Future Networks
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Flexible Networks Successful Delivery Reward Criteria (SDRC) Report.

SP ENERGY NETWORKS

Executive Summary

This document constitutes the application by SP Energy Networks for a Successful Delivery Reward Criteria (SDRC) reward for the Flexible Networks for a Low Carbon Future (Flexible Networks) project. SP Energy Networks is applying for the full 100% reward for the Flexible Networks project of £515k.

Flexible Networks for a Low Carbon Future provided network operators with economic, DNO-led solutions to increase and enhance the capability of the networks. These are capable of being quickly implemented and helping to ensure that the networks do not impede the transition to a low carbon future. Learning outcomes from Flexible Networks inform intelligent future network change management. Flexible Networks delivered all six successful delivery reward criteria, providing a robust framework within which to select and deploy one or a number of innovative techniques collaboratively to techno-economically release incremental network headroom. Our success is evidenced by:

- Achieving 20%+ additional capacity headroom at all three network trial sites, St Andrews, Whitchurch and Ruabon, through deployments of innovative techniques, providing a reduction in reinforcement costs of between 70% and 90% and total savings of £8.9M;
- Enabling the connection of a further 38% of low carbon generation customers to connect to the Ruabon network and similar networks under wider rollout, thus supporting the realisation of the UK Carbon Plan;
- Business confidence in wider deployment of these techniques within RIIO-ED1, supported by carefully justified changes to policy, practice and analysis tools delivered through Flexible Networks;
- Supporting the evolution of the industry through provision of recommendations to key industry standards and strong level of interest/engagement from other DNOs in techniques and learning outcomes;
- Delivery to budget and time through best practice project management, subject to change request, whilst maximising value to customers.

Flexible Networks involved the trialling of 4 innovative techniques; Dynamic ratings (primary transformers and OHL), flexible network control, energy efficiency and voltage optimisation. This was supported by enhanced network monitoring from 33kV to LV. Application of Flexible Networks in a holistic manner to the network has demonstrated clear benefits in enabling cost-effective release of incremental capacity headroom – deferring or avoiding costly traditional reinforcement. Already, a substation capital investment in the order of £100k was avoided just 3 months after project completion.

Key learning has been delivered both internally and to all DNOs on transfer from a trialled innovation to Business as Usual. Core to this were the personnel involved in Flexible Networks who have championed it and disseminated to the wider business.

Significantly, SP Energy Networks is the first licensee returning innovation funding through efficiencies in technology, testing and contingency costs. This amounts to a total of approximately £0.75M savings returned to electricity customers.

1 Successful Delivery Reward Criteria

1.1 Summary

The SDRC as contained in the original Flexible Networks bid submitted August 2011 were developed based on overarching project aims and objectives. Achieving the SDRC is indicative of accomplishment of the wider ambitions of the project. SDRC 3, 4 and 5 are specifically based on rewarding on the basis of success in achieving the stated project outputs. Our performance on SDRC is summarised below:

Table 1-1: SDRC performance summary

No.	SDRC		Achieved	Reward Weighting	Evidence
1	Project Budget	Delivered to budget with a variance of less than 5% between WPs.	Yes	20%	- Ongoing cost reporting in six-monthly progress reports - Project change request details - Final costs for each work package
2	Project Milestone Delivery	Delivered in accordance with timelines outlined in the Tier 2 submission and change request.	Yes	20%	- Ongoing project progress reporting in six-monthly progress reports - Project change request details
3	St Andrews Primary Network	20% additional capacity headroom, deferral of traditional reinforcement	Yes	15%	- Reported in “Case Study - Management of Network Capacity St Andrews Trial Area” - Independent verification by University of Strathclyde
4	Whitchurch Primary Network	20% additional capacity headroom, deferral of traditional reinforcement	Yes	15%	- Reported in “Case Study - Management of Network Capacity Whitchurch Trial Area” - Independent verification by University of Strathclyde
5	Ruabon Primary Network	20% additional generation capacity headroom, deferral of traditional reinforcement	Yes	15%	- Reported in “Case Study - Management of Network Capacity Ruabon Trial Area” - Independent verification by University of Strathclyde
6	Engagement, dissemination and adoption	High quality and timely engagement and dissemination Adoption of outputs into core business processes	Yes	15%	- Details of internal and external workshops included formal post-workshop surveys - Adoption of Flexible Networks innovative techniques into business-as-usual for RIIO-ED1 - Requests from other DNOs for information and tools developed as part of Flexible Networks - Details of engagement with customers in each trial area

Performance for each SDRC criteria is evaluated in further detail below with a description of the specific criterion and evidence required as given in “Project Direction – Flexible Networks for a Low Carbon Future, issued by Ofgem and dated 19th December 2011.

1.2 Impact of Change Request

A project change request was submitted in May 2014 and approved in the revised project direction letter dated 27 October 2014.

Key changes requested comprise:

- Revision of total project budget from £6.25M to £5.28M representing a significant return of project funding to customers due to voltage regulator methodology changes, more efficient monitoring costs, PNDC cost revision and reduced contingency costs;
- Change in project completion date to September 2015 due to procurement delays, system development delays and delays in availability of PNDC facility, that were outside of the control of SPEN;
- Change to methodology for installation of 11kV automatic voltage regulators resulting in installation within the St Andrews primary network only, additional learning was gained from the installation and operation of an 11kV automatic voltage regulator in Ruthin, Wales.

This has not resulted in any impacts to the key learning outcomes provided to other DNOs, or value to customers.

1.3 SDRC 1 - Project Budget

1.3.1 Criterion

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.

1.3.2 Performance

Flexible Networks was successfully delivered to budget with a variance of 5% or less between work packages.

The original project budget was superseded with a revised budget submitted to Ofgem as part of the project Change Request and approved in October 2014. This amounted to a reduction of approximately £0.75M of LCNF funding which was returned to customers. Performance against successful delivery reward criteria was evaluated for the revised budget.

Specific performance against budget is detailed in Section 2, showing the revised approved budget, outturn costs and variance against each cost category and work package. It confirms that expenditure was generally in line, with the total project budget at 99% spend.

1.3.3 Evidence

We provided details of on-going progress against budget within each six-monthly progress report including variances for each cost activity.

Section 7 of the Flexible Networks Closedown Report also assesses final outturn project budget, detailing total costs incurred per work package and for each cost activity along with justification and evidence for any variances. This is included and reported further in Section 2 of this report.

1.4 SDRC 2 - Project Milestone Delivery

1.4.1 Criterion

The project will be delivered in accordance with 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 the overall project budget as per criterion 1 will demonstrate effective project management.

1.4.2 Performance

Flexible Networks was delivered in accordance with timelines outlined in the Tier 2 submission.

Work packages were delivered in line with the dates in the Full Submission and the change request.

A number of the elements of the project have been built into the ED1 business plan. It is envisaged that during the period 2015-2023, most of the Flexible Networks techniques and supporting analysis tools that have been developed will be available to use as an alternative to existing practices for suitable network situations.

This is evidenced by the following developments:

- Adoption of the enhanced load forecasting and risk characterisation tool;
- More detailed monitoring of secondary networks – informed RIIO-ED1 LCT Network Monitoring Strategy;
- Production of policy and practice guides to facilitate adoption of 11kV voltage regulators into business as usual as detailed in Methodology and Learning Report WP2.4 Integration of Voltage Regulators;
- Enhanced transformer ratings will be applied to 10 primary networks reaching capacity over the RIIO-ED1 period (this technique is detailed in Methodology and Learning Report WP2.1 Dynamic Thermal Rating of Assets – Primary Transformers);
- Flexible network control (as described in Methodology and Learning Report WP2.2 Flexible Network Control) in will be applied to a number of primary networks reaching capacity over the RIIO-ED1 period, one network has already been identified and other networks are being actively reviewed;
- The business is moving towards adoption of a lower voltage set point at primary substations (this technique is detailed in Methodology and Learning Report WP2.3 Voltage Optimisation Methodology) which will enable larger volumes of generation to connect.

