United Utilities

IFI Annual Report 2006/07

CONTENTS

1. FOREWORD

The Innovation Funding Incentive (IFI) although still in its infancy has progressed even further over the last year. The scheme has stimulated R&D activity throughout the industry and given a strategic boost to allow manufacturers and academia to rebuild the knowledge and human infrastructure to support a long term R&D programme. Due to concerns over the long term future of the scheme Ofgem have managed a consultation process on the scheme during this year. The positive outcome of that consultation is welcomed with long term support for R&D guaranteed throughout DPCR5 and a commitment to remove restrictions on internal expenditure and review the eligibility criteria. It is our belief that these commitments are critical to the ongoing success of the IFI scheme and it is to be hoped that concerns over the eligibility of schemes can be allayed through ongoing review.

Our strategy has been a proactive one, actively seeking further ideas and projects but with a strong focus on benefits realisation. A supplier's innovation exhibition was held in September 2006 to demonstrate R&D projects and stimulate new ideas with a cross section of personnel attending. Establishing strong project management is key to achieving results, with named managers having personal responsibility for realisation of benefits and outcomes. However, it is important to factor into personal accountability the risky and speculative nature of R&D projects. Overall we are keen to support the IFI scheme and would welcome further discussion with Ofgem on how to strengthen the scheme.

There are certain areas of interest to the industry for R&D schemes which currently do not strictly meet the eligibility criteria for IFI schemes. It is to be hoped that the ongoing discussions regarding the wording in the Good Practice Guide will resolve these but it is helpful to understand the areas of interest.

> Security – All Network Operators are experiencing problems regarding security of substation sites. Over a number of years the levels of vandalism, trespass and theft has grown to a serious level and shows no signs of reducing. Currently R&D in this area falls outside of the IFI qualifying criteria.
>
> Climate Change – This is a major cause of concern around the world and its impact largely unknown. In order to try and better understand the impact on electricity infrastructure it is crucial to implement research but as this does not relate directly to primary or secondary assets it does not meet qualifying criteria.
>
> Vegetation Management – In order to comply with the requirements of the ESQCR and provide resilience cutting a variety of methods of vegetation management will be required. In order to understand what potential innovative techniques could be used to more effectively manage growth research is required but as with other areas this does not qualify.

To date the view of the industry and the regulator is that the IFI scheme has been a great success. It is hoped that with further ongoing development it can be a continued success into the future.

2. INTRODUCTION

The Innovation Funding Incentive (IFI) has enabled United Utilities to continue its programme of R&D projects. The ongoing management of the portfolio of projects continues in order to achieve short and medium term benefits to customers.

There has been a strong focus on collaborative projects to reduce financial risk and share experience or knowledge. This has involved a variety of collaborators and the right commercial partnerships, which has taken time to negotiate for the protection of all parties. In some cases, projects have started with one collaborator and expanded to reduce financial risk to the customer.

A total of 32 active projects are in progress with durations of between one to four years. United Utilities' IFI expenditure for 2006/07 is slightly over the 0.5% allowable cap but within overall allowable spend including the carry forward amount from 2005/06. Based on these figures there will be no carry forward amount for 2007/08. It is projected that expenditure for 2007/08 will be at the limit of the 0.5% cap and that it will be necessary to manage actively the prioritisation of projects due to the limit of funds available.

During this year we have successfully completed one project and the technology applied to a specific business project. Over the coming year it is anticipated that several more projects will be completed and it is intended to move the successful projects smoothly into the business with biannual Benefit Realisation meetings to be held with relevant business managers to aid the adoption process. However, it can not be guaranteed that all projects will be successful. By the very nature of Research and Development some will fail.

The Innovation Funding Incentive has breathed life back into R&D in electricity distribution and is beginning to deliver benefits to United Utilities and customers alike. It has been encouraging this year to see the efforts made by Ofgem through consultation to understand the concerns of the industry and to take the IFI scheme forward. The commitment to the scheme for the post 2010 years is a major factor in enabling us to progress projects. It is to be hoped that proposed revisions to the Good Practice Guide allow innovation to be applied in areas that are giving the industry major causes for concern such as vegetation management, security and climate change.

3. INNOVATION FUNDING INCENTIVE (IFI)

IFI is intended to provide funding for technical projects in the development of the distribution network, up to and including 132kV and to deliver value (ie financial, supply quality, environmental and safety) to customers. IFI projects can embrace any aspect of the distribution system from asset management through to design, construction, commissioning, operation, maintenance and decommissioning of primary and secondary networks. The detail of the IFI mechanism is set out in the Special Licence Condition C3 and the IFI Regulatory Instructions and Guidance (RIG). In addition Distribution Network Operators (DNOs) follow the Energy Networks Association's (ENA) Engineering Recommendation G85 “Innovation in Electrical Distribution Network Systems; A Good Practice Guide”(GPG).

A DNO is allowed to spend up to 0.5% of its Combined Distribution Network Revenue on eligible IFI projects. The GPG provides guidance on the characteristics of such eligible projects. The DNO is allowed to recover from customers a significant proportion of its IFI expenditure. This proportion is set at 85% in 2006/07 reducing in equal steps to 70% in 2009/10.

Ofgem do not approve IFI projects, but are willing to give guidance on eligibility for larger projects. DNOs have to report openly their IFI activities on an annual basis. Ofgem reserves the right to audit IFI activities if this is judged to be in the interest of customers.

4. UNITED UTILITIES R&D PROCESSES

Internal policies and procedures have been developed and issued to ensure R&D/IFI projects are managed from inception through the whole lifecycle, including post-adoption review. In addition, internal and external reporting requirements are detailed with timescales and internal responsibilities. The purpose of these documents is to provide guidance to those within United Utilities involved in the management and reporting of R&D/IFI projects to meet the requirements of ER G85 and IFI regulatory instruction and guidance.

4.1. UU's Engineering Policy Decision 030: Research & Development

This policy defines the focus of research and development (R&D) activities required to deliver value to shareholders and to the end customer. R&D will generally aim to provide benefits that improve safety, reduce costs and improve customer service. R&D projects shall be assessed, approved and managed in accordance with UU's CP030. Where possible a collaborative approach shall be applied to R&D activities to ensure maximum benefit for United Utilities' investment. The policy follows the principles set out in the industry guidelines within ENA Engineering Recommendation G85 "Innovation in Electrical Distribution Network Systems; A Good Practice Guide".

United Utilities will aim to supplement the funding of R&D activities from external funding sources and where appropriate take advantage of the Innovation Funding Incentive (IFI) introduced by Ofgem. Where appropriate, R&D activities will be reported annually to Ofgem in accordance with the Regulatory Information and Guidance (RIG). The application of the RIG for the IFI within United Utilities is described in CP031.

The policy embraces all R&D activities for the management and technical development of the electricity distribution networks up to and including 132kV, with the objective of delivering financial, supply quality, environmental and safety benefits to stakeholders. It shall be applied to the life management of R&D activities including:

- Innovation
- R&D providers
- Funding
- Approvals
- Project management
- Reporting

4.2. UU's Code of Practice 030: Approval and Management of Research and Development Projects

This documents summarises and provides guidance to United Utilities project managers on the main points detailed in ENA Engineering Recommendation G85 "Innovation in Electrical Distribution Network Systems; A Good Practice Guide". The procedures are provided to ensure a consistent approach to the R&D process.

Suitable projects are assessed by the R&D Panel through a 'virtual sitting' by email voting. The R&D Panel is formed from eight members with a variety of backgrounds including Management, Electrical, Regulation, Financial and R&D. This virtual sitting ensures the approval process is time efficient, however, occasionally larger and more complex projects have required face to face meetings.

The Project Record Sheet, as provided to the R&D Panel for approval and covers the lifecycle of the projects, is divided into the following parts:

- PART A – Project Initiation
- PART B – Risk Assessment
- PART C - IFI Eligibility Assessment
- PART D – Project Approval
- PART E – Project Milestones Reviews
- PART F – Project Adoption
- PART G – Project Completion/Appraisal (including 12 month post-adoption review)

Code of Practice 030 concludes with the responsibilities, procurement of R&D, funding, budgets and internal reporting.

4.3. Code of Practice 031: Application of the regulatory information and guidance for the Innovation Funding Incentive

CP 031 describes the procedures to be adopted for the application of the Innovation Funding Incentive Regulatory Information and Guidance within United Utilities including reporting, timescales and responsibilities.

5. COLLABORATION

R&D/IFI projects will be completed internally or externally to United Utilities. This will depend on the stage within the innovation process, but it is more likely for projects at the demonstration phase to be undertaken internally. External R&D providers shall have the necessary depth of knowledge and experience to undertake an R&D project.

Where practicable, United Utilities have taken a collaborative approach to all R&D activities as this reduces the cost and risk involved. Consequently, it is expected that the majority of United Utilities' R&D projects will be collaborative. However, demonstration projects have incurred more internal costs as this involves trialling of equipment on the network and requires technical and practical activities.

Collaboration may take several forms including partnerships with:

- EA Technology Ltd
- Other research organisations
- Other Distribution Network Operators (either directly or via the EA Technology Strategic Technology Programme)
- Universities
- Manufacturers
- Consultants
- Internal United Utilities departments

Commercial agreements have been signed for various collaborative projects. A collaborative R&D programme with all other DNOs has been continued under the Strategic Technology Programme managed by EA Technology. Further projects have been formed with a smaller number of DNOs and single manufacturer developing a product or application to be utilised on the distribution network. Trials of new products or developed products that are new to the UK are being evaluated and in some cases this has lead to further development projects due to feedback from DNOs. IFI has initiated a spirit of 'working together' to develop new and re-engineer products with DNOs and manufacturers.

Whilst it is important to develop new or existing products and trial those products, it also important to collaborate with universities, as this valued applied research feeds into products and applications developed by manufactures and DNOs. United Utilities is presently working with a number of Universities, manufacturers and DNOs on several IFI projects. Many of these projects have additional funding via other sources and collaboration is high resulting in a reduced risk and provides a high gearing to the individual collaborator. It is hoped that some of these projects will produce bench-top demonstrations and lead on to further projects.

Departments and sections within United Utilities have been collaborating to trial products on the network. Feedback from operational staff has been relayed back to external collaborators. It has been important to involve field staff at the start of the projects to ensure there is a business need, to seek their view of the potential applications and to provide the highest likelihood of the business successfully adopting products.

Projects that show a high probability for adoption during the demonstration phase have lead to discussions with potential business adopters in United Utilities to determine the likely requirements for business cases and future budgets. This is to ensure a smoother and faster adoption process by the business and realisation of benefits to customers.

6. ADOPTED PROJECTS

Distributed IO

This project utilises fibre communications technology within Grid and Primary substations, linking together smaller versions of Microsol RTUs in a distributed I/O approach. This required the development and trial of remote cell technology with a fibre ring and updates to control system software. The first installations of this technology are at Penwortham East & West substations with further installations planned over Xd4 & 5.

Development of a distributed I/O technology has enabled a standard build to be used for all new substation installations resulting in the following benefits:-

- The use of distributed RTU's and fibre communication will greatly reduce the amount of hard wiring required. Savings are achieved by not having to hard wire each individual plant item back to a single RTU cabinet resulting in savings of up to £100k per 132kV site.
- The capability for future integration to intelligent protection devices would enable relay management and retrieval of substation data to be achieved both locally and remotely.
- A fibre-based system does not suffer from electrical interference or induced voltage resulting in less potential mal-operations of relays and communication systems, plus a safer system of work.

7. OUTLOOK

During the innovation process project timescales on some projects may slide and milestones deliverables may not be met, whereas, other projects may gather pace and result in early adoption. Last year it was reported that no projects were likely to be adopted in 2006/07 and a small number were more likely in 2007/08. The projects outlined included:-

Distributed IO

You will note that this project has been completed and adopted earlier then expected. The summary of the project and benefits have been included in section 6 – Adopted Projects.

Rezap Fault Master

The following developments have been completed in 2006/07 and are now on trial in UU.

- Mobile Phone Controller
- Trips to Lockout and Auto Reset capability
- Load Profiler

It is expect the new Rezap Fault Master will be adopted by United Utilities in 2007/08

Further developments are planned for 2007/08 with trials in 2008/09 and likely adoption in 2009/10.

- Single Ended Fault Distance Estimation
- Over The Air Reprogramming
- i-Host Integration

T-P22 LV Fault Locator

Communication developments including Bluetooth, remote polling and event notification are presently under trial and it is expected to be adopted in 2007/08.

Low Voltage Regulator

Overall the trial is progressing well, although, it is expected further development may be necessary to take account of flicker and a further trial may be required. It is expected adoption is more likely in 2008/09.

LineTracker

The development of LineTracker to include high voltage application, conductor size and temperature measurement is now complete. Further work to develop remote communications is presently underway, which once complete will allow a trial to be carried out. Adoption is now more likely in 2008/09.

Modular Rezap Fault Master (FM)

The modular Rezap FM will be designed to fit in low voltage substation cabinets and pillars. Developed units should be available for trial 2008/09 and likely adoption 2009/10.

A supplier's innovation exhibition was held at the Reebok stadium in September 2006 to communicate key R&D projects to a broad cross-section of United Utilities employees. Twenty five manufacturers attended, of which around half were already collaborating with United Utilities and the others were invited to demonstrate recent or possible future innovations. The feedback from manufacturers and employees was very positive enabling a forum for discussion, demonstration and developing new ideas.

