Low Carbon Network Fund Project Progress Report June 2015

Flexible Networks for a Low Carbon Future

Version: 1.0

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1. Executive summary

1.1. Project Background

This project will trial a combination of smart network interventions and customer energy efficiency measures at three network locations. The objective is to demonstrate how they can release capacity on the HV network, allowing greater take up of low carbon technologies such as solar PV, heat pumps and electric vehicles without the need for traditional network reinforcement. The project will also encourage specific industrial and commercial (I&C) customers to improve the energy efficiency of their buildings to reduce their electricity demand in order to alleviate the need for reinforcement.

The results from these trials have the potential to inform future network planning and operational practices. This project will help DNOs more accurately assess operational plant ratings using dynamic techniques and how best to actively control the network at the EHV/HV level. It aims to provide evidence of the capacity headroom available in existing networks that can be used before traditional network reinforcement needs to take place. This will enable networks to connect more customers and plan network reinforcement activities to be timed optimally.

The overall project is divided in to 12 distinct work packages which complement each other and provide multiple methods which work together to achieve the overall aim of a 20% increase in network capability.

1.2. Project Progress Highlights

During this sixth reporting period of the project (December 2014 – June2015) the project has made progress in a number of key areas.

We have achieved our objective of releasing 20% headroom capacity in the trial site areas, thus deferring conventional reinforcements.

The project team are currently working on preparation of the closedown report for the areas of the project that are complete and identifying a major dissemination event for the conclusion of the project The closedown report will be ready later in the year giving full details of the project delivery, outcomes and learning. We are currently in discussions with a peer reviewer from another DNO.

The dynamic or ‘enhanced’ thermal rating trials on primary transformers have given SPEN the confidence to adopt this intervention into our ED1 reinforcement plans on a number of primary transformers.

Successful completion of the installation and commissioning of the telecontrol/ monitoring system on the St Andrews voltage regulator. The design of this installation has now become the ‘standard’ for future installations.

Using the next generation automation equipment trialled under the project we have successfully recovered analogue data from NOJA PMAR’s for the first time.

Several internal stakeholder workshops have been held to disseminate the learning and encourage adoption of the interventions of the project trials.

In total, 4 papers arising from the project have been accepted for CIRED, (the largest European distribution conference), in June 2015.

1.3. Key Risks

At this stage many of the risks have either arisen and been dealt with, or not materialised. The team continue to consider areas which may impede the progress of the remaining elements of the project. The risk table has been updated to reflect the current perception.

An ongoing risk that we were mindful of is that there may have been a substantial change to the load in the area, such as a new large customer which would have changed the network topography and change the need for the project. No major changes occurred within the time period of the project and this risk did not materialise.

1.4. Learning Outcomes

Learning points are reviewed by the Flexible Networks project team at regular meetings to establish what was learned from the activities undertaken.

Consideration of customer's lifestyle is an important factor for utilising the iBoost Solar PV to Hot Water controllers. We hadn't fully understood that the benefit of the device's operation needs to fit with the electricity and hot water demand pattern of the customer.

The LV supply monitors issues were significantly greater than expected and the learning was not to underestimate the configuration, set-up and data retrieval issues that will be encountered using new technology equipment. Details of the issues are explained in section 2 – Work Package 1.2.

Also as part of Work Package 1.2 we have obtained significant new learning from a data analytics trial undertaken in conjunction with IBM.

We encountered some new issues with pole mounted weather stations during the reporting period, including problems with a solar power supply, and distribution line electromagnetic interference with line current/temperature sensor operation. These are further described in Section 2 – Work Package 2.1.

2. Project manager's report

The last six months period has seen progress in a number of areas and the project is close to the amended plan in our approved Change Request. The progress and details of each of the work packages is set out below

Work Packages 1.1 - Improved use of primary substation data

This work package is complete. Key learning points include:

• In combination, the following techniques can result in determination of a higher network capacity than traditional techniques:

- better data error detection and correction techniques being applied to raw measured data
- an improved understanding of network asset loading behaviour
- more sophisticated load forecasting techniques
- a more probabilistic assessment approach.

• Using the resulting higher, actual capacity for design purposes can help defer network reinforcement.

- Various internal stakeholder engagements have been held in order to achieve user buy-in and adoption into the main business as business-as-usual.

Work Package 1.2 - Improved secondary substation data monitoring

As reported previously the monitors continue to experience intermittency in communications through the GPRS network.

The Landis & Gyr devices being used as LV voltage monitors, installed in several customer premises have been particularly problematic with intermittency of data capture, GPRS signal adequacy and function set up issues. To help with the GPRS signal issues a number of devices were fitted with Orange SIM cards instead of the Vodafone SIM cards to improve signal strength and consistency of data capture. This has helped but has not completely eradicated the problem. A data retrieval scheduling software (called ADVANCE) was obtained from Landis & Gyr to enable frequent/automated data downloads from the devices. Prior to obtaining ADVANCE the data was manually downloaded periodically (every 2-3 weeks) using the free MAP software. Issues were experienced using this method, in that the time to execute the data set download was excessive and often the transmission would fail after a time-out. The failure to retrieve the data this way meant a visit to site to plug into the meter with a laptop. Therefore we changed to an automated daily download using the ADVANCE software installed on an iHost slave server. Some teething issues were encountered with the software interface and data extraction but Nortech and Landis & Gyr worked together to resolve these.