1.4.3 Evidence

Ongoing project reporting was provided to Ofgem formally in six monthly project progress reports which identified how well the project was being delivered in accordance with timelines set out in the original bid and change request.

1.5 SDRC 3 - St Andrews

1.6 Criterion

Successful delivery reward criteria for the St Andrews primary network are as follows:

- Creation of a flexible network and 20% headroom increase;
- Network monitoring to improve knowledge of the network and provide robust evidence of the benefits of the physical solutions;
- Flexible network control, dynamic asset rating and voltage regulators to provide additional back-feed capability such that the existing substation and OHL reinforcements can be deferred or avoided.

1.7 Performance

Flexible Networks achieved 20% capacity headroom increase at St Andrews through flexible network control, dynamic asset rating and voltage regulators allowing existing substation and OHL reinforcements to be deferred or avoided.

Growing load requests in St Andrews were a significant area of concern in East Fife along with the lack of capacity available in the 33kV distribution circuits at the Cupar grid supply point. This drove 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.

The baseline load capacity headroom for St Andrews is 0.6MVA which is 3% of the existing network load capacity (baselined to 2009/10 prior to bid submission) detailed in the Network Capacity Headroom Positioning Paper. The primary limiting network capacity parameters are the summer rating of the 33kV circuit conductors connecting St Andrews primary substation to Cupar grid substation and the thermal rating of the primary transformers. Voltage drop during load transfer to Cupar, Leuchars or Ansthruther 11kV networks under N-1 conditions also limits existing capacity. The identification of additional network capacity headroom allows the deferral of reinforcement and enables further time to confirm the materialisation of growth.

Flexible network control (further enabled by a voltage regulator), enhanced transformer asset ratings and dynamic overhead line ratings were successfully applied to identify additional capacity headroom such that the existing substation and OHL reinforcements can be deferred. An increase in demand capacity of 20% was achieved and the LTDS updated accordingly.

The capacity provided by the individual technologies trialled is as follows:

- Flexible network control – 6%
- Enhanced transformer thermal rating – 14%
- Voltage regulator – enabler of flexible network control

Detailed network monitoring installed on the St Andrews network was used to calculate and verify the benefits. Stated benefits were verified by Flexible Networks partner University of Strathclyde [1].

1.7.1 Evidence

Evidence provided for achievement of benefits for St Andrews is contained in "Case Study - Management of Network Capacity St Andrews Trial Area" and is as follows:

- 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;
- Evidence detailing how a 20% headroom has been achieved along with details of the methodology.

In addition, there is:

- Supporting verification from the University of Strathclyde;
- Comparative analysis of traditional reinforcement solution to demonstrate magnitude of the savings in "Case Study - Management of Network Capacity St Andrews Trial Area";
- Work was undertaken within the permitted CI/CML allowance with no health, safety or environmental incidents as reported in the six-monthly progress reports.

1.8 SDRC 4 - Whitchurch

1.8.1 Criterion

Successful delivery reward criteria for Whitchurch are as follows:

- Creation of a flexible network and 20% headroom increase;
- Network monitoring to improve knowledge of the network and provide robust evidence of the benefits of the physical solutions;
- Flexible network control, dynamic asset rating and voltage regulators to provide additional back-feed capability such that the existing substation and OHL reinforcements can be deferred or avoided.

1.8.2 Performance

Flexible Networks achieved >20% capacity headroom increase at Whitchurch through flexible network control and dynamic asset rating allowing existing network reinforcements to be deferred or avoided.

Several enquiries were made in 2010/2011 regarding the connection of additional demand in this area of network over the next 3 years. This would have triggered significant local network reinforcement based on historical and existing underlying peak loads. A cascade effect on the rest of the network would also have required higher voltage levels to 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 limit of P2/6 compliance, hence the desire to seek cost effective incremental capacity.

The baseline load capacity headroom for the Whitchurch network group is less than 1% for new load connections at Whitchurch Business Park, the main load centre (baselined to 2009/10 prior to bid submission) detailed in the Network Capacity Headroom Positioning Paper. This limitation is due to the thermal rating of the local 11kV circuits.

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. The identification of additional network capacity headroom will allow deferral of reinforcement and enable further time to confirm the materialisation of growth.

Flexible network control and enhanced transformer asset rating were successfully applied to identify additional capacity headroom such that Whitchurch 11kV network group and wider 33kV network reinforcements can be deferred. An increase in demand capacity of 21% was achieved. The LTDS is being updated accordingly with the 10% demand capacity improvement achieved through the deployment of enhanced transformer ratings. A further 11% demand capacity improvement will be reflected in the LTDS once flexible network control is deployed when required in the future.

The capacity provided by the individual technologies trialled is as follows:

- Flexible network control – 11%
- Enhanced transformer thermal rating – 10%

Detailed network monitoring installed on the Whitchurch network group was used to calculate and verify the benefits. Stated benefits were verified by Flexible Networks partner University of Strathclyde [1].

1.8.3 Evidence

Evidence provided for achievement of benefits for Whitchurch are contained in "Case Study - Management of Network Capacity Whitchurch Trial Area" and are as follows:

- Business case paper detailing the full basis, costs and benefits of the installed Flexible Network solution sufficient for SPEN to defer or avoid the business as usual reinforcement;

- Evidence detailing how a 21% headroom has been achieved along with details of the methodology.

In addition, there is:

- Supporting verification from the University of Strathclyde;
- Comparative analysis of traditional reinforcement solution to demonstrate magnitude of the savings in "Case Study - Management of Network Capacity Whitchurch Trial Area";
- Work was undertaken within the permitted CI/CML allowance with no health, safety or environmental incidents as reported in the six-monthly progress reports.

1.9 SDRC 5 - Ruabon

1.9.1 Criterion

Successful delivery reward criteria for Ruabon are as follows:

- Cascade monitoring to improve knowledge of the network and provide robust evidence of the benefits of the physical solutions,
- Allowing further PV connections without significant reinforcement as was originally envisaged.

1.9.2 Performance

Flexible Networks achieved more than a 20% increase in generation capacity headroom (microgeneration volumes) at Ruabon through enhanced monitoring and improved characterisation of network and customer behaviour, allowing existing network reinforcements to be deferred or avoided.

The Ruabon distribution network is primarily residential, and many of the domestic properties are council-owned. The combination of managing a large housing stock and having social responsibilities in terms of fuel poverty and environmental sustainability has led the local council to take a proactive approach in the management of their tenants energy use. As part of their strategy, the council has installed solar PV on the roofs of many of their properties. This has led to the connection of large "clusters" of PV installations to the local distribution network, sufficient to cause significant voltage rise and therefore potentially affecting the power quality of other, non-PV connected, customers. Restrictions were placed on the amount of PV generation that could be accepted on to each of the LV distributors until the impact could be further understood. The existing generation capacity headroom available in the Ruabon network is limited by the upper voltage statutory limit at LV being exceeded under reverse power flow conditions. Analysis of the baseline generation headroom capacity using existing business as usual techniques indicated that there was no generation capacity available on the Ruabon network as detailed in in the Network Capacity Headroom Positioning Paper.

Based on the detailed secondary substation and LV feeder monitoring data, and development and validation of modelling techniques to improve characterisation of the impact of PV on the LV network, an increase in generation capacity headroom of 38% was achieved. The application of network voltage optimisation (reduced system voltage) will allow further significant PV generation volumes (typically 90% for a 2% voltage reduction) to connect. Stated benefits were verified by Flexible Networks partner University of Strathclyde [1].

Key rules-of-thumb derived from this approach will be applied to assess the impact of PV uptake on LV networks in future and trigger deployment of monitoring at an appropriate time.

1.9.3 Evidence

Evidence provided for achievement of benefits for Ruabon are contained in "Case Study - Management of Network Capacity Ruabon Trial Area" and are as follows:

- 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 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 and a comparative analysis with the volume of microgeneration which could be connected pre-project. Further evidence of new microgeneration connections in Ruabon is provided in Annex B.