8. CONSULTATION AND CONSTRAINTS

Over recent years the R&D intensity had reduced to 0.1% of UUE turnover and the natural pressures from the RPI-X mechanism to encourage short term cost reductions were making it less likely that new R&D projects would be adopted. IFI has now stimulated R&D activity, including collaboration with R&D providers, manufacturers, academia and other DNOs. This report demonstrates we have projects already planned or committed that will take up all of the IFI allowance for both this year and next. It is expected that this level of expenditure will be sustained in the future with the pressure on being able to prioritise projects to ensure no overspend.

The consultation process this year and the commitments from Ofgem regarding the future of the scheme have been widely welcomed. The ongoing consultation on the wording of the Good Practice Guide it is expected will lead to the IFI scheme being able to cover the major concerns of the industry.

9. CONCLUSIONS

United Utilities have further increased their portfolio of projects this year with a wide variety across the 32 projects that are being effectively managed through internal policies and procedures. The management of the portfolio has changed focus slightly with the limitation of the amount available causing a much greater degree of prioritisation to be enforced. United Utilities maintain a strong focus on the whole project lifecycle and in particular the realisation of project benefits when adopted by the business. All layers of management within United Utilities are committed to maximising the benefits of IFI and R&D projects.

The result of the Ofgem consultation on the IFI scheme is a great reflection of the success of the scheme to date. It is clear that in order to be able to commit to projects the scheme needed to be extended and running until the end of DPCR5 provides excellent opportunities. It is encouraging also that Ofgem recognise the variance that will occur with internal costs during the differing development stages of projects. Our internal costs reported this year rose to 22% of the total IFI investment reflecting the work involved with several projects going through trial phases as well as one being completed and adopted.

The introduction of IFI stimulated R&D back into the industry and the further agreed changes to the scheme this year have provided even greater commitment. There are ongoing concerns regarding the range of projects that meet eligibility criteria, but it is expected that current discussions regarding the wording in the Good Practice Guide will prove successful in removing the perceived limitations.

A1. INDIVIDUAL IFI PROJECT REPORTS

Throughout 20006/07 United Utilities have had 32 active projects. Work has focused on technical and commercial approval of projects. Considerable resources have been involved in working on and agreeing collaboration agreements with R&D providers and manufactures, which have delayed the start up of some projects.

UU1 to UU 4 form the core of R&D activities in the industry with the majority of DNOs participating. The output from these activities result in improvements to maintenance processes, company specification, services and products. UU16-UU19 are projects managed by Steering Groups at the Energy Networks Association (ENA). The remaining projects are either project managed in-house or by R&D providers/manufacturers, while the whole IFI/R&D programme is managed in-house.

<table>
<tr><td>Description of project</td><td colspan="5">UU1 - 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">£40,000</td></tr>
<tr><td>£43,244</td><td>£38,936</td><td>£4,308</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The STP overhead network programme for budget year 2006/7 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 to also 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 which require technical investigation and development.

The projects within the programme aimed to:
• S2126_3 - Undertake long-term monitoring of conductor temperature by obtaining and analysing 12 months trial data.
• S2132_2 - Validate current and proposed new ice accretion models
• S2136_2 - Participation in European Project COST 727: Measuring and forecasting atmospheric icing on structures.
• S2138_2 - Investigate live-line jumper-cutting limitations Stage 2 is to undertake a controlled test programme.
• S2143_1 – To detect in-situ degradation of aluminium overhead line conductors
• S2144_1 – Determine the residual strength of tower fittings through experimental means
• S2145_1 Explore the use of novel conductors for uprating tower line circuits.
• S2146_1 Undertake torsion testing to evaluate possible limits for composite tension insulators
• S2147_1 Investigate the effect of multiple Spiral Vibration Dampers (SVD’s) on the performance of overhead line conductors
• S2149_1 – Explore high durability overhead line fittings. Initial stage to identify the range of fittings and materials.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technical Substitution / Radical</td></tr>
</table>

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, then 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; • reduce lifetime costs by the appropriate use of alternative materials.		
Expected Timescale to adoption	Range 1-5 years - dependent on project	Duration of benefit once achieved	Range 3-10 years - dependent on project
Estimated Success probability (at start of project)	Range 1-10% - dependent on project		

PV of Project Costs	£36,972 (nb. This is identified early stage cost. It does not reflect the likely full costs of implement ation. These will be identified providing the outcome of the early stage is positive.)	PV of Project Benefits	£63,564	NPV of Project	£26,592
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_3 - Undertake long-term monitoring of conductor temperature by obtaining and analysing 12 months trial data. First year form initial test site data suggests that uprating may be possible in specific circumstances. A further site has been established and is being monitored. • S2132_2 - Validate current and proposed new ice accretion models. Data has been gathered from the test site and is being analysed prior to presentation to members. • S2136_2 - Participation in European Project COST 727: 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. Involvement is continuing with data exchange with other participants. This in turn will allow the most appropriate structure to be constructed. • S2138_2 - Investigate live-line jumper-cutting limitations Stage 2 is to undertake a controlled testing programme. The aim is to establish practical and safe limits for operational jumper cutting. • S2143_1 – To detect in-situ degradation of aluminium overhead line conductors. The preliminary work to explore available techniques has been completed. • S2144_1 – Determine the residual strength of tower fittings. A possible technique is being investigated which has clear financial benefits compared with traditional				

	methods. • S2145_1 Explore the use of novel conductors for uprating tower-line circuits. This project is determining the applicability at the distribution level of novel conductor designs used at transmission voltages to allow increased ratings using existing structures. • S2146_1 Undertake torsion testing to evaluate possible limits for composite tension insulators. Laboratory testing has indicated torsion limits for a range of such insulators, which can be used to inform field staff. • S2147_1 Investigate the effect of multiple Spiral Vibration Dampers (SVD's) on the performance of overhead line conductors. The application of either multiple SVD's or heavy duty SVD's could allow increased overhead line tension • S2149_1 – Explore high durability overhead line fittings. Initial stage to identify the range of fittings and materials. This project is at an early stage and possible materials and treatments to improve corrosion resistance have been identified.

<table>
<tr><td>Description of project</td><td colspan="5">UU2 - Strategic Technology Programme Cable 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">£40,000</td></tr>
<tr><td>£42,168</td><td>£36,972</td><td>£5,196</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The STP cable network programme for budget year 2006/7 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.

The projects undertaken within the programme during 2006-07 aimed to:
S3132_6 - Addition of single core MV paper cable modeling functionality within CRATER cable rating software.
S3132_7 - Addition of cable crossing modelling functionality within CRATER cable rating software.
S3132_8 - Addition of load curve modelling functionality within CRATER cable rating software.
S3132_9 - Addition of fluid filled cable modelling functionality within CRATER cable rating software.
S3132_11 - Addition of EHV polymeric cable modelling functionality within CRATER cable rating software.
S3140_2 – Towards Best engineering practice for ducted cable systems.
S3145_1 – Investigate shrink back performance of PE sheath and insulation – Establish reliable test method.
S3146_1 – Testing of fire retardant coatings and tapes.
S3148_1 and S3148_2 - Requirements for earthing and bonding of single core MV power cables
S3149_1 Assessment of different HV polymeric cable designs
S4158_1 – Investigate user requirements for ducts
S3159_1 - Series resonant testing of short lengths of HV cable</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technical Substitution / Radical</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">If the projects are technically successful and the findings and recommendations from the projects are implemented, then the projects will potentially enable each DNO member of the programme to gain the following benefits, including:</td></tr>
</table>

	• offset future increases in CAPEX and OPEX; • CI/CML savings per connected customer; • increased safety of staff and public by reducing the number of accidents / incidents.				
Expected Timescale to adoption	Range 1-3 years - dependent on project	Duration of benefit once achieved	Range 2-7 years - dependent on project		
Estimated Success probability (at start of project)	Range 2-20% - dependent on project				
PV of Project Costs	£36,972 (nb. This is identified early stage cost. It does not reflect the likely full costs of implement ation. These will be identified providing the outcome of the early stage is positive.)	PV of Project Benefits	£53,490	NPV of Project	£16,518
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. • S3132_6 - Addition of single core MV paper cable modeling functionality within CRATER cable rating software. The functionality to model and analyse this cable type is now available within the CRATER software tool, allowing member companies to evaluate a wider range of circuits. • S3132_7 - Addition of cable crossing modelling functionality within CRATER cable rating software. Comprehensive cable crossing functionality is now available in CRATER, allowing member companies to determine their own cable ratings and the interaction with NGC cables. • S3132_8 - Addition of load curve modelling functionality within CRATER cable rating software. The load curve				

	modeling functionality in CRATER now allows a more accurate representation of the loads when determining ratings. • S3132_9 - Addition of fluid filled 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 fluid filled cable ratings, using approved methods of calculation. • S3132_11 - Addition of EHV polymeric cable modelling functionality within CRATER cable rating software. The functionality to model and analyse this cable type is now available within the CRATER software tool, allowing member companies to evaluate a wider range of circuits. • S3140_2 – Towards best engineering practice for ducted cable systems. The report will form a sound basis for the creation of engineering recommendations and guidance documents for ducted cable systems. • S3145_1 – Investigate shrink back performance of PE sheath and insulation – Establish reliable test method. The project has demonstrated that shrink back can occur at lower temperatures and proposed a test to predict in service shrink back. • S3146_1 – Testing of fire retardant coatings and tapes. The project has, through testing, demonstrated an effective means of fire protection for triplex cables. • S3148_1 and S3148_2 - Requirements for earthing and bonding of single core MV power cables. Cable engineers can now determine the size of circulating currents and losses for their cable networks and use this information to determine, if appropriate, a cable size based on whole life costs. • S3149_1 Assessment of different HV polymeric cable designs. The initial stage of this project has not identified a suitable replacement design to lead sheaths for use as an effective moisture barrier in HV XLPE insulated cables rated at 66kV and higher. • S4158_1 – Investigate user requirements for ducts. This project will allow DNOs to better tender for all types of plastic cable ducts since the requirements have been agreed between all users and all the major manufacturers • S3159_1 - Series resonant testing of short lengths of HV cable. This project will determine whether the use of variable frequency test sets is too onerous for the commissioning of short lengths of HV cable.

<table>
<tr><td>Description of project</td><td colspan="5">UU3 - Strategic Technology Programme Plant 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">£40,000</td></tr>
<tr><td>£41,946</td><td>£36,972</td><td>£4,974</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 of the large scale that was seen in the 1950’s to 1970’s. The challenge is to constantly review and innovate 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 which were approved for funding from the STP substations module budget and were undertaken in 2006/07 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 and they aimed to:
• S4164_3 – On load tap changer monitor – Stage 3.
• S4176_2 – Comparison of available earth testing instruments
• S4185_2 – AM Forum membership.
• S4191_1 – Update and populate CBMVAL database.
• S4193_2 – Enable effective quantification of risk and reliability.
• S4194 – Regenerative transformer breathers.
• S4197_1 – Concrete structure assessment.
• S4200_1 – Methods to assess oil bunds and intelligent pump technology
• S4201_1 – Corrosive sulphur in transformers
• S4202_1 – Out of phase switching
• S4203_1 – Review of INSUCON
• S4205_1 – Assessment of contact greases for outdoor applications.
• S4206_1– Substation security
• S4207_1 – ERS33 switchgear rating at reduced temperature
• S4208_1– Investigate the re-assessment of switchgear</td></tr>
</table>

	ratings • S4209_1 – Post maintenance testing • S4211_1 – Management and use of actuators • S4215_1 – Internal arc considerations in substations		
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, then the projects will potentially enable each DNO member of the programme to gain the benefits including: • Offset future increases in CAPEX and OPEX • Increased safety of staff and public by reducing the number of accidents/incidents; • 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	1-3 years - dependent on project	Duration of benefit once achieved	Range 2-7 years - dependent on project
Estimated Success probability (at start of project)	5-40% - dependent on project		

PV of Project Costs	£41,946 (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	£59,559	NPV of Project	£17,613
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. • S4164_3 – On load tap changer monitor – Stage 3. The results from extending the laboratory system into a live substation have been very encouraging and a subsequent stage will allow an extended trial on a wider range of tap changers. • S4176_2 – Comparison of available earth testing instruments. The project permitted cost effective comparison of four different types of electrode system to evaluate each instrument in relation to accuracy, cost, usability and robustness. • S4185_2 – AM Forum membership. This project allowed members to be updated on substation asset management policies and practices adopted by other European Transmission System Operators (TSOs) and Distribution Network Operators in a cost effective manner. • S4191_1 – Update and populate CBMVAL database. This project has delivered an up-to-date and easy-to-use software tool that enables members to make a valid assessment of the net financial benefits that might accrue from the implementation of CBM. • S4193_2 – Enable effective quantification of risk and reliability. The project collated and analysed the consequences of recent events (over the past 10 years) in order to establish 'benchmarks' to quantify risk. • S4194 – Regenerative transformer breathers. The project undertook an independent evaluation and cost benefit				

	analysis of “maintenance-free” desiccant breathers. • S4197_1 – Concrete structure assessment. The project highlighted the more common types of concrete degradation and the testing that is available to assess the extent of this degradation • S4200_1 – Methods to assess oil bunds and intelligent pump technology. The project will enable members to compare the different policies, practices and bund pump technologies that have been adopted and to identify best practice. • S4201_1 – Corrosive sulphur in transformers. The project informed members regarding the issues and consequences of the failures in transformers due to corrosive sulphur. • S4202_1 – Out of phase switching. The project facilitated expert debate of out of phase switching issues. It was necessary for DNOs to fully understand the underlying system conditions and agree a common approach in this matter. • S4203_1 – Review of INSUCON. This project provided a cost effective summary commentary of INSUCON content and its relevance to members. • S4205_1 – Assessment of contact greases for outdoor applications. The project will recommend suitable products for the lubrication of outdoor contacts and identify best practice for their application. • S4206_1– Substation security. This project will undertake a wide review of the concept of, and approach to, the physical security of substations in order to deter theft. • S4207_1 – ERS33 switchgear rating at reduced temperature. The project will provide guidance that may allow utilities to run switchgear above maximum normal rated current values under specific conditions. • S4208_1– Investigate the re-assessment of switchgear ratings. The project will consider the provision of a methodology for understanding the risk of re-assigning switchgear fault level ratings without type testing. • S4209_1 – Post maintenance testing. The project will enable members to carry out the most appropriate testing regimes both from a financial and technical perspective and to establish pass/fail criteria. • S4211_1 – Management and use of actuators. This project should assist the members in ensuring that the risk of actuator failure is reduced, their reliability is increased and maintenance and testing is optimised. • S4215_1 – Internal arc considerations in substations. The project will enable members to better select HV/LV switchgear with respect to internal arc and ultimately lead to enhanced safety within the substation environment.