The LV network in Ruabon is currently running with a reduced network voltage and we are continuing to gather voltage data from the primary and secondary substations and the customer LV supply points. Summer is an important period for monitoring the effect of PV on the network. We will analyse the data from this period and include the results in the close down report.

During the period we reached the conclusion of a data analytics trial undertaken in conjunction with IBM. The trial used data collected as part of our Flexible Networks project, together with data extracted from other business systems.

We undertook the trial because, in common with other DNO's, there is an exponential growth in data being collected across the business which is often held in separate systems. As a result there is a need for tools to enable us to pull data from different source systems and efficiently analyse it in a way that provides visualisations and reports that provide business benefit. Analytics has the potential to improve our cost efficiency, improve our asset management techniques, and facilitate new or improved services to customers.

The scope of work agreed with IBM included the data that SPEN would need to provide and the type of visualisations and reports that the package would provide. For the trial, data relating to the 11kV / 400V secondary networks in St Andrews and Ruabon project trial areas was considered. These 2 areas were selected because they have enhanced monitoring and also allowed any issues resulting from the different network topologies and differences in the IT applications between our 2 licence areas to be considered.

Through the implementation process we developed methods of obtaining the data required, and documented the difficulties that were encountered in obtaining some of the data in the necessary format.

We now have examples of the output from the analytics package using actual data. These include visualisations of substation location, connectivity and utilisation overlaid on Google Maps. Examples of reports available include a 'Hot Substations' report and a 'Voltage and Power Factor' report.

It is concluded that the trial has been a valuable first step towards implementing data analytics and there has been valuable learning on the potential for business benefit and also the difficulties that can arise in obtaining data in the correct format from disparate systems. As an example of the benefits, the visualisations created were considered particularly helpful to new connections designers in allowing them to quickly assess the sources of available capacity in a network, with the potential to improve the efficiency of the customer quoting process..

As a next step we intend to undertake a NIA project which will use analytics to build a 'Network Controllable Points Alarm Processor'. This will be a decision support solution, analysing the increasing volume of data and alarms and will consider the potential benefits of predictive data analytics for fault prediction.

Work Planned during the next 6 months:-

- Continue monitoring of the operation and reliability of the devices, data communication and storage.

- Continue harvesting of data for the other work packages and interventions.

- Quantify the potential value of enhanced network monitoring and data analytics.

- Finalise the documentation required for the close down report.

Work Packages 1.3 and 1.4 - Improved operational and planning tools

The University of Strathclyde (UoS) and TNEI are developing the operational and planning/design tools. A key feature of this work is to bring together the different tools which are currently being used for design and operations and provide a common framework.

A series of technical reports and technical notes have been produced to document the learning outcomes, covering:

- PV Generation headroom
- LV Phase imbalance assessment
- Diversity in secondary substation load
- Transformer enhanced rating assessment tool (prototype)

A further report documenting learning about improvements in HV and LV network modelling techniques is being finalised

Learning outcomes include:

- Improved characterisation of PV generation capacity headroom in LV networks. This has resulted in proposed revisions to SPEN policy.

- Improved assumptions for modelling of HV and LV loads in power systems models (e.g. voltage dependency of load and typical load power factor)

- Potential for LV network capacity release by re-balancing poorly balanced feeders

- Transformer ratings can be enhanced, based on actual measured annual load profiles and local measured ambient temperatures

The work planned during the next reporting period is to

- Finalise the draft reports and technical notes referred to above for the closedown report,

- Present posters on LV phase imbalance assessment methodology and LV PV characterisation for power system applications at the CIRED conference,

- Run a workshop with project partners and internal users to develop a methodology for deploying the design/operational tools into business as usual,

- Update the current SPEN draft PV generation policy document based on the learning outcomes from the PV Generation headroom report.

Work Package 2.1 - Dynamic thermal ratings (DTR)

Progress on the implementation of real time thermal rating (RTTR) of the Cupar to St Andrews 33kV overhead lines is summarised as follows;

RTTR has been operational since early summer 2014 on the two 33kV circuits from Cupar grid supply point to St Andrews primary. The system comprises GE line monitoring equipment at four selected sites along the circuits, weather stations at 4 primary substations, and communications between monitoring equipment and the PowerOn Fusion server hosting the RTTR calculation engine The RTTR system results are available through a live web link to a PowerOn dashboard designed specifically for reporting the RTTR of Cupar-St Andrews circuits. All the monitored data and calculated RTTR are also stored in SP Energy Networks' PI historian.

- We now have now had a full12 months experience with the system operating and have captured data for analysis throughout this period. The outcomes of this analysis will be presented in full in our closedown report. In summary the results confirm that uplifts of approximately 10% in energy transfer can be achieved using the system.