In addition, there is:

- Supporting verification from the University of Strathclyde;
- Comparative analysis of traditional reinforcement solution to demonstrate magnitude of the savings in "Case Study - Management of Network Capacity Ruabon Trial Area";
- Work was undertaken within the permitted CI/CML allowance with no health, safety or environmental incidents as reported in the six-monthly progress reports.

1.10 SDRC 6 - Engagement, Dissemination and Adoption

1.10.1 Criterion

Internal and external stakeholder engagement and dissemination activities were delivered within Work Package 3.

Successful delivery reward criteria are as follows:

- High quality and timely engagement and dissemination with the internal and external stakeholders.
- Adoption or incorporation of 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.

1.10.2 Performance

Flexible Networks was successful in engaging with internal and external stakeholders to achieve adoption into business as usual and disseminate learning outcomes to other DNOs.

A number of internal and external stakeholder engagement activities were held throughout the course of the project and are summarised below.

1.10.3 Internal Stakeholder Engagement

A number of internal stakeholder engagement workshops and events were held throughout the course of the project including:

- As reported in Project Progress Report June 2012, early workshops were held with the Design Teams and Operations in March 2012 to support development of scope for analysis tools to improve network planning and operations. A number of smaller workshops were held with key internal stakeholders from Design and Operations as the analysis tools were developed to ensure future user input;
- As reported in Project Progress Report December 2012, two internal innovation conferences were held for over 100 staff in both SPD (5th September 2012) & SPM (11th September 2012), where staff across the whole SP Energy Networks businesses learnt of various internal innovation initiatives and about the LCNF projects ongoing in other DNOs;
- Internal business champions were established at manager level to ensure staff engagement and adoption of successful technology roll-out as reported in Project Progress Report June 2013;
- In Project Progress Report June 2014, it was reported that meetings and workshops had 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;
- A number of elements of the project were adopted into ED1 proposals as reported in detail in the Flexible Networks Closedown Report. 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 dynamic rating of some primary transformers;
- Two workshops were held in January 2015 with the Design Teams and two workshops were held in March 2015 with Operations sections to progress the Flexible Networks techniques into business as usual as reported in Project Progress Report June 2015. A further internal workshop and site visit was undertaken in August 2015 for Engineering Standards, and Planning & Regulation staff;

- Publication of an internal Flexible Networks 'Narrative' document as an easily accessible overview of the scope of the project and its deliverables in September 2015.

Team briefings and internal document circulation also supported raising staff understanding of the Flexible Networks project and its aims and objectives.

1.10.4 External Stakeholder Engagement

The following activities were completed to foster engagement with external stakeholders, seek feedback on project direction, early results and disseminate learning outcomes:

- Project website established to provide overview of project in April 2012;
- As reported in Project Progress Report June 2012, presentations were made at:
    - Smart Grid GB LCNF Overview (London, 20th March 2012); and
    - Smi Conference also in (London, 9th May 2012).
- First dissemination event held at PNDC in October 2013 including a formal post-workshop survey as reported in Project Progress Report December 2013, detailed responses from the event Q&A session and audience feedback are provided in Annex C;
- The Scottish Power 'Flexible Networks' Project together with ENW's 'Smart Street' featured in a series of presentations at an IET event on Smart Grids, held in the Manchester Conference Centre in April 2015;
- Project activities were also presented to the Energy Technology Partnership (ETP) in Dundee, Scotland, April 2013 where the project learning to date and future adoption plans were discussed;
- Dissemination to other DNOs and the wider industry at all LCNI Conferences from 2012 to 2015 via exhibition stands and presentations;
- Four technical papers were presented at the CIRED Annual Conference in 2015. These comprised:
    - 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, this should be publically available in June 2016;
- Meetings were held with Wrexham Borough Council at the commencement of the project as reported in the Project Progress Report June 2012;
- Meetings were held with Shropshire Business Enterprise;
- Final dissemination event in October 2015 in London with key industry stakeholders in attendance. This included a detailed workshop survey and Q&A with results included in Annex C.

These are detailed further in Table C.1 in Annex C and Section 11 of the Flexible Networks Closedown Report.

1.10.5 Evidence

Evidence provided for engagement, dissemination and adoption SDRC are as follows:

- External workshops included formal post-workshop surveys to effectively score the success of the learning, as summarised in Annex C. Surveys included points on whether there was sufficient high level information to understand the project context, as well as detailed information on the solution design, data/information gathered and shared, wider applicability, challenges for integration into BAU and how the acceptance process within SP Energy Networks progressed;
- Adoption of Flexible Networks innovative techniques into business-as-usual for RIIO-ED1;
- Requests from other DNOs (UK Power Networks, Electricity North West, Scottish and Southern Energy, Aston University) for information and tools developed as part of Flexible Networks;
- An informal survey 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. Due to the limited number of affected stakeholders in each trial area e.g. local councils and large industrial and commercial customers (on energy efficiency measures) this was achieved through one-to-one meetings and email communications (as evidenced in Table C.1, Annex C and in Methodology and Learning Report: Work Package 2.3 Energy Efficiency);
- Further milestones which demonstrated this success are:
  - Project website established to provide overview of project in April 2012;
  - Several formal dissemination events to disseminate outcomes.
  - Presentation of learning outcomes at key industry conferences and workshops.

2 Cost Effectiveness

The total approved project budget was £5.28M as set out in the revised project direction letter dated 27 October 2014. This was revised in 2014 during a change request when it became apparent that the total SPEN and LCNF contributions of £6.25M would not be needed (Low Carbon Networks Fund – amendments to Flexible Networks for a Low Carbon Future Project). The revised budget amount represented a significant return of LCN funding to customers which was identified at that stage in the project. At completion of the project a further small underspend of £67k across the overall project was realised as reported in the Flexible Networks Closedown Report.

The SDRC Application Guidance requests explanation of any variance of expenditure in excess of 5% at project budget line level. Table 2-1 shows the revised approved budget, outturn costs and variance against each cost category. The original submission budget is also shown for reference. It identifies that expenditure was generally in line with the total project budget at 99% spend. Reasons for variance > 5% and process for deriving an efficient cost are explained in the commentary below.

Category	Original Submission budget	Change request Approved budget	Project Outturn Costs	Variation %
Labour	**2049**	**1,203**	**1,129**	94%
Project managment	479	452	379	84%
Internal stakeholder engagement	65	44	44	100%
Installation and maintenance	456	40	51	128%
Internal engineering days	1049	668	655	98%
Equipment	**2007**	**1,815**	**1,948**	107%
WP 1.2 Monitoring Equipment (Whitchurch)	326	284	264	93%
WP 1.2 Monitoring Comms (Whitchurch)	38	40	40	100%
WP 1.2 Monitoring Equipment (St Andrews)	499	551	571	103%
WP 1.2 Monitoring Comms (St Andrews)	59	42	42	100%
WP 1.2 Monitoring Equipment (Ruabon)	189	234	227	97%
WP 1.2 Monitoring Comms (Ruabon)	22	32	32	100%
WP 2.1 Dynamic rating equip. (Whitchurch)	70	15	16	107%
WP 2.1 Dynamic rating equip. (St Andrews)	155	90	203	226%
WP 2.2 Control equip. (St Andrews)	194	334	363	109%
WP 2.1 Dynamic rating equip. (Ruabon)	70	5	10	198%
WP 2.2 Control equip. (Whitchurch)	146	59	53	90%
WP 2.4 11kV Voltage Regulators	240	128	128	100%
Contractors	**1105**	**1,533**	**1,556**	102%
TNEI days	147	291	297	102%
Internal Engineering days	94	148	145	98%
University assistance	318	380	372	98%
Other contractors	474	680	697	103%
Legal & Procurement	102	34	45	132%
IT	**319**	**319**	**292**	91%
System development / Network control functionality	125	125	128	103%
Software licences and contractor days	44	44	14	32%
IT upgrades and incorporation of equipment technology	150	150	149	99%
IPR costs	0	0	0	
Travel and Expenses	**44**	**22**	**21**	97%
Travel expenses	44	22	21	97%
Payments to users	**100**	**100**	**-**	0%
WP 2.3 Energy efficiency	100	100	0	0%
Contingency	**303**	**223**	**152**	68%
Whitchurch	64	21	0	0%
Ruabon	31	26	0	0%
St Andrews	100	84	84	100%
TNEI days	4	4	4	100%
Internal engineering days	20	20	20	100%
Contractors	34	34	34	100%
IT	14	14	4	33%
Legal & Procurement	5	5	5	100%
Payments to users, maintenance, faults and decommissioning	8	8	0	0%
11kV Voltage Regulators	24	8	0	0%
Decommissioning	**45**	**33**	**30**	90%
WP 1.2 decommissioning days (secondary s/stn monitors)	45	33	30	90%
Other	**278**	**37**	**91**	247%
Work at PNDC and other lab work	224	37	91	247%
Interuptions	54	0	0	
Totals	6,279	**5,284**	**5,218**	99%

2.1 Cost Efficiencies

Please note that this is referenced to the change request budget.