<table>
<tr><td>Description of project</td><td colspan="5">UU4 - Strategic Technology Programme Distributed Generation 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">£40,000</td></tr>
<tr><td>£41,243</td><td>£36,972</td><td>£4,271</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The projects undertaken through budget year 2006/7 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.

Fifteen new project stages were approved during the year.
These projects aimed to:
• S5147_3 – Monitor Microgenerator Clusters
• S5149_4 – Explore Active Voltage Control
• S5142_2/3 – Generator Data and Structure for DG Connection Applications Stages 2 and 3
• S5152_2 – Latest developments in the connection of distributed generation
• S5154 –Voltage Control Policy Assessment Tool on the IPSA Platform
• S5157_1 – Evaluate the Performance of Small Scale Reactive Power Compensators Stage 1
• S5157_2 – Evaluate the Performance of Small Scale Reactive Power Compensators Stage 2
• S5160_1 – ACTIV Active Voltage Control
• S5161 – Standard risk assessment approach to DNO protection
• S5162 – Risk assessment analysis of voltage step changes
• S5164 – Managing network risks associated with the application of ER P”/6
• S5167 – Assessment of enhanced ratings for overhead lines connecting wind turbines
• S5168 – Design and operation implications for Grid Code compliance
• S5180 – DNMS functions to support active network management</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Incremental / Significant / Technological Substitution</td></tr>
</table>

Expected Benefits of Project	With government policy driving significant increases in generation connection to distribution networks the members need a range of innovative solutions to connection and network operation issues that are cost effective and which maintain the present level of network reliability and safety. If the findings and recommendations from the projects are implemented, then the projects will potentially enable each DNO member of the programme to gain benefits including: • 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); • 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	1-7 years - dependent on project
Estimated Success probability (at start of project)	5-30% - dependent on project		

PV of Project Costs	£36,972 (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	£69,827	NPV of Project	£32,855
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. • S5147_3 – Microgenerator Clusters. Installation of monitoring points is complete at both the substation and LV network level. A twelve month monitoring programme has commenced. • S5149_4 – Explore Active Voltage Control. Modelling of typical radial and interconnected networks in preparation for flexing key parameters to examine limits of active voltage control. • S5142_2/3 – Generator Data and Structure for DG Connection Applications. A rationalised data structure has been agreed and implemented with all terms defined. • S5152_2 – 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. • S5154_1 – Develop a voltage Control Policy Assessment Tool on the IPSA Platform. An interface between the existing eaVCAT software and the widely used IPSA power system analysis software has been established with eaVCAT making use of an embedded IPSA analysis routine. • S5157_1 – Performance of Small Scale Reactive Power Compensators. Five devices were identified, detailed information gathered and comparisons made using key criteria measures from members. • S5157_2 – Performance of Small Scale Reactive Power Compensators. This project examined the usage of DStatcoms with large windfarms and explored the				

	implications for DNOs. • S5160_1 – ACTIV Active Voltage Control. An initial scoping study was completed and further work will be undertaken outside of the STP programme. • S5161 – Standard risk assessment approach to DNO protection. This stage of the project identified possible standard risk assessment approaches that could be developed for the selection of protection systems at the DNO / User interface • S5162 – Risk assessment analysis of voltage step changes. The project investigated voltage step changes in order to define possible limits used when planning network developments and generator connections. • S5164 – Managing network risks associated with the application of ER P2/6. The project examined the application of P2/6 across members and developed a baseline view of the network required to deliver minimum-security standards. • S5167 – Assessment of enhanced ratings for overhead lines connecting wind turbines. The project will determine if enhanced ratings can be safely applied to lines connected to wind-farm generators without the risk of infringing statutory line-to-ground clearances, and if so to recommend appropriate correction factors. • S5168 – Design and operation implications for Grid Code compliance. The project explores the network design and operational implications of the Grid Code target volts and slope concept. It will develop a testing procedure for DNOs to check the necessary voltage control with recommendations for 'standard' settings. • S5180 – DNMS functions to support active network management. To inform members of the additional active network management functionalities available in DNMS systems that are not typically being used in the control rooms at present.

Description of Project	UU5 - Condition Based Risk Management (CBRM)				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£31,041
	£54,597	£32,701	£21,895		
Technological area and/or issue addressed by Project.	Condition Based Risk Management (CBRM) is a methodology that uses all available knowledge, experience and information relating to physical assets in order to define the present condition of the asset and then estimate future performance on the basis of ongoing degradation				
Type(s) of innovation involved	Incremental Innovation				
Expected Benefits of Project	Financial - better targeting of Asset Replacement, methodology to justify reduction in Capex whilst maintaining fault rates at their current level. Supply Quality, Environmental and Safety - removal of assets most likely to fail				
Expected Timescale to adoption	3 years	Duration of benefits once achieved	5 years		
Estimated Success probability (at start of project)	50%				
PV of Project Costs	£157,474	PV of Project Benefits	£353,678	NPV of project	£196,204
Commentary on project progress and potential for achieving expected benefits	Condition Based Risk Management is aimed at developing a process to better understand the asset condition of electrical plant and hence better inform investment decisions on plant replacement. Work during the period 06/07 has progressed the overall understanding of the company asset base to allow ranking of specific asset groups. This with the continuing collection of data has resulted in the following asset group having CBRM methodologies developed: Towers; Switchgear and Transformers. Further work is now on going to develop Health Indices for woodpoles and LV Switchgear. Additionally during the year work has been undertaken in determining probabilities of failure for all plant types as well as degradation rates to enable the data to be aged and hence determine capital investment needs beyond the usual 5 year planning timescales. These results are also being tested against actual as found condition of plant as it is changed on our network and these results are being fed into the CBRM process to ensure as much as possible we reflect this in our investment plans.				

Description of Project	UU6 - Criticality Assessment				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£72,387
	£105,921	£90,901	£15,019		
Technological area and/or issue addressed by Project.	The key elements of this approach are Investment, Maintenance, Operation and Service and their effect on Company risk and profit. Criticality assessment helps to identify the optimum intervention strategy for an asset, a combination of investment in new assets, maintenance and operation, to deliver the desired level of service for the business.				
Type(s) of innovation involved	Incremental Innovation				
Expected Benefits of Project	Financial - better targeting of Asset Replacement which may result in reduced network investment Supply Quality, Environmental, Operational and Safety - removal of assets most likely to fail				
Expected Timescale to adoption	3 years	Duration of benefits once achieved	5 years		
Estimated Success probability (at start of project)	50%				
PV of Project Costs	£159,282	PV of Project Benefits	£353,678	NPV of project	£194,396
Commentary on project progress and potential for achieving expected benefits	Work has been ongoing over the year to establish asset criticality criteria and scoring factors. The scoring spreadsheets have been populated with network and asset information to enable risk scores for assets to be produced and the results tested. The first batch of work has concentrated primarily on Transmission assets although progress has been made on establishing criteria for distribution assets. The results produced so far have indicated that the project will be successful in enabling the company to better target asset investment plans based on risk across a range of factors in addition to asset condition and probability of failure.				

<table>
<tr><td>Description of Project</td><td colspan="5">UU7 - Alternative Oils for Transformers</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">£31,440</td></tr>
<tr><td>£12,259</td><td>£8,870</td><td>£3,389</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">Evaluation of the characteristics of alternative oils for retro-filling power transformers and for use in new transformers</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technological substitution</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">The benefits of using alternative oils in transformers are based around two main points, safety/environment and lifetime ageing performance</td></tr>
<tr><td>Expected Timescale to adoption</td><td colspan="2">7 years</td><td>Duration of benefits once achieved</td><td colspan="2">20 years</td></tr>
<tr><td>Estimated Success probability (at start of project)</td><td colspan="5">50%</td></tr>
<tr><td>PV of Project Costs</td><td>£24,057</td><td>PV of Project Benefits</td><td>£40,429</td><td>NPV of project</td><td>£16,372</td></tr>
<tr><td>Commentary on project progress and potential for achieving expected benefits</td><td colspan="5">The following summarises what has been achieved in terms of technical understandings:
o Have quantified dielectric performance of ester oils as insulation materials through experiments and tests, dielectric performance is represented as electrical strength (kV/mm) under AC and Lightning voltages, with the effects of temperature, moisture contents and ageing conditions
o Have performed statistical analysis onto the experimental results to ensure that electric strength (kV/mm) could be linked with reliability index or probability of failure in an engineering environment
o Have identified electrical strength (kV/mm) of ester impregnated paper and pressboard under AC and Lightning voltages, along this line a reliable laboratory based solid insulation drying and impregnation procedure has been developed
o Impregnation procedures with ester oil have been studied through laboratory experiments, with</td></tr>
</table>

	theoretical study on capillary effect and viscosity as the backup o Have identified/**identifying** DGA fingerprints, DP and Furfuran analysis of transformer insulation system when using ester oils (***expected to be completed within the present term of research***) **On-going** research identifying dielectric capability of transformer insulation systems using ester oils, including ● oil performance under realistic large oil gaps, a test cell up to 300kV (this limit is due to the external corona on the connecting pipe) has been designed and fabricated, tests for oils under the distance of 5, 10 and 15 mm have been carried out. Withstand voltage test for 100mm under 250kV for a half hour has been carried out for ester oils. Identified the need to monitor pre-breakdown using optical and discharge measurements. ● Six month paper ageing to study the relationship between DGA, DP and Furfuran results. Quantify the AC and impulse breakdown strength of aged paper, in kV/mm. Identify the possible differences between esters and mineral oil in terms of paper ageing mechanism and by-products

Description of Project	UU11 - Reference Networks - Phase 2				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£57,260
	£-13,452	£-15,000	£1,547		
Technological area and/or issue addressed by Project.	Phase II of the project will produce a practical software tool to create optimum disaggregation groups and analyse existing networks and proposed performance improvement strategies				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	Ensuring that capital expenditure on improving the performance of the network will be optimised both in respect of the type of improvement work to be considered and in applying the improvements to circuits where the greatest benefit can be obtained. Providing a standardised method for comparing the performance of different types of circuit, both internally within United Utilities and externally between DNOs.				
Expected Timescale to adoption	3 years	Duration of benefits once achieved	5 years		
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£52,689	PV of Project Benefits	£318,310	NPV of project	£265,621
Commentary on project progress and potential for achieving expected benefits	Project is nearing completion. The final report and software expected during summer 2007. The project was extended through the joining of an additional DNO, at no cost to UU. Most of the problems giving rise to discrepancies in the output from the program have been identified and addressed. Analysis of real data, supplied by Distribution Network Operators and the development of comparative analysis is proceeding on schedule.				

Description of Project	UU12 - Distribution Transformer with on-load tap changer				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£52,414
	£117,492	£114,158	£3,334		
Technological area and/or issue addressed by Project.	Increased penetration of DG on the LV network, particularly domestic combined heat and power (DCHP) units, is expected to have a significant adverse affect on the voltage regulation. This is a concern especially when a large number of DCHP units are installed in existing properties within a small geographical area. The LV network would be established, and not therefore designed to accommodate the potential voltage effects of the generation.				
Type(s) of innovation involved	Significant				
Expected Benefits of Project	If successful the distribution transformer with on-load tap-changer facility would provide a simple solution to the problem and minimise the disruption to customer supplies. This solution would also negate the requirement to install new distribution substations and associated cable, therefore reducing costs and the environmental impact.				
Expected Timescale to adoption	3 years	Duration of benefits once achieved	5 years		
Estimated Success probability (at start of project)	50%				
PV of Project Costs	£210,103	PV of Project Benefits	£409,913	NPV of project	£199,810
Commentary on project progress and potential for achieving expected benefits	Design phase completed and 80% of prototype components have been delivered including the tap changer tank. The low quantity requirements of the project have meant long delivery times for certain components resulting in a slippage of the project. Routine and type testing of trial transformer with tap changer is planned to take place in early July 2007 at AREVA T&D Transformer factory in Turkey where the transformer was manufactured.				

