Project Code/Version No: SPT2003 - v3

Low Carbon Networks Fund
Full Submission Pro-forma

Section 1: Project Summary

1.1 Project title

Flexible Networks for a Low Carbon Future

1.2 The Lead DNO

SP Distribution

1.3 Project Summary

Flexible Networks for a Low Carbon Future will provide the network operators with economic, DNO-led solutions to increase and enhance the capability of the networks. Crucially, these will be capable of being quickly implemented and will help to ensure that the networks do not impede the transition to a low carbon future.

Our solution will provide a 20% increase in network capacity through a number of innovative measures. This will create customer benefits enabling more customers to make the transition to new generation and demand technologies. The project involves enhanced monitoring and analysis to precisely determine existing performance, and the deployment of novel technology for improved network operation - including flexible control and dynamic rating. To ensure representative and replicable outputs, the project involves three carefully selected trial areas across SP Distribution and SP Manweb, covering various network topology and customer demographics: St Andrews in Scotland, Wrexham in Wales and Whitchurch in England.

The cost will be £6.4M over three years with a £2.6M investment from Scottish Power. Financially this solution represents a saving of £8.1M against traditional network solutions. The project is ready to start with senior level buy-in and strong project partners and has well staged deliverables including early outputs.

1.4 Funding

Second Tier Funding request (£k)	£3,600k		
DNO extra contribution (k)	£2,588k	**External Funding (£k)**	£174k

1.5 List of Project Partners, External Funders and Project Supporters

University of Strathclyde - Project partner
TNEI - Project partner
Nortech - Project partner
BRE - Project supporter

1.6 Timescale

Project Start Date	January 2012	**Project End Date**	December 2014

1.7 Project Manager contact details

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Section 2: Project Description

The Problem to be Addressed

The UK electricity network is forecast to have demand growth of 1-2% per annum (DECC) which will effectively double energy demand by 2050. This will largely be due to the de-carbonisation of transport and heating, which will be utilising electricity from both centralised and distributed sources of low carbon energy. The distribution network will be required to connect and manage increasing levels of demand from electric vehicles, heat pumps, and general load increase; while at the same time addressing the uptake of renewable generation at various voltage levels.

An overall growth of 1-2% would be manageable if the load is evenly spread. However, the growth of low carbon technology on the network is likely to be rapid and localised, with limited forward visibility to allow the DNO to plan and implement network upgrades. the rate of change within some parts of the network could exceed the capability of the DNO to respond with traditional solutions.

There are also complexities associated with demand and generation profiles for low carbon technology that have the potential to significantly increase peak network flows and produce substantial voltage rises. This heightens the risk on the network in terms of network integrity, quality of supply and service to the customers, with existing design standards, due to these rapid rates of change.

The distribution network has generally been designed and operated in a conservative manner, this has been deemed the appropriate techno-economic solution in the past to minimise risk and cost. The traditional solution for dealing with increasing load above network constraints has been to install additional capacity on the network; this involves building new substations, overhead lines and laying cables. This can be a time consuming, expensive and energy intensive exercise. For example, obtaining new substation sites and line or cable routes can be difficult due to land access and environmental issues.

Alternative methods available to release and increase capacity headroom are not yet sufficiently technically and/or economically proven. Therefore, it is not possible to prepare a sufficiently well justified business case for these to be incorporated into the SP Energy Networks business plan for RIIO-D1 and beyond. We believe that LCNF is a perfect environment to trial these proposed solutions. Measures are needed that can:

Determine more accurately the capacity headroom while maintaining licence obligations,

Allow that headroom to be exploited in a safe, reliable and cost-effective manner, and,

Provide incremental increases in headroom in a timely and cost-effective manner.

The primary driver is to allow higher levels of low carbon technology to be accommodated without adversely affecting quality of supply, but also allow reinforcements where appropriate to be deferred until greater certainty on the nature of future loads can be gained. This then allows appropriate business decisions on reinforcements to be made without the risk of stranding assets or inefficient network investment.

We have identified three areas of our network with known capacity issues and consequently offer a real opportunity to analyse and implement alternative flexible solutions to network reinforcement. All three sites have different but representative characteristics and customer demographics, and are similar in that they have near-term constraints due to increasing demand and an uptake of low carbon technology. The rapid nature of these changes both imposes a requirement, but also provides the opportunity to trial solutions that are faster and more cost-effective to implement than traditional reinforcement.

The specific issues facing us in these three locations are mirrored across the UK electricity distribution network, and this project will be able to provide generic solutions and recommendations to address these. This is an excellent opportunity to develop and demonstrate innovative solutions through the LCNF and also provide learning to the rest of the UK electricity distribution industry. For the learning to be relevant, representative and robust, it is essential that there is a strong focus on statistical verification of the trials. These were critical factors in the trial site selection process as well as the partnering decisions with Strathclyde University to provide high quality verification and TNEI to provide analysis credibility.

Changes since the Initial Submission

The key changes since the ISP are that the costs and programmes have been refined resulting in a modest overall cost reduction and increase in Scottish Power contribution due to the increased commitment to taking forward an innovative approach to resolving the problems in one of the trial areas.

2: Project Description cont.

Our Proposed Methods:

The methodology for this project focuses on how the network can economically and rapidly adapt to the connection of low carbon technology and associated increases in demand. It is based on optimised network management, rather than demand side management. Although it is recognised that demand side management may form part of the overall solution, we feel that this is already being adequately addressed by a number of other LCNF Tier 1 and 2 projects and therefore we are deliberately avoiding duplication.

Our project involves a series of 12 individual work packages that are integrated with the overall objective of the project, described in detail in Appendix C. This enables a number of smaller, simpler steps to be taken rather than a single large complex step. This approach also minimises the risk that a failure or change in a single step places the entire project at risk or creates knock-on delays. Knowledge gained from work packages with an early delivery will be used to inform work packages with longer timescales. The final outcome will be an intelligent, flexible approach to network management that enables a Low Carbon Future.

The project method is designed to establish a set of robust, evidence based technical and economic trials and case studies, and will capture learning that can be fed through into future network business plans with the focus on RIIO-D1 in the immediate future. The key stages of the project can be summarised as:

Establish a baseline to improve understanding of network and demands

Deploy innovative network technology for improved network operation and control

Review of outcomes and dissemination of learning

Establishing a baseline will involve the monitoring of the three trial sites to a higher degree of accuracy than is currently undertaken. This process will allow the demand on the network and contribution of generation to be extensively understood. From this process, the exact headroom will be determined and the proposed network technology design finalised. This data will be used to compare existing design assumptions with and improve existing policies and practices.

The monitoring regime for this project is focussed on understanding the interdependence of the HV and LV network from primary HV substations down the chain to the customer across the LV networks. This is an innovative “cascade” approach and will provide strong learning on how the network can respond in a timely and cost effective manner to increasing demand driven by the connection of low carbon technology. This is complementary to other Tier 2 projects with a significant monitoring element, such as WPD's LV Network Templates. It will refer to the methodology and outcomes from these projects to identify synergies and to further test and verify project outcomes and provide robust learning for the wider industry.

Innovative network technology to be deployed will include dynamic rating of network assets to create additional headroom where possible, flexible network control to help re-balance network loading using neighbouring network groups to support demand, and the integration of voltage regulation and power compensation equipment to release voltage constrained capacity, and to assist with re-balancing the network. The project will trial targeted energy efficiency and demand reduction measures for Industrial and Commercial customers via collaboration with the Buildings Research Establishment, Energy Supply Companies and an independent party. This will focus on the use of technology such as voltage optimisation, power factor correction, and low energy appliances that do not directly require customer behaviour change.

Some of these techniques and technology have been investigated or utilised individually on a special case basis. They are however by no means ubiquitous within distribution networks, and it is the integration of these technologies and methods into a holistic network management approach that is unique and innovative.

Following the deployment of the network technology and analysis of network data, the outcomes will be assessed to inform future applications of the various techniques. This also involves the dissemination of the project learning to other parties to ensure that all customers and DNOs can benefit from this project.

The key differentiator for this LCNF project is the focus on optimisation of the network operation and management and facilitating user adoption throughout the business and the wider industry. This is a network-based solution in contrast to customer-based solutions through demand side management and other control techniques. Customer behaviour change is important as part of the low carbon network solution, however we firmly believe that equally valuable gains are to be made from improved utilisation and capacity release from network optimisation. This is what this project will be quantifying and valuing.

2: Project Description cont.

Our Network Trial Sites:
The network trials will be undertaken across three different areas of the Scottish Power network; St Andrews (Scotland), Wrexham (Wales) and Whitchurch (England). We have already undertaken a thorough process to identify the best sites for this project. The selected sites encompass a range of different network configurations (radial and interconnected, rural and urban), with different customer types (industrial, commercial, domestic). Network areas with different levels of low carbon technology penetration will be compared to better understand the diversity between base case and future low carbon networks. A background to the three sites is provided below and Appendix D contains further details of network trial sites including network maps, characteristics and customer demographics that were key to selection.

St Andrews, Fife, Scotland
Growing load requests in St Andrews are a significant area of concern in East Fife along with the lack of capacity available in the 33kV distribution circuits the Cupar Grid grid supply point. This is driving the need to consider additional Primary level reinforcement in the area. St Andrews is predominantly a University and Tourism load centre, with many sensitive customers at certain times in the year. At present the key demand growth drivers are due the expansion of the town and general load increase although there has been contact from some of the major consumers around energy efficiency and low carbon technology measures. In addition, one developer has also shown interest in connecting a 12MW wind farm onto the 11kV network which would add another dimension of complexity to the management of this network's capacity.

The level of 11kV interconnection is poor for St Andrews Primary and it is considered a largely "isolated" load centre. An additional primary substation is planned for late within the DPCR5 period, however this is likely to be challenging to deliver due to the lack of land availability within the town, limited access to roads for laying the additional cables, and difficult way-leaves for new overhead lines due to the land use around the town.

Due to the urgent nature of reinforcement within St Andrews and the challenges this would present, we believe this is an ideal site to undertake a project of this nature. It will deliver true benefits to the network and valuable learning on the ability to react to challenging reinforcement cases, as well as benefits to the community through lower costs and reduced construction works. To demonstrate our commitment, SPEN are planning to use a proportion of the DPCR5 allowance for this project to offset the costs to the LCNF.

Whitchurch, Shropshire, England
Whitchurch is facing an increasing demand similar to St Andrews. Several enquiries have been made recently regarding the connection of additional demand in this area of network over the next 3 years. Based on this and historical underlying load growth, it is expected that load will increase over the next 5 years to a level that triggers a significant local network reinforcement. This will have a cascade effect on the rest of the network which will require higher voltage levels to also be reinforced.

The existing 33kV network around Whitchurch is run interconnected as a single group and fed from three 132/33kV grid transformers at Whitchurch, Oswestry and Marchwiel. The 33kV group is a mixture of some industrial and mostly domestic customers. During outages in the Whitchurch area, elements of the network can be loaded up to 99% of their rating which means that this network is on the edge of being P2/6 non-compliant - hence the desire to seek cost effective incremental capacity. Network monitoring shows that demand is increasing and based on customer engagement there is every likelihood that this will continue.
Due to the length of the feeders the wider network is broadly voltage constrained, which also makes it an ideal site for exploring the benefit of coordinated dynamic network control. This type of network situation is typical of GB networks and is a comparable test case to load growth due to low carbon technology.

Wrexham, North Wales
Wrexham Council has recently indicated that they wish to install photovoltaic panels on approximately 3900 properties (circa 6,300kW) of their housing stock as a carbon reduction initiative. The distribution network in this region supplies urban residential and rural agricultural areas. The LV network is based on small radial distributors due to the low load density, and for this type of network, even small amounts of generation can bring about unacceptable voltage rises on the network. Currently, restrictions have been placed on the amount of PV generation which can be accepted on to each of the LV distributors until the impact can be further understood.

Within the Wrexham area, the Ruabon primary substation has the highest potential PV penetration and has been selected for detailed network monitoring to establish whether the demand modelling and planning assumptions can be further refined to free-up technical capacity and allow more of the PV to be connected.

2: Project Description cont.

Our Proposed Solution

We have set a target for this project to create headroom of up to 20% at each of the three trial sites. This will defer further network investment for at least ten years, and potentially longer, unless significant load growth materialises beyond that which is currently foreseeable.

The justification for 20% being achievable is based on the following build-up:

Flexible network control:	9% of peak load can be redistributed on the network at appropriate times
Dynamic rating:	7% increase in capacity following site specific assessments
Voltage optimisation:	2% reduction in demand by reducing voltage where appropriate
Energy Efficiency:	2% reduction by reducing overall demand

Once verified, the integrated network management approach developed for this project, and the range of measures comprised within it, can then be rolled out across the network and to other UK distribution networks to achieve comparable increases in headroom. It will be possible for DNOs to select the appropriate network solution/s for near-term network issues relating to increased demand and connection of low carbon technologies, and have the confidence that it is a proven solution.

There is flexibility within this approach to support a range of network topologies and customer demographics. This will ensure continuing P2/6 compliance and network security whilst enabling connection of increasing low carbon technology.

Solutions that are faster and easier to deliver than traditional reinforcement will be of significant value to a rapidly changing network, particularly as tools for managing risk when faced with uncertain or rapid load growth that are challenging to meet in an efficient and timely manner with existing methods. In some circumstances rapid load-growth may result in short-term non-compliant networks irrespective of best endeavours. The network monitoring and new operational tools are key to providing improved operational risk management methods to reduce customer risk exposure to network outages.

This project will create the ability to identify and respond to load growth associated with low carbon technology, and develop a verified knowledge of the sensitivity of the network to its characteristics. This aspect is key to enabling more efficient and low risk network management in the low carbon future.

Using the approach of multiple, integrated work packages maximises the likelihood of success. If it becomes clear that the traditional approach of network reinforcement is more cost-effective than the measures investigated, then this is a still an important learning outcome and as such we commit to publishing any negative as well as positive outcomes. A negative outcome of a particular activity still creates a base of verified knowledge from which to develop robust strategies within the business and supply chain to enable more rapid turnaround of network reinforcements for the network areas identified and UK electricity distribution as a whole.

The outcomes and learning of this project need to be robust and representative of other distribution networks in the UK to ensure applicability to other DNOs. With this in mind, urban, rural and market town network groups in three different UK regions have been purposely selected for trials with varying current and predicted future penetration levels of low carbon technology and different customer demographics.

During the project the analysis tools and network technology will first be trialled in a controlled test environment such as the simulation laboratory at University of Strathclyde or the Power Networks Demonstration Centre (PNDC), prior to carrying out network trials. This will help ensure the robustness of the trials, provide an opportunity for refinement, as well as reducing deployment risk.

Technical Description of Our Project

The project is divided into three main work packages with 12 sub-packages for the actual delivery:

Enhanced Network Monitoring	(Work Package 1)
Dynamic Network Control	(Work Package 2)
Stakeholder Engagement and Dissemination	(Work Package 3)

The work packages reflect the aims and objectives of the project and form an integrated network change management approach across the business to enable connection of low carbon technology. The following is a high-level description of the work packages and sub-packages with the full project briefs and technical details provided in Appendix C.

2: Project Description cont.

Work Package 1 - Enhanced Network Monitoring

Although network monitoring and analysis is not in itself an innovative technique, the innovation in this work package is the core focus on development of integrated use of existing network data across the business to create knowledge and foresight of the existing and changing environment. At present the data from the network that is collected is the technical and economic minimum set based in part on legacy technology, communication and archiving systems. The data also tends to be for acquired for individual network control or monitoring requirements rather than as full integrated business intelligence.

This existing process works sufficiently well in the current environment where there is limited time-pressure as load-growth rates are generally low and connection requests manageable. To manage accelerated load growth scenarios due to low-carbon technology uptake, the existing systems will rapidly create a bottle-neck in development, or risk inefficient investment due to higher volumes of assessments based on the existing conservative assumptions due to the lack of definite network loading information.

Therefore, the application here is to focus on learning for intelligent network design and operation in a future low carbon environment where networks will be more heavily stressed and demands may grow rapidly. This in itself is an innovative application. Enhanced network monitoring will also allow us to characterise the potential energy savings that can be made by deployment of innovative network technology.

WP 1.1 Improved use of primary substation data - £108k

Network operators such as SPEN already gather and store a moderate amount of data from their Primary Substations for use in monitoring and analysis. The data however is stored as raw data and requires manual extraction and interpretation on a case by case basis when analysis is required. Typically this is done on an annual basis to monitor load-growth, or as part of a new connection assessment. The low carbon technology growth pressure means that there is a significant need to extract more information, and thereby develop better knowledge of the demand characteristics, and critically, how best to apply this to network analysis.

This work package will develop robust analysis techniques for existing primary substation measurements to inform asset ratings, planning and operational decisions. It will improve understanding of asset loading characteristics, identification of underlying demand behaviour changes, and verification of capacity headroom increases. The learning from this work-package will inform the requirements and equipment specification for future permanent enhanced monitoring for both Primary and Secondary substations.

Measurements will be compared with existing analysis techniques to improve the modelling of transformer voltage control, voltage regulators, generators and demand. This will include an investigation of measurement and modelling uncertainties, representation of diversity, bad data detection, and crucially how the data and network models can best be used to inform business decisions on efficient network investment. Network trials are not required so this work package can begin immediately, and with a short timescale this allows early delivery of project outcomes that can be disseminated and applied to other work packages.

WP 1.2 Improved secondary substation data monitoring - £2,212k

At present, Secondary substations in the UK distribution networks have very basic maximum demand meters that do not provide any information on the timing, duration, or frequency of the peak demand. As these require manual reading, the data is gathered infrequently and because of this has limited use for network planning, and is no use for network operations. As network planning and reinforcement decisions require a good characterisation of the network and the connected demands and profiles, a lack of good quality data means that conservative assumptions must be made to safeguard the network and customers.

The network risk posed by a growth in demand driven by low carbon technology cannot be adequately managed using existing approaches without incurring large levels of costly network investment. However, simply putting a secondary substation metering programme in place would not in itself resolve the issue. An inappropriately designed system will create volumes of data and communication bandwidth requirements that are unmanageable, not cost effective and ultimately would not address the root issues.

The key to this, and the innovation proposed in this work package, is to develop a metering programme led by the network planning and operational needs, taking due consideration of the relatively low cost margins required by Secondary distribution networks. Once this data is available in the right form, this work package will then assess the value of the information in allowing increases in the allowed network capacity to enable greater levels of low carbon technology to be connected than is presently permissible.

2: Project Description cont.

The project involves the prototyping of secondary substation meters using flexible programmable units that can perform on-board data analysis and processing so that only minimum amounts of key information need to be communicated back to a central database system. In effect, rather than streaming full 10 minute raw data back to the central system (3,000kB/meter/yr), they will only upload processed monthly demand profiles (10kB/meter/yr). Considering the number of secondary substations within the UK, this issue is a significant barrier to roll-out of Secondary network monitoring unless an innovation of this scale is adopted.

The innovative "cascade" approach has the measurements synchronised in time, and monitoring equipment is installed from the primary substation down the chain to the customer across the secondary networks as illustrated in Appendix D. The learning provided from this approach will allow a targeted roll-out in the future based on intelligent interrogation of Primary substation data to identify areas where growth, or behaviour change is occurring. This ensures that the future network metering roll-out can be done in an efficient and timely manner on an as-needed basis rather than a blanket high cost and impact roll-out.

WP 1.3 Improved operational tools - £173k
The availability of higher resolution network data will also need to be utilised in the control room to improve risk management capability through real-time analysis of data to provide information that is in-line with the planning methodology and equipment capability. At present the network operators have limited feedback from the network in the form of warnings and alarm systems, and of this, it is predominantly only on the EHV and Primary networks. As network planning methodologies and network technology become increasingly sophisticated, the network operators need to also be provided with more information to help them manage and control the network in-line with the planned technical limits. Simply increasing the volume of information is in itself not the answer, the network controllers need to be provided with useful interpretation of situations to aid with their decision making processes.

This work package will assess the challenges and opportunities as described above, to trial control room tools fit for purpose for a future low carbon network. A key element will be engagement with operations staff to maximise buy-in and user adoption of the new planning and network operation methodologies and equipment capabilities such as dynamic thermal rating and flexible network control.

WP 1.4 Improved planning tools - £158k
At present, as with all DNOs, SPEN undertake an annual assessment that provides a ranked portfolio of network capacity issues. These then get prioritised based on value, criticality and deliverability. As the networks become more dynamic in nature, and the demand growth increases driven by low carbon technology adoption, network planners will need more sophisticated Decision Support tools to cope.

This work package will build on the information and knowledge generated by the monitoring analysis from WP1.1 and WP1.2 and initially develop a best-practice guidance on the management of system capacity in this environment, whilst optimising network investment and ensuring P2/6 compliance. The core philosophy will be based on a standard assessment across the network, with more detailed monitoring and site-specific assessment as the network capacity headroom becomes depleted. A review of existing tools and processes will be undertaken, and new Decision Support tools developed as required.

Work Package 2 - Dynamic Network Control
The core objective of this package is to improve the flexibility with which primarily the 11kV and some of the 33kV network can be operated to enhance the existing network capacity, and to provide useful increments of network capacity on a rapid and reasonable cost basis. Some of these techniques are about using technology advances and cost reductions to allow us to deploy approaches already used on the transmission and EHV networks but at lower voltage levels. Others are about focusing on the specific issues that limit network capacity and using better data and control to be able to reduce or remove the barrier.

A needs-based approach is being taken for each of the key opportunities identified through discussions with the different teams within SPEN as to where there is potential for releasing or incrementing network capacity. The sub-packages are based on the philosophy of first identifying what the network requirements are in terms of flexibility or capacity limitations, then to identify a suitable technical approach and design a minimum requirement trial. The trials will test whether the theoretical benefits of the approach can be achieved in practice, and to establish timescales, costs and any real-world limitations.

The key innovative aspects of this work package include the use of dynamic ratings on 33kV networks, implementing flexible network control on the 11kV network, the use of targeted energy efficiency measures, and the development of a packaged solution for series voltage regulators and reactive power compensation.

2: Project Description cont.

An essential feature of this flexible network approach is the full business integration of this methodology across all core business areas from Planning, Operations and Field Services. This is a key innovative measure that will provide real achievable savings through deployable capacity increments.

WP 2.1 Dynamic thermal ratings of assets - £783k
Present industry best-practice revolves around the use of fixed equipment ratings based on conservative seasonal conditions. Improved thermal management of network assets using real-time dynamic ratings can help to release additional network capacity, potentially avoiding triggering of unnecessary network reinforcement for relatively small levels of demand growth.

Temperature monitoring will be installed at 8 primary substations to capture thermal loading of transformers and 33kV circuits supplying the primary over the course of a year. Weather monitoring will also be installed to investigate how asset rating can be optimised by considering real-time environmental conditions. An advanced thermal management system will be developed in parallel to the monitoring with consideration of appropriate thermal modelling tools. A small number of secondary substations will also be monitored using simple external measurements to trial the value of having basic temperature information on a traffic light basis for the operational decision making on the network. SPEN have experience in trialling this technology at 132kV overhead line as part of a LCNF Tier 1 project. However, this work package will trial multiple sites and on composite combinations of assets. The evidence from this trial will be used to develop a cost-benefit assessment and the corresponding business case for consideration as part of the wider SPEN business plans leading into RIIO-D1.

WP 2.2 Flexible network control - £851k
Incremental capacity can be created on the secondary (11kV) network by using of flexible open points to link neighbouring groups with different demand profiles. This work package will trial flexible network control by installing automated intelligent 11kV switches onto secondary networks in two of the trial sites to provide the capability to dynamically transfer load between primary substations. Results from the trial will provide proof of concept and quantify the benefits and costs of using this type of network control.

Further quantification will be achieved through the validation and use of the prototype tool developed by University of Strathclyde and SPEN on how network reconfiguration should be done to reach a suitable compromise between losses and reliability. The real benefits of the developed methods have previously been difficult to quantify due to lack of real-world data. Work Package 1.2 is therefore a key input to this work-package as it will provide such data through some additional higher resolution network data. An expert control system will be developed to run in parallel with the existing operations system.

WP 2.3 Energy efficiency and voltage optimisation - £362k
There is an opportunity to achieve increases in capacity headroom on the distribution network by working with customers and energy suppliers to identify and implement appropriate energy efficiency measures that can reduce power demand as well as energy demands, i.e. voltage regulators, reactive compensation and low energy appliances. The campaign will be targeted on specific areas served by stressed network assets rather than a blanket approach, and be specifically focused on reducing electrical power demand; provided this also results in an overall neutral or better reduction in energy demand for the customer.

Energy efficiency surveys will be structured to identify potential demand reductions that could be achieved, provide advice and support to customers, and where consented, share this information with Energy Suppliers to see if they could assist. A provision of £100,000 will be set aside to subsidise customers where a demand reduction is possible and, although the technology is not economic in terms of energy saving for the customer, the solution can be justified based on the demand reduction benefit to the DNO. This work package will also investigate optimising the demand of major customers in the industrial and commercial sector as this is where the largest power and energy savings are likely to be achieved.

Substations at which network voltage could be reduced to the statutory minimum during periods of peak demand will be identified and tested to determine if this provides a measurable demand reduction and consequently if there is any wider energy saving benefit to the customers. Network monitoring installed in Work Package 1.2 will be crucial in evaluating the cost-benefit of these trials.

WP 2.4 Integration of voltage regulators and reactive power compensation - £603k
Rural networks, or "Isolated Urban" networks, are often complex and difficult to reinforce due to long feeder lengths. These networks are also the ones that may be early adopters of low carbon technologies such as heat-pumps and renewable generation due to economic drivers from off-gas grid heating, or fewer planning

2: Project Description cont.

restrictions. Often the network "P2/6" capacity limitation is due to the back-up capacity in the event of a network problem (N-1), rather than the normal "intact" network. These long secondary network feeders tend to be voltage constrained rather than thermally constrained, and so the use of series voltage regulators, or in some circumstances reactive power compensation, can create useful levels of an incremental capacity in a comparatively rapid and low-cost manner.

This work package covers the development of the detailed design, testing and deployment of prototype package solutions for 11kV voltage regulators and reactive power compensation. Certification, procurement, installation and integration specifications of these packages will also be considered. The resultant package is intended to be a `plug-and-play' solution that can be rapidly deployed to stressed network areas as a generic solution to provide the required incremental network capacity.

Once the package design has been verified in the controlled environment of the Power Networks Demonstration Centre, three of these will be deployed into the project trial areas to gain real-world experience of installation, operation and maintenance. Their ability to create incremental capacity will be verified in part by the network monitoring installed as part of WP1.2, and the cost-benefit analysis and corresponding business case will be developed based on this physical evidence.

Work Package 3 - Stakeholder Engagement and Dissemination
This work package will develop and implement stakeholder engagement strategies to maximise learning from this process and enable large-scale rollout of successful measures. Key stakeholders include internal staff, external stakeholders such as other DNOs, major customers, local councils and authorities, energy suppliers, local community groups and MPs.

The University of Strathclyde will provide guidance on the dissemination of project learning as well support from the SPEN corporate communications team. The dissemination will include a series of papers presented at academic conferences and LCNF events, training sessions at the PNDC and University of Strathclyde simulation laboratories for internal staff and other DNOs. Policy changes such to internal policy and to the distribution code, will be investigated as well as ongoing liaison with industry decision making bodies. Appendix E contains further details on the proposed customer engagement strategy.

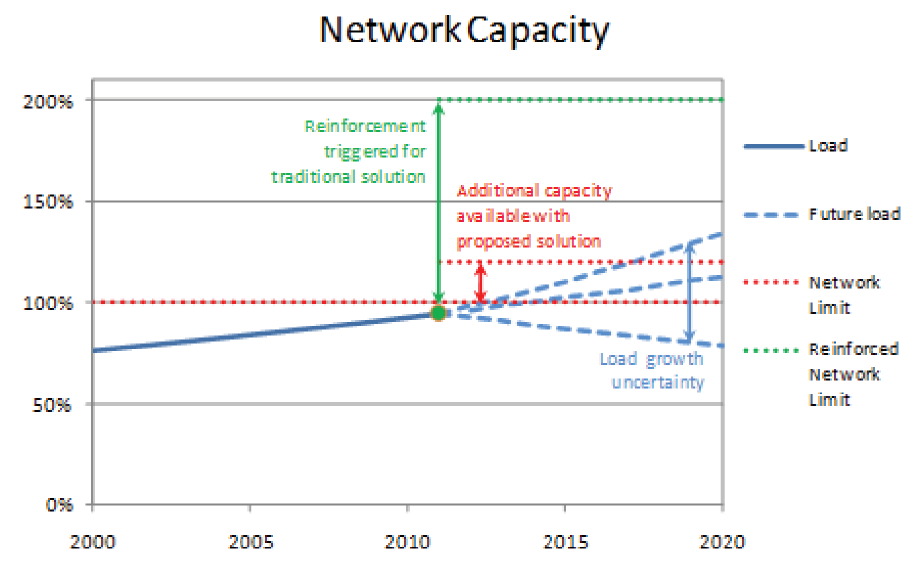
WP 3.1 Internal Stakeholder Engagement - £119k
Internal staff engagement strategies will be aimed at promoting staff empowerment, attitude change, and optimising knowledge transfer. This will include engagement at key phases through the course of the project to obtain staff input, training and user adoption. Key activities include the training of staff at the Power Network Demonstration Centre, rotation of staff through the project team to help with practical learning, identifying project champions within each business area, and an annual internal technology conference.

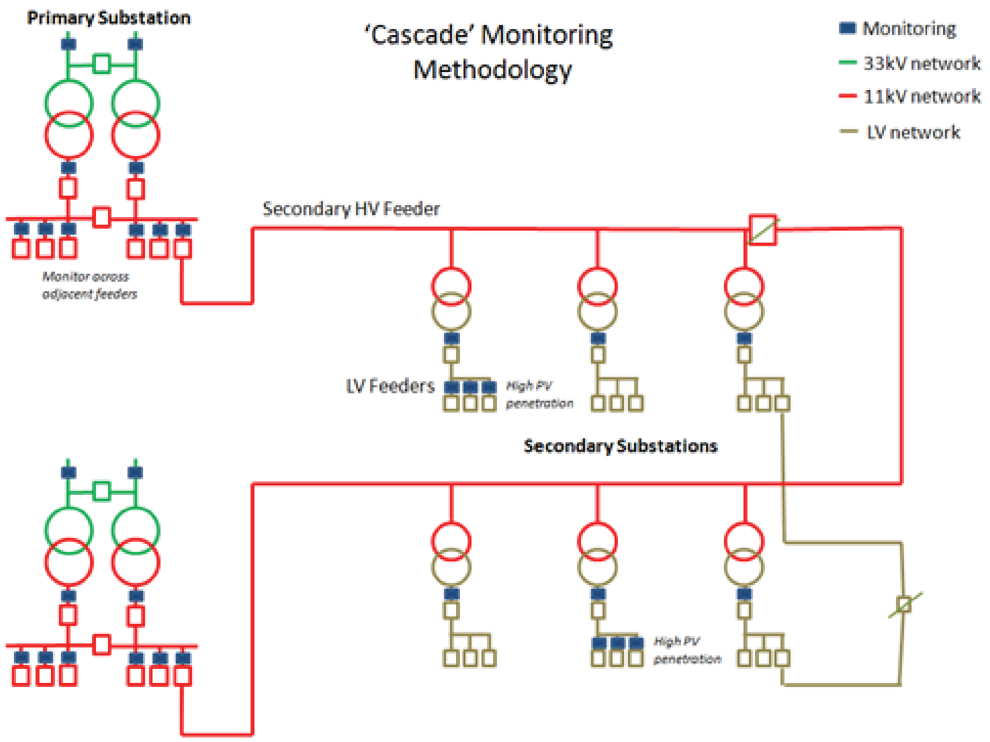
WP 3.2 External Stakeholder Engagement - £258k
This work package will address engagement and knowledge dissemination with external stakeholders. This includes major users, suppliers, local councils and authorities, local community groups and MPs and other DNOs. Key activities include practical demonstrations and trialling of equipment at the Power Networks Demonstration Centre, academic papers on the outcomes of the project by the University of Strathclyde, involvement of partners who will have their own dissemination channels and a project specific website to allow public access to project information. Data will be shared with other DNOs as appropriate.

