engineering intellectual content and that projects involve load-carrying assets or their control and electrical protection.

11. The report has been prepared in accordance with standard condition 51 of the electricity distribution licence, the associated regulatory instructions and guidance (RIGs) and the Energy Networks Association (ENA) Engineering Recommendation (ER) G85 (the Good Practice Guide (GPG)), which states:

3.4 Annual Regulatory Reporting Requirements for IFI Projects

Ofgem requires a report to be published annually (i.e. by no later than the 31 July immediately following the end of the reporting year as required by the RIGs) by each distributor on its IFI [Innovation Funding Incentive] project activity…distributors will normally be required to provide the following information at the end of the reporting year and by no later than the immediately following 30 June [sic]:

• IFI budget carry-forward

• eligible IFI expenditure

• eligible IFI internal expenditure

• combined distribution network revenue

• the IFI annual report.

The minimum level of accuracy required when reporting to Ofgem is as follows:

• IFI carry- forward nearest £1k

• eligible IFI expenditure nearest £1k

• eligible IFI internal expenditure nearest £1k

• combined distribution network revenue nearest £0.1m

The IFI annual report will describe the IFI projects for which the distributor has incurred expenditure. The report should provide a summary of IFI project activities and details of costs and anticipated benefits of individual projects. A distributor may undertake one or more discrete programmes of IFI projects that are best grouped together to ease administration and reduce overheads. For each such programme a

de minimis level of expenditure by an individual distributor of £40k per programme will apply. Individual projects with an annual expenditure below this level may be aggregated and reported as a programme…

12. The programmes and major projects that will be discussed in this report are:

- CE's internal innovation programme;
- externally-driven activities, including:
  - the DTI/Ofgem Energy Networks Strategy Group (ENSG) and subsidiary workstreams;
  - the DTI Technology Programme; and
  - the IEE Technical Architecture project, whose work has now been taken up under ENSG;
- the EA Technology Limited (EATL) Strategic Technology Programme (STP) module 2 (overhead networks);
- EATL STP module 3 (cables);
- EATL STP module 4 (substations);
- EATL STP module 5 (distributed generation) (DG);
- the Energy Networks Association (ENA) R&D working group (covering relevant activities of the ENA Operations and Systems Group (OSG) and Approvals and Standards Group (ASG));
- ASL superconducting fault limiter;
- remote fault passage indicators;
- condition-based risk management using helicopter inspections; and
- Woodhouse steel girder mast replacement specification.

13. As permitted by the GPG, this report aggregates portfolios of projects under the STP and work for DTI.

Registered Power Zones

14. Registered Power Zones (RPZs) are intended to encourage distributors to develop and demonstrate new, more cost-effective ways of connecting and operating generation that will deliver specific benefits to new distributed generators and broader benefits to consumers generally. The RPZ mechanism provides for an enhanced rate of return for distributors, by extending the general generation funding mechanism recently introduced by Ofgem.

15. We remain committed to developing an RPZ in the YEDL or NEDL networks, subject to delivering tangible benefits to customers and shareholders. We have actively supported the DTI-funded RPZ feasibility study carried out by Econnect and NaREC. That study concluded that there were few viable opportunities for RPZs, not least due to the practicalities of customer need and system need coinciding.

16. Nevertheless, we remain vigilant, and have reviewed a number of opportunities during the year, including:

- the potential for active management of constraints on the existing system to facilitate more efficient generator connections by avoiding reinforcement.
- the potential for active management of constraints on system extensions to facilitate more efficient generator connections by reducing the amount of new infrastructure required.

- demand to be secured by adjacent high load-factor generation, avoiding substantial reinforcement.
- connecting controllable generation to an existing feeder dominated by export from an existing wind farm, to 'fill in' low export periods and avoid the need for reinforcement.

17. Each of these opportunities (and we have had several in each basket) has arisen from genuine customer enquiries. None has been developed speculatively, on the basis that an opportunity might arise on the network. However, each has failed due to a combination of lack of customer commitment and unfavourable economics: conventional solutions are simply often more economic.

Externally-driven activities

18. This section considers those projects driven by bodies outside the distribution sector where, although we have the choice as to whether or not we become involved, they fall outside our direct governance. We are, therefore, effectively unpaid sub-contractors. Following discussion with Ofgem it was accepted that these costs for labour supplied to DTI & ENSG projects will be recorded as external costs.

ENSG and subsidiary work streams

<table>
<tr><td>Description of project</td><td colspan="5">ENSG – DWG
DGCG – TSG</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£18,875</td><td>£18,875</td><td>£0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The Electricity Networks Strategy Group (ENSG) provides advice to DTI, Ofgem, Defra, the Scottish Executive and the Welsh Assembly on issues associated with the development of the electricity distribution and transmission networks. The ENSG has a number of sub-groups, the Distribution Working Group (DWG) and the Transmission Working Group (TWG).

The Distribution Working Group (DWG) continues the work of the earlier Distributed Generation Coordinating Group's (DGCG) Technical Steering Group (TSG), examining the issues to enable the integration of generation onto the distribution network. The DWG manages four work programme areas and CE Electric have been actively involved in three out of four of the current modules, as follows:

Work Programme 01: Horizon Scanning

To assess the current state of technology, likely developments, R&D progress, actual and forecast trends in penetration levels and future scenarios, regulatory and political policy to guide and formulate the programmes of work that would commence in approximately 18-24 months' time, on a rolling basis.

Work Programme 02: Network Design for a Low-Carbon Economy

To evaluate the technology, tools, techniques, processes and standards that would be required to construct power systems compatible with the developing trends in low-carbon energy technology.

Work Programme 03: Enabling Active Network Management

Developing the technologies, protocols, tools, processes, techniques and standards that would be needed to ensure that low-carbon</td></tr>
</table>

	compliant power systems could be operated on an active basis to ensure efficient use of investment and an effective contribution from potential market participants. In addition to the DWG projects, CE Electric also contributed to TSG work streams 3 & 5 within this reporting period. This work is now being continued by the DWG projects. **TSG Work Stream 3 Short-Term Solutions.** The purpose of this work stream was to address technical, regulatory and commercial network issues pertaining to achieving greater use by DNOs of basic active management, and thus providing an early transition path to active networks. It aims also to identify short-term measures under the existing security standards to allow fuller recognition of the contribution of distributed generation to network security and performance. **TSG Work Stream 5 Long-Term Network Concepts and Options** This work stream addressed technical, regulatory and commercial issues pertaining to the longer-term transformation of distribution networks in order to facilitate distributed generation deployment. During this reporting period 62% of the total costs incurred in this area actually came from work on TSG, rather than DWG, projects.
Type(s) of innovation involved	Significant / Technological Substitution / Radical
Expected benefits of project	DTI/Ofgem have not published a PV benefit for the DWG/TSG projects. We have modelled a cost/benefit ratio for the DTI Technology Programme, then assumed that this should also apply to CE Electric investment.
Expected timescale to adoption	2-10 years, dependent on projects.
Estimated success probability (at start of project)	Estimated 25%

PV of project costs	£17,657	PV of project benefits	£35,313
Commentary on project progress and potential for achieving expected benefits	the programme is at an early stage, with projects in the course of mobilisation		

DTI Technology Programme

<table>
<tr><td>Description of project</td><td colspan="5">DTI Technology Programme</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£4500</td><td>£4500</td><td>£0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The Technology Programme is a crucial part of the government's Science and Innovation Investment Framework - £370 million over three years (2005-2008) to support companies by sharing some of the financial risk of their medium to long-term investments in technology. Below is a list of some of the projects that CE Electric have been involved with on a consultancy basis.
Econnect islanding
Energy-free Edmondsley
DTI: NaREC/Econnect RPZ
Newcastle heat pipes
DTI: Northumbria/Econnect LV controller</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Significant / Technological Substitution / Radical</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">DTI have not published a PV benefit for the Technology Programme. We have modelled a cost/benefit ratio, then assumed that this should also apply to CE Electric investment.</td></tr>
<tr><td>Expected timescale to adoption</td><td colspan="5">2-10 years, dependent on projects.</td></tr>
<tr><td>Estimated success probability (at start of project)</td><td colspan="5">Estimated 25%</td></tr>
<tr><td>PV of project costs</td><td colspan="2">£4,210</td><td>PV of project benefits</td><td colspan="2">£8,419</td></tr>
</table>

EATL STP module 2 (overhead networks)

<table>
<tr><td>Description of project</td><td colspan="5">Strategic Technology Programme Overhead Network Module</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£36,875</td><td>£36,000</td><td>£875</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The STP overhead network programme for budget year 2005/06 aimed to reduce costs and improve performance of overhead networks by increasing understanding of issues that have a negative impact on costs and performance. The programme is expected also to have a positive impact on safety and environmental performance. The projects all address real problems that have been identified by the module steering group members as significant and that require technical investigation and development.