Table 2-1: Summary of cost effectiveness

Line Item	Budget Cost (£k)	Actual Cost (£k)	Variance (%)	Savings (£k)	How Savings were achieved	Savings Type
Labour - Project Management	452	379	84%	73	Effective project management meant that less man-hours were needed than anticipated which enabled a reduction.	Project Management Efficiency
IT - Software licenses and contractor days	44	14	32%	30	Detailed analysis and development of the strategy for business-as-usual integration identified that purchase/integration of a "dynamic" software package for transformers was not required as originally envisaged. Also, PowerOn development work costs were to some degree included within other development work ongoing.	Project Delivery Efficiency
Payment to Users	100	0	0%	100	This was for subsidies for energy efficiency equipment as necessary. Despite consultations with numerous customers, none of the identified efficiency measures were carried out and therefore no payments were made for this allocation.	n/a
Contingency – Whitchurch	21	0	0%	21	The contingency amount for this trial area was not required.	Project Management

Line Item	Budget Cost (£k)	Actual Cost (£k)	Variance (%)	Savings (£k)	How Savings were achieved	Savings Type
						Efficiency
Contingency - Ruabon	26	0	0%	26	The contingency amount for this trial area was not required.	Project Management Efficiency
Contingency - IT	14	4	33%	10	Only £4k was required for data hosting costs.	Project Delivery Efficiency
Contingency - Payments to Users, Maintenance/Faults and decommissioning	8	0	100%	8	The contingency amount was not required.	Project Management Efficiency
Contingency - 11kV Voltage regulators	8	0	100%	8	The contingency amount was not required.	Project Management Efficiency

2.2 Variance of Budget

Please note that this is referenced to the project change request budget.

2.2.1 Labour

Installation and Maintenance - Variance 128% (Overspent by £11k)
The original amount for this labour element was £456k and was reduced to £40k in the change request for several reasons, mainly due to the reduced installation costs of monitor installations and the omission of the voltage regulators in Wrexham and Whitchurch sites. However after it was reduced in the change request, some of the remaining installation work were more difficult and took longer than expected.

2.2.2 Equipment

WP 2.1 Dynamic Rating Equipment (St Andrews) – Variance 226% (Overspent by £113k)
The original amount for this element was £155k and was reduced to £90k in the change request. When the transformers were condition assessed for enhanced rating duty, the cooling banks at St Andrews primary required improvement which was a significant additional cost.

2.2.3 Contractors

Legal & procurement – Variance 132% (Overspent by £11k)
The original amount for this element was £102k and was reduced to £34k in the change request, because at the time most of the legal matters of collaboration agreements etc. had been concluded. However some extended legal negotiations with landowners over the consents for the voltage regulators required additional legal work.

2.2.4 Other

Work at PNDC and other Lab work – Variance 247% (Overspent by £54k)
The original amount for this element was £224k and was reduced to £37k in the change request, because at the time the schedule of tests had not been completed and the amount allocated was based on a generic testing example. When the detailed testing programme was compiled this required considerably more work and the revised cost reflected this.

2.3 Procurement Process

SP Energy Networks procurement must comply with EU Utilities Directive 2004/17/EC. Typically procurement follows defined sequential steps from pre-qualification through to contract award. This ensures robust governance and value for money for the customer.

The procurement of secondary substation monitoring is described in detail in "Detailed Network Monitoring Methodology and Learning Report" and is summarised below. In order to maximise both cost efficiency and learning outcomes, three different devices were selected to satisfy various scenarios for installation and measurement types. A key consideration was the relative cost between the cost of the monitoring equipment itself, and the cost of installation. The balance between the costs of the devices and their installation/removal was at a point where it made sense to install them for a period to capture the load and voltage profiles of a particular area of network and then once that was complete to move them to another site which had issues of changing customer demands. This has provided key learning outcomes for efficient specification and procurement of future network monitoring which should maximise value for customers. Monitoring communications were procured through a competitive approach.

Flexible network control equipment and enhanced transformer thermal rating analysis and monitoring were procured through a competitive process with multiple suppliers. For flexible network control equipment, there were only two companies who could provide the required devices so it should be noted that the existing supply chain is limited. For overhead line dynamic thermal ratings, it was most efficient to utilise the system that was previously developed and trialled in North Wales for a SP Energy Networks innovation project. This best facilitated future integration into network planning and operation.

The procurement of automatic voltage regulators was undertaken through a single supplier as only one supplier is approved in the UK currently.

The procurement of innovative technology was generally found to take longer than expected compared to standard plant and services and provided some learning points that were applied to future innovation projects.

2.4 Contingency Budget Use

SP Energy Networks applied robust project management techniques and processes to Flexible Networks. The requirement and justification for contingency cost use was identified initially through regular meetings in which project budget, programme, progress and risks were regularly reviewed for individual work packages. This was then discussed and agreed with the project managers and relevant team members. Use of contingency budget was monitored closely to ensure no exceedances.

Details of the contingency budget elements that were not utilised are described in Table 2-1, demonstrating cost effectiveness achieved through project management efficiencies. It should also be noted that the contingency budget was reduced significantly in the project change request from £303k to £223k, by £80k.

2.4.1 St Andrews

The total contingency amount was £84k of which 100% was spent. This was primarily towards the condition improvement to the St Andrews transformers to enable them to be enhanced thermally rated.

2.4.2 TNEI

The total contingency amount was £4k of which 100% was spent. TNEI provided additional support to SP Energy Networks on finalising work package reporting. The value of this was justified through their extensive involvement and knowledge of all work packages. The need for this was identified in early 2015.

2.4.3 Internal Engineering Days

The total contingency amount was £20k of which 100% was spent. This was due to the extended involvement of project staff on closedown and dissemination activities.

2.4.4 Contractors

The total contingency amount was £34k of which 100% was spent. This was due to a mixture of elements which included additional contractor support days for the voltage regulator trial, the support for the flexible network control system and additional support for the data analysis work.

2.4.5 Legal and Procurement

The total contingency amount was £5k of which 100% was spent. This was due to some extended legal negotiations with landowners over the consents for the voltage regulators required additional legal work.

3 Project Management

3.1 Project Management Arrangements

A robust and comprehensive approach to project management and governance was applied to this project in order to ensure success of delivery and effective knowledge dissemination. A dedicated and experienced project manager was responsible for overall project delivery and coordination of multiple internal and external stakeholders and delivery consultants who shared a common objective combined with individual expectations and opinions.

Two delivery managers with regional responsibilities reported directly to the project manager. One delivery manager was responsible for delivery of trials for St Andrews and PNDC testing, the second delivery manager was responsible for delivery of trials for Wrexham and Whitchurch. Delivery managers were responsible for day to day management planning and execution of the project including cost control and maintenance of the risk register. A dedicated design resource and regulatory support were also closely involved with bid development and subsequently project delivery.