- As previously reported the foreseeable risk of communications or sensor failures mean that a graceful degradation algorithm is required to gracefully degrade the RTTR to the seasonal rating as an increasing number of monitored weather parameters are lost. User acceptance test of the graceful degradation implementation has now been carried out successfully and this algorithm is now available as an enhancement to the RTTR system.

- An additional anemometer was installed at a span near the Cupar grid supply point in order to trial 2 different technologies and make recommendations as to the suitability of each. Results of this trial are inconclusive and we believe that mounting techniques for the anemometers, to avoid the shielding effect of poles etc. have a significant effect on wind speed measurement.

- Different methods of attachment for the line sensors' temperature probe were trialled in order to identify the appropriate method that would represent the conductor temperature accurately. We have identified a potential issue with the readings from line temperature sensors being affected by ambient temperature and solar radiation. We will therefore recommend that further work is carried out in this area to investigate the issue with the aim of reducing the errors from line temperature sensors.

- We identified an issue with electromagnetic interference from the power line affecting the radio communications from the line sensors that had not been previously identified during laboratory testing. This issue was resolved with a change to the sensors firmware.

- During the winter period one of our solar powered weather stations shut down due to low battery levels as this site was in an area extremely shaded from solar radiation. This issue was corrected by the addition of an extra solar panel.

- A paper on graceful degradation methodology was accepted by the CIRED technical committee and will be presented at the poster session of the CIRED 2015 conference. ..

- RTTR methodologies for overhead lines have not yet reached a mature stage in the DNO community. We recognise that there are a number of alternative solutions to the state estimation technique we have trialled. Other DNO's have highlighted the potential risks associated with RTTR including those associated with the ESQR compliance. We therefore believe that an ENA working group would be an appropriate way forward to develop common industry standards.

The work planned for the next 6 months is as follows:

- Present the poster on graceful degradation methodology to CIRED conference;

- Finalise the close-down report and include the data analysis for the winter period;

- Continue to work with internal stakeholders and equipment suppliers to develop a methodology for deploying the RTTR in business as usual process;

- Promote the potential for an ENA working group to develop industry standards for RTTR of overhead lines.

Progress on the enhanced thermal rating of primary transformers is summarised below;

The results of the previously completed site surveys and modelling confirm that the transformers are able to supply increased peak loads without resulting in adverse aging of the transformer active part. For St Andrews primary transformers increased loading has been modelled to the point where the capability of associated cables and switchgear become the limiting factor. The level of peak load increase of 14% can be achieved with negligible impact on the remaining expected lifespan of the transformers and an acceptable winding hot spot temperature. These modelled results are currently being verified through experimental loading tests on the transformers.

For Whitchurch group primary transformers increased loading has been modelled to the point where the capability of associated 11kV cable circuits become the limiting factor. The level of peak load increase of 10% can be achieved with negligible impact on the remaining expected lifespan of the transformers and an acceptable winding hot spot temperature. A transformer loading test, described below, has verified these results.

The firm capacity of St Andrews primary substation and the Whitchurch group will be increased in the long term development statement (LTDS) line with the enhanced transformer rating.

In the Whitchurch group, instrumentation with remote monitoring has been installed on a primary transformer at Liverpool Road substation to replace the conventional winding temperature instrumentation. An experiment has been conducted to compare the winding temperature predicted by the DNV KEMA and TNEI models against that actually measured.

Following the Transformer temperature monitor installed on the Liverpool Road primary transformer in Whitchurch, we undertook an increased load test on the transformer. This was done by rearranging the network between the three primary substations in Whitchurch to move the majority of the load on to Liverpool Road. The rearrangement of the network was left in place for four days to obtain data across several daily loading cycles. We would have preferred to have loaded the transformer to between 10-11MVA, to observe an anticipated operating temperature of 90-100DegC. However, this would have meant placing the whole of Whitchurch on to one transformer and the risk of losing supply to over 7000 customers. Therefore we maintained some customers on the other two transformers at Whitchurch Primary and Yockings Gate primary to allow staged feeder restoration in the event of losing the Liverpool Road transformer whilst it was carrying the majority of the load.

The table below shows the loading between the transformers in both system normal and the rearranged configuration and also the temperature change on the Liverpool Road transformer.

Loading	Liverpool Road Transformer (MVA)	Whitchurch Transformer (MVA)	Yockings Gate Transformer (MVA)	Liverpool Rad Transformer Temperature (Deg C)
System Normal	4.8	3.9	3.0	39
System Rearranged	9.1	2.3	0.7	70

The Liverpool Road transformer is a Brush (2001 year) 33/11kV 7.5MVA ONAN.

The measured temperatures are lower than those predicted by the models. We have therefore been able to conclude that the models are conservative (as would be expected), which leads to greater assurance that transformers will not be adversely affected by application of the enhanced rating.

Further transducer transformer temperature monitors have been fitted at St Andrews substation transformers and further experimental results will be gathered to verify our initial conclusions.

The transformer loading tool developed by TNEI under the project is being used in business as usual to assess suitability of primary transformers for enhanced loading. Approximately 12 primary transformers have so far been identified as suitable for this technique. The TNEI tool will be available to be licenced free of charge to other DNO's to use on an enduring basis.