The projects within the programme aimed to:
• S2126_2 - Undertake long-term monitoring of conductor temperature by obtaining and analysing 12 months' trial data.
• S2132 - Validate current and proposed new ice accretion models.
• S2133 - Investigate the use of sacrificial anodes for protecting tower foundations to defer or remove the need for full foundation refurbishment.
• S2134_1 - Determine the susceptibility of currently used surge arresters to the principal modes of failure.
• S2135 - Evaluate the life expectancy of copper conductors.
• S2136 - Participate in European project COST 727: measuring and forecasting atmospheric icing on structures.
• S2138_1 - Investigate live-line jumper-cutting limitations. Stage 2 is to define a realistic experimental programme.
• S2139 - Evaluate a new corona discharge camera system.
• S2140 - Explore possible means of checking the foundations of</td></tr>
</table>

	newly installed poles.		
Type(s) of innovation involved	Technical Substitution / Radical		
Expected benefits of project	Due to the age profile of system equipment it is inevitable that, unless significant new technology is used to extend asset life, CAPEX and possibly OPEX will need to increase significantly to maintain the present level of network reliability and safety. If these projects are technically successful and the findings and recommendations from the projects are implemented, the projects will potentially enable each DNO member of the programme to gain benefits including: • avoid redesign, reconstruction or refurbishment of overhead lines where this is driven by a perceived need to increase ratings or strengthen lines, and is required to conform with existing standards but which may be unnecessary; • reduce levels of premature failure of assets; • provide more cost-effective and early identification of damaged insulators and discharging components, which if not addressed would result in faults; • confidently extend the service life of towers and reduce potential levels of tower failures; and • reduce lifetime costs by the appropriate use of alternative materials.		
Expected timescale to adoption	Range 1-7 years - dependent on project	Duration of benefit once achieved	Range 2-10 years - dependent on project
Estimated success probability (at start of project)	Range 5-20% - dependent on project		
PV of project costs	£34,495 (nb. This is	PV of project benefits	£54,643

	identified early-stage cost. It does not reflect the likely full costs of implementation. These will be identified providing the outcome of the early stage is positive.)		
Commentary on project progress and potential for achieving expected benefits	Some projects within the programme are at an early stage, whilst others are complete. Issues have been identified relating to both operational and capital expenditure which, if successfully addressed, would enable the expected benefits to be achieved. • *S2126_2 - Undertake long-term monitoring of conductor temperature by obtaining and analysing 12 months' trial data.* The trial is continuing with the expectation that the results will indicate it should be possible to re-rate (up-rate) some overhead line circuits in certain circumstances. • *S2132 - Validate current ice accretion models.* The data currently being collected will be used to revise national overhead line design standards. • *S2133 - Investigate the use of sacrificial anodes for protecting tower foundations to defer or remove the need for full foundation refurbishment.* A practical reference document has been produced to assist in the application and specification of such devices • *S2134_1 - Determine the susceptibility of currently used surge arresters to the principal modes of failure.* The findings provide a review of the capabilities of a range of surge arresters, allowing informed and more cost-effective specification of these devices. • *S2135 - Evaluate the life expectancy of copper conductors.* The results of initial laboratory testing of samples of varying age provided from UK distribution networks will be available shortly. They should allow an initial assessment of the overall condition of copper-based conductors to be made.		

	• *S2136 - Measuring and forecasting atmospheric icing on structures.* This is part of a much larger European collaborative project aiming to provide more accurate mapping of ice-prone areas. This in turn will allow the most appropriate structure to be constructed. • *S2138_1 - Investigate live-line jumper-cutting limitations.* Controlled testing regime has been specified and this should lead to improved working practices being adopted. • *S2139 Begin to evaluate a new corona discharge camera system.* This project is at a very early stage. • *S2140 Explore possible means of checking the foundations of newly installed poles.* An initial review of worldwide practice and commercially available techniques has begun.

EATL STP module 3 (cables)

<table>
<tr><td>Description of project</td><td colspan="5">Strategic Technology Programme Cable Networks Module</td></tr>
<tr><td rowspan="2">Expenditure for financial year 2005/06</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£19,300</td></tr>
<tr><td>£37,574</td><td>£35,924</td><td>£1,650</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The STP cable network programme for budget year 2005/06 aimed at identifying and developing opportunities to reduce the costs of owning cable networks. The reduction of whole-life cost through greater reliability and improved performance of cables and associated accessories comes under the remit of module 3. Where appropriate module 3 worked with other modules to achieve common goals. Eight new projects were approved during the year (shown in bold below).

The projects undertaken within the programme during 2005-06 (including some approved in previous years) aimed to:
• S3100_2 – Define better functional requirements for link boxes.
• S3108_2 – Produce software for assessing earthing practice on PME systems.
• S3115 – Determine the corrosion resistance of aluminium foil cables.
• S3120 – Assess novel flame retardant coatings for cables in basements.
• S3121 - Produce a cable fluid sniffer stage 1(b) feasibility study.
• S3123 – Produce a guide and specify functional requirements for the selection of cable ducts.
• S3125 - Assess new degreasing products for MV and LV cables.
• S3126 - Explore issues associated with the use of polyurethane and development of alternative jointing</td></tr>
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	resins. • S3131 – Produce a summary of CIGRE issues relating to HV cables. • S3113_2 - Addition of duct bank modelling functionality within CRATER cable rating software. • S3113_3 - Addition of paper cable modelling within CRATER cable rating product. • S3132_1 - Addition of HV polymeric cable modelling functionality within CRATER cable rating software. • S3132_2 - Addition of LV cable modelling functionality within CRATER cable rating software. • S3132_3 - Addition of cyclic and emergency rating modelling functionality within CRATER cable rating software. • **S3132_4 - Addition of limited time rating of mixed-circuit modelling functionality within CRATER cable rating software.** • **S3132_5 - CRATER cable rating software, overview report.** • **S3132_6 - Addition of single-core MV paper cable modelling functionality within CRATER cable rating software.** • **S3132_7 - Addition of cable crossing modelling functionality within CRATER cable rating software.** • **S3140_1 – produce a spreadsheet tool for pulling-in of cables into ducts.** • **S3144_1 – Evaluate the Hydragel process for the treatment of redundant fluid filled cables.**
Type(s) of innovation involved	Technical Substitution / Radical
Expected benefits of project	If the projects are technically successful and the findings and recommendations from the projects are implemented, then the projects will potentially enable each DNO member of the programme to gain benefits including: • offset future increases in CAPEX and OPEX; • savings of the order of 0.25 CML per connected customer;

	• increased safety of staff and public by reducing the number of accidents / incidents.		
Expected timescale to adoption	Range 1-5 years - dependent on project	Duration of benefit once achieved	Range 2-10 years - dependent on project
Estimated success probability (at start of project)	Range 2-30% - dependent on project		
PV of project costs	£35,149 (nb. This is identified early-stage cost. It does not reflect the likely full costs of implementation. These will be identified providing the outcome of the early stage is positive.)	PV of project benefits	£59,521
Commentary on project progress and potential for achieving expected benefits	Some projects within the programme are at an early stage, whilst others are complete. Issues have been identified relating to both operational and capital expenditure which, if successfully addressed, would enable the expected benefits to be achieved. • *S3100_2 – Define better functional requirements for link boxes.* A document that defines functional requirements for LV link boxes has been produced for member companies. Previously such a document did not exist. • *S3108_2 – Produce software for assessing earthing practice on PME systems.* An assessment tool has been produced for earthing practice on PME systems that evaluates the compliance with regulations and practices and carries out a check of LV cable circuit design. • *S3115 – Determine corrosion resistance of aluminium foil*		