The executive sponsor and project governance board were ultimately responsible for delivery of the project. The project governance board consisted of:

- Executive sponsor
- Project manager
- TNEI Services Limited
- University of Strathclyde
- Project delivery managers

The role of the governance board was to provide oversight and strategic guidance to the project and to ensure appropriate action was taken to rectify any issue that arose, meeting on a bi-monthly basis.

The executive sponsor provided frequent review on a monthly basis:

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

All key roles described above were internally resourced within SP Energy Networks ensuring strong understanding of technical, commercial and regulatory aspects relating specifically to SPD and SPM. Most of these personnel were closely involved with bid development providing continuity and strong commitment to project success.

The project governance board and key roles were formalised following notification of project award from Ofgem in November 2011, as per the bid submission Section 6.

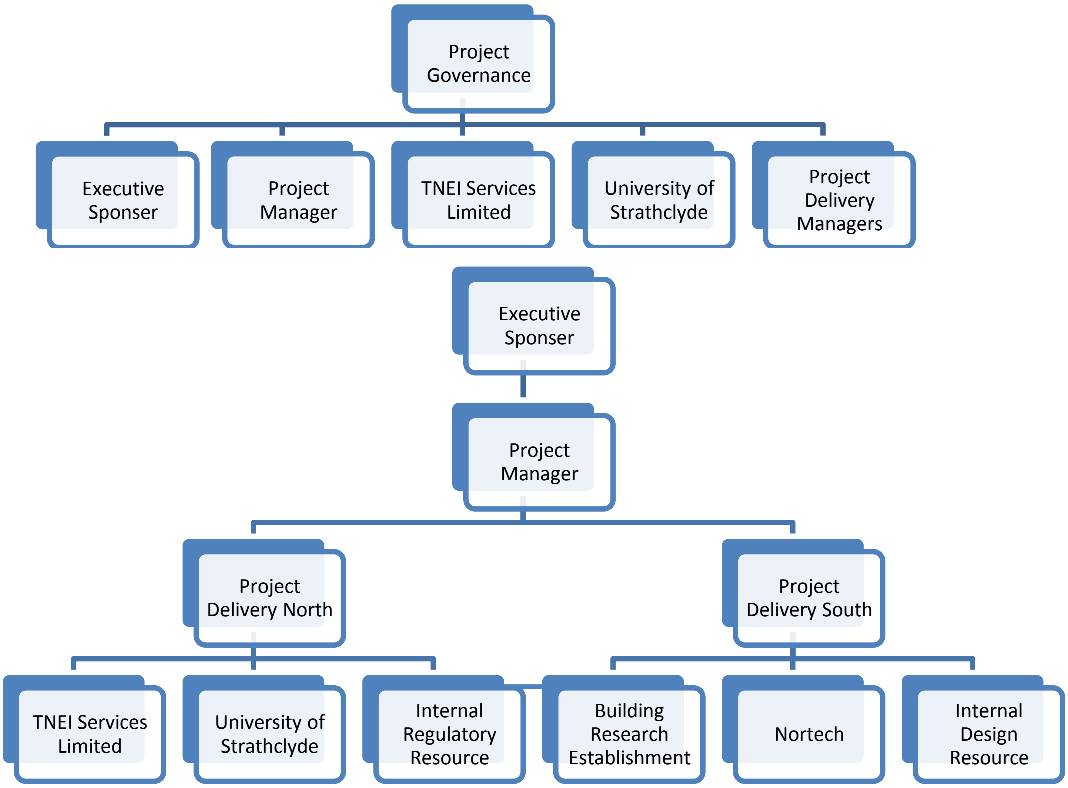


Figure 3-1 Flexible Networks Governance and Delivery

3.2 Project Management Approach

The project manager utilised a number of best practice project management principles and techniques used internally within SP Energy Networks. Core project management activities included:

- Management and update of project programme plan including;
    - Integration of regular update reports from each project team member for their area of responsibility;
    - Assessing wider impacts on project programme and critical milestones and putting in place appropriate measures to manage;
- Coordination of internal and external stakeholder engagement including
    - chairing of regular monthly team project meetings including setting/agreeing actions and confirming that actions are completed.
    - leading of regular one-to-one project meetings including setting/agreeing actions and confirming that actions are completed;
- Cost control through management of individual project activity budgets with delivery managers and project partners, coordination with project programme and approval of expenditure;

- Quality assurance through development and implementation of a detailed quality assurance plan that included approval and sign-off of completed project documents and tools and verification of project benefits;
- Management of risks through maintenance of risk register on a frequent basis, escalating risks with the executive sponsor and project governance board when being realised, agreeing and implementing mitigations, reviewing success of mitigations and assessing and managing wider impacts on project programme and budget;
- Coordination with project governance board and executive sponsor on project progress, risks and mitigating actions.

Outturn costs are detailed in the Section 2. The approach to project management ensured pre-emptive identification of risks, and implementation of appropriate and measured interventions as evidenced in the six-month progress reports. These reports were all provided on time and accepted by Ofgem, and also included details of risk management identification/actions as referenced above.

3.3 Management of Change and Risk

Best practice project management techniques were applied during the delivery of the project to manage risks and respond with mitigating actions to maximise value for customers.

3.3.1 Risk Register

A detailed risk register was prepared for the project in order to identify and manage risks, with appropriate mitigations and contingency plans prepared. This was 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 provided guidance for the management of contingency costs associated with each work package.

3.3.2 Project Programme

A detailed project plan was prepared with indication of key tasks and the critical path. The critical path was focussed on the development of functional specifications, procurement and installation of substation monitoring installation as these provide the network benchmark for quantifying energy savings of innovative techniques trialled. The project programme was updated regularly throughout the course of the project, adapting to any realisation of risks and mitigations and provided to Ofgem in the six monthly progress reports.

3.3.3 Risk Management

During the course of the project, the following key risks were realised as presented in Table 3-1. These were flagged and reported in the six-monthly project progress reports for Flexible Networks. Ongoing risk monitoring and pre-emptive identification enabled implementation of contingency plans to minimise the impact on the project learning outcomes and thus value to customers.

The solution developed and the methods trialled in the project remained consistent with those set out in the full submission. The realisation of these risks has not resulted in any impacts to the successful delivery reward criteria or most importantly, key learning outcomes provided to other DNOs and value to customers.

Table 3-1: Risk management summary

No.	WP	Risk description	Risk Identification	Contingency Plan	Opportunities/Lessons Learnt
2	1.2	There is a risk that procurement timescales could lengthen if monitoring equipment is not readily available.	Delays in procurement of monitoring were identified in the Project Progress Report December 2012 and reiterated in Project Progress Report December 2013. Due to the complexities associated with procuring innovative technology, procurement took 3 months longer than expected. The key risk was that this could potentially reduce the quantity of data collected and thus quality of analysis of trial benefits for a project completion date of December 2014.	A change request was submitted to extend the project completion date to September 2015, thus ensuring maximum value for customers. It was also possible to reduce the monitoring installation program from 6 months to 3 months however the original procurement delay meant that the late delivery of the new network data impacted on the progress of some other elements of the project, e.g. the voltage regulator deployment analysis. This was reported in Project Progress Report June 2014.	Completion of full procurement exercises for monitoring equipment ensured correct governance and best value. However, due to the complexities associated with procuring innovative technology, procurement typically took three months longer than expected. One practical measure that will be applied in future to reduce procurement timescales is to issue technical requirements specifications to suppliers ahead of the full tender documentation to allow suppliers more time to address technical requirements.
13	2.2	It may not be possible to achieve the expected energy efficiency savings or there may be a lack of customer uptake.	Insufficient uptake in energy efficiency measures by customers was identified in Project Progress Report December 2013 although significant mitigatory effort was put into focussed customer engagement and site surveys.	Energy Suppliers were involved as a contingency measure to further the opportunity to engage with customers on energy efficiency as reported in Project Progress Report June 2014. A small capacity gain was achieved through the energy efficiency work package however not the 2% anticipated. Shortfall was mitigated with additional gains from other work packages. Whilst energy efficiency has not proved to be as beneficial as anticipated, we believe that it may still have potential, perhaps through a different delivery model.	If undertaking the project today, based on the learning outcomes of this project, a different approach would be recommended that takes advantage of emerging programmes which includes the Energy Saving Opportunity Scheme and DECC's Electricity Demand Reduction pilot. A cooperative approach that allowed all those parties that benefit from energy efficiency improvements and peak load reduction to contribute to the initial capital cost of the interventions would be the ideal scenario.
15b	2.4	Trial sites may not be suitable for the deployment of Automatic Voltage regulators (AVR).	Detailed analysis of enhanced network monitoring data indicated that there was no requirement to install voltage regulators to facilitate flexible network control within Whitchurch and Ruabon trial networks. This	New generation connections with AVR installations were used to capture learning on the design, specification and engineering for the equipment. A voltage regulator was installed in the test	Whilst this trial focussed on the use of AVRs to facilitate flexible network control, increased assessment of AVRs for generation connections due to deployment of the contingency plan provided additional benefits for application of