Description of Project	UU13 - NaFIRS HV Fault Data				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£26,572
	£	£	£		
Technological area and/or issue addressed by Project.	The main aim was to identify and capture key specific parameters from the NaFIRS and related data, which can be used to improve modelling studies of the HV network and which can also be used to monitor changes in the long term condition of the HV network and identify poorly performing components and network. For the latter it was especially important that the statistical variation was established so that significant changes could be recognised and action taken where necessary.				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	Ensuring that the fault performance of the network will be optimised both in respect of the operational techniques to be applied and in the collection of statistical data relevant to the performance of individual circuits. Consistently poor performance of particular circuits and types of equipment will be identified, leading to the identification of cost-effective methods of performance improvements.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	5 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£25 272	PV of Project Benefits	£660 000	NPV of project	£634 728
Commentary on project progress and potential for achieving expected benefits	Project completed. Final report received June 2006. No further payments during 2006/07. The benefits will be obtained, only after the report has been assimilated by United Utilities and the indicated actions determined and completed.				

<table>
<tr><td>Description of project</td><td colspan="5">UU 14 - SuperGen V</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">£52,800</td></tr>
<tr><td>£6,274</td><td>£1</td><td>£6,273</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The EPSRC (Engineering and Physical Sciences Research Council) is the major research-funding agency for Universities in its area, and is run by DTI. One of its initiatives is funding work in the area of Sustainable Power Generation and Supply. A call was put out in 2004 and EPSRC have put together a group of universities to address the UK energy infrastructure. EPSRC, which addresses UK emission targets, produces step changes in technology, and has active collaboration with UK industry. This call is intended to focus on plant, systems aspects having been addressed in other Supergen calls.

The Universities involved in the £2.8M proposal are;
Manchester University: the management hub for this activity
Southampton University; the finance hub
Edinburgh University,
Liverpool University,
Strathclyde University
Queens University, Belfast

In essence there are 5 main activities:
improving knowledge of plant ageing
developing condition monitoring techniques
developing plant with reduced environmental impact
developing new protection and control techniques
enhanced network performance and planning tools</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technical Substitution / Radical</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">The consortium expect to deliver:
a suite of intelligent diagnostic tools for plant
integrated network planning and asset management
improved and reduced environmental impact plant
models and recommendations for network operation and management</td></tr>
<tr><td>Expected Timescale to adoption</td><td colspan="2">12 Years</td><td>Duration of benefit once achieved</td><td colspan="2">20 Years</td></tr>
</table>

Estimated Success probability (at start of project)	25%				
PV of Project Costs	£86,628	PV of Project Benefits	£160,119	NPV of Project	£73,491
Commentary on project progress and potential for achieving expected benefits	As a result of a number of issues, the Consortium Agreement was not signed until November 2006. The agreement has led to the establishment of a Steering Group and an Executive Management group to provide full engagement, and effective participation, of all parties. Dependant on their internal regulations, some universities were able to start work in February 06 (when the offer letter was received), and others had to wait until November 06. Unfortunately November is not a good time of year to recruit PhD students or Research Associates. The project is being brought on track, after the delayed start and is expected to meet original objectives. In particular there have been some delays in Work Package 3, as a result of delays in recruitment, and these are being managed in the context of the whole project. It is likely however that, although the majority of the project will be complete at the end of the four years, some students will still be active for a short period thereafter. Overall the management processes are strong and have been effective. Key links to industrial partners are now being formed, and in particular through Work Package 6, the first demonstrators on networks are being discussed. The first technical meeting was a major success with excellent attendance and participation. A number of papers have been written on work from within the project. <u>Outputs and Deliverables</u> The following are formal outputs from the consortium. Reports: - Report on 'Evaluation of G59 Protection relays - Discussion Document on Vision and Priorities for Industrial demonstration - Condition Monitoring Specification - Lessons learnt from writing consortium agreement - A review of voltage control - Condition monitoring -State of the art report from Activity 5.2 Technology: - A low cost RF unit has been produced based on the chromatic methodology of deploying the RF sensors. - A fibre optic based acoustic sensor for detecting abnormal signatures from plant is near completion.				

	- Prototype knowledge based partial discharge analysis software. This is generic and can be applied to all partial discharge phase resolved signatures. It can categorise the discharge. - Equipment to control power quality of a voltage supply is nearing completion. The above has been extracted from the full Supergen V annual report.

<table>
<tr><td>Description of project</td><td colspan="5">UU15 - Fibre Comms</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">£13,334</td></tr>
<tr><td>£6,770</td><td>£1,956</td><td>£4,813</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The project is a trial of new technology numeric line current differential relays using digital communications over UUE’s SDH fibre network.

Project Aims

• To trial the relays using a number of different communications configurations and paths. This will inform on the use of such relays over the UU SDH network and the actual communications requirements. The trial will include direct fibre, multiplexed fibre and mixed fibre/copper communications paths.

• To ensure that the relays trialled using digital communications operate correctly for in zone and are stable for out of zone faults. (The circuits chosen have poor fault history and are associated with other circuits with poor fault history)

Project Objectives

• To ensure that with an ageing population of traditional relays and pilot cables, there will be an option that provides a completely new system of unit protection not relying on unsupervised copper pilot cables.

At 132kV, protection commonly uses rented BT circuits. This is used for line current differential, distance protection and intertripping. Experience gained in the trial will assist in the migration of these functions to the UUE fibre network. This is particularly important as proposed changes to the BT system (21st Century Network) may render it unusable for protection schemes.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technical Substitution / Radical</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Financial

• There are about 30 pilot faults per annum at a cost of £11k per annum (Likely to rise with lane charging). Most of this cost could be avoided as protection is migrated to the SDH network.

• There are a number of important pilot cables reaching the end of their life and some will need replacement in the near future unless alternatives are available. The SDH network provides an</td></tr>
</table>

	existing alternative that can be utilised once the equipment has been trialled. If the replacement of a single pilot cable can be avoided, the saving could be in the order of £500k. **Supply Quality/Safety/Operational.** Benefits in all the above areas will be achieved by continued correct operation of protection.				
Expected Timescale to adoption	3 Years		Duration of benefit once achieved	10 Years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£18,868	PV of Project Benefits	£1,003,380	NPV of Project	£984,512
Commentary on project progress and potential for achieving expected benefits	The relays on trial are Reyrolle Solkor N and Siemens 7SD61. The trial using dedicated fibre end to end has been completed and has been entirely successful. Trialling the relays using the multiplexed SDH network have been delayed due to issues over compatibility of communications protocols. These have been resolved and the trial of the Siemens relay is underway. The trial of the Solkor N will be underway after a planned outage in June to change the communications interfaces.				

<table>
<tr><td>Description of project</td><td colspan="5">UU16 - Lightning Protection</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">£1,800</td></tr>
<tr><td>£0</td><td>£0</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 CML's</td></tr>
<tr><td>Expected Timescale to adoption</td><td colspan="2">3 Years</td><td>Duration of benefit once achieved</td><td colspan="2">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>£324,932</td><td>PV of Project Benefits</td><td>£380,403</td><td>NPV of Project</td><td>£55,471</td></tr>
<tr><td>Commentary on project progress and potential for achieving expected benefits</td><td colspan="5">Draft document completed and sent to DNOs for comment.</td></tr>
</table>

Description of Project	UU17 - Fault Level Monitor				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£5,800
	£2,042	£266	£1,775		
Technological area and/or issue addressed by Project.	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 to the specification agreed by the ENA's Operations and Systems Group (OSG). The FLM's measurements will be based on normally occurring events, so no customer supply interruption will be required. The technical development risks are reduced as the underlying methodology has been proven with EA Technology's existing Extended Supply Monitor.				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	The main benefits that a FLM will bring to the Distribution Network Operators (DNOs) are: • it will allow the DNOs to accurately assess fault infeed 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.				
Expected Timescale to adoption	3 years	Duration of benefits once achieved	20 years		
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£39,000	PV of Project Benefits	£72,858	NPV of project	£33,858
Commentary on project progress and potential for achieving expected benefits	A number of activities have been pursued by both EA Technology and the University of Strathclyde in the progression of this project. These are summarised as: • **Candidate monitoring sites and Deployment of loggers**– Network distrurbance data from 6 member have now been obtained using the Dranetz PX5 Power Quality instruments. • **Algorithm Evaluation and assessment –** The Fault Level				

	Algorithm has been coded within the Matlab environment. A network model with known parameters was created in Matlab/Simulink and the fault level estimated for a range of scenarios. Results from the applied scenarios (voltage and current waveforms) are passed into the Fault Level algorithm and results compared. • **Dranview disturbance record analysis –** Dranview data at the 6 sites is being processed for integration into the coded Fault Level algorithm. The results from the 'real' data and the result from the Fault Level algorithm are then to be compared to the relevant power network models supplied by the site hosts (studied in PSS/E). • **Experimentation and Laboratory investigations –** A fault level monitor instrument is been tested on the University of Strathclyde Micro-grid system. This laboratory work will enable scenario results from a very well known and modelled network to be compared against the performance of an existing Fault Level instrument. Tests with static and active loads are being carried out.

<table>
<tr><td>Description of project</td><td colspan="5">UU18 - Functional Spec - ROCOF Relay</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">£1,800</td></tr>
<tr><td>£3,457</td><td>£2,776</td><td>£680</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Studies have been carried out to assess the capabilities of loss of mains relays to withstand system disturbances. Whilst this is an important characteristic to maintain generation as systems move increasingly towards active networks the prime consideration in determining a suitable setting must be safety and compliance with regulations.
The stability setting requirements to ride through anticipated system disturbances may form the minimum desired setting.
Previous work carried out on testing the stability of relays to genuine network disturbances, show that there is a wide variation in the response of relays from different manufacturers to the disturbances. The results also show that relays from the same manufacturers have different responses at different settings.
Issues
It is equally important to understand how sensitive a loss of mains relay is to a genuine loss of mains.
• How many cycles are required to detect the condition i.e. how many cycles does the relay need to sample before it can detect a loss of mains?
• What percentage change or mismatch of load compared to generator rating is required for the relay to detect a loss of mains? This can vary with construction and size of generator?
ENA Members need to have confidence in a loss of mains relay to demonstrate that they meet the Environmental Test Requirements of ENA TS 48– 5 and have a time delay setting from 0-60 seconds.
ENA Members require an Engineering Report that captures the issues above and the terms of reference below. From which a new Engineering Recommendation will be written.</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">Use of more effective settings
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</td></tr>
</table>

	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 producing a quote to generators. **More effective Use of Loss of Mains relays** 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	3 Years		Duration of benefit once achieved	10 Years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£3,208	PV of Project Benefits	£90,378	NPV of Project	£87,170
Commentary on project progress and potential for achieving expected benefits	• Final report published.				

<table>
<tr><td>Description of project</td><td colspan="5">UU19 - 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">£6,800</td></tr>
<tr><td>£680</td><td>£</td><td>£680</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. ESQRC Regulation 8(2) (b) requires that HV electrodes are installed and used in such a manner so 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 which 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>
</table>

Expected Benefits of Project	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 may be impractical and costly to achieve and maintain.				
Expected Timescale to adoption	3 Years		Duration of benefit once achieved	40 Years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£24,137	PV of Project Benefits	£110,534	NPV of Project	£86,397
Commentary on project progress and potential for achieving expected benefits	• Part 1 (Investigation at Test Facility): report and CIRED paper completed. Measurements are carried out at the S&S Ltd test facility to enable better understanding of transfer potential. The measurement results were compared to predictions using the CDEGS software. The initial results are encouraging and suggest that there would be benefit in proceeding with more detailed investigations at 11kV distribution substations where the HV and LV earths are known to be separate (Part 2). • Part 2 (Investigation at 11kV substations - site tests): Identification of suitable sites has been underway. Two sites were identified in WPD area and the site work has commenced. Additional test sites in CN and CEE areas still to be proven and confirmed as suitable.				

<table>
<tr><td>Description of project</td><td colspan="5">UU20 - LineTracker Trial</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">£31,610</td></tr>
<tr><td>£680</td><td>£0</td><td>£680</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">The LineTracker is a fault and load monitor device, whereby data is downloaded by wireless radio link either up to 100m away or back to the control room or office via GSM PMR etc. The LineTracker can be installed and removed live on HV overhead lines by Gripall Live Line rods up to 11kV. The technology has been designed and manufactured in Australia.
The key aims:
Trial LineTracker on United Utilities overhead network to assess the potential benefits to United Utilities. The devices will be assessed in reinforcement assessment, HV unbalance, operation and grading of overhead protection devices, assessment of the operation of HV voltage stabilisers and intermittent, transient and permanent faults.
Develop a Live Line trial procedure for installation/removal of the LineTracker by a single line team. It is intended to only install the device on 'Clean poles'.
Train a small number of engineers to download data and Line teams to install/remove devices from live overhead conductors (6.6/11kV) to allow for trials on the overhead distribution network in a variety of situations and location through United Utilities.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technological Substitution</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">• Deferred/part Reinforcement resulting in financial saving of £30,000pa
• Confirmations of outage circuit loading where circuit ratings are near capacity in an outage. Reduce stressing of the network in an outage.
• Checking Unbalance on the Overhead network, which may be overloaded in normal running or outage. Checking unbalance with the operation of trial HV Voltage Stabilisers in the Great Eccleston, Near Preston. Improved Power Quality. Reduction in customer complaints.
• Intermittent, transient and permanent faults.
• Correct operation of GVR/protection and grading. LineTracker senses voltage on or off and load/fault current between 5-25,000 Amps.</td></tr>
<tr><td>Expected Timescale to adoption</td><td colspan="2">3 Years</td><td>Duration of benefit once achieved</td><td colspan="2">10 Years</td></tr>
</table>

Estimated Success probability (at start of project)	75%				
PV of Project Costs	£28,035	PV of Project Benefits	£139,043	NPV of Project	£111,008
Commentary on project progress and potential for achieving expected benefits	The LineTrackers(LT40) have been utilized in applications for measuring load and narrowing down transient overhead faults. Suggested minor improvements have been feedback to the manufacture – Gridsense. Applications are limited when installed locally and project work under UU21 & 27 will widen its application with conductor/ambient temperature and remote communication.				