	cables. Tests have shown that corrosion of the laminated aluminium foil sheath is likely if the outer sheath of the cable is damaged leading to moisture penetration to the cable core. • *S3120 – Asses novel flame retardant coatings for cables in basements.* Findings recommended the use of a system consisting of a water-based intumescent coating and an associated water-resistant topcoat. This should give valuable long-term fire protection to polyethylene-sheathed cables in basements and substations. • *S3121 - Produce cable fluid sniffer stage 1(b) feasibility study.* Laboratory familiarisation has been carried out and field trials are being undertaken. • *S3123 – Produce guide and specify functional requirements for the selection of cable ducts.* A report giving some advice on the use of plastic ducts in heavily loaded circuits has been produced. • *S3125 - Asses new degreasing products for MV and LV cables.* The project defined a suitable wet-wipe that will ensure satisfactory cleaning of LV, MV and HV cables without adversely affecting their performance. • *S3126 - Explore issues associated with the use of polyurethane and development of alternative jointing resins.* The project concluded that, under current legislation, and provided employers comply with the requirements of the COSHH Regulations, the continued use of polyurethane resin systems is acceptable. Alternative systems are available, but currently more expensive than polyurethane resins. • *S3131 – Produce summary of CIGRE issues relating to HV cables.* An extensive report (140 pages) provides a comprehensive picture of work carried out by Cigré over the past 5 years, as well that currently underway and some that is planned. This places the work of the module in an international context. • *S3113_2 - Addition of duct bank modelling functionality within CRATER cable rating software.* The spreadsheet produced is a valuable tool for cable engineers. It ensures correct rating of

	cables installed in non-standard ducts and conditions. • *S3113_3 - Addition of paper cable modelling functionality within CRATER cable rating software.* A user-friendly spreadsheet tool for the cable engineer was created to determine sustained, cyclic and distribution current ratings for MV paper cable ratings, using approved methods of calculation. • *S3132_1 - Addition of HV polymeric cable modelling functionality within CRATER cable rating software.* A user-friendly spreadsheet tool for the cable engineer was created to determine sustained, cyclic and distribution current ratings for HV polymeric cable ratings, using approved methods of calculation. • *S3132_2 - Addition of LV cable modelling functionality within CRATER cable rating software.* A user-friendly spreadsheet tool for the cable engineer was created to determine sustained, cyclic and distribution current ratings for LV cable ratings, using approved methods of calculation. • *S3132_3 - Addition of cyclic and emergency rating modelling functionality within CRATER cable rating software.* A user-friendly spreadsheet tool for the cable engineer was created to determine cyclic and emergency current ratings for most practical mixed-circuit problems. • *S3132_4 – Addition of limited time rating of mixed-circuit modelling functionality within CRATER cable rating software.* The basic functionality is now incorporated into CRATER and operation with grouped circuits is being developed. • *S3132_5 - CRATER cable rating software, overview report.* The report, which is in preparation, will cover a range of practical applications for CRATER. The intention is that the report will form a handy reference to be used in conjunction with the basic operating manuals. • *S3132_6 - Addition of single-core MV paper cable modelling functionality within CRATER cable rating software.* Preliminary scoping work has been carried out and a questionnaire sent out to ascertain user requirements. • *S3132_7 - Addition of cable crossing modelling functionality*

	within CRATER cable rating software. The method for calculating ratings of cable crossings has been established and development work is ongoing. • *S3140_1 – Produce a spreadsheet tool for pulling-in of cables into ducts.* Proprietary software is being evaluated for this project, which is at an early stage. • *S3144_1 – Evaluate the Hydragel process for the treatment of redundant fluid-filled cables.* Information has been collected on the two available processes and further information is being gathered from members.

EATL STP module 4 (substations)

<table>
<tr><td>Description of project</td><td colspan="5">Strategic Technology Programme Substation Module</td></tr>
<tr><td rowspan="2">Expenditure for financial year 2005-06</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£24,850</td></tr>
<tr><td>£40,500</td><td>£36,000</td><td>£4,500</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Issues with the age profile of substation assets within the UK electricity distribution system are well known. Also, both regulatory and shareholder pressures preclude substantial investments on the large scale that was seen in the 1950s to 1970s. The challenge is to constantly review and innovate to produce new solutions to monitor and define asset condition, thereby allowing risks to be clearly defined and sound investment decisions to be taken

The programme of projects that were approved for funding from the STP substations module budget and were undertaken in 2005/06 encompass both developing new innovative asset management processes and practices and developing innovative diagnostic techniques. The aim is to develop already well established themes such as life extension of aged assets within legal and heath and safety constraints; examination of new technologies; developing an understanding of, and innovative solutions for, the impact on substation assets of increasing levels of distributed generation on networks; and condition-monitoring techniques.

Eighteen new projects were approved during the year (shown in bold below). The projects undertaken within the programme during 2005-06 (including some approved in previous years) aimed to:

<u>In-progress projects</u>
• S0499 - Extend the TASA tap-changer diagnostic trial.
• S4107_2 – Field test on a sample of switchgear, using the headspace gas-testing technique to indicate the condition of oil-filled switchgear
• S4180 – Develop an indicator to detect discharge activity in</td></tr>
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	substations. • **S4172 – Follow-up of S0455 paint preparation for tanks to determine the longer-term performance of the technique.** • **S4173 – Enhance the transformer thermal rating assessment system.** • **S4178 – Testing and management of substation standby batteries.** • **S4181 – Ongoing programme of transformer post-mortems to provide better correlation between condition assessment tests, true condition and remaining life.** • **S4182 – Develop a better understanding of frequency response analysis of transformers.** • **S4186 – Study of PM cast resin VTs.** • **S4188_1 – Assess replacement insulator grease.** • **S4189_1 – Examine substation noise.** • **S4190_1 - Review of pad-mounted substations.** • **S4193_1 - Develop a common approach to risk and reliability.** <u>Completed Projects</u> • S0497 – Transformer post-mortems to assist estimation of remaining life from non-invasive tests. • **S4130_4 – Assess wipes for HV oil-filled equipment.** • S4149 - Assess the quality, performance and longevity of recent substation equipment. • S4155 - Investigate ester-based insulating oils. • S4162 – Extend the range of non-intrusive PD for > 90kV switchgear. • S4164 – Feasibility study into on-line tap-changer monitoring. • S4167 – Improve CBRM by use of better understanding of degradation processes. • **S4172 – Scoping studies on transformer refurbishment, fault passage indicators, out-of-phase switching and fire legislation for substations.** • **S4174 - Compare a range of power system protection software.** • **S4175 – Assess circuit breaker cleaning techniques and materials.**

	• **S4176 – Compare available earth testing instruments.** • **S4179 - Explore in-situ testing of vacuum interrupters.** • **S4187_1 – Hold a risk modelling workshop.**		
Type(s) of innovation involved	Incremental / Significant / Technological Substitution / Radical		
Expected benefits of project	Due to the age profile of the current system assets it is inevitable that, unless significant new technology is used to extend asset life, CAPEX and possibly OPEX will need to increase significantly to maintain the present level of network reliability and safety. If the projects are technically successful and the findings and recommendations from the projects are implemented, the projects will potentially enable each DNO member of the programme to gain benefits including: • Offset future increases in CAPEX and OPEX; • Increased safety of staff and public by reducing the number of accidents/incidents; and • Both preventing disruptive failures of oil-filled equipment to reduce land contamination and avoiding unnecessary scrapping of serviceable components will alleviate environmental impact.		
Expected timescale to adoption	1-5 years - dependent on project	Duration of benefit once achieved	2-7 years - dependent on project
Estimated success probability (at start of project)	1-20% - dependent on project		
PV of project costs	£37,886 (nb. This is identified early stage-cost. It does not reflect the likely full costs of implementation. These will be identified providing	PV of project benefits	£64,168

	the outcome of the early stage is positive.)		
Commentary on project progress and potential for achieving expected benefits	Some projects within the programme are at an early stage, whilst others are complete. Issues have been identified relating to both operational and capital expenditure which, if successfully addressed, would enable the expected benefits to be achieved. <u>In-progress projects</u> • S0499 - *Extend the TASA tap-changer diagnostic* trial. The original trial had a low sample population and this work aims to increase the sample size. If earlier results are confirmed then the technique offers the potential for non-invasive condition assessment of tapchangers, with consequent improvements in network performance due to avoided failures and reduced OPEX from better targeted maintenance. • S4107_2 - *Headspace gas testing of oil-filled switchgear using gas chromatography in conjunction with mass spectrometry.* Working closely with members, the project aims to collect headspace gas samples from units within the field and resolve any issues. If correlation is successful, the project offers the prospect of targeted maintenance and reduction of invasive inspections. • S4180 – *Develop an indicator to detect discharge activity in substations*. Results suggest the device in its present form cannot reliably detect/indicate discharge activity in many substation environments. This development will not be pursued within STP, but related trials of an electronic NO_x detector are being undertaken by the Discharge User Group. • *S4172 – Follow-up of S0455 surface preparation of tanks.* The performance of the paint systems is being reviewed as a follow-up to earlier work. • *S4173 – Enhance transformer thermal rating assessment system.* This project is to re-develop the current transformer thermal rating software to enable members to assess BSP Transformer safe loading limits. • *S4178 – Testing and management of substation standby batteries.* The project aims to assess the effectiveness of battery		