No.	WP	Risk description	Risk Identification	Contingency Plan	Opportunities/Lessons Learnt
			may be due in part to the highly interconnected nature of the legacy Manweb network. Therefore there was no compelling reason or opportunity to deploy voltage regulators at these two sites. Identification of this was delayed due to delays in procurement and delivery of monitoring equipment and thus installation and analysis of network data. However detailed analysis and assessment of secondary substation monitoring data available This risk was added to the risk register in Project Progress Report December 2013.	network at the Power Network Demonstration Centre (PNDC) which was funded as part of the establishment of the PNDC. This was utilise to evaluate the performance of the regulator through a range of test scenarios that wouldn't be possible to carry out on a DNO network. This ensured that there was no impact on key learning outcomes for this work package.	AVRs to generation connections to reduce the extent of voltage rise. This will support the connection of generation projects without the need for network upgrades. Also, since voltage regulators were not required to facilitate flexible network control on the Wrexham and Whitchurch networks, this had no effect on the overall project target of creating 20% capacity headroom in each of the trial networks. This led to a cost reduction due to the omission of the two regulator installations, providing value for money to customers.
15c	1.2	Lack of availability of new enhanced network monitoring data to inform and develop other work packages.	Delays in procurement of monitoring were identified in the Project Progress Report December 2012 and reiterated in Project Progress Report December 2013. This specific risk was added to the risk register in Project Progress Report December 2013. Installation of monitoring was identified as being on the critical path in the original Flexible Networks bid project programme.	The monitoring installation program was sped up to enable the rapid delivery of new network data as described above in Risk 2 Contingency Plan. Also, advance preparation work for other work packages reliant on new network data was undertaken. Early data analysis was carried out as soon as feasibly possible, to steer the direction of the other work packages.	The late delivery of the monitoring installation work package did impact other work packages, primarily WP 2.4 as indicated above in Risk 15b. However, the team was able to continue to develop the outputs for all work packages, focussing on the elements that were not contingent on the monitoring data, ensuring that any impact on the project programme was mitigated were possible. A key learning outcome is to continue to ensure for future innovation projects, there is some decoupling of the critical path i.e. not all project activities are coupled to the critical path.
15d	General	There is a risk of delays for procurement of new technology products	Some delays were encountered for procurement of new technology products due to the need for the specification to be developed collaboratively with the supplier rather than the traditional procurement tender process. This specific risk was added to the risk register in Project Progress Report December 2013.	A collaborative approach to developing the tender specification was used however, this impacted the project programme.	A key learning outcome from realisation of this risk is that collaboration agreements could be used in future for new technology products. Also, the use of prototype equipment in test case trials before committing to contract would be a preferred strategy.

3.3.4 Project Change Request

During the course of the project, it was necessary to submit a change request for extension of the project completion date and restructuring of the budget to enable the project to deliver its objectives at the required level of quality within the original funding. The solution developed and the methods trialled in the project remained consistent with those set out in the full submission. This has not resulted in any impacts to the key learning outcomes provided to other DNOs, or value to customers.

The change request was driven by the realisation of risks relating to:

- Reduced scale of voltage regulator trials;
- Insufficient uptake in energy efficiency measures by customers;
- Delays in procurement and delivery of monitoring equipment.

Details of these risks, the contingency plans deployed and opportunities and key learning outcomes are described above in Table 3-1. These risks were flagged and closely monitored as soon as they started to become realised from towards the end of 2012. Robust mitigation measures were included within the project delivery and contingency plans were deployed as soon as risks were flagged.

The project change request comprised:

- Revision of total project budget from £6.25M to £5.28M representing a significant return of LCN funding to customers due to voltage regulator methodology changes, more efficient monitoring costs, PNDC cost revision and reduced contingency costs;
- Change in project completion date to September 2015 due to procurement delays, system development delays and delays in availability of PNDC facility, that were generally outside of the control of the project team;
- Change to methodology for installation of 11kV automatic voltage regulators resulting in installation within the St Andrews primary network only, additional learning that will be gained from the installation and operation of an 11kV Automatic Voltage Regulator in Ruthin, Wales.

Intention to raise a change request was stated in the Project Progress Report December 2013 as it became clear that in order to maximise value of the project to customers, it would be necessary to extend the project delivery date despite mitigation measures and deployment of contingency measures. This was to ensure that sufficient monitoring data was available to support verification of innovative technologies.
The initial change request was then submitted on 14th February 2014 followed by several clarification requests. The final change request was prepared and submitted in May 2014 comprising details of the change request and amended bid submission including project programme and Appendices. The change request was accepted by Ofgem in October 2014 with no modifications and appropriately revised project direction. The timeline of the change request is detailed in Annex D.

Annex A - References

[1] University of Strathclyde, Review of Experimental and Analytical Design and of Project Benefits, July 2015.

Details of six monthly progress reports are provided below.

Low Carbon Network Fund Project Progress Report June 2012

https://www.ofgem.gov.uk/sites/default/files/docs/2012/06/project-progress-report-low-carbon-networks_0.pdf

Low Carbon Network Fund Project Progress Report December 2012

https://www.ofgem.gov.uk/ofgem-publications/46035/spd-flexible-networks-progress-report-dec-2012.pdf

Low Carbon Network Fund Project Progress Report June 2013

https://www.ofgem.gov.uk/ofgem-publications/83234/spenflexiblenetworkssixmonthlyreportjune2013.pdf

Low Carbon Network Fund Project Progress Report December 2013

https://www.ofgem.gov.uk/sites/default/files/docs/2014/02/spd_-_flexible_networks_progress_report_dec_13.pdf

Low Carbon Network Fund Project Progress Report June 2014

https://www.ofgem.gov.uk/ofgem-publications/89330/flexiblenetworksforalowcarbonfuturereportjun2014.pdf

Low Carbon Network Fund Project Progress Report December 2014

https://www.ofgem.gov.uk/ofgem-publications/93447/flexiblenetworksdec2014.pdf

Low Carbon Network Fund Project Progress Report June 2015

https://www.ofgem.gov.uk/sites/default/files/docs/2015/09/spen_flexible_networks_lcnf_project_progress_report_jun_2015_0.pdf

Annex B – Evidence of PV Installed - Ruabon

Secondary Substation	PV Installations Accepted*
Broughton	84
Caia	74
Gwersyllt	57
Wrexham Central	66
Plas Madoc	64
Rhos	50
Total	**395**

* following reassessment using Flexible Networks Project methods

Annex C – Knowledge Dissemination Evidence

Flexible Networks Interactive Dissemination Day – October 2013 at Power Networks Demonstration Centre

Questions and Answers Session

Q. Given SAP what is the future for electric heating?
A The various forms of electric heating all have a very important role to play, particularly for off gas grid customers, and this role is only likely to increase with the de-carbonisation of the grid.