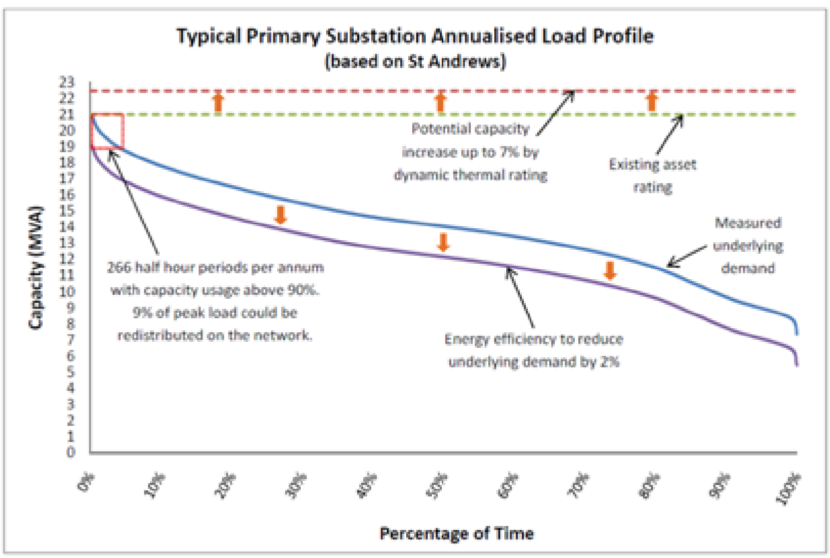
WP 3.3 Experimental Design Review - £33k
The University of Strathclyde is a key partner and will be carrying out an independent review of the experimental design of each work package to ensure that the methodology is technically robust, statistically sound and that outcomes are verifiable, reproducible and applicable to other DNOs. The University will also be involved in the Project Review Group, providing high level review of the objectives and the outcomes of the project to ensure that the learning remains relevant to the aims of the LCNF and the wider industry.

WP 3.4 DNO Policy Changes - £110k
The outcomes from this project will be used to inform and modify a number of internal policy and guidance documents such as design manuals used by network planners, control room and training manuals, risk management policy and procedures and business process documents. A key output of this project is to inform the development of future engineering technical recommendations, with particular focus on ER P2/6, the current distribution network planning standard. SPEN will also be looking to inform regulatory policy based on project outcomes through Ofgem, DECC and DTI policy consultation documents and liaising with industry bodies such as ENA and other DNOs.

2: Project Description Images, Charts and tables.







Section 3: Project Business Case

Context

Flexible Networks for a Low Carbon Future will create a faster, lower cost, DNO-led solution to increasing the capacity of the network. The proposed solution will facilitate an increasing demand on the electricity network as customers make the transition to a low carbon economy and they increase their dependence on electricity for heating, transport and other appliances. The project will also enable future network trends to be identified and managed in a forward looking manner with faster delivery of appropriate and cost-effective solutions.

The current level of investment for general load related reinforcement across the GB in DPCR5 is over £1.5bn, which represents 11% of the total network expenditure. This number reflects a 32% increase on the DPRC4 investment due to the significance of load growth. Of the total allowance in DPCR5, ScottishPower will spend over £140m between 2010 and 2015.

In the next price review period (2015-2023) it is likely that general network reinforcement will increase again due to accelerated load growth, triggered largely by the uptake of electric vehicles and other low carbon initiatives. Based on the percentage increase between DPCR4 and DPCR5, this could result in an increase in investment to between £3-5bn for the period 2015-2023.

These levels of investment are largely based on "traditional" solutions which involve installing additional assets on the network to add capacity. These solutions are deployed on fit and forget basis, which provides a reliable, secure and low risk investment even though the cost, impact and delivery time can be high.

This project verifies alternative methods that offer smaller, faster and lower cost incremental increases in network capacity where it is not clear that a significant step change is capacity is required such as an additional substation; or where a more rapid solution is required.

Within Scottish Power there are a number of locations which currently present difficulty in providing demand and generation connections due to system voltage and thermal capacity limits. These situations present an immediate opportunity to undertake a trial and gain transferable learning for alternative solutions to traditional network reinforcement.

The trial is targeted at sites that are representative examples of the challenges that will be faced for the adoption of low carbon demand initiatives which could be applied to other networks areas in future to facilitate lower cost and quicker connections to customers.

Three trial locations in Scottish Power's area where demand or generation connections are restricted have been selected, one each in Scotland, England and Wales. The identified locations for the trials are:-

- **Whitchurch, England** and **St Andrews, Scotland** - there are currently constraints for demand connections due limited network capacity, which will trigger reinforcement and these risks are inhibiting economic development in the area. It is believed that that we can identify additional network capacity/headroom to allow proposed developments to go ahead without triggering immediate reinforcement and provide cheaper connections to the customers. This may only defer reinforcement, but gives a period of time to see the materialisation of growth.

- **Wrexham, Wales** - there is an existing restriction on photovoltaic connections due to voltage issues being created on the LV network, thereby preventing the take up of renewable generation. Enhanced analysis is needed to identify if the network issues perceived from the installation of such a density of PV generation do actually cause network issues or not, and whether the demand patterns/behaviour of users changes thereby negating or exacerbating the issues.

3: Project Business Case contd.

Business as Usual Baseline

The existing method to provide increased system capacity for demand and generation would be traditional investment such as the construction of a new substation, the installation of transformers and the laying of cables. DNOs are familiar with these technologies and have served the UKs needs over the years and offer a reliable low risk solution. However these take considerable time and resources to deploy and therefore can result in inefficient network development when demand change is variable and unpredictable.

At St Andrews, the lowest cost traditional method would involve reinforcement works including two new 33/11kV transformers to be installed, new 11kV switchgear, 17km of 33 kV overhead line and extensive cable works to reconfigure the 11kV network. Due to consents matters across the various land owners, experience has shown that this project would take approximately 3 years to implement and is budgeted at a total cost of circa £6.2m.

At Whitchurch, the lowest cost traditional methods would involve reinforcement works and the construction of a greenfield primary substation. This would include a 33kV switchboard, one 33/11kV transformer, 11kV switchboard and connecting 33kV and 11kV cables interconnected into the existing networks. This would take approximately 2 years to complete and would be budgeted at £3.1m. The Manweb network has a slightly different design, which only requires one transformer to be installed hence the reduced cost when compared to the St Andrews case.

At Wrexham, traditional methods would require a number of additional 11kV/LV substations to be installed across the network. It can be particularly difficult to establish these substations in mature housing developments where spare land is generally unavailable. Extensive cable works would also be required to integrate these new substations onto the network. This would take approximately 1-2 years to complete and is budgeted at a minimum of £1.2m.

The above is further summarised in table 1 on page 17.

The level of impact to deploy the traditional methods can also be significant to the local community as substations require land to be made available and the installation of cables can cause significant disruption. The effects of installing these would typically include:-

Overhead lines

- Impact on agricultural land
- Visual amenity
- Additional maintenance costs

Underground cables

- Traffic disruption
- Waste disposal issues and increased landfill
- High installation cost

Transformers & Switchgear

- Use of environmentally harmful substances within switchgear and transformers
- Access to land which may be scarce and expensive

3: Project Business Case contd.

Drivers for Alternative Solutions

To facilitate the encouragement of low carbon technologies there is a need for the electricity network to provide connections for additional renewable or low carbon generation, or additional demand such as electric vehicle charging. The limits of the existing networks and the inherent delay and costs in deploying traditional reinforcement methods can have a significant impact on the take up of these technologies.

Customers also want the availability of their connections to be much quicker than the timescales experienced for traditional reinforcement methods, which can be prolonged when it is necessary to install significant amounts of asset. Therefore the availability of a quicker lower cost connection can facilitate low carbon initiatives and economic development and growth.

With traditional solutions, often the standardised incremental step of reinforcement may provide capacity that is significantly higher than what the individual customer needs. Sometimes this is higher than may ever be utilised by future customers at the location. This can create a significant financial challenge for the customer to justify the connection costs that they face.

This is particularly relevant in speculative development areas, where development agencies cannot take the risk of paying for network reinforcement and infrastructure that does not get used within a reasonable timeframe.

The level of step capacity increases in certain situations could potentially provide sufficient capacity headroom for 20 or 30 years. Given the possibility of the changing needs of electricity networks in future, it may be that the investment could have been avoided all together if it was able to have been deferred for a period of say 2-3 years.

An example of this scenario would be where load is currently growing to a point which triggers reinforcement work which may take 2-3 years to construct, by which time carbon saving encouragement may appear in that area of network which reduces the load back below the point which triggered the reinforcement.

Flexible Network Approach

This project will investigate and trial new approaches to how we determine solutions to demand and generation change across the distribution network. With the forecast and the ongoing encouragement in low carbon technologies it is fully expected that this will create a need for electricity networks to be more flexible and more rapidly facilitate the connection of these technologies.

The project will identify and trial the practical, technical and economic feasibility of a range of new technologies, design tools and operational practices that have not had extensive operation on the distribution network, nor fully integrated within DNO operational activities as described in Section 2.

Ideally the monitoring timescales for each of the sites would require 12 months of data over the annual load cycle to verify potential of revised network utilisation. However once the revised learning and understanding of the viability of utilising any further headroom in the network is complete, it is expected that use of this approach can be repeated at a much lower cost and in a shorter timescale .

The project will also draw learning from other LNCF projects such as WPD's - Low Voltage Network Templates, which should provide enhanced understanding of LV networks and customer supply information. Also the CE Customer-led Network Revolution, which should complement our project with the learning with the advanced customer voltage control devices and customer behaviour. We will also be looking to link this project with other Tier two projects being proposed in 2011 as be believe that some of these will complement the learning in this project.

3: Project Business Case contd.

Benefits of Proposal

It is considered that the outcome of the project will lead to changed future connection design strategies, charging methodologies, and a more rapid delivery of additional capacity. The effects of this will permit carbon saving measures that otherwise may not have occurred due to network constraints or enable carbon saving measures to occur sooner.

The learning acquired from this project may also challenge the current thinking and the requirements of the distribution code and the obligations on DNO to avoid network risk, which in turn creates networks designed for worst case scenario.

Looking at the situation for the Wrexham site, 6.26MW of PV generation would be expected to return at least 18,000MWh of electricity per annum, which based on current fossil fuelled power levels would save 8,200 tonnes of CO_2. This is based on a typical figure of 450g/kWh of CO_2 for electricity generation and an average household CO_2 production of 1695kg.

The proposed trial of new technologies will provide better understanding of network operation and actual capability versus predicted capability. The benefits of which are:

- **Identify** additional capacity headroom and delaying the major reinforcement
- **Improve** understanding of network trends, load growth and risk management
- **Increase** facilitation of low carbon technology demand
- **Enhance** the working relationship with external stakeholders

This project will improve understanding and management of the network, in turn leading to better prioritisation of reinforcement and better informed solutions in the long term. Given the encouraged growth of low carbon initiatives, the future operation of the electricity network will need to be more flexible to changes in the demand and generation profiles across the network.

Therefore through better understanding it is more likely to avoid unnecessary reinforcements.

Trial Project Costs and Rollout (Method) Costs

The total costs for this project involve a number of one-off elements due to additional design, research and development that would not be incurred in a full roll out. A number of elements of WP 1 are focussed on optimising the way that we handle the limited data that we already have available.

WP1.2 in particular has costs associated with the design and installation of the monitors that we have never previously rolled out. These are prototype devices and as such, their volume production costs will be much lower once standardised. We will reviewing the learning from other LCNF project have developed for installing this equipment to avoid duplication.

WP 1.3 and WP 1.4 involve engagement with the various business units to better understand their requirements and inform them of the tools that this project has developed. These costs are likely to be significantly lower in a full roll-out, but are a key component of the project to ensure strong business buy-in, as well as the developed tools being robust for future applications.

WP2 involves additional engineering cost as this technology is being rolled out for the first time and will involve internal approval as well as one-off design costs for integrating the various techniques onto the network. Costs have also been factored into this work package for trials and demonstration at the Power Network Demonstration Centre.

The focus of WP 3 is on engagement and academic oversight of the project that would not be required to the same extent in the future rollout of the solution. This is however necessary to ensure the outcome is robust, and is communicated effectively to other DNOs and interested parties.

3: Project Business Case contd.

Net Benefits

The total project cost stands at £6.4m, and our calculations indicate that a future method cost for these same three sites will be approximately £2.4m in total. Compared to the Base case costs of £10.5m, this alone would provide a net benefit of **£8.1m**.

The three sites that have been trialled offer a range of net benefits, which range from a reduction in reinforcement costs of between 40% and 80%. From analysis of the SP Energy Networks reinforcement plans, should this project successfully achieve a saving of 20% in network capacity, we believe that these solutions could be deployed on up to one third of our reinforcement schemes.

Over DPCR5 this would have provided a saving of between £20m and £36m for Scottish Power, or on the same basis across Great Britain, a total saving of between **£225m** and **£400m**. This is based on a total investment requirement of £1.5bn over DPCR5.

Projecting this forward for RIIO-D1, we estimate an investment of between £3-5bn over 2015 to 2023 is required based on traditional reinforcement methods. These solutions could therefore create a net benefit of **£400m** to **£670m** over this period, based on the same conservative capital savings of 40% across one third of the required reinforcement schemes.

It should be recognised that this solution is only providing an incremental solution and additional substation reinforcement may still be required at some point in the future. In some instances future load may not materialise as expected, or overall demand will decrease due to energy efficiency. The ability to provide small capacity increments would therefore avoid the cost of constructing assets that were only required for a short period of time and then become stranded.

Additional Benefits

This project will provide additional value to customers in the form of facilitating faster renewable generation connections. An example of this is in Wrexham where the demand to connect solar PV to the network has been temporarily constrained due to the lack of detailed knowledge and the estimated impact on the network. The Energy Savings Trust estimate that a solar PV can generate £920 pa of savings/income in one year for a domestic property, which is a material benefit for a household if they can connect to the network faster. Additional societal savings will be achieved by mitigating the cost of carbon that would otherwise need to be funded from fossil fuelled generation.

Delays or prevention to development and economic growth at other locations across the network is difficult to assign a monetary value to, but these too can be substantial. This can occur when the customer does not wish to initiate a development due to lack of network capacity, and the DNO cannot speculatively reinforce the network without firm connection requests in the hope that the reinforcement assets will be utilised at some point in the future.

Reinforcement deferral has a wider benefit when considering the present value of money in an investment decision. In addition to maintaining network security as the demand growth is established and confirmed (i. e. it materialises and is maintained thereby reducing the large reinforcement risk), the deferral of a £1m major investment requirement by a £100k incremental capacity investment can be justifiable even over relatively small deferral periods.

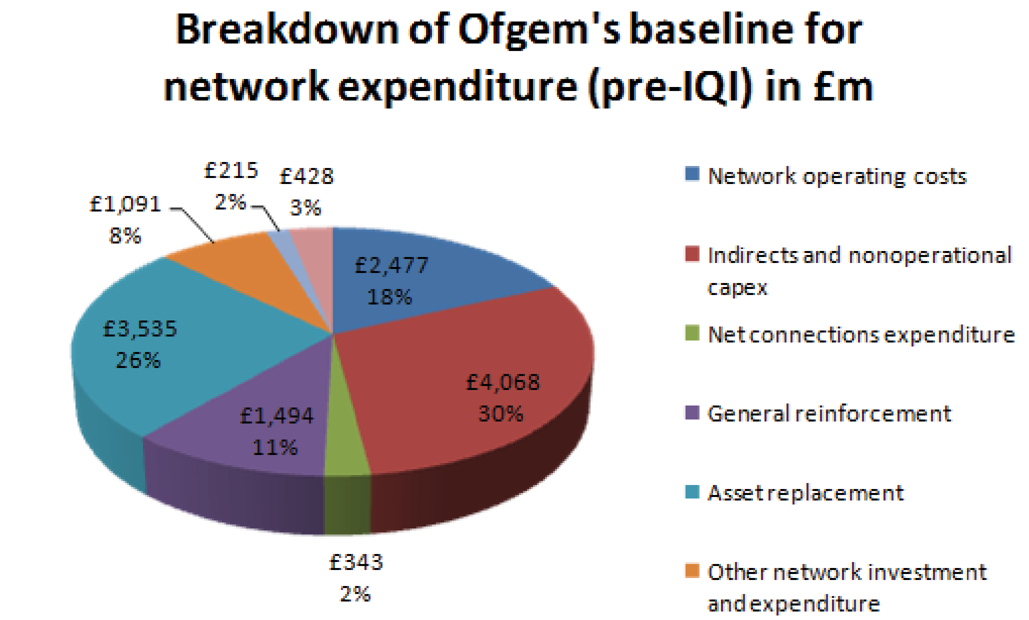
Clearly this decision and benefit is dependent on the cost of capital used by the business, but for typical DNO rates of return, any deferral beyond 3 years is likely to be financially beneficial at these relative levels of spend.

3: Project Business Case contd.

SP Energy Networks Contribution to the Project

SP Energy Networks are providing funding to this project in the form of direct benefits which will be achieved by utilising part of the funding allowance for reinforcement works in St Andrews in DPCR 5. An allowance was granted when the DPCR 5 settlement was made for reinforcement in this region. Part of this funding will go towards the costs of the St Andrews site, demonstrating the commitment SP Energy Networks have made to this project. This will provide a benefit to the customer as the funding is not going towards another site which does not have as immediate a problem. This approach a has been agreed with Ofgem. In total, SP Energy Networks are making a contribution of 41% to this project through direct benefits, opposed to the minimum 10%, which reduces the overall cost to the customer. We have deliberately focussed the project in areas of the network with immediate issues to provide a greater benefit to the customer.

3: Project Business Case images, charts and tables.



Reproduced from Figure 3-2, in Electricity Distribution Price Control Review Final Proposals, Ofgem, 9 December 2009.

Table 1 – Base Costs for Trial Sites

Location	Traditional Reinforcement Works	Installation Timescales	Reinforcement Cost
St Andrews, Scotland	Construct new substation and install two new transformers and switchgear. New 33 kV circuit, and significant changes to the 11kV network.	3yrs	£6.2m
Whitchurch, England	Construct new primary substation (one transformer and associated switchgear), construct new 33kV circuit and associated network connections	2yrs	£3.1m
Ruabon, Wales	Install new HV/LV substations, LV distributor cables	1-2yrs	£1.2m

Table 2 – Comparison of Base, Trial and Method Costs for Trial Zones

Location	Base Case Costs (Traditional Solution)	Project Trial Cost	Method Cost (Est. future cost for roll out)	Net Benefit	% Saving
St Andrews, Scotland	£6,200k	£2,522k	£955k	£5,245k	84%
Whitchurch, England	£3,100k	£2,076k	£744k	£2,376k	76%
Ruabon, Wales	£1,200k	£1,466k	£687k	£513k	42%

Section 4: Evaluation Criteria

(a) Accelerates the development of a low carbon energy sector

Contribution to Low Carbon Transition Plan
The solution to be developed is a faster, more cost-effective, holistic network management approach that will achieve carbon savings through;

- *Facilitating higher volumes of low carbon generation and faster connection.*

Increasingly, renewable microgeneration such as PV and small to medium scale wind, are being installed to supply local areas as well as taking advantage of feed-in-tariffs and sell electricity back to the network. However, this requires suitable network capacity as the lack of local generation profile diversity can cause higher loading and voltage increase in some circumstances. The connection of low carbon technology required to meet the UK Low Carbon Transition Plan are likely to exceed the capacity of the existing 11kV and LV distribution networks.

The solution to be developed will enable the capacity headroom on distribution networks to be increased to cope with both underlying demand growth as well as more rapid changes due to the connection of low carbon technology such as microgeneration. Whilst network reinforcement may still be required, the solution will buy some time to better optimise network design, reduce bottlenecks for consenting, procurement and installation which can have timescales of 4 years or more. This addresses a key element in the Low Carbon Transition Plan for a UK Smart Grid, which is a grid that enables individuals and businesses to sell electricity into the network as well as buying from it, through microgeneration and on-site technologies. Also, increasing the connection of low carbon generation onto the network will facilitate the use of this as an energy source rather than alternative higher carbon energy source.

- *Facilitating additional demand from the transition to EVs and heat pumps.*

Connection of low carbon technologies such as EVs and heat pumps increase electricity network demand as well as reducing load profile diversity, placing the network under increasing stress. A report commissioned in December 2010 by British Gas predicts that by 2020, electric vehicles could account for approximately 10% of all cars sold in the UK, equivalent to approximately 260,000 vehicles.

Currently, demand is not managed in the same manner as generation; domestic customers demand can increase without the DNO being notified and this is only identified from secondary substation maximum demand indicators. There are no formal or legal requirements for the DNO to be notified, either in advance, or after the event, about the connection of significant new demands to existing connections. Some of these demand growths are driven by external subsidies such as the Renewable Heat Incentive or rising energy costs and have the potential to be rapid, localised and unpredictable, thereby exacerbating network stresses.

Improved monitoring and use of data to create higher resolution knowledge of network metrics will be trialled to better characterise the changing distribution network and identify fundamental long-term and dynamic loading trends, due in part to increasing low carbon technology. This will improve selection of control measures and prioritisation for more efficient network reinforcement. Control room tools will be developed to optimise real-time data use and decision making for network operation scenarios such outage planning, dynamic thermal ratings and flexible network control. This will result in more efficient network operation and should prevent the distribution network from acting as a barrier to the deployment of low carbon technology such as EVs and heat pumps and intermittent low carbon generation.

- *Optimising the network to reduce losses through dynamic network control, limiting the need for more reinforcement. This will reduce the embodied carbon in additional assets such as transformers and cables and carbon emissions from transport of assets to site, and landfill from excavation.*

The primary aim of the project is to develop a DNO-led network management solution to quickly and efficiently respond to increasing demand on the network. The solution toolbox will contain measures that can be deployed faster and at lower cost than traditional reinforcement, thereby providing a technically and economically advantageous network solution. Alternative solutions that provide 10% to 20% headroom could avoid traditional reinforcement for an extended period of time, whereas those that provide 5% to 10% may defer reinforcement and provide more time to understand network reinforcement priorities and plan an efficient network investment programme. This will lead to carbon savings from avoided embodied carbon within traditional network assets as well as carbon emitted during the construction process.

4: Evaluation Criteria contd.

Contribution to Low Carbon Transition Plan for GB Rollout

The rollout of the project outcomes across the UK could significantly contribute to the aspects of the Low Carbon Transition Plan identified above and help to accelerate the low carbon sector by providing easy access to the network. The measures are being trialled for network areas that are already highly loaded where connection of low carbon technology would trigger the need for reinforcement. This will generate learning that is immediately relevant in terms of deferring reinforcement and facilitating the uptake of low carbon technology.

The measures that are being proposed to facilitate the solution have low associated carbon emissions. Most of the equipment costs are for transducers, monitors and voltage regulators which are relatively small and can be manufactured at high volume efficiently. A significant proportion of the project is dedicated to developing improved tools and processes, that will enable DNOs to better manage the network for future low carbon environment rather than the large-scale manufacturing of new equipment.

Traditional methods for increasing network capacity through reinforcement have an inherent carbon cost. The manufacture of network assets such as transformers, overhead lines and cables, laying cable and transportation all produce substantial carbon emissions.

This project will provide a toolbox of proven solutions which can be deployed much faster than traditional reinforcement. Groundwork would not have to be repeated by each DNO, the measures would be packaged and ready for rollout at the completion of the project along with optimised strategies for procurement, installation and operation. Waiting for pre-connection network reinforcement would delay the deployment of low carbon technologies and therefore put the UK carbon reduction targets at risk. Challenges with installation, supply chain delays, obtaining land rights and planning permission and delays when laying cables in congested roads can result in lengthy reinforcement times up to 4 years or more in some cases.

From analysis of SP Energy Networks DPCR 5 plans, we believe that the solution this project is proposing could be applied to around one third of our Reinforcement projects. The nature of the project solution is readily applicable to other DNO networks and therefore we believe it would be appropriate to make the same assumption for the application of this solution to other DNOs reinforcement plans. This would equate to a saving of between **£225m** and **£400m** across DPCR5. More importantly from the perspective of carbon savings, one third of reinforcement schemes could be deployed in a timeframe of less than 12 months compared to up to four years for a traditional solution enabling customers to adopt electric heating and transport faster.

4: Evaluation Criteria contd.

(b) Has the potential to deliver net financial benefits to existing and/ or future customers

Customers will benefit from this project in both direct and indirect means. Direct benefits will include:

- Faster connection of microgeneration and the additional FiT they can generate.

Customers will benefit through the faster deployment of solutions on the network that will allow them to connect low carbon technology without levels of constraint that may otherwise be expected. Customers installing small-scale PV, micro CHP and small to medium scale wind turbines are able to sell electricity back to the network and are eligible for feed-in-tariffs that can provide a significant financial benefit over time, in the order of thousands of pounds per year for a domestic installation.

For the Wrexham area, which is considering installation of up to 6.26MW of PV, this would be more than £6,000/day of revenue, plus the (carbon free) unit saving of electricity which would amount to approximately £1,100/day. Therefore, it can be seen that the speed of accepting the PV connections is very important to the customer and to carbon emission saving objectives.

- Faster connection of other low carbon technology such as EVs and heat pumps.

The faster connection of other low carbon technology such as EVs and heat pumps may bring other associated financial benefits to customers through reduced heating costs for example.

- Reduced Use of system charges through reducing the investment required in reinforcement.

15% of a household bill for electricity is distribution network charges, so any reduction will flow through to a saving in the bill.

- Reduce demand through energy efficiency

This solution will include measures to reduce customer demand through energy efficiency devices such as voltage regulators, reactive compensation and low energy appliances, and voltage optimisation, without requiring customer behaviour change. These measures will initially be targeted at customers with the potential to have the most significant energy savings.

It should be possible to achieve up to 2% energy savings due to energy efficiency measures although this will vary from customer to customer. This will translate to savings on electricity bills.

In-direct savings

- Facilitating more renewables in the form of microgeneration which will reduce fossil fuelled generation and the associated cost for carbon which ultimately customers will pay for.

This solution will facilitate the faster connection of microgeneration, with potentially lower levels of reinforcement. This will reduce the overall cost of the network which will feed through to customers bills.

- Reduced supply interruptions through the flexible network control.

Flexible network control technology to be trialled in this project has the potential to reduce risk of unplanned supply interruptions by giving control room staff the power to remotely operate equipment. Additionally, enhanced network monitoring should enable more rapid fault finding and repair.

- Economic growth as customers can be connected faster.

- Reduction of inconvenience of construction work such as road closures for laying cables which may also impact the local economy.

4: Evaluation Criteria contd.

Net financial benefits

The total project cost stands at £6.4m, and our calculations indicate that a future method cost for these same three sites will be approximately £2.4m in total. Compared to the Base case costs of £10.5m, this alone would provide a net benefit of **£8.1m**.

The three sites that have been trialled offer a range of net benefits, which range from a reduction in reinforcement costs of between 40% and 80%. From analysis of the SP Energy Networks reinforcement plans, should this project successfully achieve a saving of 20% in network capacity, we believe that these solutions could be deployed on up to one third of our reinforcement schemes.

Over DPCR5 this would have provided a saving of between £20m and £36m for Scottish Power, or on the same basis across Great Britain, a total saving of between **£225m** and **£400m**. This is based on a total investment requirement of £1.5bn over DPCR5.

Projecting this forward for RIIO-D1, we estimate an investment of between £3-5bn over 2015 to 2023 is required based on traditional reinforcement methods. These solutions could therefore create a net benefit of **£400m** to **£670m** over this period, based on the same conservative capital savings of 40% across one third of the required reinforcement schemes.

It should be recognised that this solution is only providing an incremental solution and additional substation reinforcement may still be required at some point in the future. In some instances future load may not materialise as expected, or overall demand will decrease due to energy efficiency. The ability to provide small capacity increments would therefore avoid the cost of constructing assets that were only required for a short period of time and then become stranded.

4: Evaluation Criteria contd.

(c) Level of impact on the operation of the Distribution System

The focus of the project is to develop a more flexible, intelligent network management system that can increase available capacity headroom and facilitate connection of low carbon technology. The impact on the design and operation of the distribution system will be positive and highly beneficial.

A range of technologies have already been identified that can provide material cost savings in terms of either reinforcement avoidance or reinforcement deferral. They can either release sufficient thermal capacity on the existing network, or enable the network to be run at a tighter margin over limited and critical periods of peak demand.

Learning and benefits for Network Planning and Development

Focussed network monitoring will improve DNOs understanding of the behaviour and characteristics of the network. When deployed in network areas that are becoming heavily loaded, this can help to identify any additional capacity headroom that could be exploited in the short or long term. Also, having better forward visibility of network trends through monitoring, particularly any changes associated with low carbon technology uptake, will help to determine whether demand will continue to increase, requiring a more traditional future reinforcement solution at some point, or if demand will stabilise. This will reduce the likelihood of stranded assets.

Using improved planning tools and processes, the timeframe for deferred network reinforcement will be better quantified, providing greater certainty to DNOs, the supply chain and customers seeking new connections. The network planner will have a number of packaged novel technology solutions such as flexible network control that can be deployed quickly to defer major network investment.

Currently at SPEN, 80% of a network planner's time is spent facilitating new connections with the remaining 20% spent primarily on future network design and modelling. We believe that this is fairly representative of other UK DNOs. Streamlined data management and analysis tools developed as part of this project will enable improved tools and processes to be adopted to free up time to focus on new challenges.