	impedance testing methods to replace traditional discharge testing. • *S4181 – Ongoing programme of transformer post-mortems.* Further work in this area to build on the good results obtained in an earlier project, where a good correlation between non-invasive tests and internal examinations had been shown. • *S4182 – Understanding frequency response analysis.* Frequency response analysis is a potentially useful condition assessment technique that can be significant in identifying and defining end of life for grid and primary transformers. Initial tests have produced some good results. • *S4186 – Study of PM cast resin VTs.* Members are completing an issues questionnaire and testing regimes are being developed. • *S4188_1 – Assess replacement insulator grease.* The project is to compare the performance of Insojell grease with its proposed replacement, Dow Corning 3099 HVIC, by performing a number of pre-specified accelerated aging tests. • *S4189_1 – Examine substation noise.* The project is investigating and clarifying the issues surrounding substation noise and will develop a common, agreed framework to enable members to assess noise issues and take appropriate actions. • *S4190_1 - Review of pad-mounted substations.* The project will provide an overview of members' experience and identify any issues that may be arising through changing legislation. • *S4193_1 - Develop a common approach to risk and reliability.* The objective of this initial stage of work is to quantify the information requirements and determine its availability. An outline of the approach to be adopted has been produced and is currently being refined. <u>Completed projects</u> • *S0497 – Transformer post-mortems to assist estimation of remaining life from non-invasive tests.* A good correlation between non-invasive tests and internal examinations has been shown. This will assist in interpreting ongoing non-invasive testing of other transformers. • *S4130_4 – Assess wipes for HV oil-filled equipment.* Final development and testing of a new 3rd party high-performance wipe, which was specially developed to the specification that was

	developed in early stages of the project, was undertaken. This is now a product available for members. • *S4149 - Assess the quality, performance and longevity of recent substation equipment.* An analysis of failure rates and reliability of modern substation equipment was undertaken and has highlighted a number of issues that warrant further investigation. • *S4155 - Investigate ester-based insulating oils.* The project concluded that both natural and synthetic ester oils offer advantages over mineral oil in terms of biodegradability and electrical performance, although oxidation stability and viscosity are poor. • *S4162 – Extend the range of non-intrusive PD for use on > 90kV switchgear.* The work identified the population of equipment suitable for PD testing, concluding that some types would benefit from such testing. • *S4164 – Feasibility study into on-line tap-changer monitoring.* The project concluded that it is possible to consistently characterise the operation of such devices using acoustic emissions techniques. • *S4167 – Improve CBRM by use of better understanding of degradation processes.* Mathematical models of asset ageing have been refined and calibrated in order to improve the accuracy of CBRM results. • *S4172 – Scoping studies on transformer refurbishment, fault passage indicators, out-of-phase switching and fire legislation for substations.* A series of short projects have been carried out that allowed specific issues to be examined before deciding if a larger project in that area is appropriate. • *S4174 - Compare a range of power system protection software.* The available power system protection software was ranked in terms of its functionality, cost and ease of use. This will be used to assist members in making informed decisions. • *S4175 – Assess circuit breaker cleaning techniques and materials.* This project assessed different techniques and materials for cleaning circuit breaker contacts. A number of materials have been recommended, together with a working practice. • *S4176 – Compare available earth testing instruments.* The

	project examined the operation of a number of simple clamp-on instruments and compared their effectiveness. The results showed that several instruments were quite inaccurate and could give misleading results. • *S4179 - Explore testing of vacuum interrupters.* The project investigated current and alternative methods of testing vacuum interrupters. It concluded that routine loss of vacuum testing would provide little benefit. It would be more appropriate to determine "at risk" interrupters and inspect these more frequently. • *S4187_1 – Hold a risk modelling workshop.* A workshop for members and experts to discuss risk quantification was held. The objective of the workshop was to define a practical risk framework as developed in the CBRM process.

EATL STP module 5 (DG)

<table>
<tr><td>Description of project</td><td colspan="5">Strategic Technology Programme Distributed Generation Module</td></tr>
<tr><td rowspan="2">Expenditure for financial year 2005/6</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£20,300</td></tr>
<tr><td>£44,286</td><td>£36,286</td><td>£8,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The projects undertaken through budget year 2005/06 were aimed at enabling cost-effective connections and ensuring techniques are in place to plan, operate and manage networks with significant amounts of generation. Most projects also had positive impacts on safety and environmental performance. The projects all addressed real problems that had been identified by the module steering group members as significant and which required technical investigation and development.

Fourteen new project stages were approved during the year (shown in bold below).

The projects undertaken within the programme during 2005-06 (including some approved in previous years) aimed to:

<u>Projects in progress</u>
• S5138 – Review of industry codes
• S5147_3 – Monitor microgenerator clusters
• S5149_4 – Explore active voltage control
• S5150_2 – Review G59/1 and G75 protection and identify improvements
• S5151_3 – Model network risk
• S5142 – Define generator data and structure for DG connection applications
• S5154_1 – Develop a voltage control policy assessment tool on the IPSA platform
• S5155_1 – Explore lower cost connection solutions for distributed generation
• S5157_1 – Evaluate the performance of small scale reactive power compensators</td></tr>
</table>

	Completed project stages • S5144 – Workshop on regulatory and economic issues • S5145 – Dynamic circuit ratings • S5147_1 - Microgeneration clusters • S5149_1 - Active voltage control • S5150 Stage 1 – G59 and G75 protection • S5151_1– Network risk modelling • **S5133 – Tapchangers reverse power capabilities** • **S5143 – Produce a draft code of practice on stability** • **S5149 Stages 2 & 3 - active voltage control** • **S5151 Stage 2 – network risk modelling** • **S5152_1 – Examine the latest developments in the connection of distributed generation**
Type(s) of innovation involved	Incremental / Significant / Technological Substitution
Expected benefits of project	With government policy driving significant increases in generation connections to distribution networks, the members need a range of innovative solutions to connection and network operation issues that are cost effective and that maintain the present level of network reliability and safety. If the findings and recommendations from the projects are implemented, the projects will potentially enable each DNO member of the programme to gain benefits including: • Reducing the probability of voltage supply limit excursions resulting from increased distributed generation (eaVCAT interface to IPSA software tool); • Improving quality of supply and reducing risk of component failure (by understanding the effect and optimising use of impedance in the system); • A better understanding of the risk presented by the distribution assets when considered as a network rather than discrete components; • Greater use of distributed generators to meet current DNO obligations (by assessing, from a DNO perspective, the

	implications of pending Distribution Code provisions relating to distributed generation); and • Reducing the amount of reinforcement needed (by use of dynamic ratings to allow network components to be used to their full capability) - the use of dynamic circuit ratings is a vital step in the move towards active management of networks.		
Expected timescale to adoption	1-5 years - dependent on project	Duration of benefit once achieved	1-5 years - dependent on project
Estimated success probability (at start of project)	5-25% - dependent on project		
PV of project costs	£41,427 (nb. This is identified early-stage cost. It does not reflect the likely full costs of implementation. These will be identified providing the outcome of the early stage is positive.)	PV of project benefits	£57,104
Commentary on project progress and potential for achieving expected benefits	Some projects within the programme are at an early stage, whilst others are complete. Issues have been identified relating to both operational and capital expenditure which, if successfully addressed, would enable the expected benefits to be achieved. • *S5138 – Review of industry codes. A draft report has now been compiled and is under review.* • *S5147_3 – Microgenerator clusters.* Installation of monitoring points is currently underway and a new substation is being commissioned. Monitoring will commence upon completion of installation and commissioning. • *S5149_4 – Explore active voltage control.* Initial modelling work of typical radial and interconnected networks is underway. A		

	load-flow engine is currently being developed in order to carry out further studies to examine the limits of active voltage control. • *S5150_2 – G59/1 and G75 protection.* An initial review is complete and further work is pending results from allied university project. • *S5151_3 – Model network risk.* Following establishment of user requirements a review of available risk models and approaches is being undertaken. • *S5142 – Define generator data and structure for DG connection applications.* The generator data has been identified and a data structure agreed. Rationalisation of this data should now be considered. • *S5154_1 – Develop a voltage control policy assessment tool on the IPSA platform.* The interface between the existing eaVCAT software and the widely used IPSA power system analysis software has been developed and is currently being tested. • *S5155_1 – Explore lower cost connection solutions for distributed generation.* This project is at the information gathering stage, but intends to identify lower cost solutions. • *S5157_1 – Evaluate performance of small scale reactive power compensators.* Four devices have been identified and detailed information is being collated. User requirements are being sought from members. <u>Completed project stages</u> • *S5144 – Workshop on regulatory and economic issues.* A workshop to ensure the regulatory and economic environment is fully understood to assist selection of most appropriate technical developments. • *S5145 – Dynamic circuit ratings.* A report has been produced that summarises international work to date, evaluates available technologies and examines how these could be applied to UK distribution networks. • *S5147_1 – Monitor microgeneration clusters.* The project initiation document has been prepared and approved. • *S5149_1 – Explore active voltage control.* The project initiation document has been prepared and approved. • *S5150 Stage 1 – G59 and G75 protection.* The project initiation document has been prepared and approved.