Work Planned during the next 6 months:-

- Completion of the Methodology and Learning report on the enhanced rating of primary transformers.

- Further verification of modelled results through analysis of site data from multiple transformers. Continued adoption of primary transformer enhanced rating into business as usual.

Work Package 2.2 - Flexible network control

Two main aspects of this work package contribute towards the end objective of redistributing peak load on the 11kV network at appropriate times. These aspects comprise; modelling of switching algorithms; and implementation of field devices.

As previously reported modelling work has been completed to evaluate the available thermal headroom at St Andrews primary substation, and at adjacent primary substations. Opportunities to increase the headroom at St Andrews by permanent, seasonal or dynamic network reconfiguration to transfer load onto adjacent primary substations were identified and analysed.

Through discussions with the wider business, we arrived at a preferred solution comprising a seasonal switching regime to redistribute approximately 6% of St Andrews peak load.

In order to implement switching algorithms required for flexible networks, new generation automation equipment has been installed at a number of sites in St Andrews earlier in the project. Central Communications Units (CCU), with enhanced radio bandwidth to serve the purposes of the project have been installed at 3 primary substations, and new-generation outstations for monitoring and control have been installed at a number of secondary substations to supplement legacy automation equipment on the network. During this period we achieved a significant milestone by recovering analogue data from a NOJA PMAR over the new UHF radio for the first time. Technical difficulties that had to be overcome in achieving this included the development of a power supply to enable 2 radios to be connected to a NOJA simultaneously.

As a result of agreement of the switching algorithm a small number of additional pole mounted devices were identified as being necessary on the St Andrews network. During this period planning has been underway to install these devices – obtaining landowner permissions etc.

The switching logic for flexible network control is being implemented using our PowerOn Fusion SCADA system. Work has been ongoing with our SCADA team and Senior Control Engineers in order to implement the required algorithms.

Work Planned during the next 6 months:-

- Complete the commissioning of the additional automation points on the St Andrews Network.
- Prepare the Methodology and Learning Report for work package 2.2.
- Implementation of the switching algorithms in St Andrews and Whitchurch.

Work Package 2.3 - Energy efficiency

As previously reported stakeholder engagement continues to be a difficult area. BRE have continued their engagement with a number of large customers in the trial areas and have discussed detailed option assessment reports with these stakeholders. However a number of stakeholders have removed themselves from the process during this period.

In conjunction with an energy supplier we have prepared fully costed proposals for the interventions with St Andrews University. The agreed interventions are now at delivery stage.

We worked with Wrexham Council to implement a small scale trial of PV to domestic hot water technology in the social housing stock in Ruabon. This involved the installation of an iBoost controller unit which will turn on electric hot water heating when surplus energy to that being used by the property is being produced by the solar PV. We will assess the potential of this technology to facilitate increased connection of PV onto the network.

Eleven controllers were installed in Wrexham Borough Council's tenanted properties in the Wrexham area, however one customer asked for it to be removed as she wanted hot water to be available continually throughout the day for her needs. An important learning point came out of understanding why the customer was not happy with having the iBoost controller. It was not realised when looking at the operation of the iBoost Solar PV to Hot water device (there are a number of devices on the market with similar functionality), that the customers lifestyle and timing of hot water requirements does need looking at. In the case of this customer, she was an elderly lady who was home all day and used the hot water repeatedly during the morning and afternoon period. As the iBoost controller switches on the electric water heater when the PV output is greater than the demand of the appliances in the property, with the lady being at home with the TV, fridge freezer, cooking and making drinks etc, then there was seldom a time that there was surplus PV output to activate switching on the electric water heater. Therefore due to the consumption of the appliances, the size of the hot water cylinder and with the continual hot water demand during the daytime period, the iBoost was not initiating a 'charge' of hot water in the cylinder. The device has two hot water 'boost' times available which are typically set to an early morning charge and a teatime charge. Therefore during the daytime the device really needs the cylinder to 'calling for heat' i.e. partially cold, to allow the PV surplus energy to be utilised by the cylinder. If the customer is at home with several appliances running, then there is no surplus PV energy for the controller to divert from going to the grid by switching on the electric water heater. This means the electric water heater is not switched on and the water does not get heated until the next boost timer period is reached. If the customer wants hot water during this period and the cylinder is partially cold awaiting the next boost period, the customer may not have sufficient hot water for their needs. Other customer comments to the council staff have been positive to the operation of the device. The controllers have a kWh register incorporated for longer term evaluation of the amount of energy diverted from the grid for use in the property. This will identify the benefit of the device over time.

A meeting has been held with Wrexham Borough Council - Climate Change and Carbon Reduction Dept. To discuss and determine a way forward for the iBoost controllers fitted to the council's tenanted properties. We have agreed with them that once the project concludes and the devices become out of warranty, that the council's own maintenance teams will undertake any troubleshooting or repairs to the iBoost functionality. The one removed iBoost unit is being retained as a strategic spare for future use.