Description of project	UU21 - LineTracker Development				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£111,742
	£-17,098	£-19,311	£2,212		
Technological area and / or issue addressed by project	The LineTracker is a fault and load monitor device, whereby data is downloaded by wireless radio link either up to 100m away or back to the control room or office via GSM PMR etc. The technology has been designed and manufactured in Australia. A trial of the 'standard' LineTracker is being carried out under UU20 - LineTracker Trial. The objective is to develop LineTracker to assist in determining dynamic conductor ratings. The key aims are to add conductor and ambient temperature, upto 132kV voltage and larger conductor applications. Present conductor ratings based on the load current and typical ambient temperature in winter, spring/autumn and summer. The table rating of conductors are defined in ENA Engineering Recommendation P27, which was based on experimental work carried out some years ago. Actual temperature measurements and profiles would assist in determining maximum conductor loading for specific overhead lines and defer or reduce investment in load related cases.				
Type(s) of innovation involved	Incremental Development				
Expected Benefits of Project	The temperature and ambient enhancement would give the following benefits: • Record a profile of temperatures and load currents • Allow the maximum load flow through conductors • Reduce the capital investment of reinforcing overloaded circuits at 11/33/132kV • Assist the connection of Distributed Generation				
Expected Timescale to adoption	3 Years		Duration of benefit once achieved	10 Years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£128,337	PV of Project Benefits	£1,019,646	NPV of Project	£891,308
Commentary on project progress and potential	Fifteen prototypes of LineTracker LT50's have been delivered in February 2007. The project has slipped by 3 months due to a couple of technical issues and problems releasing the units from the UK				

for achieving expected benefits	shipper. Gridsense provided on-site training and uploading of firmware upgrades to resolve protocols between LineTracker PAC's and iHost. United Utilities will continue to lead the project, however, Scottish Power jointed the project in 2006/07 as joint sponsor and has fund £54,000 reducing United Utilities contribution. The intention in 2007/08 is to trial the developed LineTrackers at 5 sites with network constraints in normal or abnormal running. Firstly, iHost, under project UU27, will be developed to allow data to be downloaded and notification of events to UU Control Room Management System.

<table>
<tr><td>Description of project</td><td colspan="5">UU22 - Distributed IO</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">£91,556</td></tr>
<tr><td>£349,919</td><td>£240,179</td><td>£109,739</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">In order to rationalise substation design the use of distributed fibre optic communications is to be proven via trialling.
Key aims:-
• Bench test the new RTU equipment (standalone)
• Test with existing 132kV substation control system
• Test with fibre communications
• Extended trial to include distributed RTU's

The latest fibre comms technology to be used within BSP Grid and Primary substation design means the current MICROSOL RTU needs to be deployed using a distributed I/O approach. This requires development of remote cell technology. A cell would be installed in each protection cabinet, communicating via a fibre ring back to the main and standby comms cabinet. The cell would interface to the Substation plant locally within each protection bay via klippon links eliminating the need to hardwire back to the MICROSOL cabinet via a marshalling cabinet. This would initially be as stand-alone but with the capability to integrate directly to the RTU subject to the interface protocol being agreed.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technological Substitution</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Development of a distributed I/O technology enables a standard build to be used for all new Substation installations resulting in the following benefits:-
• The use of distributed RTU's and fibre communication will greatly reduce the amount of hardwiring required. Savings are achieved by not having to hard wire each individual plant item back to a single RTU cabinet.
• Saving in installation/commissioning costs of £1,278,000
• It is anticipated the installation/commissioning time-scales would be reduced with the installation of Distributed IO and a Fibre Ring.
• The capability for future integration to intelligent protection devices would enable relay management and retrieval of substation data to be achieved both locally and remotely.</td></tr>
</table>

	• A fibre-based system does not suffer from electrical interference or induced voltage resulting in less potential mal-operations of relays and communication systems, plus a safer system of work.				
Expected Timescale to adoption	3 Years		Duration of benefit once achieved	10 Years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£328,430	PV of Project Benefits	£665,132	NPV of Project	£336,702
Commentary on project progress and potential for achieving expected benefits	The aim of the project was to provide an alternative method to the traditional multi-core cabling approach to substation design. This was to be achieved by installing a single fault tolerant dual fibre ring running round the substation control room to communicate with distributed electronics cells. The cells would be installed within the protection panels, interface with the I/O locally within the panels and communicate to the main RTU via the fibre interface. The technology was developed on a test bed system and following successful trials and acceptance tests hardware was installed and is now live at Penwortham East and Penwortham West Grid Substations. The success of the project was dependent on developing several new hardware and software builds including:- • Develop and test an increased database to address up to 32 cells of I/O (previously a maximum of 5) • Develop and test a single fault tolerant fibre based communication system • Integrate the cells into the protection cabinet environment and interface locally with the protection devices while providing a point of isolation via klippon links • Prototype, test and install a distributed execute and dummy control board. • Develop and test a new central switch panel to provide remote indications and test facilities for safe plant simulation testing. • Implement a new Substation authorisation code 249 to enable support staff to test remote Tele-control equipment				

Description of project	UU23 - Vista (Mapping Underground Assets)				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£2,182
	£1,519	£338	£1,180		
Technological area and / or issue addressed by project	UKWIR successfully bid for DTI funding and will be project managing the £2.4 million VISTA project. It will investigate the use of global navigation satellite technology linked to existing asset records to produce 3-D images of utilities' underground assets The project is supported by £0.9 million of DTI funding with over 20 collaborators, covering a wide range of utilities in the UK.The project will be carried out by the Universities of Leeds and Nottingham				
Type(s) of innovation involved	Radical				
Expected Benefits of Project	The timing of the research is opportune given that the *Traffic Management Act* will require all utilities to exchange digital (GIS) asset location information by June 2008 Utilities open up 4 million holes in UK streets each year at an estimated cost of £1bn with indirect costs of £4bn. With 750,000 km of water mains and sewers, there are large potential savings to be made by UKWIR members and other utilities in rapidly and accurately locating assets without inflicting third party damage				
Expected Timescale to adoption	3 Years		Duration of benefit once achieved	10 Years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£18,394	PV of Project Benefits	£288,487	NPV of Project	£270,094
Commentary on project progress and potential for achieving expected benefits	The following milestones have all been delivered:- • Initial exploitation & communication plan • Agree location for preliminary trials • Agree methodology for field trials • Completion of data model and ontological specification • Document protocols for field trials • Identify locations for further field trials • Report on preliminary field trials				

<table>
<tr><td>Description of project</td><td colspan="5">UU24 - Fault Master</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">£106,376</td></tr>
<tr><td>£31,690</td><td>£27,736</td><td>£3,954</td></tr>
<tr><td>Technological area and / or issue addressed by project</td><td colspan="5">Kelman Ltd has developed a new version of the rezap with additional potential beneficial features. It is proposed to trial the new equipment by installing units on transient LV faults.
Aims:-
• Controlled trial and development of the Re-zap Fault Master on LV Transient Faults
• Develop Firmware/software interface to CRMS/Cifms
• Develop additional features ie Mobile phone control, Auto-reset
Objectives:-
• Develop accuracy and effectiveness of distance to fault location.
• Assess effectiveness of Fault Thumping mode
• Assess/develop effectiveness of location tracking mode
• Develop/assess effectiveness and compatibility when used with other fault location devices produced by Kelman and others
• Develop remote/auto resetting and re-closing fault Master. Both Remote via Rezap Control software and Mobile phone technology.
• Modular Rezap for Outdoor Substations</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technical Substitution / Radical</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Financial
Could reduce the number of joint holes required during fault location.
Quality of Supply
A reduction in joint holes would save 1.5 hrs /hole. Assuming average of 30 customers /fault. 45 CML/fault, 11250 CML/annum. If the rezap FM could be reset remotely or Auto-reset this would reduce the number of CI and CML's except in situation in which the fault condition changes to a permanent fault. In this case the rezap may be re-closed remotely under certain criteria, which would need a risk assessment and a change in operational policy.
Safety.
Reducing excavations and live jointing reduce the risk
Environment
Reduction in joint holes saves environmental impact on landfill.</td></tr>
</table>

Expected Timescale to adoption	3 Years		Duration of benefit once achieved	10 Years	
Estimated Success probability (at start of project)	50%				
PV of Project Costs	£92,204	PV of Project Benefits	£387,929	NPV of Project	£295,726
Commentary on project progress and potential for achieving expected benefits	The following developments have been completed in 2006/07 and are now on trial in UU. <u>Mobile Phone Controller</u> This development has allowed the engineer to trip and close a REZAP FM remotely, with their mobile phone, while they are located in the vicinity of a suspected fault location. The Substation busbar and feeder voltages and instantaneous current are displayed on the engineers' mobile phone. <u>Trips to Lockout and Auto Reset capability</u> The Trips to Lockout (TTL) function limits the number of re-close operations that can be achieved in an installation to a pre-set value. Once exceeded the REZAP locks out leaving customers off supply. After an initial trip and re-close the REZAP FM will automatically reset to the default TTL value after a specified period of fault inactivity. This will reduce the number of times an engineer will need to visit their REZAP FM units and reduce the number of occasions where a unit enters the lockout state. <u>Load Profiler</u> It is not always apparent whether fuse operation on a LV feeder has been caused by intermittent fault activity or by overloading, particularly on highly loaded circuits. Therefore United Utilities & EDF have completed a development with Kelman to add average readings of the current over each half-an-hour, which are uploaded to the REZAP Server. These measurements can then be plotted in the REZAP Control Centre Software allowing an engineer to determine the correct condition. **Further planned developments for 2007/08** <u>Single Ended Fault Distance Estimation</u> To facilitate testing of algorithms under controllable and repeatable conditions a fault record simulation routine was created, in which the R and L of both the source and the cable to fault can be set as desired, as can the strike angle of the simulated faults. This has meant that the development could progress further before real data became essential. The initial mathematical technique for estimating R and L was completed, but was found to be unstable in the presence of noise.				

	The method was revised to include a least-squares aspect, which has produced a more robust result. This still requires work, and it seems the estimation of L is much more susceptible to noise than the estimation of R. A means of further improving results has been conceived but has not yet been realised. A major concern about a single-phase measurement of a three-phase system was the error that would be introduced by not knowing the mode of the fault, i.e. phase-to-neutral, phase-to-phase leading or phase-to-phase lagging. A method of determining the mode of the fault was proposed and the fault simulator modified to produce all three modes of fault, one mode at a time. This has shown that it is possible to discriminate between the modes. Further investigation is required to look at combined modes and the trade-off between noise immunity and the accuracy with which mode-changes can be identified. The use of real fault data had to be postponed due to the introduction of a relative phase shift between the current and voltage channels of the Rezap hardware. It is proposed to compensate for this phase shift using digital processing techniques. Modelling of the hardware filtering and sampling hardware and software is underway to facilitate testing of compensation algorithms. <u>Over The Air Reprogramming</u> REZAP FM firmware ready for OTA reprogramming. (REZAP End completed. Awaiting major version release of REZAP FM PC Suite which will contain the OTA interface and Server code to update REZAP FM units. <u>i-Host Integration</u> Initial talks between Kelman, UU and Nortech have been conducted and a specification is under development.

<table>
<tr><td>Description of Project</td><td colspan="5">UU25 - LV Voltage Regulator</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">£1,300</td></tr>
<tr><td>£92,306</td><td>£84,313</td><td>£7,993</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">The Low Voltage (LV) voltage regulator is a single-phase voltage regulator, has been adapted for mounting on a wood pole and connected into the LV line to providing fast response voltage compensation for both over and under-voltages. Two prototype units from US manufacturer MicroPlanet have been used in a limited trial on the SP-Manweb network in collaboration with SP PowerSystems.

Aims

This project seeks to undertake an extended field trial with detailed monitoring in UU to ascertain the devices short / medium term performance and potentially the full type approval of the device. It is envisaged that this device will primarily used as a means of rapidly resolving voltage complaints in rural areas. It may be capable of both temporary and permanent solutions dependent on the type of complaint and the economics of the situation. Where there is a clear case for network reinforcement, which would require time to engineer, the voltage regulator could be used to resolve the complaint whilst a reinforcement scheme is designed, wayleaves negotiated and construction undertaken. Where the voltage complaint is due to disturbing loads or unidentified causes it could provide a permanent solution due to the fast response of the device to voltage dips and sags. Where voltage rise is caused by Small Scale Embedded Generators (SSEG’s) the regulator could be used to maintain the local network within statutory voltage limits. There may be an eventual case where LV voltage regulators are used to maintain statutory voltages, to compensate for a less static voltage on the 11kV networks due to an increased penetration of distributed generation.

Objectives

• Short term performance, ensuring devices give an appropriate output and improve network voltages to within statutory limits.

• Long term performance, ensuring the reliability, longevity and robustness of the devices.