	• *S5151_1– Model network risk.* The project initiation document has been prepared and approved. • *S5133 – Tap-changers reverse power capabilities.* It was concluded that under certain conditions there is an increased probability of internal flashover for single-compartment tap-changers with single-transition resistors. Steps should be taken to increase the maintenance frequency or de-rate the tap-changer to negate these effects. • *S5143 – Draft code of practice on stability.* The draft code of practice can be used to develop policy within each member company. It will facilitate the connection of distributed generation by providing a guideline on stability issues. • *S5149 Stages 2 & 3 - Active voltage control.* An overview of current control practices and how distributed generation impacts on them has been produced and a workshop held to explore the specific issues. This provides a firm basis for in-depth studies of how active voltage control can be implemented and its advantages and disadvantages in different situations. • *S5151 Stage 2 – Model network risk.* The user requirements of a network risk model have been defined, documented and agreed and will be used to direct subsequent stages of the project. • *S5152 – Latest developments in the connection of distributed generation.* Regular updates on new developments have been provided to members to help inform and influence the research programme.

EATL partial discharge user group

<table>
<tr><td>Description of project</td><td colspan="5">EATL Partial Discharge User Group</td></tr>
<tr><td rowspan="2">Expenditure for financial year 2005-06</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£6,953</td><td>£5,953</td><td>£1,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Partial discharge is an electrical discharge or arc that bridges a portion of the insulation between two conducting electrodes. Partial discharge may occur in aged, defective or poor quality insulation and can propagate and develop until the insulation is unable to withstand the electrical stress and flashover and failure occurs.

Partial discharge is the primary cause of disruptive failure of HV switchgear. The PD user group is a technical forum where information on partial discharge related failures can be disseminated and the understanding of partial discharge on switchgear can be enhanced through targeted investigative, research and development work. This in turn will enhance the way in which HV assets are managed and maintained and make a positive impact on the safety of operators working within substations.

During FY06 the expenditure of the group was focused on the following areas:

• Enhanced data manager

The management of partial discharge data and turning this into information to enable decisions to be made on the need for maintenance and the likelihood of failure is vital to the success of comprehensive deployment of partial discharge test equipment.

• Outdoor testing</td></tr>
</table>

	The partial discharge techniques are now commonly applied on indoor metalclad distribution switchgear. Little partial discharge testing is undertaken on outdoor open busbar type equipment working at voltages from 33 to132kV. A research project was undertaken during the year to determine the applicability of utilising partial discharge test equipment on the open terminal switchgear. • **Profile of the long term degradation of switchgear** A panel of 11kV switchgear common to DNO networks was set up in a test rig and continuously energised at working voltage and monitored for partial discharge activity. The aim of the project was to assess the effect of the environment on partial discharge activity and the profile of discharge through to failure.
Type(s) of innovation involved	Technical Substitution / Enhanced methods of working
Expected benefits of project	Due to the ageing profile of switchgear and the introduction of air insulated switchgear designs using cast resin insulation, which is less tolerant to the effects of partial discharge activity, unless the condition of switchgear is actively assessed and managed there is a likelihood of increasing failure rates. The expected benefits of the projects undertaken during FY06 are: • Understanding of the potential partial discharge related failure points for all types of switchgear • Enhanced interpretation of the results of routine PD surveys • Better targeting of maintenance teams to switchgear in need of attention • Preservation or reduction of the low failure rate for HV

	distribution switchgear • Transfer of existing technology and skills to use on an ageing population of bulk oil open terminal switchgear • Understanding the effect of the environment on the levels of PD activity and condition of switchgear • Identifying the profile of degradation for surface tracking on modern cast resin insulation in air insulated chambers		
Expected timescale to adoption	Range 1 - 3 years - dependent on task	Duration of benefit once achieved	Ongoing benefit
Estimated success probability (at start of project)	Range 50 - 100% dependent upon projects		
PV of project costs	£6,504 (nb. This is cost of running the user group and carrying out the projects. It does not reflect the likely full costs of implementation of any ideas / techniques resulting from the work).	PV of Project Benefits	£11,225 per average DNO Based on the average prevention of 1 failure on an RMU and 1 failure of a switch panel across the DNO members of the year.
Commentary on project progress and potential for achieving expected	Some projects within the programme of work are complete and others are ongoing due to the nature of the work. • **Enhanced data manager** During FY06 the PD User Group invested in the formation of a		

benefits	database of results that enables significant and key information to be quickly drawn from the large population of historical results. The database can now incorporate pictures, drawings, failure records, sound files (for the analysis of heterodyned ultrasonic activity). This greatly enhances the incident reporting facilities which helps engineers to better interpret the results of partial discharge surveys and make an assessment on whether switchgear is in need of immediate attention. Input of additional data will now be the key to realising best use of the functionality. • **Outdoor testing** One of the perceived problems with undertaking PD testing of outdoor open terminal switchgear was in the level of interference within the outdoor substation environment. Frequency response analysis equipment was utilised to identify the spectrum of interference to help assess whether modification to equipment would be appropriate / required to mitigate against interference signals. A large programme of testing was completed and analysis and recommendations on the way forward will be finalised in FY07. • **Profile of the long term degradation of switchgear** The panel of 11kV switchgear has continued to operate throughout the year and significant levels of discharge have been monitored. The switchgear is now close to failure and a great deal of knowledge on the relationship between surface discharge and relative humidity and profile through to failure has been gained. Full reporting is expected to be completed in FY07 dependent upon the time of failure of the switchgear.

ENA IFI P2 - Develop a fault level monitor (FLM)

<table>
<tr><td>Description of project</td><td colspan="5">ENA IFI P2 - Develop a Fault Level Monitor (FLM)</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£1,000</td><td>£0,000</td><td>£1,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The objective of this proposal is the development of an instrument that can successfully measure fault level on a distribution network with repeatability and reliability. This instrument, to be known as the fault level monitor (FLM), will be developed by EATL to the specification agreed by the ENA’s Operations and Systems Group (OSG).

OSG Sub-group 12 (SG12) is tasked with being the project management team that oversees the development of the EATL FLM project.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Incremental</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">The main benefits that a FLM will bring to the distribution network operators (DNOs) are:
• it will allow the DNOs to accurately assess fault in-feed levels and design distribution networks appropriately;
• it will facilitate the connection of distributed generation by providing a standardised and accurate method of assessing network fault levels;
• it will enable an ongoing assessment of the effects of distributed generation to be made;
• it will help to satisfy generator developers that decisions to upgrade networks are not subjective but based on objective measurement.</td></tr>
<tr><td>Expected timescale to adoption</td><td colspan="2">3 years</td><td colspan="2">Duration of benefits once achieved</td><td>20 years</td></tr>
<tr><td>Estimated success probability (at start of project)</td><td colspan="5">25%</td></tr>
<tr><td>PV of project costs</td><td colspan="2">£41,268</td><td colspan="2">PV of project benefits</td><td>£131,676</td></tr>
</table>

Commentary on project progress and potential for achieving expected benefits	Phase one of the project requires the collection of data from a small number of major substations, preferably with different load types and profiles. As a matter of expediency, it is expected that these substations will be chosen within the United Utilities and Manweb distribution services areas. Progress to date has been restricted to discussion of the specification of suitable power quality measuring instruments and potential substation sites.