Following on from the previous voltage reduction to the network at Ruabon we have undertaken a further voltage intervention with the added benefit of having some voltage monitors recording data at customer supply points. This will allow extra clarity of the voltage impact and changes to ensure that we maintain within the statutory limits. At the location were a customer notified us about their supply voltage during the previous test, we have resolved a previously undetected fault condition on the LV network and installed a voltage monitor at their premises.

Work Planned during the next 6 months:-

- Completion of the interventions partially funded from the financial contribution from the sum allowed within the project.
- Collaboration with St Andrews University to trial voltage reduction where there are sole use supplies
- Further voltage optimising and evaluation during the summer high PV generation period in Ruabon.
- Completion of the Methodology and Learning Report for work package 2.3.

Work Package 2.4 - Voltage regulation

The Voltage Regulator has been installed and energised on the St Andrews network.; this has now been adopted as the standard design for voltage regulator installations, including the design for a telecontrol interface. The installation process provided a number of important learning outcomes which have informed our policy and specifications listed below.

A temporary GPRS data logger is installed for collection of data at St Andrews and a similar device has been installed on an existing voltage regulator at Tegfa. The data is being used to assist in the characterisation of voltage regulators for a model that TNEI are developing to include in their IPSA modelling package and will be provided to existing IPSA users.

As part of business as usual activity the following documents and procedures have been reviewed and updated.

- Voltage Regulator Policy
- Design Guidance
- Procurement
- Construction Documentation
- Commissioning Guide
- Telecontrol Guidelines
- Linesman's Manual
- Maintenance Policy
- Asset Data Model
- Field Operation Procedures
- Control Room Procedures

Work planned to be undertaken during the next 6 months is as follows:-

- Compare network capacity gains expected from the St Andrews deployment against actual performance in service.
- Analyse monitored data from a 3 tanks generation site in Tegfa North Wales. This along with the monitoring equipment installed at West New Hall (St Andrews) will be used to provide learning from AVR deployments for both generator and network connections.
- Investigate the automatic, sequenced control of an AVR as an enabling technology for Flexible Network Control.
- Analyse results of AVR performance characterisation and model validation tests at the PNDC.
- Complete the Methodology and Learning Report for work package 2.4

Work Package 3.1 - Internal stakeholder engagement

The project has helped shape our plans for the next price review period and elements of the project have been built into our ED1 business plan. Meetings have taken place between members of the project team, and our Design section to review individual project plans for adoption of flexible networks techniques. It is intended that members of the Future Networks team will contribute to the 'scheme team' approach in developing these projects.

As part of an internal stakeholder engagement strategy, workshops have been arranged for design staff in both licence areas covering the new tools and techniques available to them as outputs from the project.

Two workshops were undertaken in January with participants from our Design sections to progress the flexible networks techniques into business as usual.

Two workshops were undertaken in March with participants from our Operations sections to progress the flexible networks techniques into business as usual.

A further internal workshop and site visit is planned for August for Engineering Standards, and Planning & Regulation staff.

A tracking regime is being put in place to measure and record the benefits that the flexible networks techniques deliver for customers during the ED1 period through the reduction in conventional reinforcement.

Within SP Energy Networks there are a number of groups which provide rigour and stewardship to asset management. The project has become a normal inclusion in the activities of these groups.

Each of the members of the Future Networks team is allocated an area of the business to liaise and share innovation and learning.

SP Energy Networks staff out with the project continue to be involved and support the project operational delivery aspects. This expands and develops internal staff engagement and provides a platform to build on when taking the project findings into business as usual.

Work Package 3.2 - External stakeholder engagement

A Flexible Networks 'Narrative' document is being prepared as an easily accessible overview of the scope of the project and its deliverables.

To complement the 'Narrative' document, a series of 'one pager' documents are being produced covering the new tools for designers developed under the project.

A stakeholder mapping exercise is being conducted to understand who will benefit from the learning and therefore target communications in an appropriate manner.

We are planning a dissemination event to take place soon after the project close down report has been published.

We see the 2015 LCNI conference being hosted by SPEN in Liverpool as the ideal opportunity to disseminate the findings from the project. This is planned to include presentations within appropriate breakout sessions together with workshops at the stand where a more technical focus can be achieved.

DNO's will be invited to participate in follow up one to one sessions post LCNI 2015.

Four technical papers will be presented at the CIRED Conference in 2015. These comprise:

- LV phase imbalance assessment methodology
- Low voltage PV characterisation for power system applications
- Graceful degradation methodology for the RTTR of Overhead lines
- Dynamic rating to support safe loading of distribution transformers

Through our collaboration with BRE we have arranged for BRE Trust (http://www.bretrust.org.uk/) to produce a publication on flexible networks techniques that will make this information available to a wider audience within the building and construction sector.

A meeting has been held with Wrexham Borough Council - Climate Change and Carbon Reduction Dept. To discuss and determine a way forward for the iBoost controllers fitted to the council's tenanted properties. We have agreed with them that once the project concludes and the devices become out of warranty, that the council's own maintenance teams will undertake any troubleshooting or repairs to the iBoost functionality. The one removed iBoost unit is being retained as a strategic spare for future use

Work Package 3.3 - Verification of experimental design

UoS are in the process of reviewing the methodologies of the work packages.