Learning and benefits for Network Operation

Increased, targeted network monitoring integrated with improved control room tools that enable novel technology such as flexible network control and dynamic ratings to be utilised will improve the performance of the future low carbon distribution network and reduce risk to customers. For example, enhanced models to improve outage planning will reduce the risk of customer supply interruptions even further, leading to financial benefits to the DNO through reduced CI and CML payments. Flexible network control to shift load to different parts of the network also reduces risk of circuit overloads particularly during peak demand and thus, risk to customers. Also, it will be possible to achieve more rapid turn-around on fault restoration due to greater knowledge of the network, getting customers back on supply sooner.

It is recognised that there is the potential to increase in workload in the control room. This will be carefully considered with the aim to empower operators as decision-makers, with the majority of analysis carried out behind the user interface. Optimised network alarm systems based on enhanced network monitoring will help to improve management of warnings and risk.

The rollout of focussed energy efficiency measures in different areas of the network will contribute to the life of key assets by reducing asset loading and deferring replacement costs for aging assets which can be significant particularly for primary substation transformers for example. The loading of live assets during switching operations for maintenance or due to failure will also be reduced. Enhanced network monitoring will also improve overall characterisation of asset and knowledge of loading history. Some assets may be more heavily utilised and the trade off between asset health and capacity will be examined as part of the academic support from Strathclyde.

4: Evaluation Criteria contd.

(d) Generates knowledge that can be shared amongst all DNOs

This project is based on a multi-faceted network management approach, which is reflected in the multiple work packages within this project, with the objective of identifying and utilising additional capacity headroom to facilitate the connection of increasing low carbon technology on the network.

What will the new knowledge comprise?
The project will develop knowledge on:

- A range of new standardised solutions for UK DNOs to increase network capacity and defer reinforcement.
- A series of case studies on the deployment and impact of novel technology in a distribution network setting based on actual design, installation and live trial experience.
- Updated design guidelines relating to P2/6 and other relevant Engineering Technical Recommendations.
- Quantification of how energy efficiency measures can be used by customers in a coordinated approach with Energy Suppliers for network benefit.
- Documented understanding of customer appetite for being involved in such a project and how we should engage with customers in the future.
- Strategies for integration of the solutions into the operation of the business.

Relevance to other DNOs
The development of a more flexible, intelligent network management approach to facilitate the solution will be applicable to all DNOs. All DNOs are facing increasing demand with energy decarbonisation and will need to be able to confidently identify key network trends and deal with rapidly changes to loading. This approach will give DNOs more control to manage their network more efficiently and proactively for the future low carbon environment.

The selection of sites has focussed on network areas that are representative of GB distribution networks, customer demographics, and loading issues. i.e. constrained networks requiring near-term capacity increase and high-density installation of PV. This project is not developing bespoke solutions only suitable for the SPEN network. Also, the measures to be trialled will be disseminated in a format that can easily be adopted and deployed by other DNOs. Technology measures will be network tested and proven, with functional specifications for procurement and strategies developed for installation and operation.

How will learning accelerate low carbon transition plan
The new learning from this project will be incremental in nature as it becomes available from each work package, with a broad, integrated focus on network management. The learning can then be applied through DNO behaviour change to achieve an increase in network capacity through a series of small, low risk steps that flex the constraints of the network rather than a large, high risk step.

The solution measures are well suited to easy adoption and implementation by other DNOs as it does not involve a major step change in culture or a significant investment before measurable benefits are achieved. The flexible network management toolbox will contain a number of tested and proven packaged solutions representative of UK distribution networks that DNOs can deploy with confidence, as required.

This this project will involve some internal behaviour change, user engagement and implementation strategies i.e. policy change, to help facilitate this will be considered specifically. This will be a key learning point for other DNOs to inform how to integrate the holistic network management approach into the larger business model.

The structuring of the work programme will enable early delivery of some learning, within the first year of the project. This will be disseminated as soon as possible to help inform the business plans of all DNOs going forward into RIIO-D1 in 2015 and accelerate the low carbon transition plan.

Learning if project is unsuccessful
The diversity of measures to be trialled provides mitigation of an unsuccessful outcome overall. However, even if the outcome is that traditional reinforcement is the still the best approach, this is a point of learning and other strategies can be developed around this to improve investment decisions and timescales for installation. This project will provide new learning on the behaviour and characteristics of the network and small-scale PV generation through the programme of monitoring and this can be utilised for more efficient investment in reinforcement for example.

4: Evaluation Criteria contd.

(e) Involvement of other partners and external funding

Project Partners

University of Strathclyde has a well recognised reputation within the UK Electricity Distribution industry for research expertise. It is both the principal investigator and management hub for the largest publicly funded research initiative linked to highly distributed energy futures and low carbon distribution networks - "HiDEF" - contributing in respect of demand side management and distribution network operation.

University of Strathclyde is a key partner in the project and have already provided assistance to develop the project objectives and methodology. They will be providing strategic technical direction, learning and dissemination expertise and playing a key role in development of expert analysis tools and software. The design of experimental trials will also be independently reviewed by University of Strathclyde on a work package basis to ensure that the methodology is technically robust and that outcomes and learning will be applicable to other UK DNOs.

As part of their commitment as a partner, University of Strathclyde have provided resources to assist with the development of this project and have committed to in kind funding of **£27,000** in total over the course of the project in the form of technical and supervisory assistance. A full time research fellow will be available to work on this project full time and other key individuals have committed their time to review and provide technical guidance over the course of the project.

Nortech design and supply remote site monitoring solutions and other specialist technology to electricity utilities, telecom network providers, the security industry and other blue chip companies with geographically spread networks and assets. Nortech are actively involved in the UK electricity distribution industry and already provide SPEN with the iHost services, which is a web based SCADA system for acquiring additional monitoring data.

Nortech will be providing the iHost platform as the central host software for logging of remote monitoring data from primary and secondary substations. They will also be looking to develop `smart' monitors that can be programmed to pre-process incoming data from transducers before remote transmission. The monitor algorithms will be developed over the course of the monitoring programme as the functional requirements for the data are tested, refined and optimised, and additional functionality within iHost developed as necessary to process the incoming data. These devices will then be available to other DNOs to procure.
The financial resources that Nortech has agreed to provide for this LCNF project will be in the form of time-in-kind to develop the monitors, algorithms, and analytics for the acquired data. Much of this development will be undertaken by Nortech with a value of around **£60,000** in kind benefit.

TNEI Services Ltd (TNEI) is a power system consultancy business with significant experience in the analysis and design of distribution networks. TNEI also owns, develops and supports the IPSA power system analysis software package. IPSA forms the primary network design analysis tool for half the UK Distribution Network Operators, including SP Manweb, for the design, operation and planning analysis for their 11kV, 33kV and 132kV networks. IPSA+ engines are also embedded into custom analysis tools for long-term network planning and use of system charge calculations and are widely used in the UK as well as internationally.

TNEI will be supporting the project through the analysis and interpretation of the network monitoring data, facilitating discussions with the internal SPEN teams and the development of improved network planning and operations decision tools. This work will include the development of improved software modelling for IPSA including "plug and play" algorithms for advanced network controls, improved network modelling at LV, and linking the demand data with network models for example.

TNEI will be providing a funding contribution from the IPSA development budget due to the alignment of this project with our strategic goals for the IPSA product. The value of this contribution will be **£61,000 in kind benefit**, which is in the form of £31,000 of development time on core features across the duration of the project, as well as the provision of three full feature software licences for use in the project in the SPEN offices and Strathclyde University with a value of £30,000.

Any core IPSA software developments as part of this project will be freely available to other IPSA licensees.

4: Evaluation Criteria contd.

Building Research Establishment Ltd (BRE) operates across the UK with offices in Watford, East Kilbride, Inverness, and Port Talbot. BRE has over 600 employees and many world experts in their respective fields. The organisation is made up of construction professionals, technical researchers, social scientists and programme managers. BRE's team of social researchers are trained in a range of disciplines including environmental psychology, organisational psychology, statistics, and human factors. They undertake qualitative and quantitative research including online, postal and telephone questionnaires, face-to-face interviews, focus groups, workshops and large-scale testing programmes.

Specifically in relation to this project, BRE will be conducting site surveys of key buildings and premises within the three pilot areas and developing and reporting the findings from an online survey across a targeted population. On the basis of this they will create a model and use this to test a range of scenarios for each trial area including the uptake of energy efficiency measures and the corresponding impact on electrical load. They will help manage the deployment of any subsidised energy efficiency measures and then verify the model predictions against the actual measured performance.

BRE have extensive experience in modelling energy use in existing buildings and new buildings, and have modelling tools that can carry out high level screening of a portfolio of buildings to understand where electrical consumption is high and to model electrical load reduction opportunities. This knowledge and expertise will be invaluable in helping interpret the data from the secondary substation monitoring, and in the development of appropriate load growth forecasting tools appropriate for the low carbon future.

They also have expertise in all of the building related renewable energy technologies and can show the impact on total electricity consumption. This includes detailed dynamic simulation modelling as required to understand hour by hour consumption including PV modelling software.

As a not-for-profit organisation with charitable status, BRE are unable to provide a direct funding contribution to this project, however as a sign of their commitment to this project they have undertaken to investigate additional sources of funding through other on-going projects or funding sources. Any additional funding secured would be used to extend the scope of work to the benefit of the project and the wider industry.

Partner Summary

This number of partners is felt to be acceptable for a project of this magnitude to provide sufficient industry commitment and relevance whilst not impacting programme delivery due to overly complex management and contractual negotiations. In terms of technology suppliers for other monitoring equipment and voltage regulators for example, this will be on a standard contractual basis to ensure we achieve value for money.

A key part of this project is to develop and embed the learning of this project within SPEN by seconding and rotating core SPEN staff through the project with support being provided by external expertise as appropriate.

SPEN will be contributing a total of £2.6M to this project from the DPCR5 allowance. For the total value of the project, this is substantial and is indicative of SPEN's commitment to the objectives of the LCNF and to project delivery and success.

4: Evaluation Criteria contd.

(f) Relevance and timing

This project addresses the very immediate problem of facilitating more demand on the network due to the uptake of low carbon technology such as the electrification of heat and transport as well as microgeneration. Demand growth may be due to connection of low carbon demand sources such as EVs and heat pumps however, microgeneration such as domestic PV and small to medium scale wind also contribute to network loading whilst reducing local demand. This project does not try to resolve the future demand/generation mix in detail, but rather, trials a number of network management measures that can be rapidly and cost-effectively implemented to help the future network adapt to any rapid changes.

The network trial sites of Whitchurch and St Andrews are already constrained and further increases in load will trigger significant network reinforcement. Timescales associated with traditional reinforcement will limit network demand growth until this can be completed. The current level of general load reinforcement for the period DPCR5 is almost £1.5billion which represents 11% of the total network expenditure and could amount to £3-5 billion for the period to 2023. This indicates that significant network reinforcement is required across GB due to increasing demand. A solution that enables deferment of reinforcement will be able to reduce expenditure and risk of stranded assets in the short term as well as facilitate the decarbonisation of the energy sector.

Small-scale PV is being installed in increasingly large volumes on private domestic properties and on social housing across the UK for example i.e. Arbed initiative in Wales. This is partly driven by the current feed-in-tariff available and schemes addressing fuel poverty. One of the network trial sites for this project, Wrexham, specifically has an issue with increasing connection of domestic PV. The impact of PV on the network will be facilitated through enhanced substation monitoring and learning will be developed from this to inform all UK DNOs on how best to address localised and high-density connections of low carbon generation.

As this solution will be DNO-led, it will be possible to implement most measures rapidly without delays waiting for input from other parties. Business integration strategies have already been identified for the project and a key aspect of this will be learning for network designers to improve future network planning such as identification and prioritisation of reinforcements. A more holistic integrated network management approach developed from the project would be embedded within the design team as well as the wider business. This would then be used to inform the submission for the upcoming price control review RIIO-D1 and future reviews.

4: Evaluation Criteria contd.

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4: Evaluation Criteria images, charts and tables.

Evaluation Criteria Images

Section 5: Knowledge dissemination

☐ Put a cross in the box if the DNO does not intend to conform to the default IPR requirements

IPR Arrangements
This project will conform with the LCNF default IPR principals. It is not anticipated that the project will develop foreground IPR that will fall outside of the default IPR requirements.

Knowledge Dissemination
Knowledge dissemination is critical to the success of any LCNF project to ensure that all customers can benefit from the learning outcomes. We believe that knowledge dissemination can be split into two broad categories; dissemination to other DNOs and interested parties, and internal dissemination within ScottishPower. We have planned number of activities for both of these categories to ensure that potential users have suitable access to the learning for the learning outcomes to be used in the future.

Dissemination to other DNOs and interested parties
We have developed a number of novel methods for disseminating the learning which is developed through the course of the project including:

- Practical demonstration of equipment at the Power Networks Demonstration Centre which is being developed by the University of Strathclyde, ScottishPower and SSE.
- Academic papers on the outcomes of the project by the University of Strathclyde Chair in Smart Grids which is being sponsored by Scottish Power.
- Inclusion of data in a number of PhD research projects which are already underway.
- Involvement of partners who will have their own dissemination channels and development of technology which other DNOs will benefit from.
- A new website which will provide access for any interested party to understand more about the project
- The LCNF and other industry conferences

The principal dissemination activity for this project will be through the Power Networks Demonstration Centre (PNDC) which ScottishPower have developed in collaboration with University of Strathclyde and SSE. The PNDC is a world class research centre designed to accelerate the adoption of new technologies, from advanced power grids to electric cars and household appliances, through a live demonstration centre. The Power Network Demonstration Centre cost £12.5 million to develop and will be the first of its kind in Europe when it opens in early 2012. The site has also been supported by Scottish Enterprise and the Scottish Funding Council and is based in Cumbernauld, near Glasgow.

The Centre is designed to play a key role in increasing the UK electricity grid's efficiency and reliability, as well as testing the next generation of smart electrical technologies. This will support the integration of new renewable energy sources, electric vehicles and smart household appliances with the grid, such that emissions and cost can be minimised.

This environment will allow the various aspects of this project to be deployed on a live network to trial the operation, installation process and maintenance of equipment. This will assist with de-risking some of the technology in advance of it being rolled out, but also provide a safe environment for third parties to get a hands on experience with the technology. It is intended to host events at the PNDC where other DNOs and interested parties can see the various technologies in operation and also demonstrate the practical elements such as installation processes. We believe that this will be a unique environment for other parties to find out exactly how this project can be of benefit to them. These events will coincide with workshops for DNOs and other relevant parties to present findings from the project.

ScottishPower have a strong history with the University of Strathclyde and are in the process of appointing a Chair in Smart Grids which will be accompanied by a variety of other positions focussed on future network technology. This new team will have a key role in assisting with the academic elements of the project and using this information to publish the findings from an academic perspective. A number of PhD's are also already underway which are relevant to the planned trials. Any data that is acquired from this project will be made available to these students to inform these ongoing projects and ensure that our findings are in line with other data.

The involvement of BRE as a partner will also assist with the dissemination of learning. BRE are a leading organisation providing expert, impartial research, knowledge and advice for the built environment sector and beyond. BRE helps government, industry and business to meet the challenges of our built environment, and any learning from this project will go back into helping organisations develop the built environment.

5: Knowledge dissemination contd.

The involvement of other partners including TNEI who will be developing their IPSA network design software as part of the project will provide indirect dissemination as a variety of other DNOs also use this software and will freely benefit from these developments.

A website is planned for this project which will allow a variety of stakeholders to understand what we are doing, and to view our results. This facility will have two specific functions; a gateway for customers and other interested parties (e.g. schools and universities) to understand the project and what the project involves. The website will also be the focus point for industry to access technical information on the project such as reports and data on the various aspects of the project.

A key output of this project is to inform the development of future engineering technical recommendations, with particular focus on ER P2/6, the current distribution network planning standard. P2/6 is the standard by which the distribution network is currently designed, and this project will provide empirical data from monitoring which will influence future revisions of this standard. Other engineering standards will also be examined as part of this project such as the volumes of microgeneration which can be safely connected to the network. Other DNOs will also be making similar contributions to the development of engineering standards and policy and this will be a key vehicle to creating benefit for customers.

We will of course also be providing updates on the project through the annual LCNF conference following its success in July 2010 as well as other industry conferences which we get the opportunity to present at which have a broad audience including many international organisations.

Internal Dissemination
Dissemination within ScottishPower is a vital activity of this project to ensure the ongoing engagement of staff and that the outcomes of the project are adopted for future application. These methods will include:

- Training of staff at the PNDC on the installation and operation of equipment being trialled as part of this project.
- Rotation of staff in the role of project coordinator to help with individuals development and that practical learning can be taken back to other departments within the business.
- Identifying project champions within each business area which can be kept abreast of developments and help tailor the learning from the project for their respective teams.
- An annual internal technology conference which focuses on LCNF and IFI and is attended by up to 100 staff.

As with the dissemination of learning to external parties, we will also be using the PNDC to demonstrate and assist with the training of staff on the procedures for installing and operating equipment. This will complement our existing training facilities which we have for instructing staff on the safe and efficient methods for installing, operating and maintaining equipment. The roll out of monitoring equipment is likely to require new working procedures to be developed and the training of staff.

We will also be making the two project coordinator roles as secondment opportunities for staff, to allow for staff rotation throughout the project. The other roles will be permanent appointments for the duration of the project, however we have identified the coordinators as being suitable for changing every nine to twelve months so that a greater number of staff can be directly involved with the project and be embedded in the learning process, which will allow for more effective transfer of knowledge back to the wider business when they return to their substantive post.

As well as a project governance board which is made up of directors and senior managers from across the business, we will also be identifying project champions from each of the main business areas who will act as ambassadors and lead engagement within their business unit. This will involve providing updates and monthly team briefs and making other presentations as appropriate to keep staff informed of developments.

In 2010, we have also started to hold an annual technology conference at which almost 100 staff attend to find out about the various developments which are ongoing across the LCNF and IFI initiatives within Scottish Power and at other DNOs. This will build on the presentations made at the LCNF industry conference to inform staff of what else is happening within the sphere of LCNF activity across the industry. A broad range of staff will be invited to this from industrial staff through to managers.

We believe that this broad range of activities will provide comprehensive dissemination of the learning from this project, and that the learning will be embedded into day to day practices. Many of these processes for internal dissemination are building upon existing activities such as team briefs, while others will require additional funding which we have accounted for within the funding request.

5: Knowledge dissemination contd.

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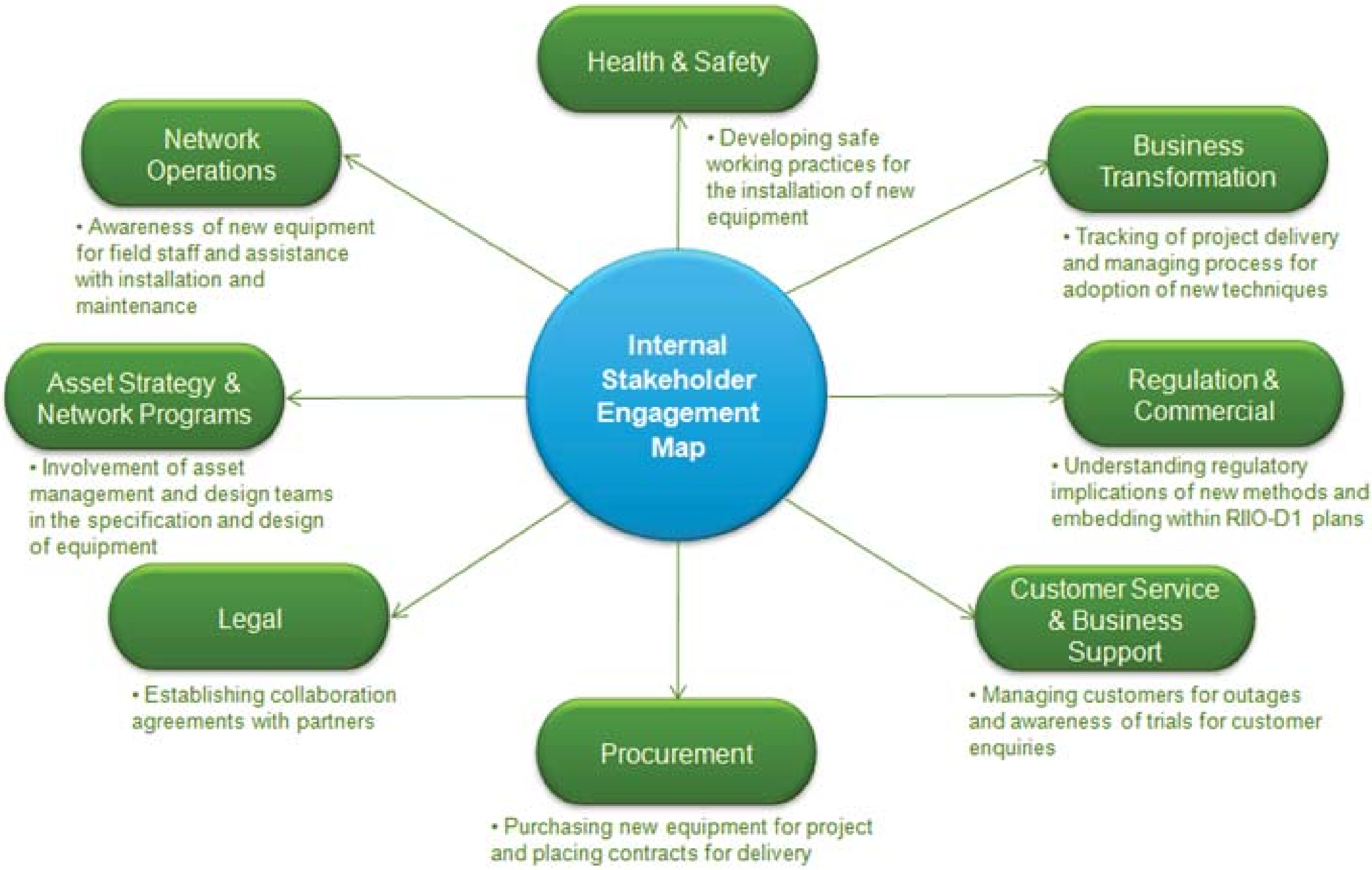
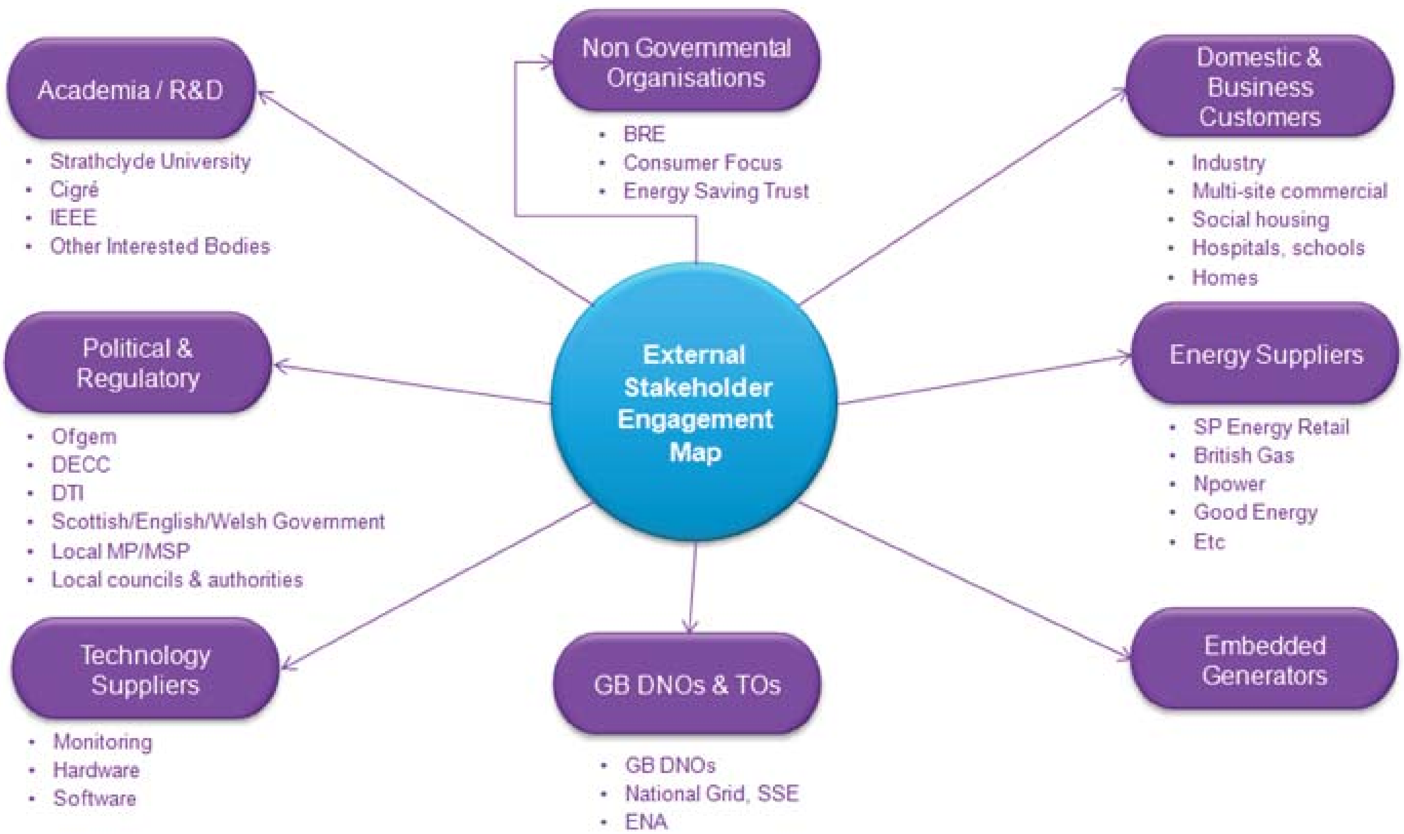
5: Knowledge dissemination images, charts and tables.





Knowledge dissemination images

Section 6: Project readiness

Requested level of protection require against cost over-runs (%).	0%
Requested level of protection against Direct Benefits that they wish to apply for (%).	0%

The project is readily deliverable with an achievable scope, and the need is imminent to inform the upcoming RIIO-D1 price review. The project has been designed to enable a rapid start and early delivery of results. The structure of the project is a series of discrete work packages that are interdependent and integrated into a philosophy of intelligent network change management. This approach reduces risk and maximises likelihood of early and successful delivery and applicability to other DNOs.

Progress to Date

During the process of developing this project bid, a rigorous analysis was undertaken of various network areas to identify sites that were representative of the problem to be addressed i.e. short term constraints due to increasing demand and an uptake of low carbon technology, the project methodology and the long term aims of the Low Carbon Network Fund. This includes ensuring that project learning is applicable to all DNOs which has been considered throughout the network trial selection process.

In order to secure early internal buy in and obtain input from key stakeholders, internal engagement across 15 different teams at various levels within the organisation was carried out. This was successful in generating ideas and feedback from across the business and critical to identification of key risks and mitigation strategies and robust cost estimation. The objectives and methodology of this project also have the buy-in of the SPEN executive board.

Project resourcing - A core project team has been established who have developed the project and will be central to its delivery which includes the project manager, design engineer and commercial consultant. Additional head count has also been secured for project coordinators to be seconded into the project and assist with the delivery. Project coordinators will be seconded so that staff can be rotated as necessary to disseminate the learning internally and also for staff development

The project organogram is provided on page 40 with further details contained in Appendix F and indicates key individuals from Scottish Power Energy Networks and Project Partners who will be involved in delivering this project. These individuals are ready to commence immediately upon award of funding.

Partners - Four partners are already involved with the development of the project (University of Strathclyde, TNEI, Nortech and BRE). Discussions have also taken place with a variety of other potential technology providers but we are aiming to strike the right balance between organisations who can provide a contribution to the project, and others who will provide equipment. We have already received formal commitment from the project partners of their involvement in this project.

Customer Engagement - Preliminary discussions have already taken place with key customers in Whitchurch, St Andrews and Wrexham to introduce the proposed project concept. There has also been early engagement with local councils, community groups and the Scottish Government. The initial response has been very encouraging and we will be looking to build on this.

Equipment Selection - The majority of the equipment we are using have been deployed before, but are being used in a novel way for this project. Equipment costing and resource requirements are built on prior experience to ensure that they are as accurate as possible. Where novel equipment is being sourced, we have held discussions with potential providers to get indicative costs. We will be following a standard procurement process to ensure that we can source equipment and for the best value for money where it is feasible. Specifications for some of the equipment are already complete and we will be looking to further develop the other equipment specifications in the approach to the project, before formally starting in January 2012.

Equipment Installation - A detailed methodology and programme for monitoring equipment installation and verification in substations is being developed. This will continue in the approach to the project, before formally starting in January 2012.

6: Project readiness contd.

Project Delivery

Following Contract Award in November/December 2011, project preparation will begin in earnest with the Project Team ready to commence in earnest following the Christmas break, in January 2012. We have recognised some of the learning from the 2010 LCNF Tier 2 projects and have factored in sufficient time at the start of the project to finalise equipment specification, establish agreements with partners and any other key parties. Following funding award, there will be a short initial period of contractual negotiations with Partners. This is not expected to stretch as there has already been a preliminary agreement of project contributions in kind with Partners. Also, University of Strathclyde, TNEI and Nortech have existing or previous contracts for provision of other services with Scottish Power Energy Networks. It will be possible to begin engineering design and internal/external stakeholder engagement processes while contracts are being finalised.

A detailed project plan is provided in Appendix F and indicates key milestones and the critical path. The total duration of the project is 3 years including dissemination of learning to other DNOs and it should be complete before the next Ofgem price review process begins in 2015.

The data monitoring Work Packages 1.1 and 1.2 are based primarily around desk based analysis and specification development and as such can start immediately without any significant set-up time. This will inform data monitoring and analysis required for Work Package 2.1, and the development of improved network operation and design tools for Work Package 1.3 and 1.4.

Standard off-the-shelf equipment is being utilised for the monitoring packages that is readily available in the quantities required, and has been considered as part of the risk identification and mitigation process during bid preparation. In addition, the installation process has been specifically assessed in all 3 selected network trial areas to provide robust estimates for the project programme.

For Work Package 2.1, SPEN has recently designed, procured and installed a similar regime of monitoring for a 132kV OHL circuit for a Tier 1 LCNF project. Thus, the costs and timescales are well understood.

For Work Package 3.2, technical papers will also be presented at key academic and industry conferences to provide delivery of early learning throughout the project.

Project Milestones - Key milestones for each work package have been identified and are summarised below.

Work Package 1.1
- Completion of a new industry best practice guide to for data monitoring and analysis that will include detailed consideration of measurement and modelling uncertainty. *Third quarter 2012*.

Work Package 1.2
- Completion of functional specifications for substation monitoring. *First quarter 2012*.
- Procurement of monitoring equipment. *Second quarter 2012*.
- Installation and verification of primary substation monitoring equipment. *Second quarter 2012*.
- Installation and verification of secondary substation monitoring equipment. *Third quarter 2012*.
- Completion of one year of data monitoring for full seasonal representation to benchmark network. *Fourth quarter 2013*.
- Completion of one year of data monitoring to assess the impact of novel network technology and possible energy savings available. *Third quarter 2014*.