• Network uses, assessing the use of the units as temporary device for relieving voltage complaints vs more permanent measures.

• Alternative, previously unidentified uses for the product.</td></tr>
</table>

Type(s) of innovation involved	Technological Substitution				
Expected Benefits of Project	**Financial** Where there is a clear case for network reinforcement, which would require time to engineer the most cost-effective solution. The voltage regulator could be used to resolve the complaint whilst a reinforcement scheme is designed, wayleaves negotiated and construction undertaken and/or a permanent solution in cases of one or two customers. **Quality of Supply** Where the voltage complaint is due to disturbing loads or unidentified causes it could provide a permanent solution due to the fast response of the device to voltage dips and sags. Where voltage rise is caused by Small Scale Embedded Generators (SSEG's) the regulator could be used to maintain the local network within statutory voltage limits. There may be an eventual case where LV voltage regulators are used to maintain statutory voltages, to compensate for a less static voltage on the 11kV networks due to an increased penetration of distributed generation.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	20 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£71,841	PV of Project Benefits	£247,187	NPV of project	£175,346
Commentary on project progress and potential for achieving expected benefits	Originally development in collaboration between SP and MicroPlanet. A number of Low-Voltage Regulators (LVRs) have been purchased from MircoPlanet to trial on the UU LV network. Prior to any installation an LVR was tested to certain possible network conditions to determine any failure modes. The LVR performed with specification, however, tests did identify some changes are required to specification and design. Five remote GPRS power quality monitors with web-based configuration and viewing have been purchased from IMH Technologies to monitor the performance of five sample LVRs. These power quality monitors are innovative in the remote wireless configuration and downloading of power quality measurements. The use of this technology has allowed all parties to view the				

	performance of the five sample LVRs both in the UK and USA. Draft installation procedures have been written to allow installation of the trial LVRs, which four have been installed on the LV overhead network. The initially feedback from both customers and staff has been positive.

Description of Project	UU26 - Super-conducting Fault Current Limiter (SFCL)				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£12,114
	£40,407	£33,508	£6,898		
Technological area and/or issue addressed by Project.	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 in order to offer an alternative to network reconfiguration/asset replacement in tackling rising fault levels. Notably, ABB have been offering their IS – limiter as a commercial product for a number of years but this has not been adopted in the UK due to concerns over fail-safety. ASL is now offering to design, construct and undertake trials of super-conducting fault-current limiters (SFCL) in the UK. The SFCL is perceived to be a lower risk device, utilising a non-linear 'high-temperature' super-conducting ceramic rather than any electronic, electromechanical, mechanical or explosive components. When the material is operated at below its critical temperature it loses all electrical resistance, thereby allowing load current to flow with negligible losses. Either the increased current density caused by fault current, or the loss of cooling medium (liquid nitrogen) causes the temperature of the super-conducting material to rise and it reverts to a normal resistive state. This added resistance has the effect of clamping the fault current to lower/acceptable limits. Being a solid state device, the SFCL has been proven to operate in a few milliseconds, after which the impedance remains high until the fault is cleared by conventional means (protection operated circuit breakers, fuses, etc.). The SFCL's operation is sufficiently fast to ensure that the first peak of the fault current is limited. The subsequent limited current can be set to suit a specific application. It will in many cases be convenient to choose this level such that existing protection arrangements do not need to be adjusted. ASL is developing SFCLs using super-conducting material from specialist manufacturer Nexans Super-Conductors GmbH (NSC). NSC supplied the material for the successful 10MVA, 10kV, 600A CURL10 trial in RWE's network in Germany in 2004. In co-ordination with ASL difficulties like high investment costs and losses have been resolved by substantially reducing the internal thermal losses in the super-conducting material and by redesigning the super-conducting components so that a much smaller quantity of the super-conducting material is required. These latest developments will form the basis of the trial installations in the UK. The project will be carried out in a consortium comprising SP Power Systems, United Utilities, CE Electric UK and ASL. This proposal is				

	for the design, development and trial of 12kV devices, suitable for use in each of the DNO partner networks.				
Type(s) of innovation involved	Radical/Technological Substitution				
Expected Benefits of Project	Successful trials will result in the development of commercially available devices that are capable of clamping fault levels to within network design limits. This can bring a number of benefits: • If proven cost effective, SFCLs could be strategically deployed onto the network in areas either with existing high fault level issues, or experiencing a high degree of distributed generation connection activity (e.g. urban Combined Heat and Power (CHP) generation systems). This could provide a method of deferring the replacement of switchboards or reconfiguration of networks whilst ensuring fault levels are maintained within acceptable limits. • There may be operational benefits in certain areas, associated with minimising the often-complicated switching requirements needed to ensure equipment operates within its fault rating during network outages. This could reduce the risk of incurring CI and CMLs arising from either network switching or operating parts of the network temporarily on a single circuit. An improvement in staff safety may also be delivered. • If network fault currents are restricted equipment will not be subjected to increased wear or stress, potentially prolonging the asset life. • SFCLs may, subject to resolution of protection issues, allow radial circuits to be interconnected, with associated improvements to customer supply quality (both CI/CML and flicker/harmonics). This could facilitate a radical change in the way networks are designed and operated.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	20 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£584,666	PV of Project Benefits	£1,704,666	NPV of project	£1,120,000
Commentary on project progress and potential for achieving expected	Bamber Bridge, Preston has been identified as the first trial site and a full specification of the SFCL has been prepared based on a detailed study of the local network impedances. Modelling of the SFCL's interaction with the network has been undertaken and no particular problems are apparent. Superconducting elements have been designed and tested and shown to provide the necessary performance. Design				

benefits	of the of the SFCL, its enclosure and associated equipment is in progress. Applied Superconductor Ltd. experienced a setback in mid 2006 when a major offer of finance from a private investor was withdrawn. The company has since secured the financial support required to ensure that the three planned pilots can be completed and the project is due to continue from the beginning of June 2007.

<table>
<tr><td>Description of Project</td><td colspan="5">UU27 - Ihost developments</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">£4,800</td></tr>
<tr><td>£20,428</td><td>£15,695</td><td>£4,733</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">Background

There are two existing projects relating to LineTracker, UU20 for the trial of LineTracker and UU21 for its development to include measurement of conductors and ambient temperatures, higher voltage and conductor applications. LineTracker data can be downloaded locally via wireless link to a laptop.

Description

Remote communications and event notification can be established via GSM/GPRS communications. Data would be held in a database for historic review (Network Planning) and interfaced with CRMS for real-time load and event notification (faults and system running). It is not thought that LineTracker would be deployed on a wide-scale basis, but at critical network points at all high voltage levels due to generation, faults and conductor rating limitations for both normal and abnormal running. LineTracker would be configured and viewed via Gridsense software over the internet (Password etc) for permanent or semi-permanent installations.

Aims

Integrate LineTracker with iHost data collection, storage and notification.

Objectives

• Identify Critical network points at all high voltage levels
• Develop Communication between LineTracker & iHost
• Develop iHost, Gridsense Software and CMRS
  • Trial developments at identified critical network points</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">Financial

Reduce the capital investment of reinforcing overloaded circuits at 11/33kV/132kV

Quality of Supply</td></tr>
</table>

	Less risk under abnormal running **Environmental** Allows for reduced connection costs **Operational** Monitoring of critical network points for normal and abnormal running				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	10 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£91,670	PV of Project Benefits	£1,019,646	NPV of project	£927,976
Commentary on project progress and potential for achieving expected benefits	Basic communications and interface software between iHOST and Gridsense remote PAC units has been completed.				

Description of Project	UU28 - Resilience and Investment Model				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£0
	£141,819	£15,551	£126,268		
Technological area and/or issue addressed by Project.	Overhead line investment has historically been carried out on parts of the network that have a high fault rate. This has led to the identified section of network being replaced/refurbished to the current code of practice no matter what environment the line resides in. Whilst this method of assessment creates assets, which in theory, have a 40 year life span it does not assess the performance of the overhead line against the different weather patterns/conditions that it may encounter. The environment in which the assets are required to perform is ever changing due to global warming. At present United Utilities does not have a proven way of assessing the effects of more onerous weather conditions (wind, ice-loading etc). Part of the project will require a UU partner to collect condition type information and create IT programmes to manage the data.				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	Better targeting of Asset Replacement, methodology to justify reduction in Capex whilst maintaining fault rates at their current level. It has been assumed that UUE rebuilds/refurbishes 300km of HV overhead line per year at a high specification. This is to cater for the worst case weather patterns seen over the entire UUE area. The consequence is that approximately 8% of all the lines rebuild/refurbished are over designed/constructed. At present UUE doesn't possess a tool to forecast weather patterns at individual locations and to assess the impact on existing lines. In addition the ability to assess the design criterion to be utilised is lacking at present. To provide a saving comparison some assumptions have been made over the percentage of overhead line that is to be re-built, refurbished and which grade of refurbishment is to be used. The calculations below give an indication to the expected savings, all costs have been based on Unit Rates V2.0a and on the Morgan average rates.				
Expected Timescale to adoption	3 Years		Duration of benefits once achieved	20 Years	
Estimated Success	75%				

probability (at start of project)					
PV of Project Costs	£89,778	PV of Project Benefits	£2,166,833	NPV of project	£2,077,054
Commentary on project progress and potential for achieving expected benefits	Work Carried Out to Date. The models software has been developed and trialled on a sample of overhead condition data collected. This has had mixed results as the model currently indicates a reasonable assumption for pole/stay failures however the conductor clashing element of the model indicate a high number of failures, higher than expected. This is due to the user inputted parameters. The model has a trial amount of overhead line condition data installed to enable a trial of the model however a simple data input system has not yet been developed. Future Work. Work is on going to simplify the data input system. A new data input front end is being developed to enable this. Overhead line condition data is being collect, and expected to be completed June 07, this data will be used to give the model a thorough trial. Once the complete data set is installed a process will begin to test the models predictions, this will be judged against actual recorded asset failures that occurred in storm conditions. Testing is on going to assess the correct default parameters to give an accurate output. Achieving Expected benefits. It is expected that the resilience model has the potential to achieve the expected benefits. Further assessment and adjustments on the default parameters is required to achieve this. Storm data and any elements of the network that have failed are being gathered at every opportunity, this data will be used to confirm the models accuracy. It is expected that he model will be ready to assist in XD5 preparations.				

<table>
<tr><td>Description of Project</td><td colspan="5">UU29 - T-P22 LV Fault Locator</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>£49,940</td><td>£45,206</td><td>£4,733</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">Since their introduction into service some 2 years ago T-P22 units, and their predecessors the T-P20 and T-P21, have been used to locate many intermittent faults – some of which had existed for many months and been impossible to locate with previously available fault location instruments. All of these fault locations were carried out by a small number of ‘specialists’ using the remote interrogation features of the T-P2X Master Station software. As the number of instruments in service increases it is becoming more difficult to ensure that the status of units and the integrity of the communication channels are checked regularly. If this is not done systematically it is possible for valuable ‘fault events’ to be over-written or for problems with a unit, or its communication channel, to go undetected until an interrogation is attempted after a fault has occurred.

When first introduced the T-P20 operated purely as a ‘triggered’ TDR with a limited range of functions. The T-P22 now includes the ‘Travelling Wave’ (TRS) mode of operation whilst still providing ‘triggered’ TDR, but with a wider range of functions. Alone, or in combination with T-V22, the T-P22 forms a 3 phase Voltage Gradient System (VGS) with remote control and interrogation. Depending on the situation, the 3 modes of operation can often be used simultaneously, or sequentially, to improve the chances of achieving a successful fault location, or to resolve an ambiguous result on a multi-branched cable.

As awareness of the usefulness of the T-P22 has grown there has been an increase in the number of non-specialist users requiring a simplified means of control and interrogation – preferably with a degree of automatic analysis and validation of the acquired data.

Against the above background it is now appropriate to re-evaluate how the full potential of the T-P22 and T-V22 units can be realised through the development of a new Master Station software package which will reduce the need for manually initiated interrogation by ‘specialist’ operators.

A number of T-P22 would be purchased to trial the developed firmware and software.

The main features of the proposed software package are listed below.</td></tr>
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	• Regular automatic polling of specified units to: • Logging and reporting of polling to: • Manual operation to allow: • Configuration tool to provide: • Investigation into possible methods of automatic fault location using: • Estimation of 'impedance to fault' from voltage measurements • Conversion of 'impedance to fault' into 'distance to fault' based on Cable records and parameters • Source transformer rating • Estimation of 'distance to fault' using TRS data • Estimation of 'distance to fault' using TDR data • Create 'automatic fault location' log giving: Results of successful locations • Investigation into methods of automatic reporting using: Subject to investigations outlined in 5 & 6 would result in a further project for automatic fault location and reporting		
Type(s) of innovation involved	Incremental		
Expected Benefits of Project	**Financial** Reduction of LV joint holes and LV Cable joints would reduce the costs of an LV fault. **Quality of Supply** A reduction in joint holes and joints would save. Assumed 1.5 hrs /hole, 50% of faults on 30% of LV Feeder/Network, Average 5 Transient Fault before a permanent Fault **Transient reductions** Assumed customers off supply for 1.5hrs/Transient, 5 Transient/permanent fault, 250 Permanent Faults pa. Applicable on 50% of faults and 30% of the LV feeder/network. 50 customers per phase. **Safety.** Reducing excavations and live jointing reduce the risk **Environment** Reduction is jointing holes saves environmental impact on landfill.		
Expected Timescale to adoption	3 years	Duration of benefits once achieved	5 years

Estimated Success probability (at start of project)	50%				
PV of Project Costs	£78,836	PV of Project Benefits	£264,728	NPV of project	£185,892
Commentary on project progress and potential for achieving expected benefits	Kehui LV Fault Locator integration with iHOST. Final coding and successful testing completed in preparation for customer demonstration on 16th April '07. Following on from demonstration the software will be formally release to all interested parties and made available on the web iHOST platform for a further 1-month assessment. After this month of further assessment a meeting will be arrange to finalise what (if any) enhancements are required.				