UoS have prepared a final report on the experimental design and results of the Ruabon voltage reduction experiment.

UoS have also reviewed our proposals for further experiments comprising; voltage reduction; N-1 operation of the network (to verify dynamic rating models); and flexible network control. A formal report will be issued covering these activities which will also include a review of the statistical work that TNEI and UoS have been undertaking as part of work package 1.

Work Package 3.4 - DNO policy changes

The activities and learning from the project are already being transferred in to BaU for ED1 and to become future standard policy. These include secondary substation monitoring and smart MDIs, enhanced rating of primary transformers and automatic voltage regulators. From the early learning of the project, the above three technologies are considered sufficiently beneficial to justify firm plans to implement.

In reviewing our trial of dynamic line rating for overhead lines we have concluded that there may be benefit in an ENA working group being set up to agree common standards and specifications for the implementation of dynamic line rating in business as usual across DNO's.

3. Key Issues

As many elements of the project are approaching their conclusion, the team is compiling the considerable amount of information into a closedown report for future dissemination.

It has been difficult to maintain resources on the project over such a long period of 3-4 years, with other changes around the business, such as ED1. This has increased our reliance on contract staff to provide support and shifted the expenditure from the 'internal engineering' category to 'contractors'.

It has been difficult to rely upon customers to undertake the energy efficiency measures identified with them. We do believe that the customers will undertake some measures in the long term, but this has not materialised within the project timescales.

The team are working closely with other parts of SPEN for the adoption of the project concepts into business as usual as we enter the ED1 period.

Ongoing development of the knowledge dissemination plan is underway to ensure that learning is transferred both internally within SPEN and to external stakeholders.

4. Project Plan

See Gantt chart attached.

5. Consistency with full submission

The solution being developed and the methods being trialled in the project remain consistent with those set out in the full submission, subject to the changes introduced as part of our approved Change Request.

Project Budget - As part of the change request approved by Ofgem we have refunded the underspend amount to the LCN fund and ultimately the customers.

6. Risk management

Several original submission risk perceptions have been updated in the risk table below, to reflect how certain risks have not materialised in those aspects of work completed with a review and consideration for those risks that still exist. At this stage of the project generally the risks to the project are considered to be low.

No.	WP	Risk Description	Mitigation	Contingency Plan	Current Perception
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.	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.	Low
2	WP 1.2	There is a risk that procurement timescales could lengthen if monitoring equipment is not readily available.	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.	Low. Only risk remaining is large scale failure of the population of units, this is perceived as low risk, as they are performing satisfactorily to date.
3	WP 1.2	Customers may suffer supply interruptions during installation of monitoring equipment.	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.	Low
4	WP 1.2	The development of a “smart‟ monitor, may require additional time due to unforeseen development risk.	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.	Low
5	WP 1.1 WP 1.2	Significantly more data will be generated to collect, communicate, store and process. Increase in costs of communication systems.	The magnitude of annual raw data storage required has been estimated. Work Packages 1.1 and 1.2 will explore the management of large datasets.	Sampling rate can be optimised as necessary.	Low
6	WP 1.2	There could be data	The existing SPEN regulations	No contingency required.	Low

		privacy issues for customers due to the extensive programme of monitoring to be deployed.	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.	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.	Low
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.	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.	Low
9	WP 1.3 WP 1.4	Failure of internal user to adopt new tools and processes.	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	Low
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.	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.	Low
11	WP 2.2	From investigation of flexible network control,	A range of representative network area topologies and characteristics	This will be a learning point in itself. This should provide some excellent	Low

		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.	are being investigated.	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.	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.	Innovative ways of engaging with stakeholders will be considered such as a 'roadshow' to visit other DNO's.	Low
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.	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 trialled 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.	We consider that the 2% capacity gain through the energy efficiency work package may not be achieved which will be reflected in the learning from the project. However we expect to mitigate the shortfall with additional gains from other work packages.
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.		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 behaviour.	No significant load or generation has been seen in the trial sites to date.

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.		This project is based on a methodology of integrated, discrete work packages which have all been identified as having the potential to provide headroom increases. Risk is mitigated through the potential for some work packages to outperform in terms of capacity gain.		Low
Additional risks identified since original submission					
15a	WP 2.2	Resource availability for integration of new network automation technology into existing company SACDA system PowerOn.	There are no other available resources to mitigate this risk.	Request project timeframe extension.	Low
15b	WP2.4	Suitability for trial sites for the deployment of Automatic Voltage regulators (AVR).	To use a new connections AVR installation to capture learning of the design, specification and engineering for the equipment. Also use PNDC AVRs to carry out enhanced testing of functionality and performance.	To consider alternative locations for AVR use.	Low
15c	WP 1.2	Availability of new enhanced network monitoring data to inform and develop other work packages.	Increase monitor installation program to speed up delivery of new network data.	Advance preparation work for other work packages reliant on new network data. Use early data analysis to steer direction of other work packages.	Low
15d	Procurement of new technology products.		Consider the use of collaboration agreements.	Use prototype equipment in test case trials before committing to contract.	Low