Work Packages 1.3
- Internal engagement with network operators to facilitate user input and buy-in. *First quarter 2012*.
- Utilise data available from network monitoring to develop improved tools and processes for control room operations. *Third quarter 2013*.
- Integration of novel technology being trialled into network control room tools and processes. *Third quarter 2014*.

Work Packages 1.4
- Internal engagement with network planners to facilitate user input and buy-in. *First quarter 2012*.
- Utilise data available from network monitoring to develop improved tools and processes for network design. *Third quarter 2013*.
- Integration of novel technology being trialled into network design toolbox for reinforcement deferral. *Third Quarter 2014.*

6: Project readiness contd.

Work Package 2.1

- Completion of functional specifications for substation monitoring. *First quarter 2012*.
- Procurement of monitoring equipment. *Second quarter 2012*.
- Installation and verification of monitoring equipment. *Second quarter 2012*.
- Completion of one year of data monitoring for full seasonal representation to assess the impact of novel network technology and possible energy savings available. *Fourth quarter 2013*.
- Completion of one additional year of data monitoring to add value. *Third quarter 2014*.

Work Package 2.2

- Completion of functional specifications for flexible network control equipment. *Second quarter 2012*.
- Procurement of network control equipment. *Fourth quarter 2012*.
- Algorithm development and network modelling. *Second quarter 2013*.
- Installation and verification of flexible network control equipment. *Second quarter 2013*.
- Completion of one year of network trials for flexible network control technology to capture full seasonal variations. *Third quarter 2014*.
- Completion of expert control management system. *Third quarter 2014*.

Work Package 2.3

- Engagement with customers and energy suppliers. *Ongoing*.
- Completion of customer energy surveys and assessment of potential energy savings. *First quarter 2013*.
- Completion of functional specifications for energy efficiency equipment. *First quarter 2013*.
- Procurement of energy efficiency equipment. *Second quarter 2013*.
- Installation and verification of energy efficiency equipment. *Third quarter 2013*.
- Completion of one year of network trials for novel technology to capture full seasonal variations. *Third quarter 2014*.

Work Package 2.4

- Completion of detailed design specifications. *Third quarter 2012*.
- Procurement of voltage regulator sets. *Fourth quarter 2012*.
- Completion of prototype testing at the PNDC. *Second quarter 2013*.
- Installation and verification of packaged device. *Third quarter 2013*.
- Completion of packaged device network testing. *Second quarter 2014*.
- Development of a functional specification suitable for certification. *Third quarter 2014*.

Work Package 3.1

- There will be a number of early user input and buy-in sessions for network designers and operators. Training and user adoption workshops will be held towards the end of the project.
- Selection of internal project `champions' within the business. *Second quarter 2012*.
- Development and implementation of business change strategies. *Third quarter 2014*.

Work Package 3.2

- Early engagement with customers through focus groups etc. *Third quarter 2012*.
- Development of customer engagement strategies for improved network management in future low carbon environment. *First quarter 2014*.
- Training and user adoption workshops for other DNOs. *Third quarter 2014*.

Work Package 3.3

- Completion of experimental design review for all work packages. *Third quarter 2013.*

Work Package 3.4

- Recommendations for technical and regulatory DNO policy changes. *Fourth quarter 2014.*

Overall Project Milestones

- Early assessment of design, operational and regulatory impacts. *Second quarter 2014.*
- Early development of business case, investment strategy and action plan for rollout in RIIO-D1. *Second quarter 2013.*
- Ofgem reporting every six months in accordance with the LCNF governance. *Ongoing*
- Project board meetings bi-monthly through out the project. *Ongoing*

6: Project readiness contd.

Costing Details

Detailed costings have been developed for each work package based on the proposed methodology and selected network trial sites and are provided in Appendix B. SPEN are making a sizeable contribution to the funding of this project through their DPCR 5 allowance for St Andrews and so the costings have already undergone a stringent internal approval process. This provides evidence of the robustness of the cost estimation.

Labour costs (Internal) - This includes engineering design and analysis, development of new tools and processes, technology assessment and cost-benefit analysis, and costs for equipment installation for network trials. Costs for project management, staff and external stakeholder engagement and training are also included. Costs are based on estimated scope of work and timescales from the proposed work package methodology and are consistent with the resourcing reserved for this project. All staff costs are based on standard costs.

Equipment costs - These have been estimated through discussion with Partners providing technology as well as engagement with other technology providers. SPEN has previous experience with similar monitoring equipment i.e. monitoring equipment for Tier 1 project on dynamic thermal ratings of overhead lines. Monitoring equipment costs are based on a cascade approach to substation monitoring from primary to LV feeders across adjacent LV networks and scaled for monitoring of multiple substation feeders at selected sites. Flexible network control is based on existing automation schemes so equipment costs are well understood.

Contractor costs - This includes provision of engineering design and analysis services, and development of new tools and processes. All contractor costs are based on current representative daily rates for each contractor and allocated contractor days for each work package task. Legal costs for setting up contractual arrangements with project partners and procurement costs if outsourced, are also included here.

IT - IT costs relate to ihost system which we already have access to and costs are for the system development. Costs for changes to our Network control system have also been factored. This system is already in use at SPEN and these costs are purely for upgrading the functionality to incorporate the technology which will be trialed.

IPR - We do not anticipate any IPR costs as any IPR development will be undertaken by the partner at their own cost which is their contribution to the project. The project is not funding the development of any technology which should create foreground IPR.

Travel and Expenses - Travel expenses have been allocated for additional travel between Scottish Power Energy Network Offices in Glasgow and Prenton for the purposes of this project, which would not be required for "business as usual". Also included is the cost of travel and expenses to present at key industry conferences and seminars as part of learning dissemination. There are no significant travel and expenses costs for international travel or travel to remote locations.

Payment to Users - £100k has been identified for payments to users in the form of subsidies for the roll out of energy efficiency measures. This funding will be to provide financial assistance where a given measure is not fully economic for the customer to make the investment, but given the saving that will be achieved, it will be valuable. The allocation of these payments will be undertaken with the assistance of BRE to ensure the maximum possible saving is being achieved. Part of the project will also be to determine the payback period industrial and commercial customers require before they are prepared to make an investment in energy efficiency.

Contingency - A risk register with risk ratings, mitigation and contingency plans has been developed for this project and is provided in Appendix F. This will be maintained and updated throughout the duration of the project. This was used to provide an indication of the level of cost contingency that will be required for each work package, broken down by cost items such as labour, equipment, contractor etc. Equipment costs were allocated a higher level of contingency due to possible prices variations in raw materials and manufacturing, an increased level of contingency was also attached to contractor costs which may be subject to change.

Decommissioning - A nominal cost for the decommissioning of monitoring equipment has been estimated for the project although it is unlikely that monitoring equipment will need to be removed unless there is an unforeseen requirement to change any network trial sites to improve data value.

6: Project readiness contd.

Other - Access to the PNDC site is included in this cost item and accounts for onsite resources and labour. Costs for use of the simulation laboratory at the University of Strathclyde for training, trials and demonstrations as an element of knowledge dissemination are also included.

IIS - penalties in the form of customer interruptions and customer minutes lost due to the installation process of monitoring equipment and flexible network control equipment has been calculated and is included in Other costs. Although it should be possible to avoid customer supply interruptions for secondary substation monitoring installations due to load switching, provision has been made for 20% of substation installations in the selected network trial areas resulting in short supply interruptions. A similar approach is used for calculation of IIS penalties associated with the installation of traditional network control equipment.

Project Management

A dedicated Project Manager is in place and will be responsible for the overall project delivery and coordination of multiple internal and external stakeholders and delivery consultants' who share a common objective combined with individual expectations and opinions. Two delivery managers have been identified, one for the delivery of St Andrews and PNDC trials, and one for the delivery of Wrexham and Whitchurch. Both of these candidates are in place and have been involved in the development of the project. The selected delivery managers have an excellent understanding of the technical, regulatory and commercial requirements of the distribution network, as well as the wider business operation and functions. The delivery managers will report directly into a Project Manager who is responsible for all LCNF activity to ensure coordination across the various projects. The Executive sponsor and project governance board have also been identified and will take ultimate responsibility for the successful delivery of the project. A full project organogram is shown on page 40.

The Delivery Managers will be responsible for day-to-day management planning and execution of the project including cost control and maintenance of the risk register. These will be overseen by the project manager who will be responsible for overall project coordination and preparation and submission of a detailed Project Progress Report to Ofgem at least every six months, demonstrating progress against the agreed Successful Delivery Reward Criteria. They will also ensure that cost control and reporting are in accord with LCNF fund governance.

A dedicated design resource and regulatory support are also in place to assist with the project, and have been heavily involved in the development of the project proposal.

Project Governance

The Governance Board will have the appropriate organisational authority to oversee the project and ensure that appropriate action can be taken to rectify any problems which arise. The governance board will meet bi-monthly to support the establishment and to ensure that it commences effectively as well as the ongoing success of the project .

The project also has an executive sponsor who will review on a fortnightly basis:

- Project milestone progress (baseline against actual);
- Monitoring of key risks and issues, including mitigating actions and the effectiveness of their application;
- Financial reporting, including value of work against forecast and budget;
- The effectiveness of communications and stakeholder management plans; and
- Monitoring of resource utilisation, including both internal and external parties.

The project board will have the power to stop the project or take the most appropriate action and identify critical points at which the project should be referred to Ofgem if necessary.

6: Project readiness contd.

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6: Project readiness contd.

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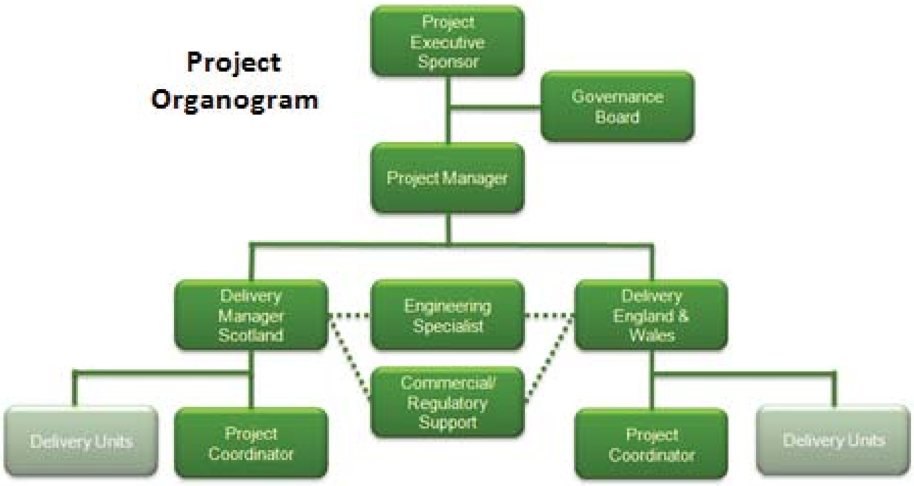
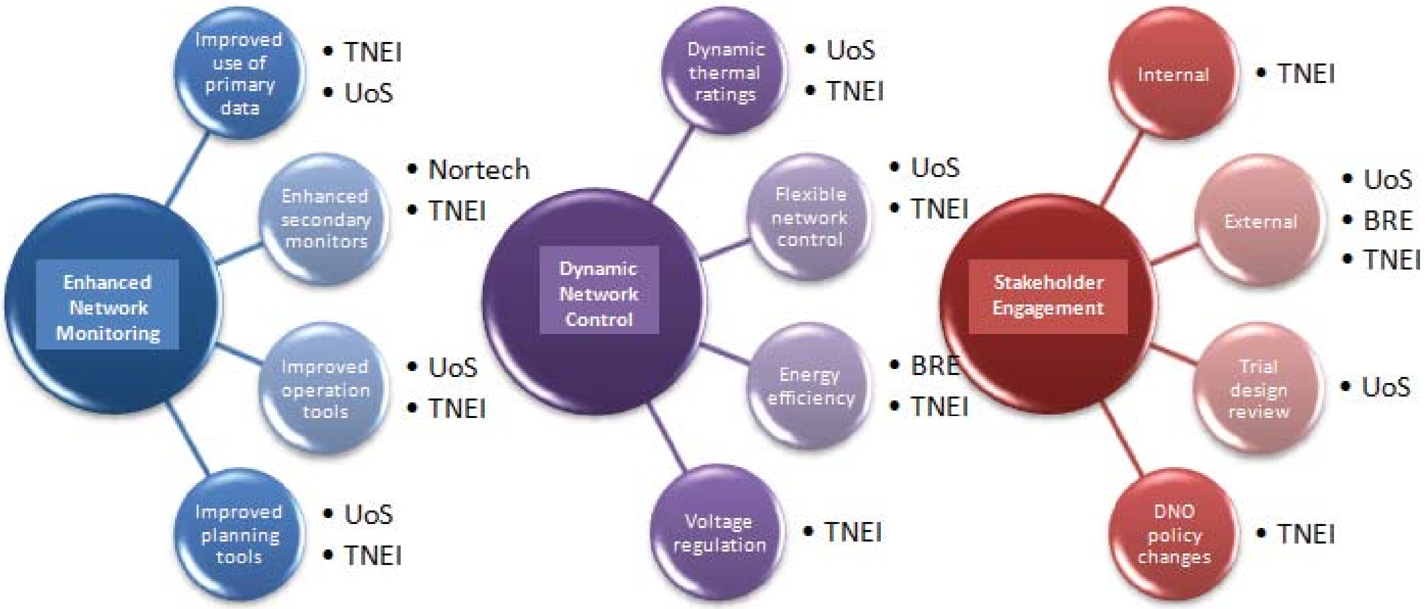
6: Project readiness images

Project Organogram

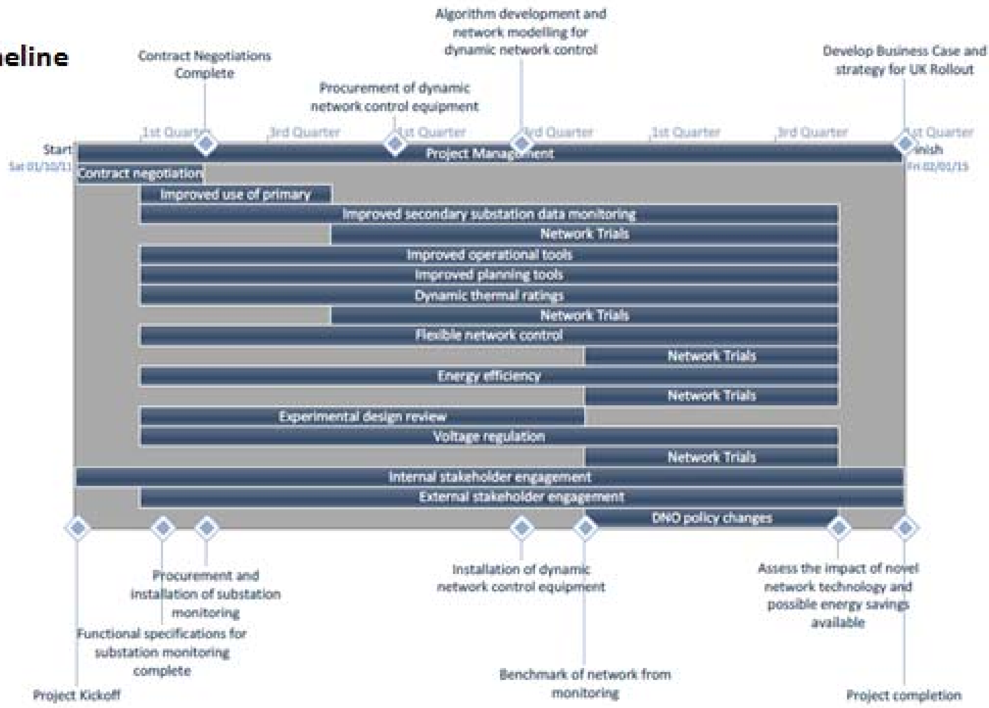


Relationship Diagram



Other parties may be added during the project

Project Timeline



Project readiness Images

Section 7: Regulatory issues

☐ Put a cross in the box if the Project may require any derogations, consents or changes to the regulatory arrangements.

As a result of implementing the proposed solution for this project, we do not anticipate that any derogations, licence consent, licence exemption or change to the current regulatory requirements would be required.

7: Regulatory issues contd.

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7: Regulatory issues images, charts and tables

Regulatory issues images

Section 8: Customer impacts

Summary

- Clear and relevant communication with Customers & Stakeholders is key to the successful delivery of our project and its objectives
- Project presents a significant opportunity to work with customers (Industrial & Commercial) to understand the relationship between energy efficiency and an overall reduction in demand as well as understanding customer behaviour and attitude towards energy efficiency
- Strong focus on the protection of existing security of supply to ensure that customers are not adversely affected by the implementation of the project
- A variety of communication mediums will be established and utilised throughout the course of the project to ensure appropriate engagement with consumers and stakeholders groups
- Effective and regular feedback of relevant information will take place throughout the project with both directly affected customers and other key stakeholders

SP EnergyNetworks realise that effective customer and stakeholder engagement is essential to the successful delivery of the project which is hoped will drive future benefits for GB energy consumers. A priority of the project is the establishment of a comprehensive communication strategy that will be relevant, meaningful and focused on positive engagement of all stakeholders present in the three locations identified for the rollout of the project, of which further information is detailed in Appendix F.

As with every major project which we undertake as part of our business activity, we have developed an appropriate stakeholder engagement map which identifies key stakeholders that will be directly affected or have an interest in the learning from the project. Analysis of the three locations has been undertaken with respect to understanding the customer demographic and a comparison made with UK average to ensure that learning from the project will be relevant to the wider GB energy network market.

Communication with Directly Affected Customers Groups

Within the three areas identified for rollout of the project there is a mix of both Industrial & Commercial and Domestic customer groups. Initial communication will be targeted towards raising awareness of the projects and its objectives, and to clearly demonstrate the potential impact, both positive and negative, that it may have upon customers. Initial dialogue will also enable SP EnergyNetworks to gain a further understanding of customer's energy requirements and dependencies which will in turn enable customers to make an informed decision on their interaction and commitment to the project.

A primary focus of our engagement with both these customer groups will be to create dialogue and seek agreement on the balance to be achieved between the need to undertake the project and deliver its objectives, while maintaining a commitment to deliver a secure supply of energy to customers by taking steps to minimise potential supply interruptions as the project progresses.

We anticipate that the project will require a small number of outages whilst equipment is installed on the network. We will however endeavour to minimise the impact on customers through using live line techniques and other recognised methods to minimise disruption. An initial estimate is that of all the sites where we intend to install monitoring equipment, 25% may require an outage for a two hour period which equates to 0.19 Customer Interruptions and 0.15 Customer Minutes Lost in the Ofgem IIS standards .

Industrial & Commercial Customers - We recognise the need to gain an understanding of users energy requirements and engage with customers on their willingness to take part in the project. Work package 2.3 focuses upon Energy Efficiency and voltage optimisation. We recognise that this will require the support of customers through a willingness to give access to premises for the undertaking of energy surveys, and thereafter procuring and installing recommended equipment that will improve energy efficiency and hopefully contribute towards a reduction in peak demand.

We have also considered where the opportunity for realising the greatest gains in respect of energy efficiency and voltage optimisation are, and therefore will target predominately Industrial & Commercial consumers to test their willingness to be part of the project.

8: Customer impacts contd.

Communication methods will take the form of;

- Customer Liaison Officer (CLO) visits to customers premises
- Use of web based information supported by customer seminars and printed advertisements through local press, newsletters and leaflet drops
- Telephone surveys
- Online surveys whereby we would encourage customers to become part of our wider online community so allowing them to provide wider feedback to SP EnergyNetworks
- Clear messages and information briefs delivered direct to customers who wished to take part in the project

We will however seek clarification from customers through our planned telephone surveys if indeed this was something that customers would welcome and would wish to take part in and support.

As discussed in our description of Work Package 2.3, we will seek to provide customers with the opportunity to have an energy survey conducted at their premises. These surveys will be carried out by an independent organisation paid for by SP EnergyNetworks as part of the project. In addition upon completion, and once potential solutions to improve energy efficiency are identified, we will work with customers in procuring and sourcing the required technology, service or equipment. This will be done through providing information through third party product offerings such as those from energy suppliers.

Following on from when we have completed energy surveys, supported the customer in installing and using recommended energy saving solutions, we will then undertake to ensure an appropriate ongoing communication with those customers that will take the form of:

- Feedback surveys, whereby the customer can provide their views and issues on the actions taken to assist in realising energy efficiency
- Regular project reporting - reporting of project progress to key stakeholders on delivery of milestones, identification of issues and risks arising and proposed corrective actions taken by both the company and customers
- Completion of project close out reports

Domestic Customers - As already discussed, a key element of the project will be to inform and provide understanding on its objectives. Within the three areas taking part in the project we will commit to providing targeted and relevant information to those customer likely to be impacted both positively and negatively as the project progresses. As noted, we will undertake to minimise CI/CML impacts of the project through the use of alternative supplies on the network, live working practices or temporary generators. Where an outage is unavoidable for health and safety reasons, and a monitor is necessary for the purposes of the project, we will apply our existing policy and processes with respect to informing customers of a planned outage.

Vulnerable customers will be clearly identified prior to the project taking place to ensure that adequate arrangements are in place should there be an instance of an interruption to supply.

Furthermore all affected customers will be advised by written mail of direct contacts at SP EnergyNetworks whom they can contact should they wish to discuss any aspect of the project. These contact details will take the form of both an email address and contact telephone number.

Although we believe that targeting domestic premises with energy efficiency would be beneficial for those customers, we believe that this would only provide limited gain due to the large volume of uptake that would be required to make a material saving. For the purpose of this project, from both an economic and technical perspective we have decided to focus on Industrial and commercial customers as a larger saving is likely from a small number of customers. We do recognise that successful trials and a reduction in demand within those areas could be of benefit to domestic consumers, and will seek Energy Suppliers who may be interested in becoming involved as part of their CERT schemes. Initial discussions have been held with suppliers however it has been brough to our attention that a large proportion of these schemes are aimed at insulation which will have a lesser impact on the electricity demand.

8: Customer impacts contd.

Wider Stakeholder Engagement

A number of indirect stakeholders will have an interest or be impacted by the development of the project. Those stakeholders are shown in Section 5 who will be involved with the dissemination of knowledge, and include academic institutions, regulatory bodies, consumer groups, technology & equipment manufacturer's, energy suppliers and the existing GB network operators, who will all have the opportunity to engage in the project and share in the learning and analysis as it progresses and reaches conclusions.

Naturally different stakeholders groups will be affected in different ways by the objectives of the project. To enable an understanding of these we have provided below a list of relevant stakeholder groups and the impact we foresee upon them of the project and how we propose to engage with them.

GB Network Operators - Any learning from the project will be disseminated throughout the GB Network Operator community. Further information on the form of this engagement is covered in Section 5.

Local Government & Regional Development Agencies - In recent years we have seen an increase in the number of local authorities seeking to install generation within the communities in which they serve. This activity does have an impact upon demand and issues can arise in respect of voltage control. Through the deployment of this project we will seek to learn more about the characteristics of the network through system monitoring which we hope will lead to a greater understanding of how increased generation affects demand, and how we can maximise the performance of the network without the requirement for reinforcement. In addition, regional development agencies are increasingly interested to understand the impacts of new demand on the network, and again through dissemination of information on likely future developments, particularly that of large commercial sites, we hope to provide information of how this affects network performance and how best to accommodate these developments going forward.

we have already engaged with a number of councils in the trial areas and some of the major customers to gauge their level of interest in this project. Generally these organisations have recognised the value of the project and are keen to support it. We have not progressed these discussions any further in order to manage expectations.

National Energy Supply Organisations - The nature of competition in the GB electricity supply market implies that customers located within the three locations where the project will be undertaken will have supply contracts with different GB energy suppliers. We recognise existing initiatives/obligations being undertaken by supply businesses in respect of facilitating energy efficiency through initiatives such as CERT/CESP and in the future, Green Deal. We hope that by making Energy Suppliers aware of this project they will be interested in investing in Energy efficiency measures as part of existing obligations.

To ensure a positive customer experience, we will undertake awareness workshops with all GB suppliers to inform on the development of our project in each area to enable them to brief back office and customer facing staff should there be any occasions when customers make contact with their energy supplier or have concerns in respect of events associated with the development of our project.

Academia and NGOs - We have project support from University of Strathclyde and the Buildings Research Establishment. We believe that both of these partners are key in providing impartial analysis of the project such that the outcome of the project can be verified and recommendations made to the future adoption of the various tools and techniques. We will be seeking further engagement with other organisations who we believe will complement the aims of the project.

In conclusion our communication strategy has been developed to ensure understanding, buy-in, commitment, feedback, of and between, key stakeholders and to ensure the project is given the opportunity to provide meaningful learning and outputs. Key objectives include:

8: Customer impacts contd.

- Provision of clear and relevant messages to all stakeholders groups and understanding of possible benefits/impacts
- Effective communication with and engagement of directly affected customers to obtain feedback and on project objectives and willingness to take part
- Obtain clear understanding of customer requirements, concerns and expected deliverables from the project and understand customers willingness to change behaviour, relevant and economics of product and technology offerings and potential to reduce energy demand
- Demonstrate to customers how we plan to operate their network and to maintain security of supply
- Disseminate learning to all interested parties
- Develop solutions that can become Business As Usual

8: Customer impacts images, charts and tables

Customer Impacts images

Section 9: Succesful Delivery Reward Criteria

Criterion (9.1)

Project Budget

The project will be delivered to budget in accordance with the Tier 2 full submission. A 5% variance will be acceptable between work packages but the overall project will be delivered in line with this submission in order to demonstrate effective cost control.

Evidence (9.1)

Ongoing cost reporting to monitor progress and publication of a final report to Ofgem will identify costs incurred per work package to assess compliance with the Tier 2 submission. Project completion date of December 2014.

Criterion (9.2)

Project Milestone Delivery

The project will be delivered in accordance with the timelines outlined in the Tier 2 submission to ensure timely learning can be disseminated and adopted in advance of RIIO-ED1 commencing. Delivery in accordance with these timelines, and in line with budget as per criterion 1 will demonstrate effective project management.

Evidence (9.2)

Ongoing project reporting and formal reports to Ofgem will identify the how well the project is being delivered in accordance with the time lines set out within this submission. Should individual work package time lines deviate from plan, a lower reward weighting may be appropriate as long as the overall project is delivered on time. Completion date December 2014.

9: Succesful delivery reward criteria contd.

Criterion (9.3)

Creation of a Flexible Network - St Andrews

This criterion is to reward on the basis of degree of success on achieving the stated project outputs.

The St Andrews trial will be making use of the network monitoring to improve knowledge of the network and provide robust evidence of the benefits of the physical solutions. The flexible network control, dynamic asset rating and voltage regulators will provide additional back-feed capability such that the existing substation and OHL reinforcements can be deferred or avoided. An increase in capacity of 20% is being targeted.

Evidence (9.3)

The Evidence will be submitted in the form of a sufficiently robust business case paper detailing the full basis, costs and benefits of the installed Flexible Network solution sufficient for Scottish Power to defer or avoid the business as usual reinforcement.

At the end of the project, evidence detailing how a 20% headroom has been achieved will be published along with details of the methodology for this, along with supporting verification from one of the project partners. A comparative analysis of the traditional reinforcement solution will also be provided to demonstrate the nature of the saving.

Work will be undertaken within the permitted CI/CML allowance and with no health, safety or environmental incidents. All of these measures will form part of the internal reporting structure and will feature in any formal report to Ofgem. Completion date December 2014.

Criterion (9.4)

Creation of a Flexible Network - Wrexham

This criterion is to reward on the basis of degree of success on achieving the stated project outputs.

The Wrexham trial will be making use of the cascade monitoring to improve knowledge of the network and provide robust evidence of the benefits of the physical solutions. The improved knowledge will then be used to allow further PV connections without significant reinforcement as is currently envisaged with the target to facilitate an additional 20% of PV onto the network.

Evidence (9.4)

The Evidence will be submitted in the form of a sufficiently robust business case paper detailing the full basis, costs and benefits of the installed Flexible Network solution sufficient for Scottish Power to defer or avoid the business as usual reinforcement.

An evidence base will be published which outlines the amount of microgeneration which the project has proven can be connected to this part of the network as a result of this solution, a comparative analysis will be provided of the volume of microgeneration which could be connected pre-project, with the target to facilitate an additional 20%. This will be supported by independent analysis by an appropriate project partner to verify the results.

Work will be undertaken within the permitted CI/CML allowance and with no health, safety or environmental incidents. All of these measures will form part of the internal reporting structure and will feature in any formal report to Ofgem. Completion date December 2014.

9: Succesful delivery reward criteria contd.

Criterion (9.5)

Creation of a Flexible Network - Whitchurch

This criterion is to reward on the basis of degree of success on achieving the stated project outputs.

The Whitchurch trial will be making use of the network monitoring to improve knowledge of the network and provide robust evidence of the benefits of the physical solutions. The flexible network control, dynamic asset rating and voltage regulators will provide additional back-feed capability such that the existing substation and OHL reinforcements can be deferred or avoided. A increase in capacity of 20% is being targeted.

Evidence (9.5)

The Evidence will be submitted in the form of a sufficiently robust business case paper detailing the full basis, costs and benefits of the installed Flexible Network solution sufficient for Scottish Power to defer or avoid the business as usual reinforcement.

At the end of the project, evidence detailing how a 20% headroom has been achieved will be published along with details of the methodology for this, along with supporting verification from one of the project partners. A comparative analysis of the traditional reinforcement solution will also be provided to demonstrate the nature of the saving.

Work will be undertaken within the permitted CI/CML allowance and with no health, safety or environmental incidents. All of these measures will form part of the internal reporting structure and will feature in any formal report to Ofgem. Completion date December 2014.

Criterion (9.6)

Engagement, dissemination and adoption

This criterion covers both Internal and External engagement and dissemination activities as described in Work Package 3.

It will also monitor how SP Energy Networks adopts or incorporates the outputs of the LCNF project into the core business processes going forward. Having the positive outcomes accepted as beneficial for core business will be a strong indication of both success of the trials as well as an indication of the commitment of the Flexible Networks project team in driving the business change and acceptance process.

The key aspects of this criterion are to ensure that the project provides high quality and timely engagement and dissemination with the internal and external stakeholders.

Evidence (9.6)

Internal and External workshops with will include formal post-workshop surveys to effectively score the success of the learning. Surveys will include points on whether there is sufficient high level information to understand the project context, as well as detailed information on the solution design, data/information gathered and shared, and how the acceptance process within SP Energy Networks progressed.

A survey will also be undertaken within each trial area of the affected Stakeholders to gauge the level of satisfaction and to confirm whether they felt they were sufficiently informed of the activities, benefits and risks of the LCNF project.