Description of Project	UU30 - Delta V Developments & Trials				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£0
	£2,212	£	£2,212		
Technological area and/or issue addressed by Project.	Fault Location for Low Voltage Distribution networks DELTA V is a portable system for the accurate location of intermittent and permanent faults on complex low voltage (LV) power distribution networks. The system uses a number of small transient recorders (nodes) to record the voltage drop across the network under fault conditions and a handset to gather and analyse the fault data. The fault location is calculated using a refined version of the ´transgradient´ method and the known cable topography.				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	**Financial** Potential the Delta V would reduce the number of jointing test positions and reduce the average fault cost of a LV fault. **Quality of Supply** A reduction in jointing holes would save 1.5 hrs /hole. Assuming average of 30 customers /fault. **Safety.** Reducing excavations and live jointing reduce the risk **Environment** Reduction is jointing holes saves environmental impact on landfill. The costing for one hole.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	10 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£439,767	PV of Project Benefits	£579,344	NPV of project	£139,577
Commentary on project progress and potential	Work carried out on the Delta V 2 project includes the following: • New handset hardware with larger screen, more powerful processor, larger and more useable volatile memory, large,				

for achieving expected benefits	non-volatile memory for code and data. • Rewrite of handset software from previous handset to new handset. • Design and implementation of radio-based communications between handset, nodes and case to allow short-range data transfer from inaccessible installations. • Revision of data-structures and analysis code to permit more flexible use of data capture hardware including Rezap FM. • Revision of case to improve appearance, manufacturability, durability and to enable automatic calibration and testing of nodes. • Revision of node hardware to eliminate problems of battery failure, increase the number of records stored to 64 and to enable radio communications with the handset.

<table>
<tr><td>Description of Project</td><td colspan="5">UU31 - Modular Rezap Fault Master</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>£30,799</td><td>£28,587</td><td>£2,212</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">Kelman Ltd has developed a new version of the re-zap with additional beneficial features which is being trialled under UU24, CAB, Fault Master. Further developments are proposed to split the electronic control/power supply and the vacuum bottle. The Controller would be able to control up to three separate vacuum bottles. This will allow Rezaps FM's to be installed in Outdoor LV cabinets and Pillars. Once the product has been developed then 10 controllers and 30 modular rezaps FM will be purchased for trial in outdoors substation. 40% of UU substations are outdoor.
Aims:-
1. Develop & Trial a Modular Rezap FM for Outdoor Substation (LV Transient Faults)
2. Develop One Controller for 3 Modular Rezaps FM's
Objectives:-
1. Compact waterproof (IP rating)
2. Same features are existing Rezap
3. Specifically design leads
4. Trial a number of Modular Rezap FM's
There are yet many facets of this project that must be considered, including the available space in pillars and cabinets, the logic operation of having multiple bottles connected etc… It is proposed to research and specify the Modular REZAP project by first carrying out a feasibility phase. If the costs were more than indicated then the project will be resubmitted for approval. The projects will also include for product development and trial.</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technological Substitution</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Financial
Potentially the Fault Master could reduce the number of jointing test positions and reduce the average fault cost of a LV fault.

Quality of Supply
If the rezap FM could be reset remotely this would reduce the number of CI and CML's except in situation in which the fault condition changes to a permanent fault. In these cases the rezap may be re-closed remotely under certain criteria, which would need a risk assessment and a change in operational policy.
Auto-Reset will save CML's. Once a Rezap runs out of trip it locks out and customer with be off supply for at least one hour.</td></tr>
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	Safety. Reducing excavations and live jointing reduce the risk **Environment** Reduction is jointing holes saves environmental impact on landfill.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	10 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£176,273	PV of Project Benefits	£251,370	NPV of project	£75,098
Commentary on project progress and potential for achieving expected benefits	Work carried out on the REZAP MX (Modular REZAP FM) project includes the following: • Research in to the physical design constraints to which the REZAP MX should comply • Generating a specification for the REZAP MX • Modelling of REZAP MX Switch Module assembly in Solid Works • Schematics for REZAP MX Switch Module • PCB Layout for REZAP MX Switch Module • Architecture requirements for REZAP MX Control Module				

<table>
<tr><td>Description of Project</td><td colspan="5">UU32 - Weather Stn</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>£4,946</td><td>£3,500</td><td>£1,446</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">The met Office provides UUE with weather forecasts, but has no real time or historic data unless provided by under additional services. It is proposed to trial ten weather & lightning stns across UU. The project will include a feasibility stage, development and trial. The feasibility will investigate weather stns and ihost protocol. The developments will focus on a front-end module to UU's ihost software platform to capture the weather data and user web-based interfaces. The developments and weather stns will be trialled through out UU. Weather data would be available for use with other projects such as OHL residence model and Tree Growth modelling.
Aims
Development real-time and historic weather data for the UU area.
Objectives
1. Weather Stns including wind (speed & direction), rainfall, temperature, solar, lightning etc
2. Develop ihosts to capture weather stn data
3. Develop ihosts to display web-based map to display graphical levels of weather data across UU
4. Develop ihost to alarms/events at thresholds (email/txt etc)</td></tr>
<tr><td>Type(s) of innovation involved</td><td colspan="5">Technological Substitution</td></tr>
<tr><td>Expected Benefits of Project</td><td colspan="5">Financial
1. Potential reduction or cancellation of the existing £46,000 contract for weather forecasting provided by the Met Office.
2. Saving in on additional weather services provided by the Met Office for internal/external reporting due to incidents caused by weather. £20,000 approx
Supply Quality/Operational
Real-time weather data or alarms could provide advance notice of potential outages caused by weather.</td></tr>
<tr><td>Expected Timescale to adoption</td><td colspan="2">3 years</td><td>Duration of benefits once achieved</td><td colspan="2">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>£49,377</td><td>PV of Project Benefits</td><td>£305,894</td><td>NPV of project</td><td>£256,517</td></tr>
</table>

Commentary on project progress and potential for achieving expected benefits	Feasibility study and work is on going to:- • Identify suitable weather station and lightening detection hardware which can provide the required data in a usable format • Based on the hardware identified prepare a final set of weather monitoring features which can be added to iHost. • Identify the number of sites that will be needed to achieve a reasonable set of weather data for any roll-out. • Identify site restrictions as far as installation of new hardware is concerned.

Description of Project	UU33 - ESR Network				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£0
	£5,946	£4,500	£1,446		
Technological area and/or issue addressed by Project.	The ESR Network is an academia / industry exchange to identify and link university funded projects to key industry stakeholders. This network covers the majority of the UK universities and monitors all electricity related research activities funded by EPSRC,				
Type(s) of innovation involved	Radical				
Expected Benefits of Project	• Monitoring / data exchange of all EPSRC funded projects submitted in 'responsive mode' • Monitoring / data exchange of other UK/EU research initiatives • Network of academic contacts • Network of industrial contacts				
Expected Timescale to adoption	7 Years	Duration of benefits once achieved	20 Years		
Estimated Success probability (at start of project)	25%				
PV of Project Costs	£25,274	PV of Project Benefits	£29,498	NPV of project	£4,223
Commentary on project progress and potential for achieving expected benefits	At the end of the year 43 academics were in membership of the Network (an increase of 5) and 14 industrial companies (no change). The three Network Panel meeting held during the year were hosted by QinetiQ, SERCO Assurance and EDF Energy. During the year 5 new grants were brought into the Network's monitoring and overview process with the agreement of the grant holders. These covered the areas of electrical plant condition monitoring, combustion, structural integrity and materials for fusion, and they brought to 50 the total number of research grants which have been or are being overseen by the Network. Mid-term presentations on 6 grants were received at Panel meetings and one post-completion report was received. A total of 22 detailed review meetings were held involving the grant holders and the interested industrial				

	members. The Network Panel received presentations during the year from four SUPERGEN consortia (Wind Power Technologies, Biomass Energy, Plant Life Extension and Future Network Technologies), and from UKERC and the Energy Research Partnership. A presentation was also made by the Smith Institute on their work on uncertainty and risk in energy supply. The final version of the Network's R&D strategy paper on condition monitoring of electrical transmission and distribution plant (COMET) was posted on the Network web site, and work started through a third working group to improve further the Network's R&D Matrix, which has the aim of identifying areas for future R&D strategy papers

Description of Project	UU34 - FuseRestore				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£0
	£35,368	£32,390	£2,978		
Technological area and/or issue addressed by Project.	Just as with HV feeders LV feeders have rogue circuits - repeated faults even after a fault has been repaired. It is proposed to develop a device that can replace an existing fuse. The 'FuseRestore' would be able to hold two fuses - one in circuit and the second to restore customers after 30 seconds should the first fuse below. The units would have communication via GPRS to a Rezap server and would be able to provide events such a blown fuse or loss of supply. This would allow for scheduling via the LV fault Management system for fuse replacement. If one fuse has blow this would be replaced while it was connected. It is hoped FuseRestore could be fitted to indoor and outdoor substations. **Aims** Development a FuseRestore to replace a standard Fuse. **Objectives** 1. Develop 3 FuseRestore Device as proof of concept 2. Trial 1 above 3. Develop proto-type units 4. Trial 24 (x3)proto-type units				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	Reduction in CML's and CI's results in additional payments in IIP 240 Installation (substns) would potential save 20% in CML's & CI's - Only 80% will restore with one fuse replacement. Targeting the right LV feeder will reduce the benefit. £1.65M				
Expected Timescale to adoption	2 years	Duration of benefits once achieved	1 year		
Estimated Success probability (at start of project)	50%				
PV of Project Costs	£912,473	PV of Project Benefits	£940,687	NPV of project	£28,214
Commentary on project progress and potential for achieving expected benefits	Many iterations of design were considered for the Fuse Restore. It is now nearing the end of the design phase. A prototype switching mechanism is being manufactured for heat tests in the workshop.				

<table>
<tr><td>Description of Project</td><td colspan="5">UU35 - Expansion Planning</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>£35,694</td><td>£12,103</td><td>£23,591</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">To ensure timely delivery of the load related capital investment programme, for G&P networks, it is essential to develop a forecast of network reinforcement needs. The forecast should look ahead 20 years and be reviewed annually to produce a rolling programme. Certainty of the programme of work and its associated cost will allow United Utilities to plan its resource requirement and negotiate its revenue stream with Ofgem on the basis of a justified Price Control submission. It is proposed to specify and develop with our partners, TNEI Services, an expansion planning tool. The new software module will sit alongside the existing IPSA software suite and using the existing IPSA network model of the G&P distribution network will apply DC load flow techniques, with a set of reinforcement rules, to create an investment profile for the given time horizon.

Aims
To develop an Expansion Planning software tool capable of analysing the G&P network for multiple load conditions and outage scenarios. The tool shall check the network for compliance with thermal and voltage limits, fault level limits and Licence Standard ERP2/6. The output of the tool will be a record of non-compliance issues over the 20 year planning horizon.
It is a further requirement of the Expansion Planning software tool that it interfaces with another IPSA related development software package which calculates nodal marginal prices for DUoS charging.

Objectives
1. To specify and develop a DC load flow module for network analysis;
2. To specify and develop an expansion planning module;
3. Implement and trial the software for the creation of a forecast investment plan for a defined time horizon.</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">Financial
Although a systematic review of the network is not currently undertaken by United Utilities there is a clear business need to do so. It is anticipated that because there will be a greater knowledge of the status of the network it will be possible to develop engineering solutions that will utilise available capex more efficiently. Whilst it</td></tr>
</table>

	is difficult to accurately quantify the savings it is reasonable to anticipate a 0.5% saving (available for reinvestment) over the whole load related capital programme. Based on the XD4 load related capital programme this would deliver a £250k over the five-year period, which equates to a £50k saving per annum anticipated for each year of the 20-year programme. **Supply Quality** The Expansion Planning tool will enable United Utilities to plan and deliver an efficient and co-ordinated distribution network that will positively impact on the Supply Quality (CI & CML) delivered to customers. There is a further option to include a reliability element to the network analysis part of the tool, however the decisions whether to include this will be delayed until the other elements have been proven. **Operational** The expansion-planning tool will assist with the efficient and co-ordinated development of the distribution network. Although the output is a first order approximation of the development of the EHV distribution network, in some cases it may provide the reinforcement solution. An output of the load related investment profile is a set of 'time to reinforcement' values for the congested elements of the EHV distribution network. These values are to be used as inputs into the creation of network prices within the Structure of Charges project to signal, through use of system charges, to existing and potential users the future cost of utilising these network assets.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	5 years	
Estimated Success probability (at start of project)	50%				
PV of Project Costs	£333,518	PV of Project Benefits	£481,518	NPV of project	£148,000
Commentary on project progress and potential for achieving expected benefits	The main objective of the Expansion Planning Initiative is the analysis, design, development and testing of a new software tool to analyse UUE's network bottlenecks and non-compliance with the P2/6 planning standard. The tool will undertake complex analyses and calculations, taking into account a range of factors and data, to study the effects of forecast demand and generation for the company's distribution network over the next 20 years. In the period October 06 to March 07 the key focus of work has been to investigate, analyse, design and document the initial				

	specifications for the computational engine, and the algorithms within it, all of which form the foundation of the software tool. By end Mar 07, the computational engine specification was undergoing its first formal review and revision cycle between the designer and the relevant engineering specialists in UUE.