7. Successful delivery reward criteria (SDRC)

Project budget (criteria 9.1) – The original project budget has been superseded with the one submitted to Ofgem as part of the Change Request and this amounted to a reduction of approximately £0.75M. This revised budget is now the one which we are reporting against. The following are the key points for any variations;

- The equipment costs are above (but less than 10% above) budget. This was due to the preparation of the primary transformers in St Andrews following the health assessment
- IT costs are lower than anticipated. This is primarily due to the PowerOn development work costs being to some degree included within other development work ongoing.
- Some elements of the budget have used their contingency and others have not to date. Not all the PNDC testing costs have been incurred to date.
- The payments to users were allocated, but none have been made to date as the customers have not completed the energy efficiency measures.

Project Milestone Delivery (criteria 9.2) – At this stage in the project many of the work packages are concluded in line with the dates in the Full Submission. As a result, a considerable amount of learning is available via these reports and the full learning information will be available in the project closedown report in late 2015.

Creation of a Flexible Network (criteria 9.3-9.5) – At this stage of the project we have achieved the 20% capacity headroom objective, although the make-up of the 20% may be different across the trial sites due to the applicability of the interventions and benefit variations that each site can achieve. In the St Andrews trial area we have been able to achieve the increase in headroom for peak load by 20% and thereby achieve the DPCR5 reinforcement target set in this area.

Engagement, dissemination and adoption (criteria 9.6) –

A number of the elements of the project have been built into the ED1 business plan. It is envisaged that the during the period 2015-2023 most of the Flexible Networks key tools will be available to use as an alternative to existing practices for suitable network situations. These include secondary substation monitoring, the deployment of voltage regulators and the enhanced rating of some primary transformers.

Meetings and workshops have taken place between members of the project team, and the SP network design teams to review individual project plans for adoption of flexible networks techniques. The network design group have embraced the early adoption of the dynamic (enhanced) rating of primary transformers to assist in their ED1 reinforcement plans as a lower cost solution.

A meeting has been held with Wrexham Borough Council - Climate Change and Carbon Reduction Dept. To discuss and determine a way forward for the iBoost controllers fitted to the council's tenanted properties. We have agreed with them that once the project concludes and the devices become out of warranty, that the council's own maintenance teams will undertake any troubleshooting or repairs to the iBoost functionality. The one removed iBoost unit is being retained as a strategic spare for future use.

The project team are currently identifying a major dissemination event towards the end of 2015 to share the learning and outcomes on conclusion of the project. Further details and invitations will be made available in due course.

The LCNI Conference in Liverpool in late November 2015 will be used as an opportunity for further dissemination. In addition to the formal sessions we are planning a series of short 'soapbox' presentations to take place on our stand.

8. Learning outcomes

Learning points are reviewed by the Flexible Networks project team at regular meetings to establish what was learned from the activities undertaken.

Consideration of customer's lifestyle is an important factor for utilising the iBoost Solar PV to Hot Water controllers. We hadn't fully understood that the benefit of the device's operation needs to fit with the electricity and hot water demand pattern of the customer. Also as part of Work Package 1.2 we have obtained significant new learning from a data analytics trial undertaken in conjunction with IBM.

We encountered some new issues with pole mounted weather stations during the reporting period, including problems with a solar power supply, and distribution line electromagnetic interference with line current/temperature sensor operation. These are further described in Section 2 – Work Package 2.1.

9. Business case update

There is no change from the revised project direction document issued by Ofgem on the 27th October 2014.

Progress against budget

Table 1 below is a summary of the total project budget position from commencement to December 2014. The budget plan refers to the revised budget approved in the October 2014 project direction.

Table 1.

Activity	Budget to Jun 2015 (£k)	Actual to date (£k)	Variance (£k)	Commentary
Labour	1,115	1,070	-45	Labour costs slightly lower than plan due to use of contract resources.
Equipment	1,815	1,978	+163	Additional DTR preparation work required to transformers.
Contractors	1,515	1,667	+153	Contractor costs higher than plan and required to supplement internal labour.
IT	319	277	-42	Some IT costs less than anticipated.
Travel & Expenses	22	22	0	Project exceptional travel has been as expected to date.
Payments, Contingency & Others	356	224	-132	Certain activities have utilised some of their contingency budget to date. Customers have not carried out energy efficiency measures; therefore no payments have been made. PNDC testing work is currently incomplete.
Totals	**5,142**	**5,238**	**+96**	

In line with the funding arrangements, SPD have contributed to costs incurred for a proportion of the expenditure for which they receive a direct benefit, detailed in table 2 below. Costs for the LCN funded element have been transferred from the bank account and a copy of the statement is included in the Appendix.

Table 2.