Further proposed milestones which will demonstrate this success are:
Project website established to provide overview of project - April 2012
Site visit of PNDC for DNO and Ofgem representatives to demonstrate technology - June 2013
Formal dissemination event to disseminate outcomes - December 2014

9: Succesful delivery reward criteria contd.

Criterion (9.7)

Evidence (9.7)

Criterion (9.8)

Evidence (9.8)

Section10: List of Appendices

All Appendices are provided within the Appendices document.

Appendix A - Full Submission Spreadsheet
Full details of project costs and LCNF Second Tier Funding required in the supplied Proforma.

Appendix B - Additional Financial Information
Additional financial information is provided for support of the business case and calculation of the Base Case costs.

Appendix C - Work Package Information
Technical details for each work package are provided in the form of rationale, proposed innovation and benefits, methodology, and key challenges, experiments and learning points.

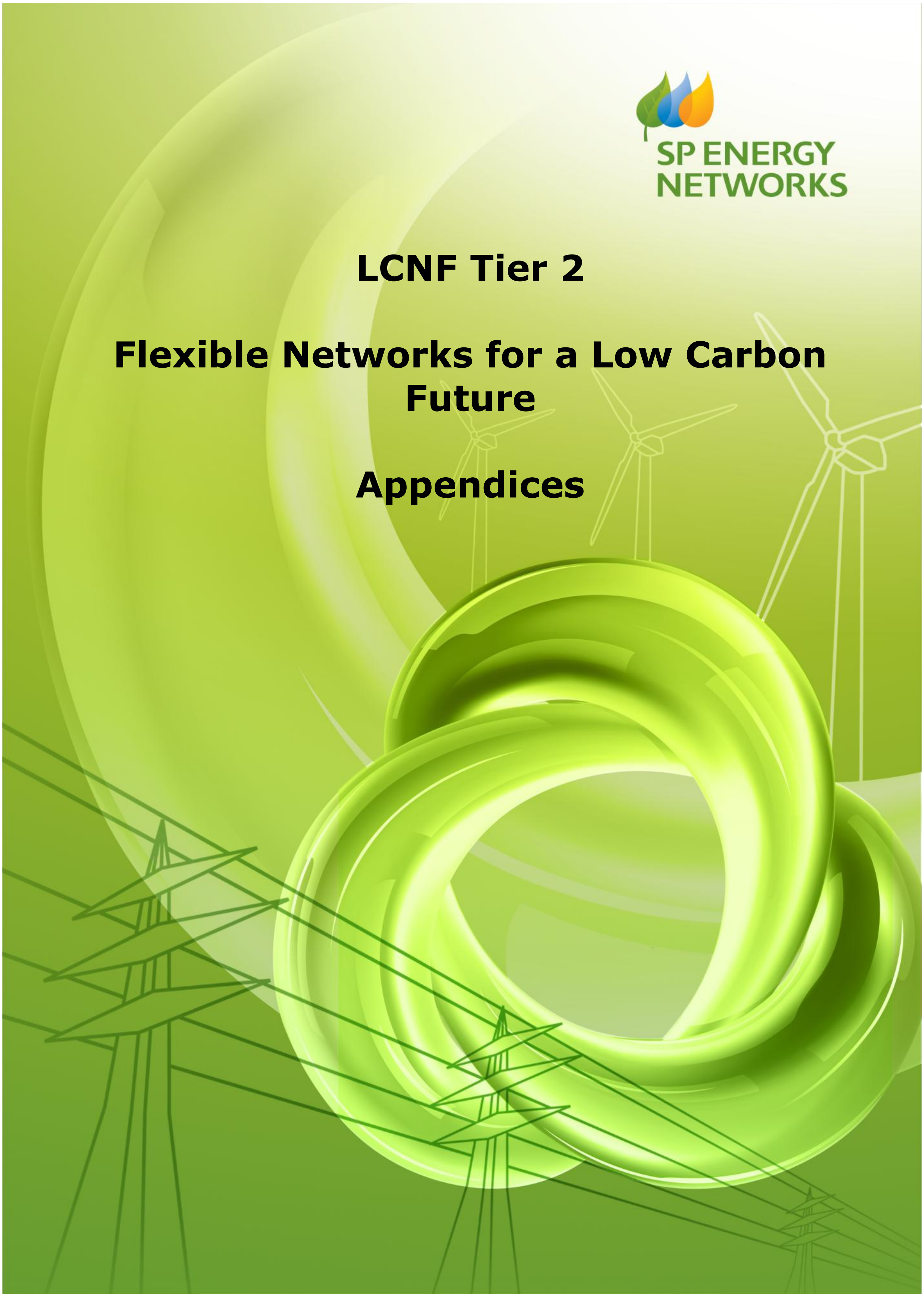
Appendix D - Network Sites
Contains background information for the SPEN network and for each site including details of capacity and low carbon generation issues, maps of network regions, and site-specific network characteristics.

Appendix E - Network Cascade Monitoring
Technical description of network monitoring methodology and installation. The network will be monitored from the grid infeed down through the voltage levels of network to the LV system where customer's supplies are taken from, at selected substations.

Appendix F - Customer Engagement Strategy
Details of the customer communication strategy and data privacy policy for this project.

Appendix G - Project Management
Details of the Project Partners such as their role and contribution to the Projectand how their funding relates to the benefits from the Project.

A detailed Project Plan indicating critical path, and a risk register with risk ratings, mitigation and contingency plans are also included.



LCNF Tier 2

Flexible Networks for a Low Carbon Future

Appendices

Version: SPT2003 – v1

Submitted: 18th August 2011

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Appendix A Full Submission Spreadsheet

This contains full details of project costs and LCNF Second Tier Funding required in the supplied Ofgem Proforma and is provided as a separate spreadsheet.

Appendix B Additional Financial Information

Additional financial information is provided for support of the business case.

Costing Explanations

The Base case costs for each site are based on the most economic solution that would normally be deployed to deliver the overall solution to network reinforcement. Each site is slightly different in terms of the exact reinforcement work that would be undertaken given the different network designs and geography of each site, as detailed in Appendix D. A brief explanation of these costs is detailed below:

St Andrews: Reinforcement would involve the establishment of a new primary substation near the centre of St Andrews. This building is generally of similar footprint to a detached house. This would contain two 33/11kV (Primary) transformers and an 11 panel switchboard. Additional 33kV overhead lines or cables would also be required back to Cupar Grid substation which is approximately 17km away. Extensive works would also be required within St Andrews town centre to re-locate a large number of 11kV/415V substations to be fed from the new primary substation. The majority of these would be connected by cable which would involve extensive excavation in the town centre. This sort of project is common place where demand is increasing as it offers a significant increase in capacity and provides a fit and forget solution on the basis that load will continue to increase in the future. This solution is low risk because of the additional capacity it offers.

Whitchurch: As with St Andrews, the lowest cost solution to accommodate additional demand would be through the construction of an additional primary substation. For reinforcement in Whitchurch, a primary substation would involve the installation of one new 33/11kV transformer and a switchboard. This area of network is designed slightly different and operates with multiple primary substations with single transformers, opposed to single sites with two transformers. This topology is not as common as St Andrews but is used in other parts of the UK. The principal which we are exploring, of increasing the capacity, is no different between the two sites as the 11kV network is operated radially, like St Andrews. Extensive 33kV and 11kV cable works would also be required to integrate this new substation into the network. Due to this primary substation only requiring one transformer, this is reflected in the cost estimate which is lower than St Andrews.

Wrexham: A different reinforcement solution would normally be deployed at Wrexham due to the problem that is created. A traditional solution would be to reinforce the 11kV network through installing additional secondary (11k/415V) substations and integrating these into the local primary substation. These would help to spread the load more effectively, however it is likely to be very difficult to obtain land in the centre of a mature housing centre, which may make installation expensive due to land access. The problem we are facing in Wrexham has never previously materialised therefore the exact nature of the solution could change.

Appendix C Work Package Information

Introduction

Existing networks typically experience fairly low, steady demand growth however, with the increasing connection of low carbon technologies such as electric vehicles, heat pumps, domestic photo-voltaics (PV) and small to medium-scale wind, future networks may experience rapid, localised growth with different load behaviour to previous. It will be critical to identify these trends and make the correct network management decisions to ensure future network compliance and security.

A series of work packages have been developed to reflect the aims and objectives of the bid. These are presented as an integrated set of individual deliverable projects that fit into an overall coherent and consistent master plan. Together, these work packages form the basis for intelligent network change management facilitated by DNO behaviour modification. That is, the development of a common approach integrated across the DNO business to manage network change expected with connection of low carbon technologies, in a proactive, cost-effective and forward looking manner.

It is recognised that there are some inherent conflicts between the ideal design, operation and management of a distribution network. A significant advantage to using a holistic approach rather than as individual independent studies is that it facilitates interaction between business functions, planning, operations and asset management, to optimise the tools and techniques developed. The proposed holistic, integrated approach is a key strength of this bid.

Ofgem has developed a new performance based model for network regulation; Revenue = Incentive + Innovation + Outputs (RIIO). This framework will be implemented for electricity distribution in 2015 for the next price control period, RIIO-D1. Outcomes from this project will contribute to developing the business plan for RIIO-D1 and for future price control submissions.

The overall objectives of these work packages can be summarised as follows;

- Develop an enhanced network monitoring methodology and based on this network data, develop and integrate improved DNO planning and operations tools and practices that are optimised for future low carbon networks (Work Package 1).
- Trial novel technology measures for improved performance of the network such as dynamic thermal ratings of assets, voltage optimisation, and flexible network control (Work Package 2).
- Identify the measures by which material improvements in the cost-effectiveness of accommodation of future energy needs can best be demonstrated.
- Develop an investment and roll-out plan over RIIO-D1 where appropriate cost-benefit exists.
- Disseminate learning to key stakeholders such as customers and other DNOs to ensure sustainable user adoption, through future technical and regulatory policy changes for example. (Work Package 3).

A summarised description of the work packages is given in Table 1. The project is structured so that learning developed in the earlier work packages on enhanced monitoring and benchmark network characteristics for example, can inform later work packages. The following sections give a more detailed description of the rationale, benefits and methodology for each work package.

Table C1 Description of work packages

Work Package		Description
Enhanced network monitoring		
WP 1.1	Improved use of primary substation data	Develop and test improved data analysis techniques to investigate key network metrics and trends, and reveal capacity headroom using existing SCADA data available from primaries and other data such as oil analysis. A new industry best practice for data monitoring and analysis will be produced that includes assessment of measurement and modelling uncertainties.
WP 1.2	Improved secondary substation data monitoring	Explore the value of focussed secondary substation monitoring, in parallel with primary substation monitoring, to increase capacity headroom and better understand network characteristics and behaviour on highly constrained networks and for high-density PV connection, for example. This includes prototyping of innovative secondary substation meters to optimise information requirements. The learning from WP 1.1 will be incorporated into data analysis techniques for WP 1.2. Secondary substation monitoring will also facilitate key learning points from other work packages.
WP 1.3	Improved operational tools	Develop improved control rooms tools and processes to optimise utilisation of available real-time network data and flexible network control technology for the future low carbon environment. This includes use of dynamic thermal ratings for key assets, flexible control strategies, improved outage planning and risk management. Engagement with operational staff to understand their viewpoint and needs with the objective of implementing changes in techniques and behaviour.
WP 1.4	Improved planning tools	Develop improved network design tools and processes to utilise additional network data and network control technology. A best practice guide for network capacity management will be produced for more focussed network investment strategies and to provide guidance for connection of low carbon generation. This will include use of real load profiles, load composition and enhanced asset thermal ratings. Engagement with network planners to understand their viewpoint and needs with the objective of implementing changes in techniques and behaviour.
Dynamic Network Control		
WP 2.1	Dynamic thermal ratings	Investigate improved thermal management through the use of dynamic thermal ratings on primary substation assets in the control room, including consideration of environmental conditions. This should release headroom and reduce likelihood of unnecessary load shedding.
WP 2.2	Flexible network control	Network trials for flexible network reconfiguration using automated intelligent switching on the secondary network to take advantage of differing load profiles or capacity headroom on adjacent parts of the network. Development of an expert control system to run in parallel with the existing operation system. Comparative assessment with network benchmark data from WP 1.2.
WP 2.3	Energy efficiency	Work with customers and energy suppliers to implement targeted energy efficiency measures i.e. voltage regulators, reactive compensation and low energy appliances, within a focussed network area. Explore ability of the DNO to reduce peak demand through voltage management. Comparative assessment with network benchmark data from WP 1.2.
WP 2.4	Voltage regulation	Develop detailed design specifications for prototype packaged solutions of 11kV voltage regulators and reactive power compensation, and test at the Power Network Demonstration Centre (PNDC). Deploy and trial a small number in network trial areas. These 'plug and play' solutions will be able to rapidly provide capacity support to stressed network areas.
Stakeholder Engagement and Learning Dissemination		
WP 3.1	Internal stakeholder engagement	Internal knowledge dissemination and behaviour change.
WP 3.2	External stakeholder engagement	Knowledge dissemination and learning for external stakeholders including other DNOs, customers, local councils and community groups.
WP 3.3	Verification of experimental design	University of Strathclyde will perform an expert review of each work package methodology.
WP 3.4	DNO policy changes	Changes to technical and regulatory standards and guidance (internal and external) to facilitate industry learning and adoption.

Enhanced Network Monitoring

The existing best practice for distribution network LV and 11kV network design and operation is based on a 'fit and forget' philosophy where there is only a limited set of representative network metrics available e.g. the magnitude of peak loading on a feeder, which generally does not provide information on the dynamic interactions of the various systems states over the course of a year of operation. Short term capacity overloads or voltage excursions are typically identified by customer complaints or investigations for new connections. Historically, it has been difficult to provide robust cost-benefit analysis in support of collection and analysis of time series data for large parts of the network.

The level of operating state uncertainty necessitated a number of assumptions which have inherent safety margins built in to minimise the risk of overloading equipment and keeping voltages within statutory limits. Also, existing load connections i.e. customers, have generally been considered to be stable i.e. load profiles and demand of existing connections do not change appreciably over time. Presently, most load changes on the network are due to new connections, rather than changes to existing connections.

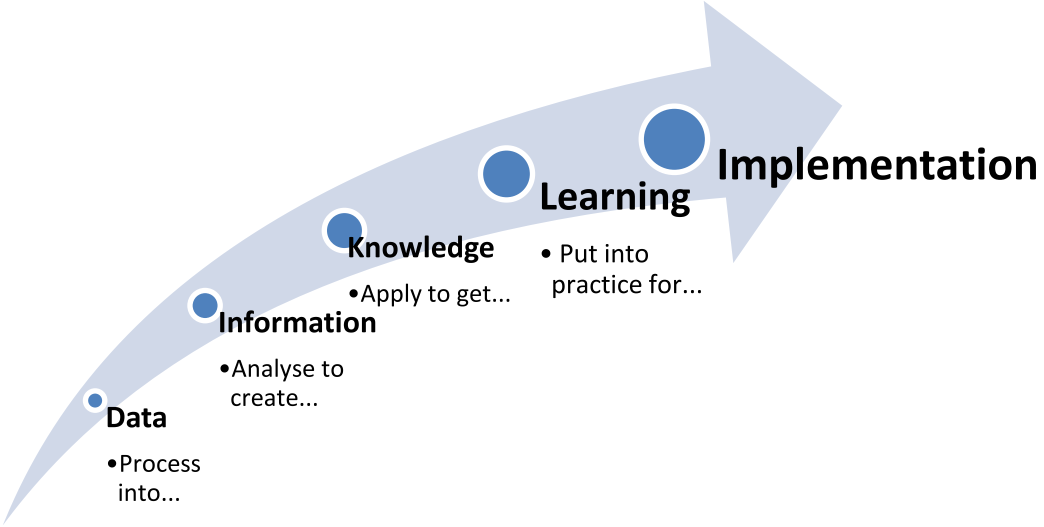
In the future, it is likely that customer consumption patterns could change radically, creating a significant impact on the distribution network over a short period of time. These changes could be localised and high-density due to rollout of electric vehicle charging points for example. This will necessitate an improved knowledge of the distribution network particularly at 11kV and LV and the ability to detect and extrapolate changes to implement the appropriate response. The focus of these work packages is to develop more knowledge of the characteristics and behaviour of the existing network, identify additional capacity headroom available and better understand the likely impact of future network changes. It will develop cost-effective tools to improve network performance and investment, and to flag network changes and trends. A key aspect will be engaging with network operations and planning staff to understand their viewpoint and needs with the objective of obtaining their buy-in to implement changes in techniques and behaviour.

The work package outcomes should allow existing inherent design and operational safety margins for capacity to be reduced, without placing the system at risk, or degrading quality of supply to customers. It will also enable the development of techno-economic strategies for management of the future low carbon network that are effective and easy to implement. Although network monitoring and analysis is not in itself an innovative technique, the innovation in this work package is the core focus on improvement of the use of existing data across the business to create better knowledge and foresight of the changing environment.

The use of existing data that is currently gathered and stored from grid supply points and primary substations will be investigated, and strategies for increasing data value to network design and operation will be developed for Work Package (WP) 1.1. For WP 1.2, a monitoring programme will be trialled in several representative network areas to assess the added value of monitoring at secondary substations. It is proposed to use a focussed, 'cascade' methodology for network monitoring, which involves characterising the network from primary to LV and across adjacent feeders. Specific low carbon technology issues will also be addressed including connection of low carbon generation and increasing demand leading to highly constrained networks. A scientifically robust and verifiable approach will be used to assess uncertainties and risks.

WPs 1.3 and 1.4 focus on improving tools and processes to integrate the new network data streams into network design and operation for a low carbon network environment. The engagement and collaboration of operators and planners will be an important consideration for these work packages.

The diagram below illustrates shows the DNO learning process for enhanced network monitoring.



WP1.1 Improved Use of Primary Substation Data

Existing Approach and Limitations

At present there is a reasonable level of data gathered in real-time from the Primary substations including transformer MW/MVAR levels, 11kV voltage and currents on the 11kV feeders. This is stored as raw data and requires manual extraction and interpretation on a case-by-case basis when analysis is required. Data is primarily used during annual network model assessment to monitor load growth and identify areas approaching capacity that may require reinforcement or additional infrastructure investment, or for new connections. There is limited requirement for real-time utilisation of the data.

The network is modelled in full in power systems analysis software down to 33kV with 11kV and LV networks typically modelled using an aggregated or localised desktop approach. In order to make greater use of network data in a future low carbon environment, an improved quantification of data and modelling uncertainties and feedback for model improvement is required to reduce conservative margins and increase headroom.

Proposed Innovation and Benefits

This work package will develop robust data extraction and analysis techniques for existing primary substation measurements (including oil analysis of transformers) to inform asset ratings, planning and operational decisions. The characteristics and behaviour of the network at the primary substation level will be integrated with results from secondary substation monitoring in WP 1.2 to provide an improved understanding of the network, possible gains in capacity headroom and the potential impact of low carbon technologies.

A new industry best practice for data monitoring and analysis will be developed and tested, that reconciles the future need for improved information for network planners and operators, whilst minimising operational expenditure. It will provide benefits such as an early warning system of underlying demand behaviour changes to flag and potential for delay of reinforcements due to improved understanding of network loading characteristics. Improved resolution of real-time asset parameters may enable running assets closer to design ratings (i.e. using temperature rather than generic "cyclic" behaviour as the cyclic assumptions are likely to be conservative) whilst complying with good asset management practice.

This work package will also investigate the identification, management and mitigation of measurement and modelling uncertainties. This will include a sensitivity assessment, strategies for risk management and how network models can best be used to inform business decisions for efficient network investment.

Network trials are not required for this work package so work can begin immediately, and the short timescale allows early delivery of learning for the project. Knowledge and learning from this work package will be invaluable to guide work packages with a longer timeframe. For example, it will help to inform the requirements and equipment specifications for enhanced monitoring using the cascade approach for primary and secondary substations.

Methodology

This work package will develop and trial data extraction, analysis and management tools and processes based on existing data monitored at grid and primary substations. It will also seek to verify network models with measured data and investigate how best to manage uncertainties in order to minimise risk.

Existing historical data will be analysed to improve network modelling, for example modelling of network voltage limitations. Historical outages of 33/11kV transformers will be examined to establish the 11kV voltage changes that actually occurred. This will be compared to the modelled results for the same outage scenario and changes in the model implemented to improve the modelled results. Observing the real system will provide evidence to improve the modelling of transformer voltage control, voltage regulators, generators and loads. It is anticipated that such changes will effectively increase 11kV system capacity by validating the more detailed models.

There are various sources of uncertainty in both measured data from the network and within network models. For measurements, this may be due to data resolution, instrumentation accuracy and calibration, interference and time syncing. The accuracy of network models is influenced by the quality of input data such as aggregated load and generation profiles, correct definition of asset parameters such as cable length and modifications to network topology, for example. Details of legacy assets in particular, can be problematic to source.

Network models at 11kV (and LV) are not typically built at present. Load flow and fault level results from network models and measurements are compared and correlated at 132kV and 33kV (11kV) busbars. Often, there are issues when balancing fault level calculations with load flows and reactive power in particular may be associated with increased uncertainty. Erroneous or inaccurate data or models can reduce network capacity by introducing conservatism into design, increased safety margins because the network measurements are not trusted. In the worst case, it can mask an actual underlying problem.

Table C2 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Investigate effectiveness of improved analysis tools for existing data and their contribution to network capacity.	Analyse existing network data available for primary substations. Verify network models using measured data, assess uncertainties and sensitivities.	Value of existing primary substation data monitoring for characterising network behaviour and trends. Improvement in veracity of network models and development of strategies to manage data and modelling uncertainties.
Changes to design practice.	Review P2/6 methodology for network loading and ratings, reinforcement prioritisation and risk management processes.	Modify relevant design policy, specifications and practice.
Changes to operational practice.	Review on-site and control room processes such as outage planning and asset ratings.	Modify relevant operational practice.
Develop investment plan.	Use learning to develop cost-benefit argument.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

Various mitigation measures for potential sources of uncertainty could include measurement error detection tools, the use and management of standard asset libraries and GIS data for network models, and the utilisation of additional data layers such switching data. These will be assessed during this work package to assess their value.

WP1.2 Improved Secondary Substation Monitoring

Existing Approach and Limitations

At present, secondary substations (HV/LV, 11kV/400V) across the UK network are only fitted with monitoring equipment on an exceptional basis. At most, these may have a Maximum Demand Indicator (MDI) which is manually read once or twice a year. This provides only a single maximum current value with no indication of frequency, duration or power-factor of this maximum current. For capacity planning purposes, these maximum demand values are augmented using typical demand profiles and general customer group metrics to create synthetic demand profiles, which are then used to determine the capacity headroom of the LV and HV networks. Existing CTs are Class 5 which are only 5% accurate on full-range. Therefore, the maximum demand readings already have an inherent uncertainty factor of 10% variation. Conservative assumptions are taken to manage the uncertainty and safeguard the network and customers. This approach may not be adequate to respond to load changes due to rapid and localised connection of low carbon technology, and may lead to inefficient network reinforcement.

Currently, Group Demand and Generation Output are based on the metered real power (MW) averaged over half an hour. Within a particular half hour, demand could peak at levels which would cause voltage or thermal issues but this would not be apparent using the present approach. Low carbon generation such as wind and PV experience continuously varying output and half hourly measurement has already been identified as a concern.

A further consideration is the move to dynamic thermal ratings. Climatic data will need to be provided in the timescale of 1, 5 or 10 minutes as an input to the thermal models to update the thermal rating of the asset. If the associated circuit loading is only updated every 30 minutes there could be lengthy period before operators or control schemes become aware of the overload. A similar issue can occur if asset short term ratings are relied upon during switching, there will be no confirmation that the asset was being operated within its rating which could result in damaging or catastrophic results.

Standard rule of thumb voltage profile curves derived in the mid-1980s (voltage planning standard PLM-ST-9) are in general use by DNOs to determine the voltage reduction required to achieve a particular load reduction requested by the transmission system operator. These describe the variation of the active and reactive power consumed by loads in different classes – 'heavy' industrial, 'light' industrial, commercial and domestic – with changes in the voltage supplied to them. The nature of loads has changed considerably since then and the voltage dependency of low carbon technologies specifically needs to be considered.

However, simply putting a secondary substation metering programme in place will not in itself resolve the issue as an inappropriately designed system will create volumes of data and communication bandwidth requirements that are unmanageable and not cost effective. Even once the data is collected, a clear plan is required on how to use the data to create value.

Proposed Innovation and Benefits

This work package will develop an information gathering programme that is optimised for network planning and operations needs, whilst aiming to minimise cost and intervention. This holistic approach to network monitoring is the key innovation. The value of secondary substation monitoring will then be explored in terms of providing a better understand of existing and future network characteristics and behaviour, and how this can be applied to increase capacity headroom, improve network performance and optimise business decision making for network investment. For stressed network areas, this will enable more forward planning to implement either short-term mitigation measures, or pre-engineering works as part of a more significant network modification.

Functional specifications for enhanced secondary substation monitoring will be developed including the prototyping of a 'smart' monitor, to provide learning on monitoring deployment to enable increases in capacity headroom and connection of low carbon technology cost-effectively. This will include assessment of data resolution, and onsite and offsite data processing and storage requirements.

The cascade approach to monitoring means that secondary metering programmes can have a targeted roll-out based on intelligent interrogation of Primary substation data to identify and detect areas where growth, or behaviour change is occurring. This ensures that the metering roll-out is done in an efficient and timely manner.

The utilisation of the data to improve planning and operations tools and processes will be studied further in WPs 1.3 and 1.4 and there will be an iterative feedback based on remote refreshes of the Nortech programmable monitor that enhances the development of this work package.

Improved secondary substation monitoring will facilitate key learning points from other work packages. It will establish a network benchmark against which the performance of network technology such as dynamic network control and voltage regulation can be evaluated.

WP 1.2 will also look to apply early learning based on existing LCNF Tier 1 and Tier 2 projects such as WPDs Low Voltage Network Templates on the application of monitoring.

Methodology

Trials will be carried out in several network areas with varying topology for approximately 185 secondary substations. The impact of high-density low carbon generation will be assessed through monitoring of areas with differing levels of PV generation. A focussed 'cascade' approach is proposed for network trials, where the measurements are synchronised in time and monitoring equipment is installed from the primary substation down the chain to the customer across several adjacent LV networks. This is intended to maximise learning and provide insights for improved system modelling and long-term monitoring requirements.

The best value data relates to when the network is under stress. This is not generally when the network is working normally i.e. with no outages, but when there are outages on the (HV) network. During network trials, the network will be deliberately switched to take the n-1 case, to increase loading and compare modelled scenarios to actual. This will be carried out through intermittently and in agreement with asset management and operations. Other measures such as switching of loads to different primaries will be explored. Careful planning of outage timings and durations will entail no material change to consumers' annual reliability of supply indices. The engagement strategy for customers that may be affected by outages is outlined in detail in Appendix F.

The work package involves the prototyping of secondary substation meters using flexible programmable units with clip-on LV CTs that can do on-board data analysis and processing so that only minimum amounts of key information need to be communicated back to a central database system. In effect, rather than streaming full 10 minute raw data back to the central system (3,000kB/yr), they will upload processed monthly demand profiles (10kB/yr) with detailed data being available on an as-needed basis only. Considering the number of secondary substations within the UK, this issue is a significant challenge to roll-out unless an innovation of this scale is adopted. In addition, several monitoring equipment packages will be trialled in parallel in order to identify the most cost-effective approach for future implementation.

The integration of data with existing planning and operations systems will be assessed in order to develop a view on functional specifications for data monitoring such as the ability to issue critical alerts of overload or failure, to identify substations approaching limits and provide details of frequency and duration of rating warnings.

The secondary substation monitoring will give an opportunity to construct an updated set of voltage profile curves. These might be built directly from measurements but also compared with measurements at primaries to evaluate how the characteristics of composite loads might be derived. This will also be correlated with a laboratory study of localised VDL by use of consumer appliances, small industrial loads and microgenerators to part validate models. This will help to inform the potential impact of low carbon technologies.

A review of existing composite demand models and their underlying assumptions regarding technology responses as currently used in GB and described in other available international documents will be carried out. Based on theoretical models of the main electrical load types and DNO data regarding customer mixes at each of a representative set of GSPs, revised aggregated demand models will be developed at the BSP and GSP level. If possible, measurements from voltage disturbance events such as before and after switching and large motors starts should be obtained for analysis with the aim of validating the theoretical models.

Learning will be used to improve the approach to network modelling and verification at 11kV and LV, using lessons learnt from modelling of 33kV and 132kV networks. 11kV and LV models are typically not modelled presently so there is a potential issue about model creation from GIS systems and ensuring that the network models are maintained once created. Details of the topology of the LV network has not needed to be well characterised in the past. Unbalanced phase for LV has been identified as a key issue for connection of low carbon technology. This work package will examine the techno-economic business case for model development and verification, particularly at 11kV, and will incorporate learning on model verification from WP 1.1. In particular, determining the appropriate incorporation of field data into deterministic network modelling tools.

Table C3 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Install data collection systems.	Access and collect data for network modelling over at least a year. Deliberately take n-1 to increase load on network and compare model to actual.	Understand costs and practicalities of data monitoring equipment for secondary substations. Understand appropriate method of including data into existing corporate systems.
Investigate the effectiveness of increased data monitoring and its contribution to network capacity.	Utilise existing theory, network modelling and data collected to inform future strategy regarding monitoring. Deliberately take n-1 to increase load on assets and compare model to actual. Apply typical future loading scenarios to model to understand implications.	Understand optimum cost-benefit case provided by the additional data. Develop sufficient confidence in network models to be able to use them to inform future design and operational practice.
Changes to design practice.	Review P2/6 methodology for network loading and ratings, voltage profiles, reinforcement prioritisation and risk management processes.	Modify relevant design policy, specifications and practice.
Changes to operational practice.	Review on-site and control room processes such as real-time warnings and outage planning.	Modify relevant operational practice.
Develop investment plan.	Use learning to develop cost-benefit argument. Includes an assessment of appropriate penetration level at different voltage levels and applications.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

WP 1.3 Improved Operational Tools

Existing Approach and Limitations

At present, network control room staff have only limited feedback from the network in the form of warnings and alarm systems, and of this it is predominantly only on the EHV and Primary networks. As network planning methodologies and network technology become increasingly sophisticated, the network control staff need to also be provided with more information to help them manage and control the network in compliance with the planned and technical limits. Simply increasing the level of information is in itself not the answer, control staff need to be provided with useful interpretation of situations to aid with their decision making processes. It is also critical to engage with them as they are the 'gate-keepers' of the network, to ensure that there is buy-in to improved tools and processes, and risk management techniques for utilisation of capacity headroom margins, and increased connection capacity for low carbon technology.

This work package will explore the challenges and opportunities associated with improvements in control room tools. In order to do this it will be necessary to understand the limitations of existing facilities and practice, to identify the areas that could be impacting on the effective capacity of the network and introduce beneficial changes. A key consideration for this work package will be the engagement of operational staff in the drive for changes in tools and behaviour.