Q. Is there a need to standardise requirements?
A. We think that it would be valuable to work together to standardise common components such as substation monitors so that the protocol of the devices and the measurement approach is also the same. We intend to coordinate a meeting with the other DNOs to try to identify commonalities in monitoring next year and how we can then share our experiences with the supply chain.

The Iberdrola Group of companies are working together to establish a common philosophy for the application of new technologies which will enable a smart approach to automation and meet the challenge of achieving a low carbon network.

Q. Should DNOs pay for customers EE devices?
A Energy efficient devices are unlikely to be an enduring solution and therefore we believe DNOs are unlikely to have an enduring business case for funding energy efficiency. Flexible Networks is trying to quantify the benefit of energy efficiency measures and a wide range of funding is already in place for this such as Green Deal, ECO etc. We have opted to partially fund energy efficiency through the project to be able to quantify the benefit.

Q. Any room for collaboration in any other areas by other DNOs?
A. We would be very keen to hear from any other DNOs who would like to work with us on any of the components of Flexible Networks or any of our other LCNF activity. We recognise that each DNO is building up their own experiences and more than one method may achieve a successful outcome. An example of this was the discussion at the session on the different ways to evaluate the dynamic rating capacity of transformers.

Q. How practical is using renewable sources for volt and VAR control?
A. Small Scale Embedded Generation is largely grid connected via an inverter and although the power factor is fixed close to unity, the output voltage is allowed to vary between quite wide ranging limits that can be in excess of Statutory Limits. Inverter control electronics could be remotely controlled to constrain outputs but we recognise it would require a complex communications and management infrastructure. We think this is something that may be worth exploring as it is an alternative way to make better use of some of the existing assets connected to the network.

Q. What percentage of load is restive and could you use AVR for reducing that load?

A. A load reduction scheme using AVR control expects a 5% load reduction for a 3% voltage drop. (10% load for a 6% volt drop etc) However regardless of whether the load is resistive, this reduction is expected to be effective for a short period only. As the voltage drops there is a corresponding reduction in power output, which is seen by dimming of incandescent lights and reduction in the output of electric space heating. It doesn't take long for more lighting to be switched on, or for a thermostat to be turned up. We understand that National Grid are currently investigating this relationship on the grid.

Q. How essential are data architecture and comms upgrades for DNOs? How expensive?
A. As the demand for the recovery of remote data grows, there has to be a corresponding increase in communications infrastructure bandwidth to handle it. The cost for the management of this data is directly proportional to how business critical it is. It is difficult to put a definitive cost against it, however as an example; the first generation of automation radio is capable of communicating 16 digital bits at 1200 Baud, whereas the new generation developed for the LCNF Project can communicate 255 bits at 9600 Baud. However the increased cost for this additional functionality is c.35%.

Q. Will the load modelling processed customer data be used to improve SP data?
A. Actual phase loading and balance taken in real-time will enable accurate mapping of network load and its distribution. This will allow the production of network designs, which will ensure our system is being properly utilised.

Q. In the BRE model; are min and max loads being used?
A. No, the load modelling is "average". Max and Min would be difficult to model accurately hence the needs for monitoring to better understand the nature of max/min/average.

Q. How did BRE chose non domestic types?
A. At stage 1, the non-domestic building types were inferred from the existing information available within SPEN's connection lists i.e. 'customer name', 'site name' or 'notes'. For stage 2 (i.e. in depth analysis by individual sub-stations) these assumptions and any unknown connections were verified by means of a virtual survey (i.e. Google street view).

Q. How do you target feeders for real time monitoring to identify failing plant?
A. For the trial, areas of the network with voltage or thermal constraints were chosen. For the future, priority will be given to circuits that are known to have a poor performance history or an uptake of low carbon technology. There is a requirement to select parts of the network with actual fault incidences in order to populate the analysis model and prove the technique.

Q. Does smart grid need to be centralised?
A. A Smart Grid can be managed using both centralised and de-centralised logical control. However for the purposes of network fault management having a centralised system allows greater flexibility for customer restoration.

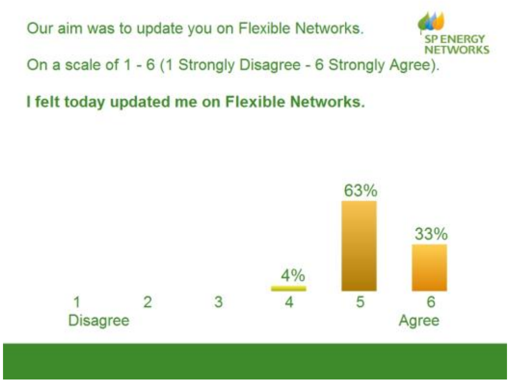
Q. Does Ruabon have a P26 derogation?
A. No, as the council’s whole scale PV installations were limited to connections that would not incur reinforcement. The network configuration for Ruabon is also such that the system can be recovered in a fault which means that a P26 derogation is not required.

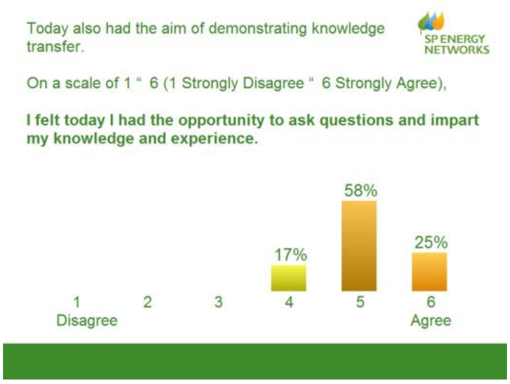
Q. Is Real Time Thermal Rating (RTTR) to be used as a standalone tool or integrated with other technologies and tools?
A. We are aiming for the RTTR to be integrated with other technologies and tools as it only offers a solution for part of the time, when the environmental conditions are appropriate. It is essential to have other interventions available which will require integration between the different solutions.

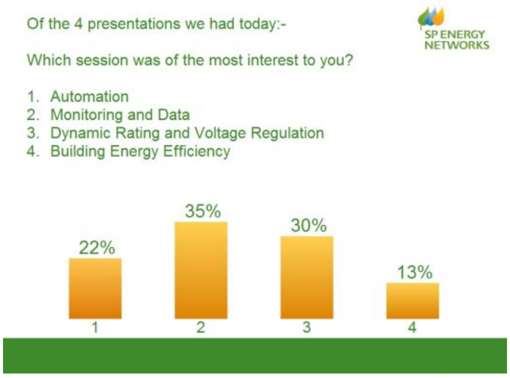
Q. Do any of the technologies trialled have a roadmap to become business as usual?
A. One of the objectives of the project is to build the confidence in the solutions for it to become business as usual. We have already proposed the network monitoring, dynamic rating and automation as technology which we will utilise in a BAU context in ED1. The use of these are detailed in our ED1 business plan:
http://www.spenergynetworks.co.uk/serving_our_customers/business_plan.asp?NavID=1&SubNavID=8&SubSubNavID=1

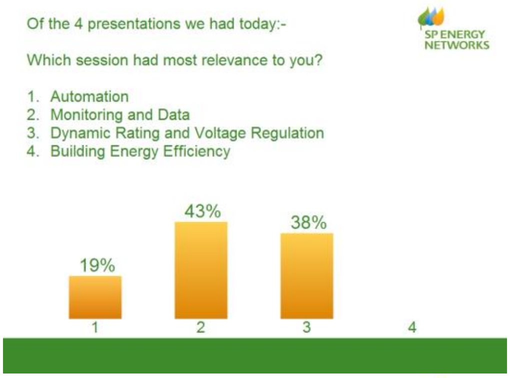
Q. Which technique will be rolled out quickest?
A. We already have a good coverage of network automation so we anticipate that the modifications to allow the Flexible Network Control to be an early success once the concept has been proven. We also expect to be utilising more substation monitoring over the next year or two and experiences from Flexible Networks, as well as other LCNF projects has helped to highlight the value of such technology. Similarly, voltage regulators are already utilised by some DNOs but the steps we are taking to increase the control and functionality is a measure that can be applied more generally in the short term.