ENA IFI P3 - Lightning protection – develop ETR 134

<table>
<tr><td>Description of project</td><td colspan="5">ENA IFI P3 - Lightning protection – develop ETR 134</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£2,588</td><td>£2,588</td><td>£0</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Produce a new ETR on lightning protection with a scope that covers:
• background information on the lightning density across the UK and the year-to-year variation as a result of factors such as sun spot activity
• catalogue current practices and procedures – with an explanation of pros and cons
• provide a view on international practices / procedures
• reference to peripheral issues such as earthing and protection, however the ETR should avoid trying to provide in-depth information on these matters
• provide a list of reference documents</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Incremental</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">• Reduction in failure/faults due to lightning
• Improved risk assessment
• Reduction in CMLs & CIs</td></tr>
<tr><td>Expected timescale to adoption</td><td colspan="2">3 Years</td><td colspan="2">Duration of benefit once achieved</td><td>10 Years</td></tr>
<tr><td>Estimated success probability (at start of project)</td><td colspan="5">75%</td></tr>
<tr><td>PV of project costs</td><td colspan="2">£324,932</td><td colspan="2">PV of project benefits</td><td>£328,703</td></tr>
<tr><td>Commentary on project progress and potential for achieving</td><td colspan="5">ETR 134 Lightning protection for networks up to 132kV is due for publication by 30th September 2006.</td></tr>
</table>

expected benefits	

ENA - IFI P8 Functional specification for ROCOF relays

<table>
<tr><td>Description of project</td><td colspan="5">ENA - IFI P8 Functional specification for ROCOF relays.</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£5,247</td><td>£3247</td><td>£2,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">To carry out tests on loss of mains relays with the aim of understanding the capabilities for sensitive detection of true loss of mains conditions and the requirements for maintaining stability during other system disturbances. This work should identify the optimum settings to meet these objectives.
• Produce recommendations for relay immunity, to a range of simulated disturbances, typically found on a distribution network: much of this work may have already been completed EATL.
• Produce a matrix of recommended settings to give optimum sensitivity based on typical generator types and ratings for Vector shift, ROCOF and perhaps changes of reactive power.
• Identify the range of protection settings that would be needed to meet the above recommendations.
• Identify from frequency records (held by NGET and ENA members) and previous work by EATL, a maximum system disturbance for which LOM relays should not operate: frequency shift of X Hz over a period of Y cycles. Instantaneous single- and two-phase voltage angle shifts of Z degrees.
• Produce recommendations for sampling period (ROCOF relays) and number of phases monitored (ROCOF & vector surge)
• Produce a matrix of recommended settings for both ROCOF and vector surge relays based on generator type, generator rating and system fault level
• Define a set of type tests to verify:
(a) Relay immunity to the disturbances specified in above
(b) Relay operation for disturbances greater than those specified above,
both the above to be carried out at a reference set of system conditions and relay settings.
(c) compliance with the relevant parts of ENA TS 48-5.</td></tr>
</table>

Type(s) of innovation involved	Incremental		
Expected benefits of project	On completion of the work there will be an improved understanding of loss of mains relays and how they respond to system disturbances and genuine loss of mains, which will enable more effective settings to be applied to relays. More effective settings will reduce the number of spurious trips of generator installations due to system disturbances. Estimating 60 unwanted trips throughout the UK per year due to system disturbances and assuming that more effective settings will reduce these by 50%, the number of spurious trips will be reduced by 30 per year. Fewer generation trips will result in fewer disturbances to other connected customers, improving quality of supply. A matrix of recommended settings and an improved confidence in the quality of loss of mains relays will reduce the time for producing a scheme design. reducing the cost of producing a quotation for generators. An improved understanding of and confidence in loss of mains relays will result in the more effective use of them as interface protection between DNO and generator, replacing the need for inter-tripping in some situations.		
Expected timescale to adoption	Two years		
Estimated success probability (at start of project)	25%		
PV of project costs	£21,038	PV of project benefits	£183,794

Commentary on project progress and potential for achieving expected benefits	Draft final report received by the Protection Assessment Panel in April for review and comment. Initial review of the report shows some very useful findings, which are quite different from the approach currently taken for loss of mains settings. The final report will form the basis of a change in the way that these settings are applied across the electricity network. It is anticipated that use of these new setting guidelines will enable the majority of the perceived benefits to be achieved.

ENA IFI P9 – Earthing projects

<table>
<tr><td>Description of project</td><td colspan="5">ENA IFI P9 – Earthing Projects.</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£750</td><td>£250</td><td>£500</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">To develop new techniques to assess the impact of lower voltage earth electrodes on higher voltage ‘hot zones’, and to measure the resistance of distribution substation earth systems.
• The advantage of this work will be that, if successful, the project will deliver a clear rationale describing the correct location of LV earth electrodes with respect to HV earth electrodes. This will have potential benefits in improving understanding of the safety of the earth installations. ESQC Regulation 8(2) (b) requires that HV electrodes are installed and used in such a manner as to prevent danger in the LV network due to a fault in the HV network. Currently the safety of the LV electrode is assured by maintaining a separation between the HV and LV earth electrode such that the LV earth electrode is situated outside the 430V rise of earth potential (ROEP) contour. This is based on longstanding requirements to ensure that the LV electrode has <430V imposed upon it under HV fault conditions.
• All designs for earthing systems consider the effects of touch and step potentials under fault conditions. However, the quantity of concern is actually the current flowing through a human body when in contact with metalwork subject to this potential and the time the current flows for. An electrode simply sited in soil that has a surface potential cannot be regarded as presenting the same hazard as metalwork with a direct metallic connection to the earth fault current return path. However, there exists at this time no methodology for assessing either the hazard posed by such an earth electrode or the possible effects of the earth when connected to a distributed system on the ROEP contours.
• This project will if successful determine these effects and provide a means to provide cost effective safe earthing systems without the need for extensive separations between HV and LV electrodes which in a PME system may be impractical to achieve and maintain.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Incremental</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">This project will determine the effects of LV earth systems on HV systems. The results of this should determine the means to provide cost-effective, safe earthing systems without the need for extensive separations between HV and LV electrodes, which in a PME system</td></tr>
</table>

	may be impractical and costly to achieve and maintain.		
Expected timescale to adoption	Two years		
Estimated success probability (at start of project)	50%		
PV of project costs	£24,137	PV of project benefits	£110,534
Commentary on project progress and potential for achieving expected benefits	Initial research work was completed to determine whether there was a need for further work in this area. The outcome of this justified further work being carried out. The earthing consultant has been in discussions with the various DNOs to identify suitable sites for testing to be carried out. Sites have been made available within Central Networks and Western Power Distribution and the testing work commenced. It is not yet known whether savings will be achieved until the outcome of the testing work is known.		

19. Most of the work done on the ENA R&D working group is focused on the four major projects described in detail in the following tables. In addition to the four major projects we also incurred an additional internal cost of £3,000. This was made up from £2,000 of costs incurred contributing to Engineering recommendations G12-3 and G78-1and £1000 was incurred attending the ENA R&D steering group. The costs incurred on the engineering recommendations are displayed separately in the summary tables at the end of this report. The costs incurred attending the ENA R&D steering group have been included within the innovation project management / project administration section.

CE's internal innovation programme

Woodhouse steel girder mast replacement specification

<table>
<tr><td>Description of project</td><td colspan="5">Woodhouse steel girder mast replacement specification.</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£67,100</td><td>£50,900</td><td>£16,200</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">In the 1930s, YEDL's predecessor, the Yorkshire Electric Power Company, built a range of long-spanned 11, 33 & 66 kV steel girder mast lines, commonly known as the "Woodhouse mast designs".

The "Woodhouse steel mast" supports were originally designed to accommodate 0.15" (7/.166") HDBC & 0.1" (7/.136") HDBC conductors using three basic design spans of 500 ft, 650 ft and 700 ft. A number of the circuits were later reconductored with 0.175" (37/.110") conductors designed on a 700 ft basic span. This was achieved without the need to carry out any alterations to the existing supports.

Over time the majority of 11 kV supports have been replaced with traditional wood pole alternatives, the majority of them resulting in interpoling as a means to reduce the long span lengths. A similar approach has been applied to the 33 and 66 kV circuits, but difficult wayleaves situations mean that around 300 km still remain.

The original specification cannot be re-used as it does not conform to current overhead line design requirements. Existing current designs such as AP1 or our proprietary OHL 9 and CE/C/37 specifications are limited to a span length of around 150m.