Proposed Innovation and Benefits

The availability of higher resolution network data from enhanced network monitoring can be utilised in the control room to improve risk management capability through real-time analysis of the data to provide information that corresponds more closely to the planning methodology and equipment capability.

One proposed innovation for improved network control tools will be to understand the potential impacts on distribution operation when dynamic thermal asset ratings are employed. Real-time information on thermal loading of feeders and transformers will be compared with modelled or monitored real-time thermal limits. This will be used to ensure that loading headrooms are correctly identified, loads are not reduced unnecessarily, and reinforcements can be deferred wherever prudent and possible. Adjustments in rating will automatically be calculated based on weather forecasts or real-time weather information.

A tool will be trialled that enables scanning of the data archive to find what happened on the network the last time the outage was taken e.g. real voltage, real load profile, combined with present-day loading and other network information to forecast the network conditions over the period of the outage. This will enable more efficient planning and management of the network outages and network capacity.

Innovative tools such as these will be developed and evaluated to determine their effectiveness and practicality as methods of improved risk management and increasing capacity headroom which will support roll-out across the UK.

Methodology

Initially, a review of current control room tools will be undertaken to identify any barriers or limitations for future low carbon networks and opportunities for developing and improving tools. The integration of real-time data from network monitoring with existing proprietary control software to give warnings and alarms will be considered. This can be implemented through "plug-in" algorithms, which have already been proven as a workable approach on previous projects. It is proposed to approach this on a prototype basis to minimise intervention with critical systems as this maintain flexibility and avoids time delay and cost overheads.

There will be a component of software development for existing software used to model the network in the control room 'on the fly'. This will add new functionality to enable improved representation of dynamic thermal ratings, outage scenario comparison and of low carbon technologies connected to the network, for example. Model verification based on monitoring data provided from WP 1.1 and 1.2 will inform this element.

There will be a process of engagement with operations staff to discuss the development of new tools and processes to improve risk management associated with low carbon technology. For example, to maximise the utilisation of increased capacity headroom. This will be an excellent opportunity to capture the input of the end-users and add significant value to the work package. It will also be a way of maximising likelihood of operator cooperative buy-in. An iterative process of providing input to the network design process and reinforcement prioritisation as well as integrating feedback from network planning developments will be a key feature.

Table C4 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Investigate opportunities for beneficial changes to control room systems.	Review existing operational practices and tools.	Effective engagement strategies with operational staff.
Development of tools and processes to improve management of existing capacity and future low carbon networks.	Develop and trial new and improved operations tools and practices.	Strategies for optimising network risk management whilst not impacting control room workload. Understand challenges associated with making changes to operational practices and how best to implement to ensure user adoption.
Changes to operational practice.	Review on-site and control room processes such as real-time warnings and outage planning.	Modify relevant operational practice.
Changes to design practice.	Review impact on P2/6 methodology and opportunities for integrating learning into consequential system design processes.	Modify relevant design policy, specifications and practice.
Develop investment plan.	Use learning to develop cost-benefit argument.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

WP1.4 Improved Planning Tools

Existing Approach and Limitations

It can take a number of years to implement network reinforcement solutions; 18 months+ for a grid transformer, up to 6+ years for an overhead line, so it is critical to identify constrained areas early on in order to respond in time. At present, SPEN undertake an annual assessment that provides a ranked portfolio of issues which then get prioritised based on value, criticality and deliverability. Reinforcement is triggered when the network capacity calculated is less than the forecast network demand for the scenario being assessed. Decisions are not made by applying thresholds to individual projects on a case by case basis, but rather all projects are stacked together and then the top project/s selected. This creates a final business case for each reinforcement. Detailed modelling to more accurately understand network constraints is carried out for selected projects, but not for projects falling below the threshold. There is therefore scope here to develop a more effective approach designed to consider future network changes particularly for scenarios involving rapid demand change.

At present, in the ER P2/6 methodology, fixed equipment ratings are used for the season being considered. These have been derived from probabilistic assessments. If 'enhanced' asset ratings based on real measured data are to be used to model networks, then a robust methodology for this needs to be developed and provided in the planning standards. Closer linkages between Planning and Operations business functions will facilitate a converged approach to identification and management of additional capacity headroom with enhanced ratings.

There is currently a large workload for associated with new connections. An increase in low carbon technology connections may create significant localised load growth with the additional workload stretching workforce and delivery significantly. It is anticipated that all other UK DNOs will be in a similar position. In addition, existing Plant Information (PI) data storage systems are not optimised for ease and automation of data retrieval required to carry out planning functions. There are significant opportunities to streamline data retrieval and appropriate information creation to help accelerate and standardise analysis and decision making.

This work package will investigate the development of improved tools to understand and predict the existing and future capacity growth of the network with low carbon technology connections efficiently, and to refine the methodology for investment decisions and pipeline management.

Proposed Innovation and Benefits

This work package will develop a best-practice guide on management of system capacity to enable large-scale rollout of low carbon technologies whilst optimising network investment and ensuring P2/6 compliance. This guide will be based on the philosophy of a high level assessment across the network, but more detailed monitoring and site-specific assessment of ratings as the network capacity headroom becomes depleted. It will incorporate learning on network characteristics and behaviour from WP 1.1 and 1.2 to enable beneficial changes to be made to network design practice.

Enhanced thermal ratings for EHV overhead lines are being investigated by SPEN and other DNOs as part of Tier 1 LCNF projects. Enhanced thermal ratings for transformers and HV overhead lines are to be investigated as part of this LCNF Tier 2 project. Results from these initiatives should be assimilated into suitable guidance for network planners that might, in due course, become part of a new ER P2/7 standard to ensure a common-approach between DNOs. This work package will investigate the process to achieve this. Also, applications for improved asset management will be explored.

Methodology

A review of the existing PI data systems will be carried out initially to establish opportunities for improvement and streamlining of data extraction and analysis, in collaboration with network designers. Improved load forecasting will be developed based on better characterisation of load profiles and investigation into the make-up of load profiles.

The capability to change load profile by engaging with customers or suppliers will also be explored. Tools and processes to flag up and manage network hotspots will be developed and new decision support tools implemented as required. The availability of ‘cascaded’ network monitoring data will create the environment in which these tools can be tested and verified.

It is intended that the best-practice guide on management of system capacity be included into the governance of DNOs, which takes into account the actual load curve and the local ambient conditions for assets. If data is unknown, then representative or industry standard information can be used. The actual risk level within the group for Intact, First Circuit Outages and Second Circuit Outages will be determined. This will feed into the economic model along with other information such as the cost of reinforcement to determine if it is reinforcement is appropriate. Case studies of particular overhead lines, cables and transformers supported by field measurements will be used to provide confidence in the modelling and demonstrate the method to assist in its adoption across DNOs.

Example

A primary substation reaches P2/6 limits based on standard design rules. The critical condition is the n-1 outage conditions when a short-term rating of 1.2x nominal is exceeded, which will normally trigger a reinforcement.

Under normal load-growth, there may be a 4-5 year window required to achieve the reinforcement. A low carbon environment may result in faster load growth and so give a critical condition shorter than the 4 year delivery timeframe of the reinforcement. The following approach could be used to avoid non-compliance and therefore avoiding placing customers at risk.

If at the point of a reinforcement being triggered, under the standard approach the actual load profiles are applied to a more detailed thermal model of the transformers/assets, this may allow a higher 'standard' ('enhanced') short-term rating to be used which allows an increased network capacity. However, this is additional network risk due to the more detailed calculations and therefore risk management needs to be put into place to mitigate this. This will involve more asset monitoring such as analogue temperature, as well as enhanced operator feedback and management tools. In the event that the operator is not happy with a situation, then "emergency" measures may need to be enacted, which ultimately will be part of the planned response.

A similar challenge is when asset management derates the transformers due to asset age and this creates a reinforcement/replacement trigger. Managing this may involve on-line dissolved gas analysis (DGA) amongst other things.

The objective of this work package is to explore these opportunities and verify their actual performance and suitability for adapting into standard practice.

Table C5 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Investigate opportunities for beneficial changes to network design practice.	Review existing network design practices and tools.	Effective engagement strategies with network design staff.
Development of tools and practices to improve management of existing and future capacity.	Develop and trial new and improved network planning tools and practices. Test network using "What if" future scenarios for sensitivity to PV and other low carbon technology, transformer replacement etc. Develop best practice guide to management of network capacity.	Application of 'enhanced' ratings for different network assets for network design. Actual network risks when assets are subjected to high loadings to inform future network design and risk management strategies. Understand challenges associated with making changes to network design practices and how best to implement to ensure user adoption.
Changes to design practice.	Review impact on P2/6 methodology for asset ratings, risk management and network reinforcement prioritization.	Modify relevant design policy, specifications and practice.
Develop investment plan.	Use learning to develop cost-benefit argument.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

Dynamic Network Control

Dynamic network control technology can be utilised to improve the flexibility with which primarily the 11kV and some of the 33kV network can be operated to enhance the existing network capacity and provide useful increments of network capacity on a rapid and reasonable cost basis.

Innovative technology and techniques have been selected that have the potential to cost-effectively release or increment capacity across the network. Some measures are similar to those used on the transmission and EHV networks but at lower voltage levels, others are about focusing on the specific issues that limit network capacity and using better data and control to be able to reduce or remove the barrier.

The work packages are designed to first identify what the network requirements are in terms of flexibility or capacity limitations, then to identify a suitable technical approach and design a minimum requirement trial to test whether the theoretical benefits can be achieved in practice, and to establish timescales, costs and any real-world limitations.

WP2.1 Dynamic Thermal Ratings

Existing Approach and Limitations

National standards assign different thermal ratings to network assets during each operating scenario, taking into account both the representative equipment loading and typical ambient conditions. DNOs have typically used two approaches in the past. The first is to 'weather correct' the demand to an Average Cold Spell (ACS) reference temperature, and then to use the rating of plant at this reference temperature. It is then assumed that if it is colder, demand will increase but at a slower rate than the increase in asset rating due to lower ambient temperature. This approach is difficult to apply to summer loadings and many Network Groups do not exhibit strong temperature dependency of demand. Often, the critical case is under planned outage conditions, and these occur in the summer. The present P2/6 default of summer peak load is 67% of winter peak which is not representative enough for current or future networks.

The second is to modify the rating to suit the season that the demand occurs within. Up to four seasons have been typical. Some DNOs have interpolated published ratings to give individual monthly ratings. For example, the Autumn rating for overhead lines includes November and demand often increases significantly towards the end of this month and can cause ER P2/6 non-compliance on paper.

Both of these existing approaches use a fixed rating. This allows the network capacity to be calculated and compared to the network demand for the scenario being assessed. The use of generic asset ratings that do not consider the actual thermal conditions experienced can lead to unnecessary triggering of network reinforcements and corrective measures to reduce load due to indications that thermal headroom is exhausted.

Key issues to address for use of dynamic ratings include;
- What load profile has been assumed and is it really representative?
- How does the load profile vary in different parts of the network?
- What is the rating versus timescale of loading for different assets?
- How should the derivation of a real time rating be integrated into thermal management?

From research undertaken to date, it may be possible to achieve additional conservative capacity of up to +70% on overhead lines, and +6% on transformers. Peak demand occurs in December when ambient temperature is lowest, which will enhance the temperature rating and thus, should provide additional capacity when it is required most.

Proposed Innovation and Benefits

This Work Package will explore the use of dynamic ratings to improve thermal management of cables, overhead lines and transformers, identify capacity headroom and to understand and manage the potential impacts on distribution system operation and design. This should ultimately delay network reinforcement and enable more efficient network investment.

Key outcomes will include the improved use of existing data and new data monitoring to increase the resolution of network loading detail, verify load representation, derive dynamic and 'enhanced' ratings and incorporate into the thermal management system. As part of this, thermal models will be compared and verified with real network data. The method of pairing demand and ratings to understand the extent of the capacity shortfall (or energy at risk) will be explored with the aim of standardising across DNOs.

Loading trend characterisation and how this impacts asset rating will be investigated to inform real time and cumulative thermal risk management. Tools will be developed to allow a more pro-active identification of problem areas on the network for testing in Planning and Operation environments.

Methodology

Online temperature monitoring will be installed at a number of primary substations to capture thermal loading of transformers and 33kV circuits supplying the primary over the course of a year. All of the assets that form a complete circuit will be considered to understand the limiting asset that will determine the capacity of the composite circuit. Weather monitoring will also be installed to investigate how asset rating can be optimised by considering environmental conditions. An advanced thermal management system that incorporates thermal modelling tools will be developed in parallel to monitoring. Transformer oil samples will be analysed and the integration of information on transformer health, gained from dissolved gas and moisture content, into thermal models will be investigated.

Table C6 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Install data collection systems.	Deploy asset temperature monitoring on a variety of distribution assets. Access and collect data for thermal modelling over at least a year. Analyse transformer oil samples and include information regarding dissolved gas and moisture content into models. Deliberately take n-1 to increase load on assets and compare model to actual.	Understand practical and cost aspects of retrofitting analogue on-line temperature measurements. Understand appropriate method of including data into existing corporate systems.
Investigate thermal characteristics of various assets and maximise their contribution to network capacity.	Utilise existing theory, thermal models and data collected to inform future strategy regarding asset loading. Apply typical future loading scenarios to model to understand implications.	Develop sufficient confidence in thermal models to be able to use them to inform future design and operational practice. Deliberately take n-1 to increase load on assets and compare model to actual. Review four seasonal cyclic loading capabilities appropriate for planning and operational purposes.
Changes to design practice.	Review impact on P2/6 methodology for asset ratings. Understand risks associated with existing network design practice and linkage between asset health, risk and life expectancy.	Modify relevant design policy, specifications and practice.
Changes to operational practice.	Review control room processes for evaluating real-time asset ratings.	Modify relevant operational practice i.e. how far can a transformer be loaded and when is it appropriate to reduce loading by disconnection?
Develop investment plan.	Use learning to develop cost-benefit argument. Assess appropriate penetration level at different voltage levels and asset types.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

A small number of secondary substations will also be monitored using simple external measurements to trial the value of having basic temperature information on a traffic light basis for operational decision making on the network.

In order to maximise the learning gained and validation of thermal models, network trials will be carried out in areas where the network assets are highly constrained and likely to be operating near thermal limits for n-1 loading scenarios. During network trials, the network will be deliberately switched to take the n-1 case, to increase loading. Other measures such as switching of loads to different primaries will be explored.

The location of thermal constraint in the network will be explored and the impact that this has on the capacity headroom gains that can be achieved with use of dynamic ratings. Asset rating can sometimes be bottle necked by other factors such as bushings, busbars, cable tails, switchgear, rather than the primary asset. Alternative methods of removing the thermal constraint will be evaluated and implemented if appropriate i.e. cost versus value upgrading the bottleneck component.

There is a definite requirement for back office systems to enable any new dynamic thermal rating approach to be adopted in volume, to avoid over-loading internal staff which will make this unworkable at scale. This is addressed in Work Packages 1.3 and 1.4.

WP 2.2 Flexible Network Control

Existing Approach and Limitations

The introduction of Telecontrol for remote network control functionality can enable use of a dynamic open point that automatically implements a switching sequence to balance the system when called by the operator and thus, optimises loading to capacity. Historically, the open point will be so positioned that the customer number will be evenly balanced in the event of a fault causing loss of one circuit to control risk. The advent of Telecontrol precludes this requirement as the network can readily be manually re-configured remotely.

As the majority of 11kV circuits are interconnected via a “fixed” open point, each individual circuit’s loading can be different. This means that any loss through heating (I2R Loss) can be disproportionate and unbalanced. Investigations on the network have highlighted the potential for release of incremental capacity by linking neighbouring groups with different demand profiles through the use of dynamic open points on the secondary network.

Proposed Innovation and Benefits

This work package will trial flexible network control using automated intelligent switching on the secondary (11kV) network and load transfer between primary substations to balance load between adjacent parts of the network, to release capacity and reduce losses. This will also enable improved contingency planning, identify opportunities for network optimisation and increase asset life. Results from the trial will provide proof of concept and quantify the benefits of having this level of network control.

A prototype tool has already been developed at the University of Strathclyde in conjunction with SPEN to explore the nature of the trade-off between minimisation of losses and maximisation of reliability, and how network reconfiguration (by carrying out switching actions to change the location of open points) should be done to reach a suitable compromise. However, the real benefits of the methods have been difficult to quantify due to lack of real-world data, in particular load duration curves for LV or even MV networks. WP 1.2 is therefore a key input to this work-package as it will provide such data. As part of WP 1.2, a limited number of special monitors will be installed at key locations to provide higher resolution network data such as load direction and phase imbalance required for this study. An expert control system will be developed to run in parallel with the existing operations system.

Methodology

Real-time load information will be recovered from the secondary HV network along with phase balance, power quality, harmonic and dc components, and load flow direction at selected locations. Software tools and protocols for real-time data retrieval and analysis in network models will be developed to facilitate this.

Algorithms will be developed to dynamically control the secondary HV network, to minimise I2R losses and maximise the contribution of low carbon generation by applying capacity to local load. This will utilise the University of Strathclyde prototype platform developed for SPARC to model the network and to trial the approach. The final outcome will be an expert system to run in parallel with the existing network control system to enable a more proactive network management approach. Network trials will be carried out on the St Andrews and Whitchurch networks with remote switching installed to facilitate automation.

HV overhead line protection is designed to grade for normal network configuration only. Should the network be in an abnormal arrangement, i.e. feeding via the network open point, protection grading will be compromised for faults in specific network locations. This work package will investigate the rollout of additional control functions through Noja pole-mounted automatic recloser protection settings group for adaptive overhead protection.

Table C7 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Investigate the effectiveness of flexible network control and its contribution to network capacity.	Trial flexible network control on secondary (HV) network utilising prototype expert management system. Compare network performance to benchmark data collected from 1.2.	Understand the challenges, costs and practicalities of implementing an automation scheme for dynamic network control on the secondary 11kV network. Develop sufficient confidence in prototype expert management system to rollout for future network operational practice.
Changes to design practice.	Review impact on network design and integration into planners toolbox as a measure to increase capacity headroom.	Modify relevant design policy, specifications and practice.
Changes to operational practice.	Develop and trial prototype expert management system to support integration of flexible network control into control room.	Modify relevant operational practice
Develop investment plan.	Use learning to develop cost-benefit case for flexible load management rollout on secondary (HV) networks.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

WP2.3 Energy Efficiency

Existing Approach and Limitations

DNOs have a role to play and can benefit from facilitating the rollout of energy efficiency measures in cooperation with energy suppliers as this could provide a solution to easing network constraints and increase capacity headroom.

Although already in existence, to date, voltage optimisation has not been used on a large-scale in the UK. We consider that system capacity could be increased through a relaxation of the statutory voltage limits that apply at each voltage level. At 11kV and above, customers could compensate for wider voltages via their own incoming step-down transformer(s). At LV it may be more economic for DNOs to invest in the replacement of non-compliant appliances rather than replacing LV mains or deploying voltage optimisers to meet a too onerous voltage limit. Trials to investigate the impact of wide ranges in voltage on customer’s are of consideration.

Proposed Innovation and Benefits

The objective of this work package will be to gain agreement from customers (predominately Industrial & Commercial) to engage in trials of energy efficiency measures within their premises and to explore the ability of the DNO to reduce peak demand through voltage management.

The development of effective engagement strategies with both customers and energy efficiency product suppliers to support large-scale implementation of energy efficiency measures will be a key learning outcome. The adoption of these measures in both specific, highly constrained network locations and across the network for a representative range of customer groups should provide an incremental increase in capacity headroom.

The business & economic case for installing voltage optimisers at customer's premises will be assessed through equipment trials and the challenges associated with integrating into planning and operational systems i.e. establish need to planned outages on the network etc.

Methodology

A key dependency of this work package will be the willingness of customers to explore the opportunities of installing voltage regulators and deploying changes in behaviour and equipment to improve energy efficiency of their premises.

Initially customers will be required to permit an energy survey of their property. Payment for this work package will be subsidised by the project and each customer who elects to have this survey performed will thereafter be able to engage with equipment and technology suppliers to install devices recommended as part of the survey.

In return for absorbing the costs of the energy survey, recommendations will be made available for review as part of the information outputs of the project.

We will engage the BRE Trust to undertake each energy survey. The BRE Trust is a charitable company whose objective through research and education, is to advance knowledge, innovation and communication in all matters concerning the built environment. As a not for profit organisation, all profits earned by the company are invested into research and education projects. In addition, the BRE Group is independent of government or commercial organisation and have over 90 years experience in the research of buildings.

Following the completion of each survey we will review each recommendation in conjunction with the customers and establish which solutions could meet both their needs and that of the project. We recognise that some solutions may be economically prohibitive therefore we will consider subsidising an element of those products identified in order to aid learning and development of our project.

In some cases payback could be accelerated through use of subsidy which in turn will produce key information to equipment providers going forward.

On completion of the project we will seek to quantify the savings realised by any investment by both the DNO and customer in respect of both energy saving and overall reduction in demand leading hopefully to a comparison of savings against the not requiring to reinforce the network.

A key risk to the development of this work package will be an unwillingness of customers to change behaviours or seek to implement the solutions recommended through the completed of energy surveys.

In addition in the absence of subsidy and incentives for the installation of technology and equipment that will aid energy efficiency and voltage regulation, customers may consider pay back periods unacceptable and too high a risk in the current economic environment which is turn could result in a key learning objective being missed.

Mitigation will be to provide incentives to customers for the installation of agreed technologies.

Table C8 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Implement energy efficiency measures at customer's premises.	Undertake surveys at customer's premises to identify potential for energy savings based on energy efficiency measures. Quantify energy savings achieved, compare with network benchmark from WP 1.2.	Develop effective engagement strategies with both customers and energy efficiency product suppliers to support large-scale implementation of energy efficiency measures. Develop matrix for generic customer load characteristics and effective energy efficiency measures.
Investigate the effectiveness of voltage optimisation and its contribution to network capacity.	Explore the ability to reduce peak demand through voltage management and automation techniques to help facilitate this.	Develop sufficient confidence in the applicability of the solution to GB rollout.
Changes to design practice.	Review impact on network design and integration into planners toolbox as a measure to increase capacity headroom	Modify relevant design policy, specifications and practice.
Changes to operational practice.	Integrate with existing control room practices for peak demand management.	Modify relevant operational practice
Develop investment plan.	Use learning to develop cost-benefit case for targeted, DNO-led customer energy efficiency measures.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

WP2.4 Voltage Regulation

Existing Approach and Limitations

Rural networks, or 'Isolated Urban' networks, are often complex and difficult to reinforce due to long feeder lengths. These networks are also the ones that may be early adopters of low carbon technologies such as heat-pumps and renewable generation due to cost drivers from off-gas grid heating replacement, or fewer planning restrictions. Often the network P2/6 capacity limitation is due to the n-1 capacity in the event of a network problem, rather than the normal 'intact' network. The long feeders are more often voltage constrained rather than thermally and so the use of voltage regulators, or in some circumstances reactive power compensation, can create useful levels of incremental capacity. This can provide a short-to-medium term deferral of the higher capacity and cost, but longer delivery time of network reinforcement.

There is currently no national specification for secondary (11kV) voltage regulators and a limited market. SPEN have several voltage regulators operating on the 33kV SPEN network however, to date there are none on the 11kV network for radial generation connection and none for core network security. Without a network proven device, it is difficult to develop a justified business case for deployment.

Proposed Innovation and Benefits

The use of voltage regulators is established as an approach to release capacity and reduce peak demand for certain network topologies. Also, reactive power compensation can be used to improve power factor which increases effective P2/6 network capacity and reduces losses. This work package investigates both devices as a packaged or a 'plug and play' solution that can be rapidly deployed on secondary (11kV) networks.

A detailed design will be developed, manufactured, tested and verified at the Power Networks Demonstration Centre (PNDC) before a small number of network trials to better understand the applications and benefits in a real-network environment. Along with development of procurement, installation, and integration strategies, this should enable the rollout of 11kV voltage regulators and reactive power compensation efficiently and cost-effectively to stressed network areas. Mitigation of other common network issues such as harmonics will also be examined through consideration of standardised packaged filters.

A key outcome from this project will be a functional specification suitable for ENA certification that can enable use in the UK in future and be used to engage with the market for fabricating in large volumes.

Methodology

Detailed functional specifications will be developed and given to a suitably qualified engineering design contractor to develop a detailed design for a prototype package. This will focus on a more generic package solution that is more suited to large scale rollout rather than a bespoke design for each network trial location. This will facilitate easier engagement with manufacturers in the future and improved risk management.

Table C9 Key challenges, experiments and learning points

Key Challenges/ Opportunities	Key Experiments	Key Learning Points
Investigate the effectiveness of package 11kV voltage regulator and reactive power compensation solutions to contribute to network capacity.	Develop detailed design specifications for prototype package voltage regulator and reactive power compensation solutions and procure from the market. Test prototype at the PNDC then trial on 11kV network to inform future strategy regarding rollout.	Understand challenges, costs and practicalities of procuring, installing and operating the package solution on the network including outage management. Develop sufficient confidence in the package solution to rollout for future design and operational practice.
Changes to design practice.	Review impact on network design and integration into planners toolbox as a measure to increase capacity headroom.	Modify relevant design policy, specifications and practice.
Changes to operational practice.	Integrate package solution management with existing control room processes for outage management for example.	Modify relevant operational practice
Develop investment plan.	Use learning to develop cost-benefit case for 11kV network for specific applications.	Develop roll-out strategy. Develop costs, timescale and action plan for roll-out over RIIOD1.

The package solution will be tested and verified at the PNDC to develop learning on equipment fabrication, installation, operation and maintenance, and will include dead as well as real live trials. This will provide confidence in the design and mitigate risks associated with network deployment, operation, and integration.

Network trials will be carried out at a small number of locations. This will provide further experience of installation, operation and maintenance. Their ability to create incremental capacity will be verified in part by the additional network monitoring installed as part of WP1.2 and planning tools developed as part of WP 1.4. A guide to package integration and risk management will also be produced for knowledge dissemination.

Stakeholder Engagement and Learning Dissemination

In order for this project to be successful, it will be critical to develop effective engagement strategies with key stakeholders to incorporate customer and staff input and disseminate knowledge and learning gained. Stakeholders include internal staff, other DNOs, customers, energy suppliers, industry bodies and local councils and authorities. This work package will develop and implement stakeholder engagement strategies to maximise learning from this process and enable future large-scale rollout of successful measures.

WP3.1 Internal Stakeholder Engagement

This work package will investigate the challenges associated with internal staff engagement and organisational behaviour change to ensure that adoption does not become a barrier to successful project rollout into the future. Outcomes will be directly relevant to other DNOs looking to implement this solution as well as providing general learning on effective internal engagement.

The following stakeholder groups have been identified as key enablers for the project:

- Asset Strategy & Network Programs
- Network Operations
- Customer Service & Business Support
- Health & Safety

In addition, the project will rely upon the services of Regulation & Commercial, Legal and Business Transformation. The overall objective will be to promote staff empowerment and attitude change, and optimise knowledge transfer and learning at all levels.

A number of key activities have been identified as part of this process and include:

- Workshops with network design and operation staff throughout the project to help facilitate participation in development of new tools and processes.
- Training of staff at the PNDC on the installation and operation of equipment being trialled as part of this project.
- Rotation of staff in the role of project coordinator to help with personnel development, with practical learning that can be taken back to other departments within the business.
- Identifying project champions within each business area which can be kept abreast of developments and help tailor the learning from the project for their respective teams.
- An annual internal technology conference which focuses on LCNF and IFI and is attended by up to 100 staff.

The PNDC complements our existing training facilities that we have for instructing staff on the safe and efficient methods for installing, operating and maintaining equipment. The roll out of monitoring equipment and flexible network control technology is likely to require new working procedures to be developed and therefore, the training of staff.

There will be a dedicated project office throughout the course of the project with a number of permanent staff appointments. A project governance board will also be formed which is made up of directors and senior managers from across the business. Two project coordinator roles will be available as secondment opportunities for staff, to allow for staff rotation throughout the project. This will enable a greater number of staff to be directly involved with the project and be embedded in the learning process, which will allow for more effective transfer of knowledge back to the wider business when they return to their substantive post.

Project champions will be identified from each of the main business areas who will act as ambassadors and lead engagement within their business unit. This will involve providing updates and monthly team briefs and making other presentations as appropriate to keep staff informed of developments. SPEN also has an in-house Business Transformation Team that will be advising on design and implementation of business change as required from the project outcomes.

Internal engagement will be supported by external expertise, to help bring new knowledge in and transfer to staff.

WP3.2 External Stakeholder Engagement

There are a number of external stakeholders for this project including other DNOs who will be keen to develop learning and apply the solution to their own business. These are identified below along with the proposed engagement strategy. Further information is provided in Section 5 and Section 8 of the Full Submission.

Other DNOs and wider industry

A number of activities have been identified for engagement with other DNOs and the wider electricity distribution industry including academic institutes involved in this field. University of Strathclyde will be providing support for knowledge dissemination.

The PNDC will be a key element in demonstrating and de-risking equipment installation and operational procedures to other DNOs in a real live network environment. This will be invaluable as a training tool for network design and operation teams as well as electrical fitters responsible for installation of monitoring equipment and technology. There will also be opportunities for focussed technical learning sessions for engineering staff in the simulation laboratories at University of Strathclyde.

This project will produce a number of technical papers (approximately 2 per year) that will be presented to the academic and industry community at recognised and relevant conferences such as IEEE and IET conferences and CIRED and Cigré meetings. The CIRED meeting in 2013 and the Cigré Paris session in 2014 will be well suited to the dissemination of project outcomes. Also, the annual IEEE PES International Conference on Innovative Smart Grid Technologies. Several Cigré working groups (C4 and C6) have been identified where involvement of personnel from the project team will help to facilitate industry learning. Also, data produced from the project will be incorporated into a number of Phd projects which are already underway. These activities will be led by the University of Strathclyde Chair in Smart Grids, a position sponsored by Scottish Power.

The involvement of other partners from industry in this project i.e. Nortech, TNEI, will facilitate further dissemination. For example, the functional specifications for the 'smart' monitor developed in Work Package 1.2 for enhanced monitoring of primary and secondary substations, will be available to other DNOs to procure and rollout across their network. Software developments in IPSA associated with this project will be available to other DNOs as upgrades to existing IPSA packages. DNOs utilising other power system software for distribution network modelling will be able to access algorithm specifications to request similar upgrades from other software providers.

A project website will be set up to provide access to progress updates, technical information and results to other DNOs as well as the general public. Contribution to the annual LCNF conference and other national and international industry events will also play a significant role in the dissemination strategy.

Customers

This includes major users such as small industry, large multi-site franchises, local councils and authorities (social housing developments), hospitals, schools, as well as domestic customers. A key element of this project is to understand and respond to future load sources which may be due to customer demand growth from connection of low carbon technology. For example, the installation of EV charging points in car parks. Therefore, it is important to develop these relationships and build information flow paths to enable early flagging of future network changes.