Activity	SPD Contribution to date (£k)	LCNF costs (£k)	Total / Actual to date (£k)
Labour	398	672	1,070
Equipment	1193	785	1,978

Contractors	602	1065	1,667
IT	92	185	277
Travel & Expenses	7	15	22
Payments, Contingency & Others	118	106	224
Totals	**2,410**	**2,828**	**5,238**

10. Bank account

A copy of the bank statement detailing the transactions of the Project Bank Account since its creation is attached to this report. The figures in the statement relate to the LCN funded costs only and not the total project costs. The total debit from the LCNF bank account is lower than the LCNF element of project costs until the date of the next costs reconciliation. Minor differences in the reconciliation between costs and funding being transferred from the bank account are due to timing of transactions.

11. Intellectual Property Rights (IPR)

The project is not funding the development of any technology which should create foreground IPR. All partners have accepted the LCNF default IPR arrangements. This approach has not changed since the project commenced and we do not anticipate any further changes.

12. Accuracy assurance statement

The Project Manager and Director responsible for the 'LCNF - Flexible Networks Project' confirm they are satisfied that the processes and steps in place for the preparation of this Project Progress Report are sufficiently robust and that the information provided is accurate and complete.

Steps taken to ensure this are:-

- Regular update reports from each project team member for their area of responsibility.

- Evidence of work undertaken by the project team is verified by the section manager as part of their day-to-day activities. This includes;
  - Checking and agreeing project plans.
  - Holding regular team project meetings and setting/agreeing actions.
  - Conducting frequent one-to-one meeting and setting/agreeing actions.
  - Confirming project actions are completed.
  - Approving and signing off completed project documents.
  - Approving project expenditure.

- Weekly reports are produced by each section manager of the progress of the work their department is undertaking.

- Director and Senior Management summary reports for the project progress are produced.

Signature (1): James Yu – Future Networks Manager

Signature (2): Colin Taylor – Engineering Services Director

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ID	Task Name	Duration
1	**Work Packages**	**1006 days**
2	**Work Package 1.1**	**259 days**
3	Design	3 mons
4	Development and Testing	9.9 mons
5	Issue of good practice guide	1 day
6	**Work Package 1.2**	**909 days**
7	**Engineering Design**	**120 days**
8	Test case design methodology	6 mons
9	Functional and Integration specifications	3 mons
10	Installation methodology	6 mons
11	**Monitoring Deployment**	**782 days**
12	Equipment procurement	9.8 mons
13	Installation	6.55 mons
14	Software development	21 mons
15	Procedure development	21 mons
16	Testing and Validation	27.85 mons
17	**Work Package 1.3**	**720 days**
18	Design	180 days
19	**Development and Testing**	**540 days**
20	Software development	16 mons
21	Procedure development	16 mons
22	Testing and Validation	21 mons
23	**Work Package 1.4**	**720 days**
24	Design	120 days
25	**Development and Testing**	**540 days**
26	Software development	12.6 mons
27	Procedure development	12.6 mons
28	Testing and Validation	21 mons
29	**Work Package 2.1**	**897 days**
30	**Engineering Design**	**393 days**
31	Test case design methodology	6 mons
32	Functional and Integration specifications	6 mons
33	Installation methodology	9.75 mons
34	**Technology Deployment**	**579 days**
35	Equipment procurement	11.85 mons
36	Installation	3 mons
37	Testing and Verification	10.5 mons
38	Software development	12 mons
39	Procedure development	12 mons
40	Testing and Validation	14.1 mons
41	**Work Package 2.2**	**988 days**
42	**Engineering Design**	**120 days**
43	Test case design methodology	6 mons
44	Functional and Integration specific	3 mons
45	**Technology Deployment**	**868 days**
46	Equipment procurement	18.7 mons
47	Installation	3.5 mons
48	Testing and Verification	16.7 mons
49	Software development	33.1 mons
50	Procedure development	33.1 mons
51	**Work Package 2.3**	**892 days**
52	**Energy Surveys**	**545 days**
53	Customer engagement	6 mons
54	Energy surveys	12 mons
55	Modelling	21.8 mons
56	**Network trials**	**347 days**
57	Installation	5.45 mons
58	Testing and Verification	11.9 mons
59	**Work Package 2.4**	**1001 days**
60	**Engineering Design**	**344 days**
61	Test case design methodology	6 mons
62	Functional and Integration specific	5.6 mons
63	PNDC test methodology	3 mons
64	**Technology Deployment**	**694 days**
65	Equipment procurement	18.85 mons
66	Installation Ph1	3 mons
67	Installation Ph2	3 mons
68	Testing and Verification Ph1	3 mons
69	Testing and Verification Ph2	3 mons
70	Procedure development	6.85 mons
71	Testing and Validation Ph1	9 mons
72	Testing and Validation Ph2	6.85 mons
73	Work Package 3.1	37.85 mons
74	Work Package 3.2	38 mons
75	Work Package 3.3	23 mons
76	Work Package 3.4	12 mons

Critical	Critical Progress	Split	Manual Task	Finish-only	Baseline	Baseline Milestone	Summary Progress	Manual Summary	External Tasks	Inactive Task	Inactive Summary
Critical Split	Task	Task Progress	Start-only	Duration-only	Baseline Split	Milestone	Summary	Project Summary	External Milestone	Inactive Milestone	Deadline