The challenge facing us is that we have around 300 km of an asset that is critical to system security and, dependent on land use, a hazard to the public as it deteriorates. The absence of a like-for-like replacement renders it difficult to obtain wayleaves for routes using current designs. This has already led to our undergrounding one circuit in its entirety (Thurcroft-Mexborough-Edlington) and a high-risk section of another (the tee to Crowle). The high costs involved were justified by the pressing need to replace these lines before they posed an unacceptable risk to</td></tr>
</table>

	public safety.		
Type(s) of innovation involved	Technological Substitution		
Expected benefits of project	The estimated benefit of a direct replacement for the Woodhouse masts is estimated at £5k per km of circuit and there are 300km of circuits using the Woodhouse masts. The PV benefit calculation has been spread over a 20-year period, which is in line with the current replacement plan for the Woodhouse masts.		
Expected timescale to adoption	The design will be delivered during 2006, followed by a trial build and proving tests. The first full circuit will be built in 2007, with the remaining circuits planned for a phased replacement over the next 20years.		
Estimated success probability (at start of project)	75%		
PV of project costs	£202,017	PV of project benefits	£368,046
Commentary on project progress and potential for achieving expected benefits	The new specification should be delivered to CE Electric by PB Power mid 06. The draft version of the specification has already been delivered and it appears to fully meet the objectives of the project. This will be validated towards the end of 2006 through the trial build.		

Condition-based risk management using helicopter inspections.

<table>
<tr><td>Description of project</td><td colspan="5">Condition-based risk management using helicopter inspections.</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£148,410</td><td>£140,160</td><td>£8,250</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Traditionally inspection of 132kV towers and lines has been performed using a dead/live top climbing team: this required a hands on approach that was labour intensive and the results produced were subjective.

This project used a helicopter and state-of-the-art digital photography techniques, together with a stabilised zoom lens to provide factual images capable of documenting the condition of an asset in great detail. The photographs also revealed early signs of failure due to component wear, ageing or inadequate installation.

In this study, the data points captured were defined by their end use in a health index assessment. This process differs from conventional inspections, which are dominated by questions that inform intrusive/remedial maintenance works. Here, we are explicitly also looking for end of life points for assets or subsystems. The health index process took this focussed set of condition points, and manipulated them to derive an overall condition grade (or health index) for: major assemblies; towers; and lines.

All images were then analysed by EA Technology’s experienced staff and condition ratings were awarded to each of the tower features selected for inspection. This information was then analysed further using EA Technology’s condition-based risk management technique (CBRM) to produce a Health Indices (HI) for each circuit.

The condition-based risk management technique has traditionally been developed for the assessment of ground-mounted substation plant and is based on assessments made by a DNO’s own staff during routine maintenance. In this case study the only involvement the DNO staff had in the process was to help EATL put together the original inspection criteria and the choice of circuits. EATL were then able to create the health indices for each circuit based only on the photographic evidence.</td></tr>
</table>

	Using new techniques that EATL have developed it was then possible to model the condition of the data at the time of the survey and also create a predicted health of the asset five years into the future. Using this information it is possible to make a better-informed decision on the actual end of life of the equipment and the correct time to intervene with refurbishment/replacement decisions. This information was then fed back into the strategic investment plan.
Type(s) of innovation involved	Technological substitution.
Expected benefits of project	• Credible, proven alternative to conventional inspection methods – change to our Inspection and Maintenance Policy • Comparable unit cost (approximately £250/tower) • Benefits far outweigh those derived from legacy climbing inspections • Safety defects promptly repaired • Proactive approach to maintenance – efficiently prioritised and programmed • Adoption of CBRM - creation of a solid link between asset condition and asset health for defining 'end of life' and understanding probability of failure • Auditable, permanent record of condition • Aids investment appraisal to define, justify and target future investment at a strategic level – ensures robust decision making. • The project will teach the business a methodology for condition-based risk assessment which could be implemented in other parts of the business.
Expected timescale to adoption	Trial has now successfully been completed.
Estimated success probability (at start of project)	75%

PV of project costs	£138,831	PV of project benefits	£141,956
Commentary on project progress and potential for achieving expected benefits	• Following the success of this trial we are now looking to expand on the CBRM principles within the company and integrate it as part of our policy for asset management. • Future implementation work will not qualify for IFI funding but will be very beneficial to the company. • Implementation of the regime into NEDL and remaining YEDL towers so that 20% of the circuits are surveyed each year. This will ensure that the entire population is assessed once every five years. • Increase the scope to include all lattice steel towers (33/66 and 132kV) • Building on the principles & methods learnt from this project we intend to implement the CBRM techniques elsewhere in the business, here are some of the projects where we intend to apply the technology in the future. - *Primary switchgear and transformers* - *33/66kV YEDL Woodhouse masts* - *Fluid-filled cables.*		

Superconducting fault limiter

<table>
<tr><td>Description of project</td><td colspan="5">Superconducting fault current limiter</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£9,100</td><td>£4,000</td><td>£5,100</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">This project is a joint venture between CE Electric, United Utilities and ScottishPower. The project is planned to run until 2009 and will see three superconducting fault current limiters installed, one at each participating DNO. The total estimated cost of the project to CE Electric is £600,000, of which £500,000 will be subject to a 25% funding grant from the DTI.

Development in the area of fault current limiting devices has been carried out by a number of leading manufacturers and research establishments for several years as an alternative to network reconfiguration / asset replacement in tackling rising fault levels. Whilst a number of devices are now becoming available, the UK has been slow to react and trial such devices over concerns of fail-safety.

The superconducting fault current limiter (SCFCL) is perceived to be a lower-risk device, utilising a non-linear ‘high-temperature’ superconducting ceramic rather than any electronic, electromechanical or mechanical components. When the material is operated at around 65K it loses all electrical resistance, thereby acting as a short circuit to load current. Both the increased current density caused by fault current and the loss of cooling medium (liquid nitrogen) cause the device to heat and the ceramic to revert to its ‘normal’ resistive state. This added resistance has the effect of clamping the fault current to lower / acceptable limits where it will remain until the fault is cleared by conventional means (circuit breakers, fuses, etc.). The SCFCL has been proven to operate in around 10ms.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Radical</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">It is envisaged that in the future CE Electric would be required to replace plant at a 33kV/11kV primary substation every two years to accommodate the increased fault level due to the connection of new</td></tr>
</table>

	distributed generation sites. The estimated cost of each plant replacement is £500,000. Avoiding this work would yield a PV benefit of £1,308,608.		
Expected timescale to adoption	The project is due for completion by 2009.		
Estimated success probability (at start of project)	50%		
PV of project costs	£483,911	PV of project benefits	£1,308,608
Commentary on project progress and potential for achieving expected benefits	The first trial site has been identified for the installation of the first SCFL device. It is planned that CE Electric will be used for the trial of the second device. The first external expenditure on the project will be made in the next reporting year, with further payments in the following two years.		

Remote fault passage indicators

<table>
<tr><td>Description of project</td><td colspan="5">Remote fault passage indicators (FPI).</td></tr>
<tr><td rowspan="2">Expenditure for financial year</td><td>Total</td><td>External</td><td>Internal</td><td rowspan="2">Expenditure in previous financial years</td><td rowspan="2">£0</td></tr>
<tr><td>£32,000</td><td>£20,000</td><td>£12,000</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">At present on some overhead HV circuits CE Electric fit Nortech fault passage indicators. On a fault the devices indicate if the fault has passed the device by indicating with a flashing LED. This allows the fault restoration team to walk the circuit until they find a device which is not flashing, which then indicates that the fault was in the previous section of circuit. By using the FPI relays the restoration team knows exactly in which span to carry out a more detailed search for the cause of the fault. This by itself reduces the fault restoration time but still requires a foot patrol to check the relays to find the last one flashing.

This project was intended to trial a new development from Nortech where the standard FPI unit has been enhanced by the inclusion of a GSM modem. With this system when a fault is indicated the units that have operated call in to a base station which then can be used by the control engineer to direct the fault restoration team directly to the faulty section of circuit.

The scope of the project was to perform a stand-alone trial on one circuit by fitting twenty of the new Nortech units.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Incremental</td></tr>
<tr><td>Expected benefits of project</td><td colspan="5">The expected savings will be realised through a reduction in customer minutes lost through shorter restoration times. It is estimated that the installation of fault passage indicators will make a saving of 1.1CML per annum and 0.046CI per annum. With this system we would expect to make an additional 10% saving in the restoration time.</td></tr>
<tr><td>Expected timescale to</td><td colspan="5">Trial installation to be monitored until end of 2006: if successful, the project will be implemented on more circuits.</td></tr>
</table>

adoption			
Estimated success probability (at start of project)	75%		
PV of project costs	£29,935	PV of project benefits	£98,699
Commentary on project progress and potential for achieving expected benefits	The equipment was installed and the trial was run from November 2005 to March 2006. During this period the line experienced several faults and the FPI responded correctly each time. In addition to the faults that were logged by the main protection the FPIs also detected several low-level transient faults that were caused by overgrown vegetation. When the line was investigated it was found that the FPIs had indicated when trees had touched the line but the faults had cleared too quickly to operate the main protection. This meant that the FPIs gave the added unexpected benefit of an early warning system for overgrown vegetation. Implementing this system could lead to a reduction in CIs as well as the expected saving in CML. To conclude the trial was successful and benefits seen during the trial were greater than expected. The project could now proceed to a full implementation.		