Work Package 2.3 will specifically focus on engagement with a range of customers in order to implement targeted energy efficiency measures. This will take the form of advertisements in local media and telephone and online surveys to raise awareness of the project and the impacts (both positive and negative) that it may have. Information packs will be provided to customers who are directly involved in the project and a customer liaison officer will be appointed to visit customer premises to provide a focused point of contact. Energy surveys will be carried out by an independent third party organisation.

The project website will help facilitate an understanding of what we are doing, and what the project involves as well as providing a forum for customer enquiries and complaints.

Government

Local councils/authorities and community groups are increasingly involved in large-scale installation of PV and heat pumps for new, 'green' council housing developments. These bodies will also be key in driving the installation of infrastructure for EVs. The earlier that a DNO has visibility of these developments, the more time there is to ensure that the local network does not act as a barrier to new low carbon connections. It is important that local councils and DNOs work together to identify network changes early on. A proposed strategy to be investigated is the provision of an additional data layer at early development stages to indicate preferred areas of connection. This can then inform long term network planning.

It is also important to obtain the buy-in of regional development agencies and MPs for the implementation of beneficial network measures that should promote low carbon technology as well as economic growth.

Energy suppliers

SPEN will engage with energy suppliers to investigate opportunities to promote energy efficiency measures with customers as part of Work Package 2.3.

Consumer Groups

Consumer education and advocacy groups such as Consumer Focus and media organisations i.e. Which magazine, that are a focus for consumer concerns, have been identified as potential stakeholders that could contribute to the success of this project. Also, non-governmental organisations such as Energy Saving Trust.

WP3.3 Verification of Experimental Design

It is critical to the success and the validity of this project that the methodology used for each work package is technically robust, statistically sound and that outcomes are verifiable and reproducible.

The University of Strathclyde is a key partner and will be carrying out an independent review of the experimental design of each work package to ensure that this is the case. This process will take place at the start of each work package, following design of the methodology, as well as at key milestones throughout the course of the work packages and the project.

University of Strathclyde has a well-established portfolio of research with clients and collaborators from industry and government, in the UK Electricity Distribution industry. The personnel from University of Strathclyde that will be involved in the experimental design review process have recognised expertise in their fields, relevant to this project and within industry. Professorial staff will also be involved in the Project Review Group, providing high level review of the objectives and the outcomes of the project to ensure that the learning remains relevant to the aims of the LCNF and the wider industry.

WP3.4 DNO Policy Changes

Technical and regulatory policy changes will ensure that project learning is widely disseminated and adopted within the business and industry. SPEN is already actively involved in contributing to a number of industry technical committees and review panels and will be leveraging these for project learning dissemination.

The outcomes from this project will be used to inform and modify a number of internal policy and guidance documents such as design manuals used by network planners, control room manuals and training, risk management policy and procedures and business process documents. This will specifically consider decision making processes such as annual network review, on-going asset management, facilitation of new connections and Ops liaison meetings. Changes to these documents will be disseminated through internal user adoption workshops and communications.

A key output of this project is to inform the development of future engineering technical recommendations, with particular focus on ER P2/6, the current distribution network planning standard. P2/6 is the standard by which the distribution is currently designed, and this project will provide empirical data from monitoring which will influence future revisions of this standard. For example, the utilisation and integration of real-time thermal asset ratings for improved network performance and design. The PAS-55 Quality Accreditation for management of assets will also be reviewed

Other engineering standards will also be examined as part of this project such as the volumes of microgeneration which can be safely connected to the network. Other DNOs will also be making similar contributions to the development of engineering standards and policy and this will be a key vehicle to creating benefit for customers.

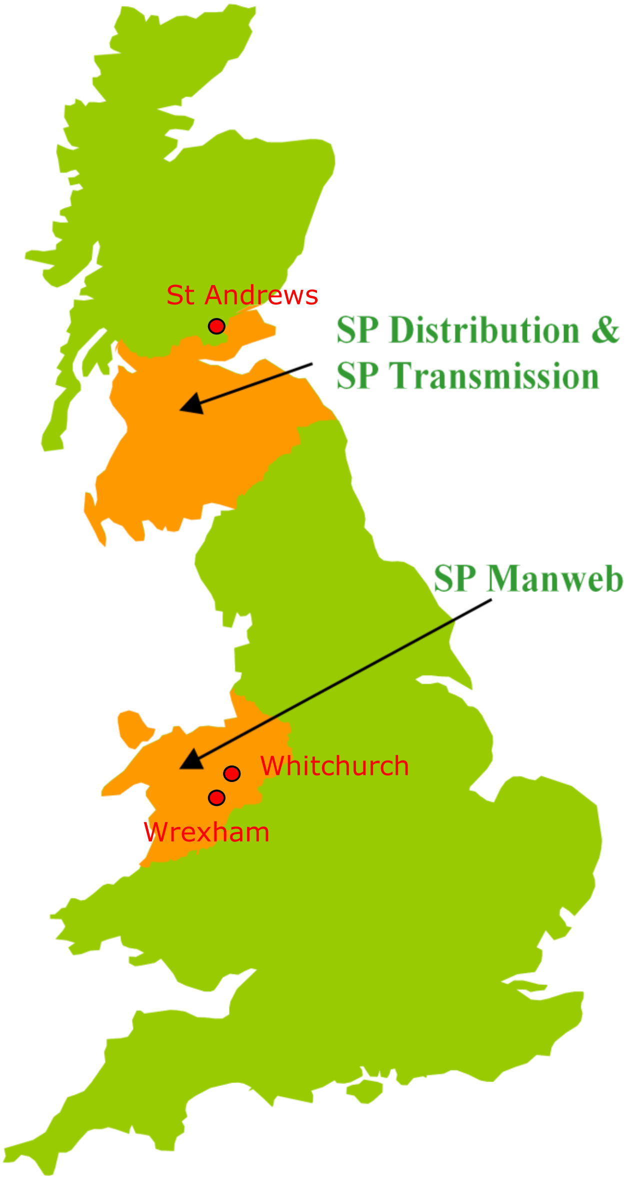
The management of impact of GB rollout on the national grid will be discussed at National Grid Liaison Meetings and an integrated response for LCNF solutions will be developed in conjunction with other DNOs. SPEN will also be looking to inform regulatory policy based on project outcomes through Ofgem, DECC and DTI policy consultation documents and liaising with industry bodies such as ENA.

Appendix D Network Trial Sites

Introduction

The proposed locations for network trials are shown below. Network trials will be carried out at several network locations in Scotland, England and Wales, with varying network topology, including radial and interconnected. This will ensure applicability to the networks of other UK DNOs. Similar network areas with relatively high and low existing levels of low carbon technology penetration will be monitored and compared to better understand the diversity between base case and future low carbon networks. Further details on each network area are provided below.

Work package activities for each site are given in Table D1.



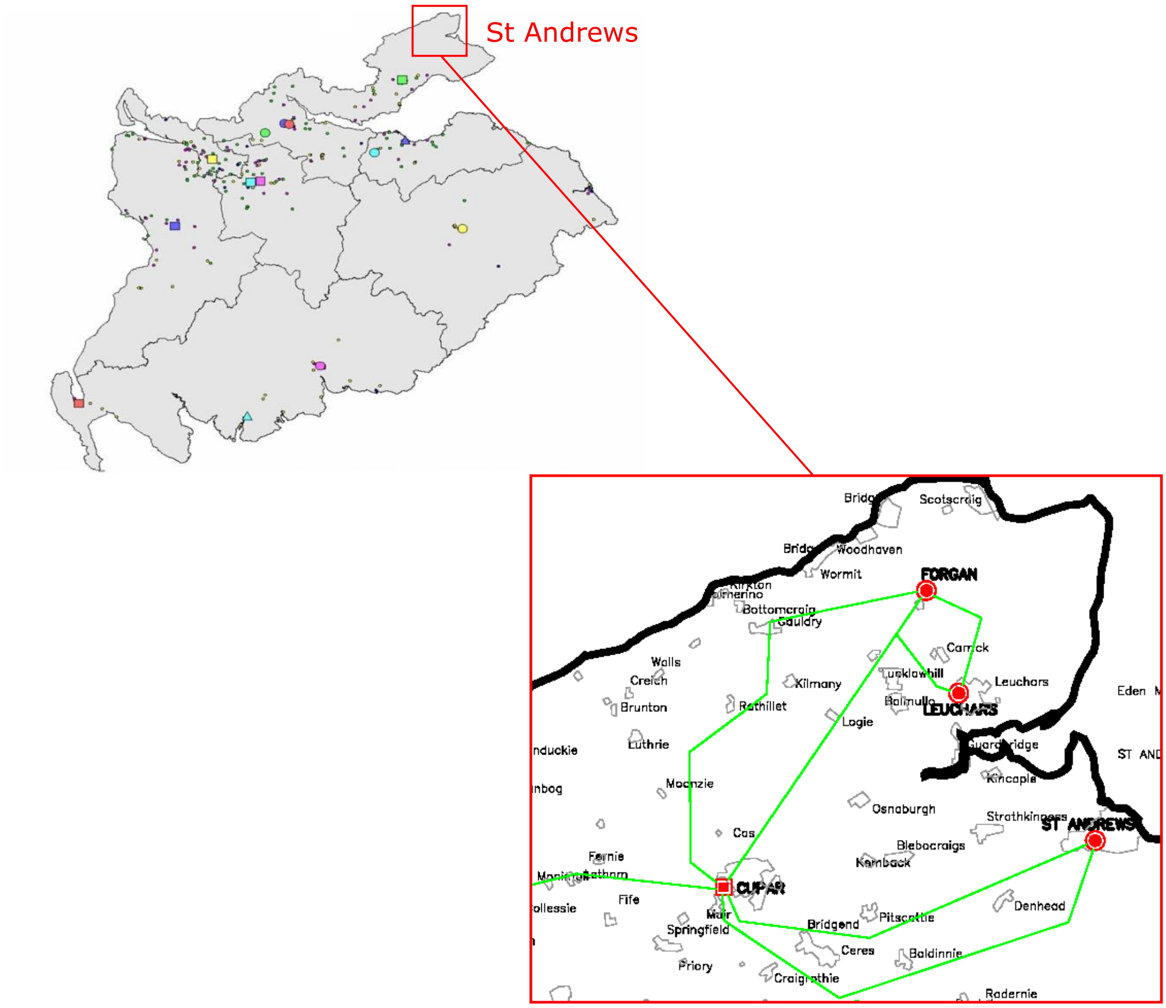
Proposed locations for network trials

Table D1 Work package activities for each network site

	St Andrews	Whitchurch	Wrexham
WP 1.1 - Analysis of primary s/s data	Activity covers all three sites		
WP 1.2 - Secondary s/s monitoring	**93 secondary substations** 8 s/s - every phase and feeder, 85 s/s- LV Busbars only, 10 primary feeders	**58 secondary substations** 9 s/s - every phase and feeder, 49 s/s- LV Busbars only, 15 primary feeders	**34 secondary substations** 30 s/s - every phase and feeder, 4 s/s- LV Busbars only, 7 primary feeders
WP 1.3 - Operational tools	Activity covers all three sites		
WP 1.4 - Planning tools	Activity covers all three sites		
WP 2.1 - Dynamic Thermal Ratings	Dynamic rating of two 33/11kV transformers and two 33kV Overhead lines	Dynamic rating of single 33/11kV Transformer	Dynamic rating of single 33/11kV Transformer
WP 2.2 - Flexible Network Control	Control of four feeders which are interconnected with other primary substations	Control of three feeders which are interconnected with other primary substations	Utilise exising network automation and control
WP 2.3 - Energy Efficiency	Activity covers all three sites but greatest focus on St Andrews and Whitchurch. Targeted at Industrial and commercial customers		
WP 2.4 - Voltage Regulation	Deployment of voltage regulation on on 11kV circuit	Deployment of voltage regulation on on 11kV circuit	Deployment of voltage regulation on on 11kV circuit
WP 3.1 - Internal Stakeholder Engagement	Activity covers all three sites		
WP 3.2 - External Stakeholder Engagement			
WP 3.3 - Experimental Design Review			
WP 3.4 - DNO Policy Changes			

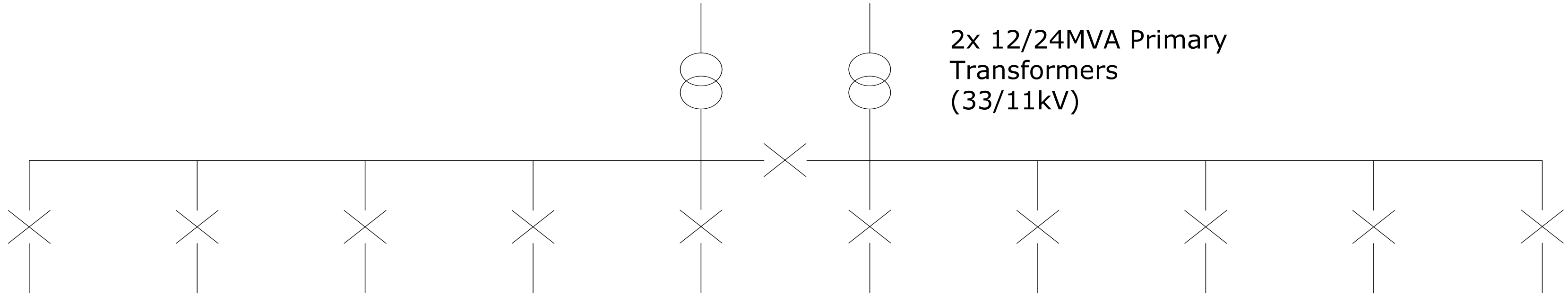
St Andrews, Scotland

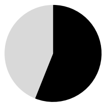
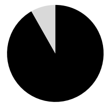
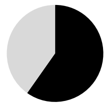
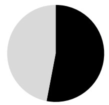
Growing load requests in St Andrews is a significant area of concern in East Fife. This, along with the lack of capacity available in the 33kV distribution circuits from Cupar grid raises a need to consider additional primary level reinforcement in the area. St Andrews is mainly a University and Tourism load centre and SPEN is currently managing a new connection application from the university to raise their available capacity from 1.9MVA to 5MVA. This along with other specific applications for a new hotel and hospital will put considerable pressure on the existing single primary feeding St Andrews. Within this current connection process, the university also indicated longer-term additional capacity aspirations that may need to be managed. Tourism also plays a vital role in St Andrews with its title of the ‘Home of Golf’ and it is expected that this will continue to be developed. Though there is also a great desire for new housing in this area, this is managed by the local council planning policies and though general load growth from new housing will be seen it may not be problematic unless the council changes its policies. The level of 11kV interconnection is poor for St Andrews Primary and it is considered a largely ‘isolated’ load centre. Eventual asset replacement of the primaries will need to be facilitated but it is not considered a priority within DCPR 5.



SP ENERGY NETWORKS

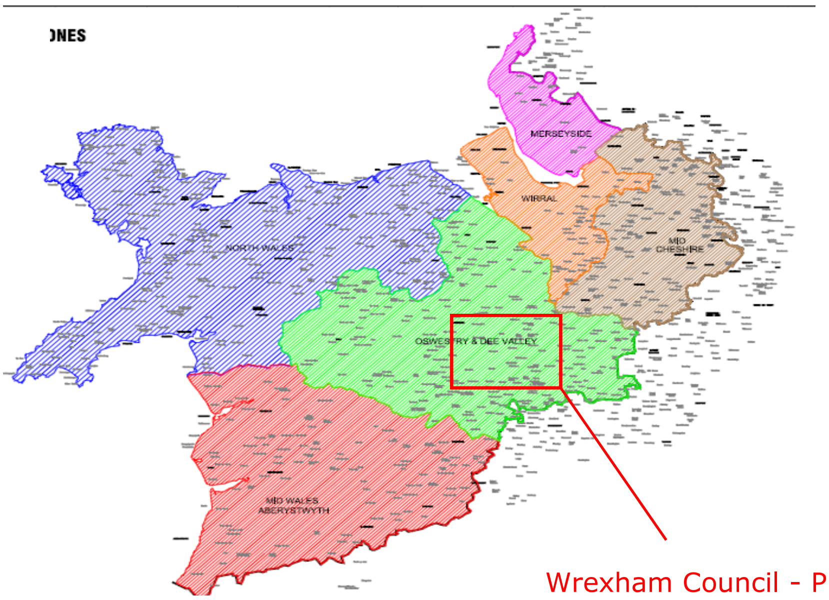
St Andrews Primary Substation – Network Characteristics



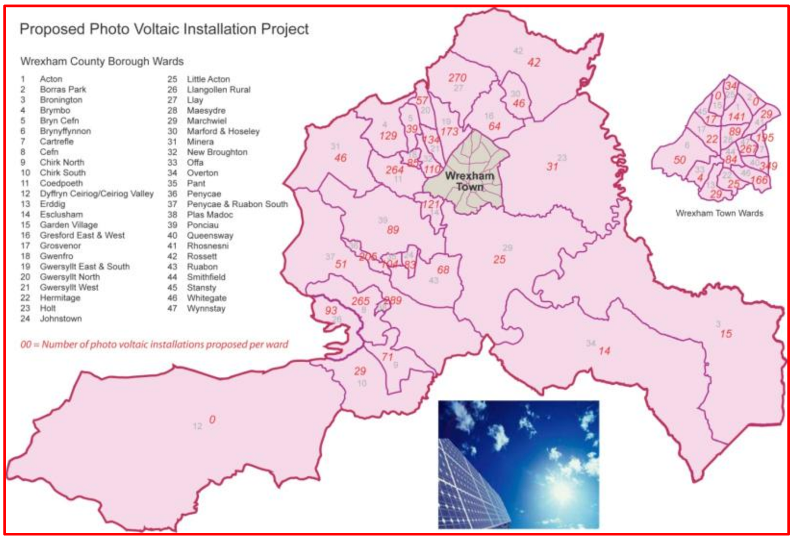
Feeder Name	SP18612	SP18613	SP18614	SP18615	SP18616	SP18622	SP18623	SP18624	SP16825	SP18626
No. of Ground mounted s/s	5	5	18	14	11	17	28	8	5	5
No. Pole mounted s/s	0	0	33	0	0	56	64	0	0	0
% of Network OHL UG										
No. Of Customers	699	449	1113	708	1441	304	323	1339	1306	795
Inter-connection	SP18626	Anstruther & SP16825	Leuchars & SP18622	SP18622/ SP18624	SP18622/ SP18614	SP18614/ SP18616	Anstruther & SP18624	Leuchars & SP18615	Anstruther & SP18613	SP18612

Wrexham, Wales

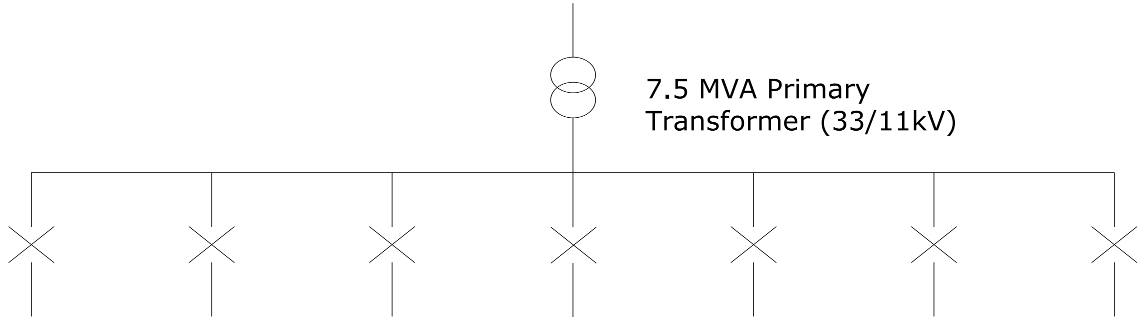
Recently Scottish Power has been approached by Wrexham Council that they wish to install photovoltaic panel to approximately 3900 properties of their housing stock as a carbon reduction initiative with a potential of 6.26MW of generation. The distribution network in this location borders between the urban residential area and the rural agricultural areas of Wrexham and hence has a mixture of underground and overhead type network. The LV network in this type of situation is typically small radial distributors due to the low load density. The result of this type of network is that even small amounts of generation can bring about unacceptable voltage rises on the network and therefore restrictions have been placed on the amount of photovoltaic generation which can be accepted on to each of the LV distributors. The diagram below illustrates the photovoltaic plans of Wrexham Council.

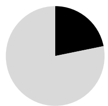
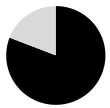
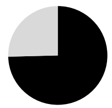


Wrexham Council - Photo Voltaic Installation Project



Ruabon Primary Substation – Network Characteristics



Name	Council House	Ruabon School	Llewsub Station	Idwal	Bodlyn	Black Lion Road	Wrexham Mineral Cables
No. of Ground mounted s/s	5	5	1	13	3	2	9
No. Pole mounted s/s	12	5	51	3	0	24	1
% of Network OHL UG							
No. Of Customers	1396	120	634	1592	113	847	764
Inter-connection	Johnstown	Johnstown	Maelor Creamery	Monsanto	Monsanto	Llangollen	Johnstown

Whitchurch, England

The existing 33kV network around Whitchurch is run interconnected as a single group and fed from three 132/33kV grid transformers at Whitchurch T1 (45MVA), Oswestry T2 (60MVA) and Marchwiel T1(60MVA). The 33kV group is a mixture of some industrial and mostly domestic customers.

For an outage of the Whitchurch grid transformer customers are supplied through the interconnected 33kV network fed from the remaining two grid transformers at Oswestry and Marchwiel; not from the second grid transformer T2 at Whitchurch. The three interconnected 33kV circuits share the power flow equally and each gets currently loaded to 99% of its rating for a grid transformer outage. The subsequent loss of any of the three interconnectors can cause loss of supplies.

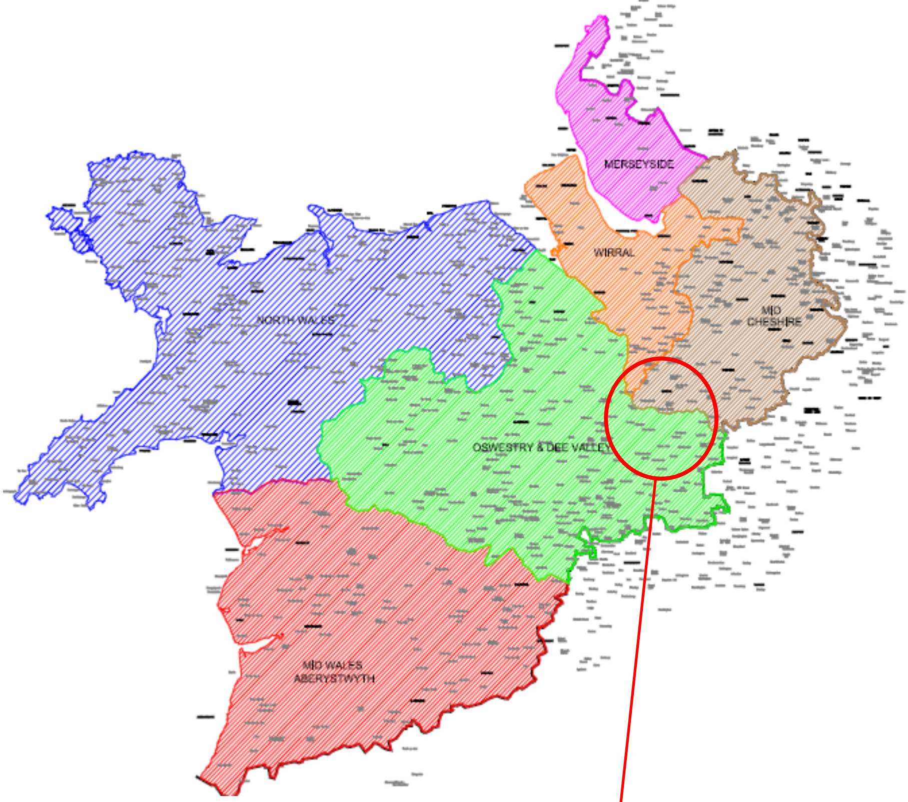
The 33/11kV system, in Whitchurch, consists of 3No 33/11kV primary transformers that supply the 11kV distribution network in Whitchurch. The 11kV circuits from these primary transformers are operated radially but with the facility to be supplied from an alternate source following a system outage. This alternate means of supply is achieved by closing an 11kV switch or circuit breaker that is operated normally open and is referred to as the normal open point, NOP. Fig 4 is a line diagram of the 33/11kV system.

The 11kV circuits currently supplying a large customer have an aggregate maximum demand of 3.5MVA and therefore cannot accept the connection of any additional demand. Based on current system demands the loss of the Grid transformer at Whitchurch forces the 33kV circuits from Oswestry Grid and Marchwiel Grid to operate at 98% of their rating. This N-1 scenario also causes voltage transgressions on the 33/11kV system.

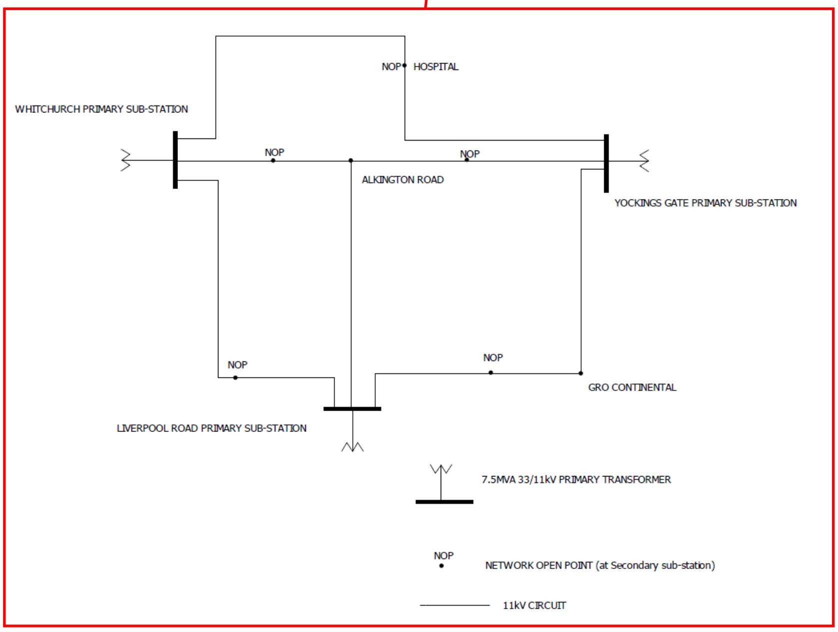
The Local Authority wishes to attract new businesses into the area, however lack the power availability headroom continually dissuades development due to the high costs of the reinforcement incremental load increases.

There are currently no thermal issues identified but it is worth noting that for a Whitchurch grid transformer outage all three in feeding 33kV interconnectors get loaded to 99% of their rating. The recent economic downturn has resulted in drooping demand on the network and this is more visible in industrial areas. It is expected that the demand will pick up quickly in the next few years to its expected level.

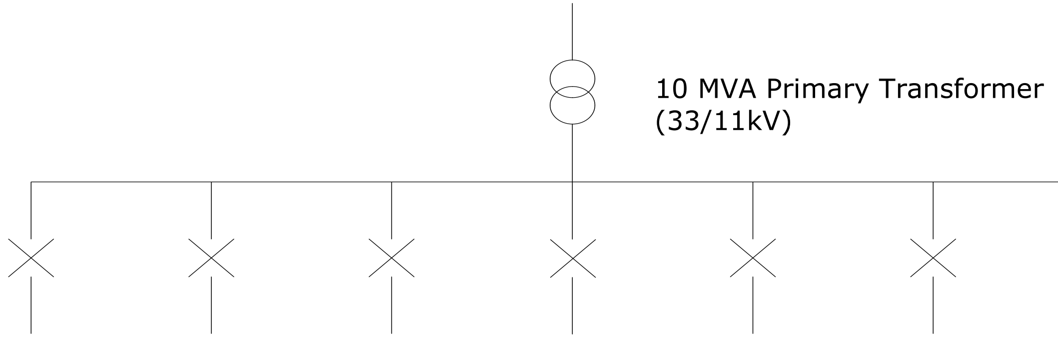
Another complication is the length of the interconnected 33kV circuits. For an unexpected outage of the Whitchurch grid transformer, a large step voltage is incurred and the recovery volts are just within the tapping range (+5%/-15%) of the primary 33/11kV transformers connected the 33kV interconnectors. The majority of the affected primary substations are 5/15 transformers.

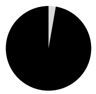
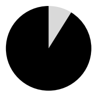
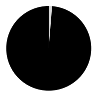
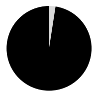


Whitchurch Area Network



Whitchurch Primary Substation – Network Characteristics



Name	Chester Rd / Barrgate	The Grove Whitchurch	Wirswall L5980	Barnfield Close	Hanmer L5005	Iscoed Ellesmere	Bradley Willey More
No. of Ground mounted s/s	2	2	1	5	3	1	2
No. Pole mounted s/s	4	4	47	6	31	123	68
% of Network OHL ■ **UG** □							
No. Of Customers	130	152	118	726	121	595	415
Inter-connection	Liverpool Road	Yockings Gate	Newhall	Liverpool Road	Prees	Maelor Creamery	Duckington

Appendix E Network Cascade Monitoring

Objectives

In order to gain enhanced understanding of the 33kV, 11kV and LV systems, it is necessary to collect data of the network operating parameters. Data on various issue areas of the network need to be captured and analysed against its capability to identify possible areas of headroom or constraints, this is generally loading information of the network equipment and the quality of supply to the customers.

Strategy

To minimise the monitoring carried out the approach is to monitor the constraining parameters of the network, and to do so in a way which provides the fullest picture of how the selected network is performing against known limits. This will be done at the three trial sites, with the learning being applicable in other network areas, from the grid infeed down through the voltage levels of network to the LV system where customer's supplies are taken from, a cascade network monitoring approach.

At present all DNO's have varying degrees of network monitoring installed for efficient operational purposes. The network monitoring project is to build on the existing SCADA (System Control and Data Acquisition) system to provide enhanced data availability.

Monitoring Equipment

The monitoring is to include the thermal demands (amperes and temperature) on the apparatus such as cables, overhead lines and transformers by recording the current loading and the operating temperature of this equipment.

It is also necessary to monitor the quality of supply across the selected networks to ensure that the network is maintained within the quality of supply standards. This is done by measuring the voltage at node points from the infeed through the levels of network to the LV system, and at selected points disturbances to frequency (harmonics) will be identified to determine if any generation equipment is affecting the 'cleanliness' of the supplies to other customers.