Description of Project	UU37 - LV Sure EATL				
Expenditure for financial year	Total	External	Internal	Expenditure in previous financial years	£0
	£5,337	£3,125	£2,212		
Technological area and/or issue addressed by Project.	EA Technology and Equipmake have developed a Patented automation system for Power Circuits called “SignalSure”. In the event of a fault on the circuit SignalSure isolates faulted sections of the circuits. Isolation of the faulted section and restoration of supply to unfaulted sections of the circuit is completely automatic and does not require communication between the devices, which comprise the SignalSure system. Currently SignalSure is installed and operational on the rail network and is used to reconfigure signalling Power circuits in the event of a fault. However, with minor modifications it can be adapted to provide an automatic network re-configuration function for low voltage electricity distribution networks, delivering an enhanced level of performance for customers. This proposal details the steps necessary to realise a fully functioning “network ready” version of the SignalSure system, suitable for implementation on the United Utilities low voltage network. The phasing of the work programme is designed to give clear decision points to mitigate risk and funding is shared between United Utilities and EA Technology.				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	**Quality of Supply** The benefits delivered by low voltage automation are those that improve the operational performance of the low voltage electricity distribution network. Reduced number of customer interruptions (CIs) Although when deployed on a radial network actual customer interruptions will still occur, the system will reconfigure the local network and restore many customers before expiry of the 3-minute transient time limit. Reduced number of customer minutes lost (CMLs) By automatically restoring many customers within a short period of time, only those customers within the faulted zone will remain off supply. Follow-up manual fault restoration resources can then be directed to the faulted zone for a permanent repair to be effected.				

	Reduced Restoration Time Fault location on low voltage networks is a time consuming activity. The system provides a means of fault localisation by isolating the faulted section, allowing fault teams to eliminate health sections of the network from their investigations.				
Expected Timescale to adoption	7 years		Duration of benefits once achieved	20 years	
Estimated Success probability (at start of project)	25%				
PV of Project Costs	£106,920	PV of Project Benefits	£148,312	NPV of project	£41,392
Commentary on project progress and potential for achieving expected benefits	Stage 1 – Applications and Benefits "Typical" radial LV network topologies have been examined. The types of faults encountered on these LV networks have been determined and specific operational practices relating to such faults are being reviewed. A preliminary analysis of LV fault incidence using data from NaFIRS is being carried out. A number of LVSure deployment options have been identified and work is on-going to quantifying the benefits in terms of the CIs and CMLs that can be avoided. Stage 2 – Technical Constraints and Financial Implications A review of applicable equipment standards and specifications has been completed and work is on going to determine any additional requirements which apply to similar LV automation / reclosing devices being used. The principal technical constraints associated with deploying this equipment on the LV network have been identified and some solutions proposed. An initial assessment of the financial implications for meeting the requirements and overcoming the technical constraints has been estimated. Stage 3 – Safety & Operational Implications A preliminary report concerning the safety and operational implications associated with the deployment of LVSure equipment on the LV network has been produced. Work carried out to date suggests that there may be opportunities to reduce the number of CIs and CMLs associated with transient faults,				

	and to a lesser extent permanent faults, by deploying this system. The preferred strategy would appear to be retrofitting ‘rogue’ LV circuits, which have the highest number of recorded transient fault incidents.

<table>
<tr><td>Description of Project</td><td colspan="5">UU 38 - Nortech Pole Mounted Fault/Load monitor</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>£1,446</td><td>£0</td><td>£1,446</td></tr>
<tr><td>Technological area and/or issue addressed by Project.</td><td colspan="5">Aims:

Develop and trial a reliable non-contact Fault/load remote monitor up to 33kV

Objectives

1. Trial POLESTAR NX DS
2. Develop load monitoring algorithm
3. Evaluate the potential replacement for POD on OHL networks
4. Feed real-time fault/load data into CRMS
5. Historical load data for planning network reinforcement or development

Description

Central Network and Nortech have developed the PoleStar NX DS and unit now needs trialling to develop it further to allow load monitoring, fault threshold setting and replacement potential for POD's (POD are being removed by customers). It is purposed to install LineTrackers (UU 20 & 21) to allow calibration of Polestars.

Purposed features:-
Overhead line fault passage indicators typically use a combination of measuring changes in voltage field and magnetic field strengths in order to confirm the passage of fault current. The results of
low power wireless wide area communication networks
detect and report the Loss and Restoration of Mains Supply.
uses more accurate measurement of resultant magnetic fields, combined with distance to conductors and conductor spacing information, presents the opportunity to report real-time and datalogged MV feeder load levels.
POLESTAR NX is installed 3 metres below 11kV conductors on the wooden pole. There is no connection between the POLESTAR and the 11kV conductors.
The POLESTAR NX uses a GSM/GPRS modem to report alarms, routine events and field capture trends to a central iHost Platform.

For purposes of the pilot scheme it is intended to make use of the Nortech web-based iHost platform in order that engineers from Nortech can closely monitor the performance of the POLESTAR units and upload configuration settings changes when required.</td></tr>
</table>

	Pilot scheme success depends on gathering information from different sites under different conditions – not just hoping to detect a single fault at a single location. For example installing units at different points along a single feeder means that load levels can be compared against related sites. Therefore it is proposed that 40 sites be selected for the purposes of running a realistic trial in a reasonably short period of time. One the Polestar has been develop further an extended trial will be conducted with an additional 40 units				
Type(s) of innovation involved	Incremental				
Expected Benefits of Project	Quality of supply Reduction in CML and CI's 1. Potential replacement for PODs 2. Could be used with Automation schemes in helping to determine which NOP to Close, ie, what load would be picked up. 3. Faster restoration Operational 1. On-line load monitoring to assist in network management 2. Fault data 3. Outage data 4. Integration into iHost and output into CMRS 5. Historical load data for planning/network development.				
Expected Timescale to adoption	3 years		Duration of benefits once achieved	10 years	
Estimated Success probability (at start of project)	75%				
PV of Project Costs	£82,423	PV of Project Benefits	£347,606	NPV of project	£265,184
Commentary on project progress and potential for achieving expected benefits	Order placed with Nortech for POLESTAR NX Overhead FPI of 40 units for trial. These units will be shipped to UU for trialling once initial product testing and trials have been completed with Central Networks. The current situation and associated time timescale are as follows. Installation of units and start of trial with Central Networks 3rd & 4th April '07.				

A2. SUMMARY REPORT OF IFI PROJECT ACTIVITIES

Number of active IFI projects.	32
NPV of costs and anticipated benefits from committed IFI Projects.	£10,270,918
Summary of other benefits anticipated from active IFI Projects.	Improvements in network performance by reducing the CML and CI. Effective network investment Increased safety of staff and the public. Introduction of Best Engineering practices
Total expenditure to date on IFI Projects.	£ 195,700 – 2004/05 £ 849,726 – 2005/06 £ 1,298,013 – 2006/07 £ 2,343,439 – Total Expenditure
Benefits actually achieved from IFI Projects to date.	UU 22 – Distributed IO The latest fibre communications technology to be used within BSP Grid and Primary substation design, the current MICROSOL RTU, has been deployed using a distributed I/O approach. This required the development of remote cell technology with a fibre ring. The first installation where at Penwortham East & West with further installations planned over Xd4 & 5. Development of a distributed I/O technology has enabled a standard build to be used for all new Substation installations resulting in the following benefits:- • The use of distributed RTU's and fibre communication will greatly reduce the amount of hardwiring required. Savings are achieved by not having to hard wire each individual plant item back to a single RTU cabinet resulting in a savings of £100,000 per132kV site. • The capability for future integration to intelligent protection devices would enable relay management and retrieval of substation data to be achieved both locally and remotely. • A fibre-based system does not suffer from electrical interference or induced voltage resulting in less

	potential mal-operations of relays and communication systems, plus a safer system of work.

A3. REGULATORY REPORTING

Regulatory report for IFI
Reporting year 2006/07

United Utilities Plc

Innovation Funding Incentive

IFI carry forward (£m)	0
eligible IFI expenditure (£m)	1.298 013
eligible IFI internal expenditure (£m)	0.273 389
Combined distribution network revenue (£m)	254.931

LineTracker Developments

LineTracker is a fault and load monitor that is fitted directly on to an overhead conductor. United Utilities (UU) and Gridsense, the Australia manufacturer, have completed a number of developments for LineTracker.

The first stage was to trial LineTracker on the UU network to assess its capabilities and applications. The original LineTracker can be fitted to conductors ranging from 6 to 25mm diameter and are used to record voltage on/off up to 69kV, line currents from both faults and normal load. Initially, the communications were on-site wirelessly for configuring and downloading data. The trial included training a small number of UU Linesmen to install LineTrackers with Live Line rods for ease and flexibility.

The LineTracker trial demonstrated some good benefits and areas for developments were identified. UU agreed with Gridsense a number of improvements including increase the line voltage to 132kV, increase the conductor clamping to diameter of 30mm and temperature monitoring of the conductor and ambient. This would allow LineTracker to be applied at all voltage levels and the majority of conductor sizes within UU. Present conductor ratings are based on rating tables for both summer and winter. The tables are based on previous trials of different conductor materials and take account of a number of factors. Factors like the type of material, load, wind speed, solar gain and ambient temperature - all affect the conductor temperature and therefore the conductor sag. Key factors such as load and conductor temperature can be used to calculate a dynamic rating, which maximises the capacity of the conductor. This is particularly important for parts of the network that are constrained due to ratings for normal and abnormal running. If the constrains are not manageable then overhead network are reinforced/rebuilt.

It is important to integrate data into UU's systems for use in real-time control of the network and off-line network planning. A Data acquisition and reporting platform - iHost developed by Nortech interfaces with UUs Control Room Management System (CRMS) and further developments to iHost will allow this integration to take place.

A network trial will be conducted over 5 sites of the developed LineTracker and iHost. Scottish Power jointed as a network partner partway through the developments and will be also conducting trials on their network.

Benefits of LineTracker

Savings on Overhead line Reinforcement.
Remote Load monitoring
Dynamic line ratings
Network management improvements
Remote Fault indication
Locating persistent transient faults
Power Outage Device
Check correct operation of protection.
Connection and Managing DG
Temporary, semi-permanent or permanent installations

REZAP Fault Master

This Innovation Funding Incentive (IFI) case study reviews a collaborative project between UU, EDF and Kelman. The aims were to trial the newly developed Kelman REZAP Fault Master (FM) and develop further improvements in Low Voltage (LV) fault restoration and fault location.

The original REZAP device was developed in 1998 with a vacuum circuit breaker and protection circuitry which still forms the heart of the new REZAP FM. The engineer can now control and interrogate the REZAP FM remotely via the internet with REZAP Control and Connect software to amend protection settings, open, close and download fault records. Additionally, the engineers can be notified of REZAP FM events via Control software, email or SMS.

Mobile Phone Controller

This development has allowed the engineer to trip and close a REZAP FM remotely, with their mobile phone, while they are located in the vicinity of a suspected fault location. The Substation busbar and feeder voltages and instantaneous current are displayed on the engineers' mobile phone.

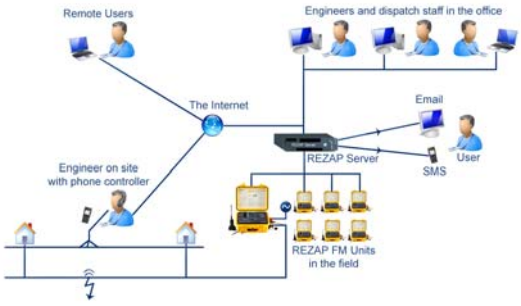

Figure 1

Trips to Lockout and Auto Reset capability

The Trips to Lockout (TTL) function limits the number of re-close operations that can be achieved in an installation to a pre-set value. Once exceeded the REZAP locks out leaving customers off supply. After an initial trip and re-close the REZAP FM will automatically reset to the default TTL value after a specified period of fault inactivity. This will reduce the number of times an engineer will need to visit their REZAP FM units and reduce the number of occasions where a unit enters the lockout state.

Load Profiler

It is not always apparent whether fuse operation on a LV feeder has been caused by intermittent fault activity or by overloading, particularly on highly loaded circuits. Therefore United Utilities & EDF have completed a development with Kelman to add average readings of the current over each half-an-hour, which are uploaded to the REZAP Server. These measurements can then be plotted in the REZAP Control Centre Software allowing an engineer to determine the correct condition.

Benefits

The developments to the REZAP Fault Master are bringing real tangible benefits to customers and the DNOs by enhancing the management and location of LV cable faults on a number of fronts. Customer satisfaction is improved by reducing the number and length of interruptions during the intermittent and transient fault stages and during the fault location phase as well as providing better information during incidents. Financial benefits accrue from reduced customer interruptions and customer minutes lost coupled with reduced and more efficient use of manpower, and reducing the number of excavations required during fault location. There are also less immediate but equally rewarding benefits from the potential for extending the life of LV cables, providing substantial financial benefit by deferring the cost of replacement and the disruptions that occur during major cable replacements.