Preparatory works

20. To co-ordinate and, as importantly, disseminate R&D activity across the firm, we have established an internal working group. The resource spent on running the R&D process within CE Electric is not a project within its own right: however, without this commitment no R&D would be possible within the company. This cost includes project administration, project management, reporting, internal working group meetings and preparatory work on future projects. We have also incurred costs sitting on such committees as the ENA R&D working group.

21. The cost of this overhead for the reporting period has been £24,800, or around 5% of the total programme spend.

Future projects development

22. A number of concepts were raised during 2005/06 that we hope to develop further during 2006/07, including:

- Non-intrusive testing of vacuum interrupters.
- Evaluation of winding temperature indicators (WTI) using direct measurements with fibre optic-based thermocouples.
- Substation environmental monitoring.
- Switchgear end-of-life performance evaluation.
- Supergen V.
- Network risk assessment
- Developing a research and development strategy.
- FPI on GM distribution substations.
- Reference networks

23. We have incurred internal costs of £12,300 on developing the business case and project specification for these activities. This kind of investment is necessary if the R&D process is to be sustainable, despite its not delivering a benefit in the short term.

Projects considered but not taken forward

24. Under the CE internal programme all innovation proposals are recorded on the bright ideas register. Around 20 of these' bright ideas' were raised but not taken forward to full project proposals. Some were not taken forward as an acceptable business case could not be established or in some cases it was deemed that the IFI criteria could not be met. Some examples of projects that have been rejected during the reporting period are.

- Develop actuators for the automation of old switchgear.
- To provide a procedure for future up-rating of the voltage and current rating of overhead lines.
- Cable sheath monitoring to detect sheath damage and the onset of corrosion.
- Remote pressure monitoring on fluid-filled cables
- Identify the technical issues, costs and benefits of introducing fibre optic pilots.

NPV methodology

25. We have adopted a simple, robust and transparent approach to assessing costs and benefits. For each project, we have assessed both costs and potential benefits over a 20-year window, discounted back at 6.9% pre-tax real. Figures for collaborative projects have been provided by the contractor. These have been scrutinised to validate estimated benefits.

26. The benefit valuations are necessarily a matter of engineering judgement, but generally take the form of assessing the size of the issue and a credible reduction in unit costs. To reduce subjectivity, we seek to benchmark these assessments externally (e.g. through peer review under STP).

Summary of current portfolio

27. We can summarise the discussion above to yield a set of costs and benefits[1] for ongoing projects across the portfolio:

Programme	PV cost	PV Benefit	Ratio
ASL SCFL	£524,070	£719,262	72.9%
Development of IFI projects not yet started.	£10,570	£0	0.0%
DTI Technology programme	£4,209	£8,419	50.0%
EATL partial discharge user group	£6,504	£11,225	57.9%
ENA IFI P2 Fault level monitor	£41,268	£131,676	31.3%
ENA IFI P3 Lightning protection.	£324,931	£328,703	98.9%
ENA IFI P8 Functional spec for ROCOF relays	£21,037	£183,794	11.4%
ENA IFI P9 Earthing.	£24,136	£110,533	21.8%
ENA Developing G12-3 & G78-1	£50,100	£61,502	0.0%
ENSG	£17,656	£35,313	50.0%
Innovation administration / project management.	£23,199	£0	0.0%
OHL high resolution digital imaging CBRM	£138,700	£138,913	99.8%
Remote FPI	£29,934	£98,698	30.3%
STP2	£34,494	£54,643	63.1%
STP3	£35,149	£59,520	59.1%
STP4	£37,886	£64,167	59.0%
STP5	£41,427	£57,103	72.5%
Woodhouse mast	£202,016	£368,045	54.9%
Total	**£1,567,286**	**£2,431,517**	**64.5%**

28. We can also derive the overall portfolio summary required by G85:

Number of active IFI projects	19
NPV of costs and anticipated benefits from committed IFI projects	£864,231
Summary of other benefits anticipated from active IFI projects	Marginal improvement in reliability
Total expenditure in reporting period.	£493,858
Benefits actually achieved from IFI projects to date	nil

29. At this stage in the programme, we would not have expected to reap any benefits.

[1] all STP benefits are currently provisional, subject to review with EATL

Summary of 2005/06 IFI investment

30. We can also summarise the discussion above to give costs incurred over the reporting window of:

Programme	external costs	Internal cost
ASL SCFL	£4,000	£5,100
Development of IFI projects not yet started.	£0	£11,300
DTI Technology programme	£4,500	£0
EATL partial discharge user group	£5,953	£1,000
ENA IFI P2 Fault level monitor	£0	£1,000
ENA IFI P3 Lightning protection.	£2,588	£0
ENA IFI P8 Functional spec for ROCOF relays	£3,247	£2,000
ENA IFI P9 Earthing.	£250	£500
ENA Developing G12-3 & G78-1	£0	£2,000
ENSG	£18,875	£0
Innovation administration / project management.	£0	£24,800
OHL high resolution digital imaging CBRM	£140,160	£8,250
Remote FPI	£20,000	£12,000
STP2	£36,000	£875
STP3	£35,924	£1,650
STP4	£36,000	£4,500
STP5	£36,286	£8,000
Woodhouse mast	£50,900	£16,200
Unconstrained Total	**£394,683**	**£99,175**
Constrained Total (15% Internal cost)	**£394,683**	**£69,650**

31. This allows us to provide the data specifically requested in the RIGs, split 40:60 in proportion to size of licensee:

IFI Costs 1/04/05 - 31/3/06	NEDL	YEDL
eligible IFI expenditure	£185,733	£278,600
eligible IFI internal expenditure	£27,860	£41,790
combined distribution network revenue	£170,887,000	£230,060,000
IFI constrained total as % of turnover	0.11%	0.12%

32. The following table shows the total spend on IFI since the project was initiated in October 2004.

IFI Costs 1/10/04 - 31/3/06	NEDL	YEDL
eligible IFI expenditure	£225,568	£338,353
eligible IFI internal expenditure	£33,835	£50,753
combined distribution network revenue	£170,887,000	£230,060,000
IFI constrained total as % of turnover	0.13%	0.15%

33. It can be seen that £29,525 of internal costs have been excluded from IFI funding, as they exceed the 15% threshold set out in the RIGs. This is to be expected, as: there are significant start-up costs for the programme; and because our financial contribution to the collaborative projects is highly-geared, so our direct participation becomes disproportionately large.

34. We have raised this issue directly with Ofgem in conjunction with our peers. We submit that there is a case for raising the acceptable proportion of internal costs to at least 20%.

35. Note that CE Electric would be eligible for an IFI budget carry through from 2005/06 to 2006/07 of £1,002,368.

Ofgem IFI budget pass-through.	2005/06
IFI pass-through rate	90%
NEDL combined distribution network revenue	£170,887,000
YEDL combined distribution network revenue	£230,060,000
NEDL IFI Cap	£854,435
YEDL IFI Cap	£1,150,300
CE UK total IFI Cap	£2,004,735
NEDL actual eligible IFI expenditure	£225,568
YEDL actual eligible IFI expenditure	£338,353
CE UK actual eligible IFI expenditure	£563,921
NEDL IFI budget carry-forward	£427,218
YEDL IFI budget carry-forward	£575,150
CE UK IFI budget carry-forward	**£1,002,368**

Outlook for 2006/07

36. With our internal processes now set up and working we are hoping that, in the next reporting window we shall see an upturn in the number of active projects within CE Electric.

37. It is our intention that some of the internal projects within CE during 2006/07 will be as a direct result of research work undertaken in 2005/06 through the collaborative projects. This way we shall ensure that we get some direct benefit from the investment made in the collaborative work undertaken, particularly work done through STP.

38. We envisage that the portfolio of IFI projects to be worked on in 2006/07 will be largely made up from:

- continuing to support:
  - ENSG and subsidiary workstreams;
  - EATL STP;
  - ENA collaborative work;
  - the Woodhouse mast replacement specification; and
  - ASL fault current limiter; and
- expanding our activities into the Supergen V programme of work and elsewhere;
- further projects, collaborative where possible but alone if not.