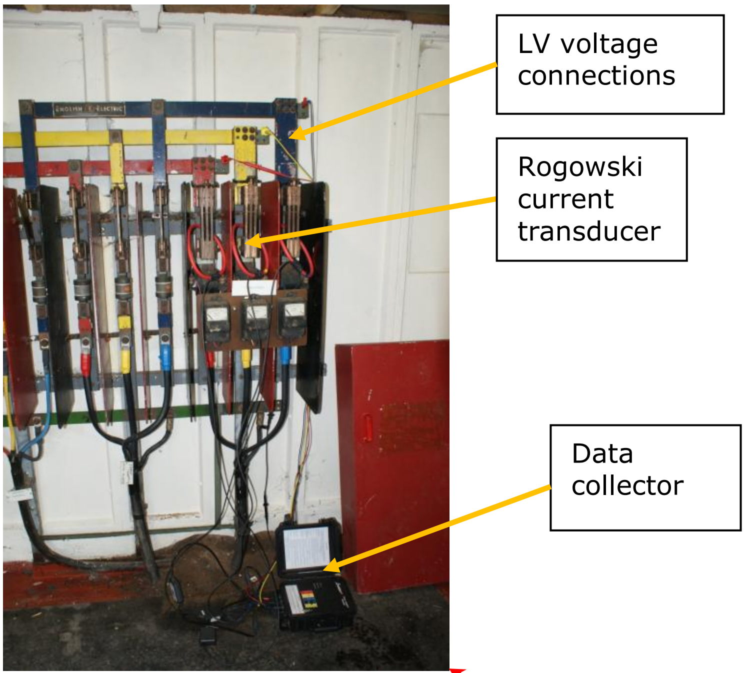
This project will install;

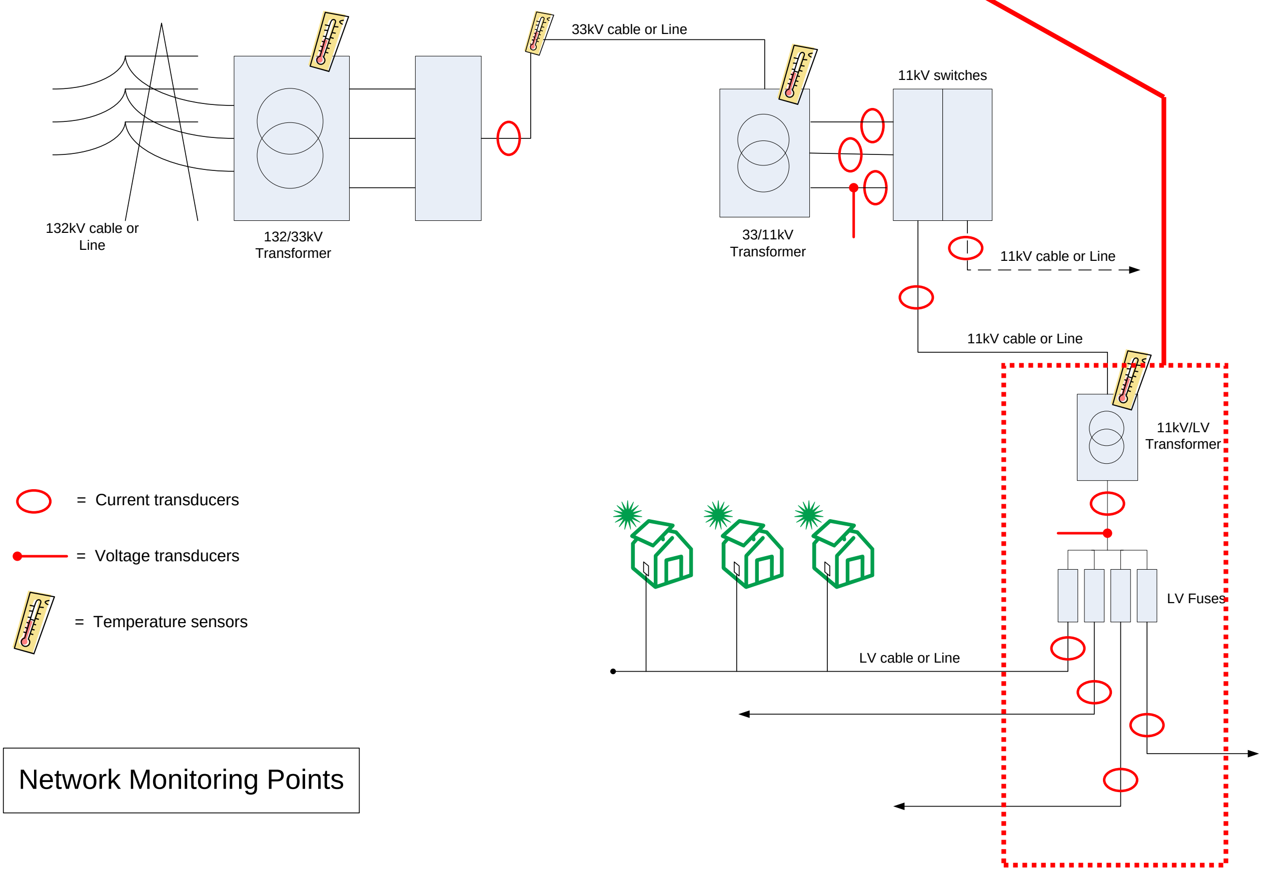
- Current transducers on cables, overhead lines and transformers – to give demand loadings on apparatus.
- Temperature sensors on cables, overhead lines and transformers – to show if apparatus is being operated to its maximum capability.
- Voltage recorders at node points, such as 33/11kV transformer outputs and 11kV/LV transformer outputs.
- In certain circumstances LV voltages will be monitored along LV cables and lines nearer to customer supply points – to capture if customer supplies are affected.

Equipment Installation

In certain circumstances it will be difficult due to the physical conditions on site to house and connect the monitoring apparatus and the environmental circumstances need to be accounted for. We have assessed that a number of installations will require a customer outage in order to safely connect the monitoring equipment. This will be kept to an absolute minimum by using 'attachable' Rogowski current transformers which remove the need to break into the supply circuit and by using established live-line techniques to connect voltage probes to live conductors. Training for staff to install this equipment safely with the minimum disruption to customers can be carried out at the PNDC.

The photograph below shows an example of old style open-busbar LV distribution equipment which facilitates easy connection of monitoring equipment and the clip-around Rogowski current transducers fitted without any supply disconnection.





Appendix F Customer Engagement Strategy

This engagement strategy addresses how SPEN will engage and communicate with customers during this project.

Customer Communication Strategy

The customer communication strategy is focused on providing and maintaining a clear communication path, with relevant and timely information. This includes engaging with customers affected by the project with special regard to vulnerable customers, engaging with energy suppliers and engaging with the wider community to publicise the project.

Forms of communication will include;

- A website as a gateway for customers and other interested parties (e.g. schools and universities) to understand the project and what the project involves.
- Regular updates and feedback to customers for project developments in their area through printed advertisements in local press, newsletters and leaflet drops.
- Liaison with customers to advise them of planned shutdowns to install equipment at substations.
- Response to customer queries or complaints on an individual customer basis.
- Deliver information briefs direct to customers who wish to take part in the project (energy survey and trial of efficiency measures), supported by customer seminars and feedback surveys.

Customer Supply Interruption

A small number of outages may be required whilst monitoring equipment and technology is installed on the network. Impact on customers will be minimised through using live line techniques and other recognised methods to minimise disruption.
Existing SPEN policy and processes with respect to informing customers of a planned outage will be used. Furthermore, all affected customers will be advised by written mail of direct contacts at SPEN whom they can contact should they wish to discuss any aspect of the project. These contact details will take the form of both an email address and contact telephone number.

Vulnerable customers will be clearly identified prior to the project taking place to ensure that adequate arrangements are in place should there be an instance of an interruption to supply.

We will also advise electricity suppliers about the project and provide a Communications Plan advising them of the nature of the planned outage, and details of the timing and nature of communications with the customers affected.

Customer Involvement in Project

We will seek to provide industrial and commercial customers with the opportunity to have an energy survey conducted at their premises, for Work Package 2.3. These surveys will be carried out by an independent organisation paid for by SPEN as part of the project. We would envisage also working with several GB Energy suppliers to enable us to evaluate and provide recommendations to customers on available third party product offerings following the completion of energy surveys.

Specific communications for the energy efficiency work package will take the form of;

- Customer Liaison Officer (CLO) visits to customer's premises and point of contact for the project.
- Information pack for customers interested in taking part in energy surveys and implementation of energy efficiency measures.
- Feedback surveys, whereby the customer can provide their views and issues on the actions taken to assist in realising energy efficiency.
- Regular progress and closeout reporting to customers.

All of our employees and contractors will carry an identity card showing their company's trading name, their own name and a colour photograph of the individual.

In addition, to ensure a positive customer experience, we will undertake further awareness workshops with all GB suppliers to inform on the development of our project in each area to enable them to brief back office and customer facing staff should there be any occasions when customers make contact with their energy supplier or have concerns in respect of events associated with the development of our project.

Data Privacy

This project will adhere to the existing SPEN regulations governing data privacy for customers. Names and addresses will be extracted from SPENs existing customer database and used for the purposes of customer communication and identification of customers to target for energy surveys. Energy survey data will be provided to SPEN by an independent third party for the purposes of advising customers of energy efficiency measures. This information will be owned by SPEN and securely managed in accordance with SPENs existing policies and procedures. The customer will require consent from SPEN share the data with third parties.

Network data will be aggregated at the LV feeder level and above so will not contain any personal information about specific premises.

At the end of the project, we will be sharing aggregated data and the results of the project with interested parties such as other DNOs and academic institutions. Any data shared with interested parties or published for general readership will not contain any personal data.

We will not provide any personal data to third parties for any marketing activity or use this project or any information collected in connection with the project to market any products or services to customers.

Appendix G Project Management

Project Team

Details of the project team are given in the organogram, provided in Section 6 of the FSP.

Partners

The University of Strathclyde, TNEI Services, Nortech and BRE have all been engaged as partners in this project. The number and scope of partners is felt to be acceptable for a project of this magnitude to provide sufficient industry commitment and relevance whilst not impacting programme delivery due to overly complex management and contractual negotiations. Further details of the partners are provided below, as required for the LCNF bid governance.

A relationship diagram is provided in Section 6 of the FSP indicating the contribution of the various partners and external contractors to the project work packages.

University of Strathclyde

Relationship with DNO

University of Strathclyde (UoS) is an educational institution and a charitable body registered in Scotland, number SC015263. It is independent of the DNO.

Type of Organisation

University of Strathclyde is a research-led educational institution. The Department of Electronic and Electrical Engineering has a wide and well-established portfolio of research with clients and collaborators from industry and government in the UK and beyond.

Role in Project

The collaborating academic team at Strathclyde will provide monitoring and evaluation through participation in the project management group and the project review group. Via a post-doctoral researcher, support will be provided in terms of: extrapolation of results to the whole of the UK, including in scenarios in which there has been significant penetration of electric vehicles and PV generation; contribution to development of proposals for new planning standards; analytical work on characterisation of the voltage dependency of load; progression of related PhD work on decision support for operators on optimal network configuration; and laboratory work in testing of adaptive protection. Finally, the team will contribute to the reporting and dissemination of results and learning outcomes.

What Partner will add to Project

University of Strathclyde have provided resources to assist with the development of this project and have committed to in kind funding of **£27,000** in total over the course of the project in the form of technical and supervisory assistance. A full time research fellow will be available to work on this project full time and other key individuals have committed their time to review and provide technical guidance over the course of the project.

The University will also provide sharing of knowledge from other investigations and make available undergraduate, MSc and PhD students to work on problems related to the Project. Through gearing with an existing strategic framework between Strathclyde and Scottish Power, the University will provide its services at a lower cost than that established for other parties.

Prior Experience

The Advanced Electrical Systems Group at Strathclyde has worked with electricity network operators on a wide variety of applications for more than 20 years. This includes power system operation, active network management and condition monitoring. It is both the principal investigator and management hub for the largest publicly funded research initiative linked to highly distributed energy futures and low carbon distribution networks – "HiDEF" – contributing in respect of demand side management and distribution network operation. It is also a leading participant in "FlexNet" and a number of other active network management projects, including Aura-NMS with Scottish Power. Its expertise is recognised internationally and the Department is among the highest rated in the UK.

How Funding relates to benefits from Project

The collaborator will benefit from a continuation of a longstanding fruitful relationship with the DNO, the maintenance of industrial relevance in both teaching and research and the opportunity to develop new approaches that promise to benefit the migration to lower carbon networks. By having a 'real world' test case and access to trial results, the collaborating team will have a genuine proving ground for ideas. Using existing publication expertise, the team will be able to disseminate outcomes and contribute to learning not only in the UK but internationally.

TNEI Services Ltd (TNEI)

Relationship with DNO

TNEI Services Ltd (TNEI) is a fully limited company and is registered in England and Wales, No. 03891836. It is independent of the DNO.

Type of Organisation

TNEI is a power system consultancy business with significant experience in the analysis and design of distribution networks. TNEI also owns, develops and supports the IPSA power system analysis software package.

Role in Project

TNEI will be supporting the project through the analysis and interpretation of the network monitoring data, facilitating discussions with the internal SPEN teams and the development of improved network planning and operations decision tools. This work will include the development of improved software modelling for IPSA including "plug and play" algorithms for advanced network controls, improved network modelling at LV, and linking the demand data with network models for example.

What Partner will add to Project

TNEI will be providing a funding contribution from the IPSA development budget due to the alignment of this project with our strategic goals for the IPSA product. The value of this contribution will be **£50,000**, which is in the form of £20,000 of development time on core features across the duration of the project, as well as the provision of three full feature software licences for use in the project in the SPEN offices and Strathclyde University with a value of £30,000.

Any core IPSA software developments as part of this project will be freely available to other IPSA licensees.

Prior Experience

TNEI has extensive experience in providing software and power system analysis services to the UK electricity distribution industry. IPSA forms the primary network design analysis tool for half the UK Distribution Network Operators, including SP Manweb, for the design, operation and planning analysis for their 11kV, 33kV and 132kV networks. IPSA+ engines are also embedded into custom analysis tools for long-term network planning and use of system charge calculations and are widely used in the UK as well as internationally.

How Funding relates to benefits from Project

TNEI will benefit from the project through access to extensive real-network data to develop industry relevant software as well as exposure to potential new DNO customers from knowledge dissemination and learning activities. Also, the provision of further bespoke software development services and support for application of LCN software features to DNOs networks could generate a revenue stream.

Nortech Management Limited (Nortech)

Relationship with DNO

Nortech is a small-medium enterprise. It is independent of the DNO.

Type of Organisation

Nortech design and supply remote site monitoring solutions and other specialist technology to electricity utilities, telecom network providers, the security industry and other blue chip companies with geographically spread networks and assets.

Role in Project

Nortech will be providing the iHost platform as the central host software for logging of remote monitoring data from primary and secondary substations. They will also provide `smart' monitors for each site that can be programmed to pre-process incoming data from transducers before remote transmission. The monitor algorithms will be developed over the course of the monitoring programme as the functional requirements for the data are tested, refined and optimised.

What Partner will add to Project

The financial resources that Nortech has agreed to provide for this LCNF project will be in the form of time-in-kind to develop the smart monitor algorithms to a total of **£60,000** in development time.

The functional specifications developed for 'smart' monitor devices as part of this project will be available to other DNOs to engage with the market for procurement.

Prior Experience

Nortech are actively involved in the UK electricity distribution industry and have undertaken software development projects for data collection and analysis for a number of DNOs. Nortech currently provide SPEN with the iHost platform for other network monitoring sites.

How Funding relates to benefits from Project

Nortech will develop software algorithms for monitoring devices that will be fit for purpose for the UK electricity distribution market to implement the solution to be investigated in this project. This will place Nortech in a good position as technology supplier for future UK rollout.

Building Research Establishment Limited (BRE)

Relationship with DNO

BRE is a wholly owned subsidiary of the registered charity BRE Trust. It is independent of the DNO.

Type of Organisation

BRE is the world's largest private sector research and technology organisation within the built environment. BRE does not design or manufacture products as part of a supply chain but works with that supply chain to deliver solutions for the marketplace.

Role in Project

BRE will carry out detailed energy site surveys for interested customers, model building energy use and identify potential for reducing demand. They will also provide support in the selection, installation and monitoring of a range of pilot electrical load reduction measures and building renewable energy technologies to quantify energy savings achieved.

What Partner will add to Project

BRE will provide independent and impartial advice on the application of customer energy efficiency measures as well as access to other potential funding opportunities.

Prior Experience

BRE has extensive experience in modelling energy use in existing buildings and new buildings built to or beyond the current building regulations. They also have expertise in building related renewable energy technologies and electrical load reduction and conservation measures. The BRE modelling team developed the UK's Energy Performance Certificate methodology.

How Funding relates to benefits from Project

BRE will gain experience in the application of energy efficiency measures and potential benefits, enhancing their existing research portfolio.

Project Programme

A detailed project plan has been prepared and indicates key tasks and the critical path, provided below. The total duration of the project is 3 years with project outcomes to inform business plans going forward into the next Ofgem price review process in 2015 as well as future business plans.

The critical path (shown in red) is focussed on the development of functional specifications, procurement and installation of substation monitoring installation as this will provide the network benchmark for quantifying energy savings of technology in WP 2. The trials for flexible network control are also on the critical path, informing a full lifecycle cost benefit analysis and development of an investment plan for rollout, in late 2014.

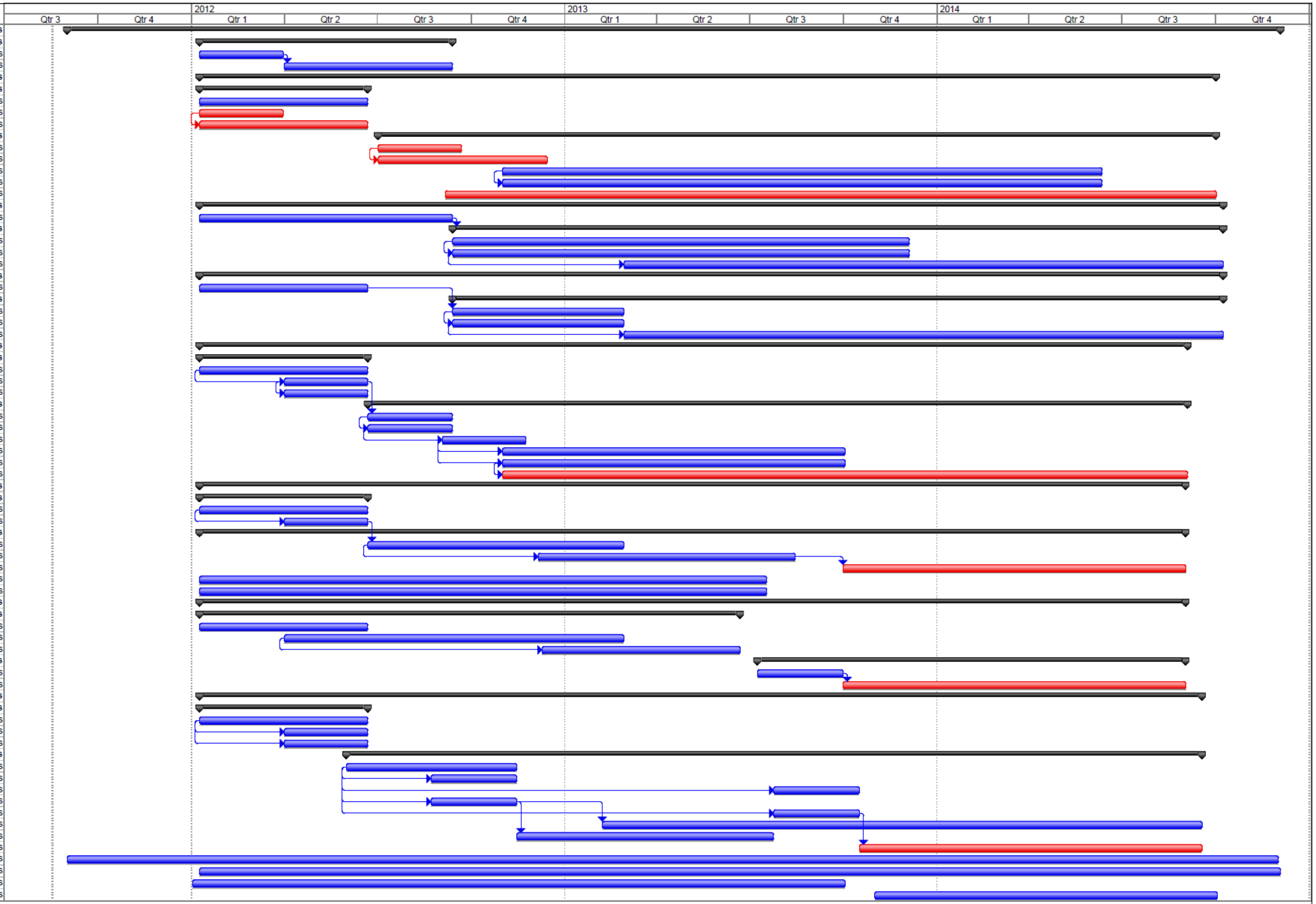
Specifications for some of the equipment are already complete and we will be looking to further develop the other equipment specifications and complete a detailed methodology and programme for monitoring equipment installation and verification in substations, in the approach to the project, before formally starting in January 2012.

Risk Register

A detailed risk register has been prepared for this project in order to identify and manage risks, and prepare appropriate mitigation and contingency plans, as shown below. This will be maintained and updated throughout the project by the project manager and reviewed on a regular basis by the executive sponsor and the project governance board. The risk register provides guidance for the level of cost contingency used for each work package. The work package/s associated with the risk item is indicated in the register.

A risk rating (**RR**) has been calculated for each risk item by allocating a probability (**P**) and a consequence (**C**) rating, where 1 is low, 2 is medium and 3 is high, and multiplying to get the overall risk rating. This enables identification of significant risk items and development of suitable mitigation and contingency plans.

ID	Task Name	Duration
1	**Work Packages**	**852 days**
2	**Work Package 1.1**	**180 days**
3	Design	3 mons
4	Development and Testing	6 mons
5	**Work Package 1.2**	**715 days**
6	**Engineering Design**	**120 days**
7	Test case design methodology	6 mons
8	Functional and Integration specifica	3 mons
9	Installation methodology	6 mons
10	**Monitoring Deployment**	**588 days**
11	Equipment procurement	3 mons
12	Installation	6 mons
13	Software development	21 mons
14	Procedure development	21 mons
15	Testing and Validation	27 mons
16	**Work Package 1.3**	**720 days**
17	Design	180 days
18	**Development and Testing**	**540 days**
19	Software development	16 mons
20	Procedure development	16 mons
21	Testing and Validation	21 mons
22	**Work Package 1.4**	**720 days**
23	Design	120 days
24	**Development and Testing**	**540 days**
25	Software development	6 mons
26	Procedure development	6 mons
27	Testing and Validation	21 mons
28	**Work Package 2.1**	**695 days**
29	**Engineering Design**	**120 days**
30	Test case design methodology	6 mons
31	Functional and Integration specifica	3 mons
32	Installation methodology	3 mons
33	**Technology Deployment**	**575 days**
34	Equipment procurement	3 mons
35	Installation	3 mons
36	Testing and Verification	3 mons
37	Software development	12 mons
38	Procedure development	12 mons
39	Testing and Validation	24 mons
40	**Work Package 2.2**	**693 days**
41	**Engineering Design**	**120 days**
42	Test case design methodology	6 mons
43	Functional and Integration specifica	3 mons
44	**Technology Deployment**	**693 days**
45	Equipment procurement	9 mons
46	Installation	9 mons
47	Testing and Verification	12 mons
48	Software development	20 mons
49	Procedure development	20 mons
50	**Work Package 2.3**	**693 days**
51	**Energy Surveys**	**382 days**
52	Customer engagement	6 mons
53	Energy surveys	12 mons
54	Modelling	7 mons
55	**Network trials**	**300 days**
56	Installation	3 mons
57	Testing and Verification	12 mons
58	**Work Package 2.4**	**705 days**
59	**Engineering Design**	**120 days**
60	Test case design methodology	6 mons
61	Functional and Integration specifica	3 mons
62	PNDC test methodology	3 mons
63	**Technology Deployment**	**600 days**
64	Equipment procurement	6 mons
65	Installation Ph1	3 mons
66	Installation Ph2	3 mons
67	Testing and Verification Ph1	3 mons
68	Testing and Verification Ph2	3 mons
69	Procedure development	21 mons
70	Testing and Validation Ph1	9 mons
71	Testing and Validation Ph2	12 mons
72	**Work Package 3.1**	42.5 mons
73	**Work Package 3.2**	38 mons
74	**Work Package 3.3**	23 mons
75	**Work Package 3.4**	12 mons



No.	WP	Risk Description	P	C	RR	Mitigation	Contingency Plan
1	WP 1 WP 2	The network trial sites may not be representative enough in terms of topology, and load and generation issues to provide learning for other UK DNOs.	1	2	**2**	Three network trial locations have been selected with different topology, varying levels of PV connection and different customer demographics. UoS will also provide expert review of experimental design to ensure that outcomes are technically robust, representative and verifiable.	Monitoring can be transferred to other sites relatively easily if required. It would not be necessary to repurchase monitoring equipment.
2	WP 1.2	There is a risk that procurement timescales could lengthen if monitoring equipment is not readily available.	1	2	**2**	The majority of the monitoring equipment has been deployed before by SPEN so procurement timescales are well understood.	As equipment for network trials becomes available, it will be installed at each of the 3 network trial areas consecutively with sites prioritised depending on criticality of network benchmarking. This will prevent any significant slip of project timescales.
3	WP 1.2	Customers may suffer supply interruptions during installation of monitoring equipment.	2	2	**4**	Installation of monitoring at substations should not require an outage in most cases and if outage is required, it should be possible to minimise customer supply interruptions by load shifting.	It has been assumed that a small percentage of secondary substations will result in supply interruptions and a detailed customer engagement strategy has been developed to deal with this.
4	WP 1.2	The development of a 'smart' monitor, may require additional time due to unforeseen development risk.	2	1	**2**	To mitigate this, SPEN will be engaging with a technology partner (Nortech) with expertise in developing algorithms for these devices and with a clear business plan in line with the aims and objectives of the LCNF project.	This is not on the project critical path.
5	WP 1.1 WP 1.2	Significantly more data will be generated to collect, communicate, store and process. Increase in costs of cumminication systems.	1	2	**2**	The magnitude of annual raw data storage required has estimated. Work Packages 1.1 and 1.2 will explore the management of large datasets.	Sampling rate can be optimised as necessary.
6	WP 1.2	There could be data privacy issues for customers due to the extensive programme of monitoring to be deployed.	1	3	**3**	The existing SPEN regulations governing data privacy for customers will be used in this project.	
7	WP 1.2	Increased visibility of the network through enhanced monitoring may actually erode anticipated headroom.	1	2	**2**	Traditionally, there has been a degree of conservatism applied to network design.	Greater knowledge of headroom will improve risk management and reinforcement prioritisation for the network, protecting customers and ensuring P2/6 compliance.
8	WP 1.3 WP 1.4	The development of new tools and processes for the control room and network design involves some complexity and time/cost risk.	2	1	**2**	SPEN has engaged partners with expertise in the development of tools/software for this application (UoS, TNEI).	This is not on the project critical path.
9	WP 1.3 WP 1.4	Failure of internal user to adopt new tools and processes.	2	3	**6**	This project contains a detailed component of internal stakeholder engagement (WP 3.1), from the start of the project, to obtain user input and maximise likelihood of adoption. Business change techniques will also be utilised.	Executive buy-in could be utilised to leverage more support for business change.

No.	WP	Risk Description	P	C	RR	Mitigation	Contingency Plan
10	WP 1.3 WP 1.4	The 11kV network has not been modelled in entirety, only in limited network areas when it has been required. The LV network is not modelled in detail at all. There is minimal data available on legacy assets at these voltage levels. Once 11kV and LV network models are created, there needs to be a clear maintenance strategy to reflect new connections.	3	2	**6**	The impact of this on the value of data will be investigated through a detailed uncertainty analysis. In addition, tools that can be used to automate the process of model creation will be investigated. It is not the intention to model all LV networks in detail but rather to improve representation of them. Strategies for model maintenance, through engagement with key customers for example, will be developed.	UoS has developed a GIS software that could be used to accelerate input of overhead line lengths.
11	WP 2.2	From investigation of flexible network control, it may be found that the trial networks are already running efficiently or that there are diminished returns associated with the use of this network technology.	1	2	**2**	A range of representative network area topologies and characteristics are being investigated.	This will be a learning point in itself. This should provide some excellent insight into the capacity headroom increases possible with this technology for a range of representative topologies and characteristics.
12	WP 2.3 WP 3.2	Engagement with external stakeholders i.e. customers, other DNOs, academia, local councils and authorities, community groups, may not be very effective.	1	2	**2**	A detailed element external stakeholder engagement is included in the project and UoS is providing support on knowledge dissemination. A customer engagement strategy has already been developed and BRE Trust will be involved in carrying out the energy surveys.	
13	WP 2.3	It may not be possible to achieve the expected energy efficiency savings or there may be a lack of customer uptake.	2	2	**4**	A focussed approach will be used to target customers who should be able to achieve the most energy savings through proposed energy efficiency measures. A network benchmark will be established through monitoring before energy efficiency measures are trialed to provide a technically sound appraisal of possible benefits.	A customer cash incentive of £100k in total will be made available to encourage uptake. A reasonable outcome may be that energy efficiency measures do not have an adequate cost-benefit case.
14		There is a possibility of the unforeseen appearance of a load of up to 5-6MW at St Andrews or Whitchurch before the next price control period, that would require reinforcement. Even though this load is a marginal increase, it may cause P2/6 non-compliance.	1	3	**3**	Use early outcomes from LCNF project to delay reinforcement where possible.	Typically, the onus would be on the connecting customer to subsidise network reinforcement although regional development agencies may contribute. The network may need to be reconfigured but would still provide useful learning on network behavior.
15		The project may not provide the expected capacity headroom increases and St Andrews and Whitchurch may need to be reinforced using the traditional approach and/or it is not possible to connect much additional PV at Wrexham.	1	2	**2**	This project is based on a methodology of integrated, discrete work packages which have all been identifed as having the potential to provide headroom increases. Risk is mitigated through diversity.	Load increases are not expected until the next price control period, which provides adequate time to reinforce.

SPT2003 Addendum

Proforma box number / Spreadsheet	**Change Made**	**Reason for change**
Section 9, pages 49-52	Succesful delivery reward criteria updated to reflect changes made in response to question 19.	In response to **question 19** and for clarification purposes.
Spreadsheet, **Direct Benefits** worksheet and **LCN Funded costs** worksheet	LCN Funded costs worksheet updated to include links to other sheets for clarity. Direct Benefits Worksheet updated to provide greater breakdown of costs. No values were changed in this process.	In response to **question 8 and 10** for clarification purposes.
No further changes have been made to the submission as responses to any other questions were for additional information and have not changed the submission.		

Updated Full submission: SPT2003 – v2 Final Proforma

Updated spreadsheet: SPT2003 – v3 Appendix A Spreadsheet