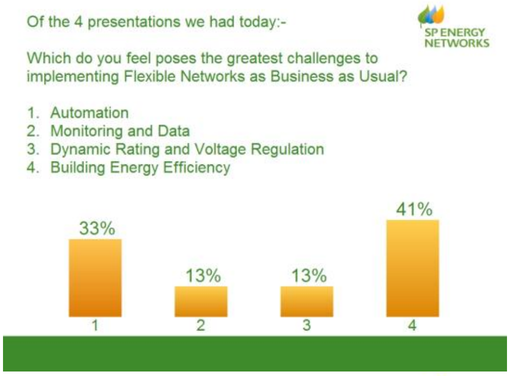
Audience Satisfaction Feedback

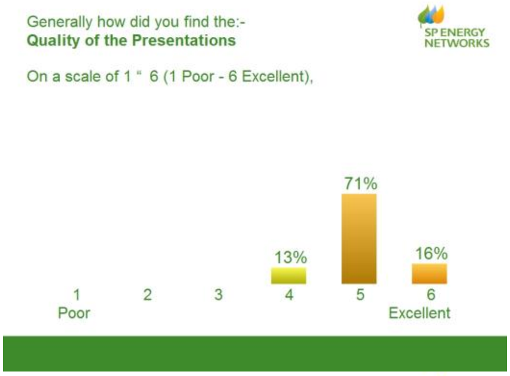


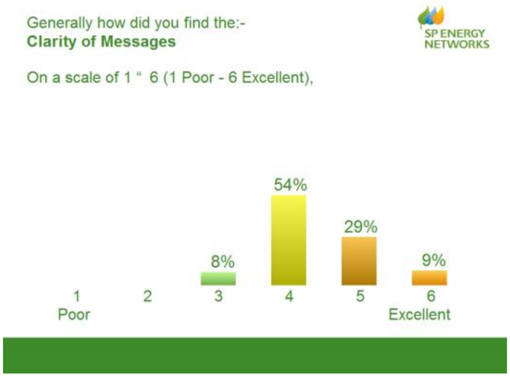


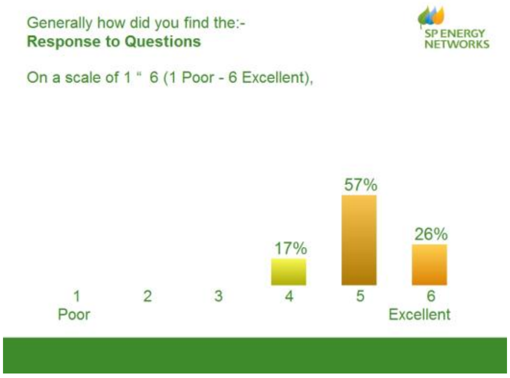

Of the 4 presentations we had today:-
Which session was of the most interest to you?
1. Automation
2. Monitoring and Data
3. Dynamic Rating and Voltage Regulation
4. Building Energy Efficiency
22%
35%
30%
13%
1
2
3
4


Of the 4 presentations we had today:-
Which session had most relevance to you?
1. Automation
2. Monitoring and Data
3. Dynamic Rating and Voltage Regulation
4. Building Energy Efficiency
19%
43%
38%
1
2
3
4


Of the 4 presentations we had today:-
Which do you feel poses the greatest challenges to implementing Flexible Networks as Business as Usual?
1. Automation
2. Monitoring and Data
3. Dynamic Rating and Voltage Regulation
4. Building Energy Efficiency
33%
13%
13%
41%
1
2
3
4


Generally how did you find the:-
Quality of the Presentations
On a scale of 1 " 6 (1 Poor - 6 Excellent),
13%
71%
16%
1 Poor
2
3
4
5
6 Excellent


Generally how did you find the:-
Clarity of Messages
On a scale of 1 " 6 (1 Poor - 6 Excellent),
8%
54%
29%
9%
1 Poor
2
3
4
5
6 Excellent


Generally how did you find the:-
Response to Questions
On a scale of 1 " 6 (1 Poor - 6 Excellent),
17%
57%
26%
1 Poor
2
3
4
5
6 Excellent

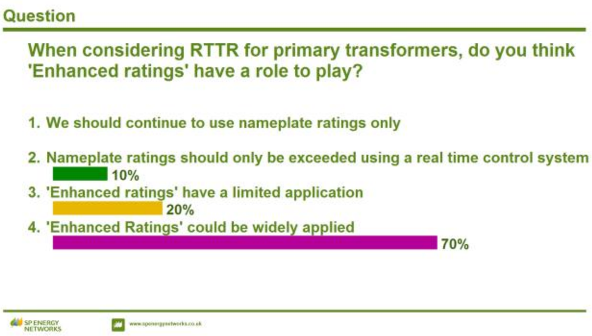
Flexible Networks Final Dissemination Event – October 2015 in London

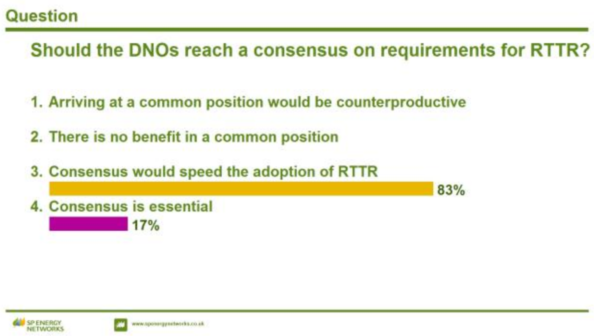
Ipad Questions

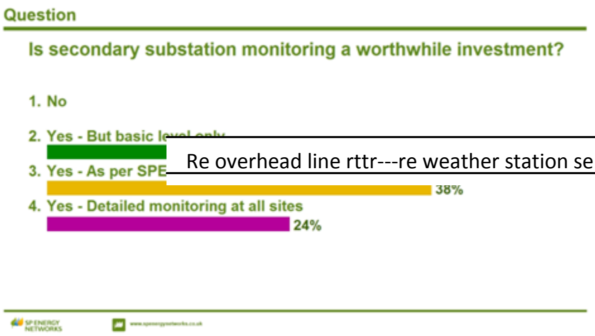
No.	Question
1	Is the transformer ageing as a consequence of heat in the transformer additional ageing or absolute ageing?
2	I see there are a series of booklets available with learning. When will they be available?
3	How were node points for voltage measurements out on the network selected?
4	On the subject of transformer enhanced ratings; it wasn't clear if the ratings were for ONAN or OFAF or for both. Can you clarify please?
5	Did you carry out any checks for bad data?
6	What alternatives to this monitoring approach were considered?
7	For monitoring, were roaming sim cards considered to overcome data loss?
8	Voltage control: For the change request on regulators, was the process more simple offering your solution, or were you questioned heavily on quality?
9	Did you have to put in place operational restrictions on nop, where regulators were fitted?
10	Your PV cluster, how have you mapped the existing PV on your design tool, or is it just visual overlay on GIS?
11	Do any new facilities, e.g. software or standard sets of data, need to be made available to network planners to enable them to make use of likely headroom available from real time thermal ratings on transformers or ohl, and to do so consistently and easily?
12	Re overhead line rttr - re weather station sensor calibration / accuracy over time. Is this an issue?
13	Will smart meter bring back voltage data in addition? Could this be used to apply voltage optimisation in the wider network without the need for significant monitoring on DNO side?
14	How different the data communication system requirement in your trial, compared with potential roll out?
15	Engineering judgement suggests a certain minimum sample rate for voltage and current, or wind speed, temp, etc.. One important thing is the verify that certain rates are indeed adequate for different applications, and I think Ian Elders has done that as part of the project. However, as I understand it, the std smart meter spec will record only half-hourly energies and not voltage at all. What is your view on that?
16	Was an estimation of the existing electrical age of the transformer undertaken?

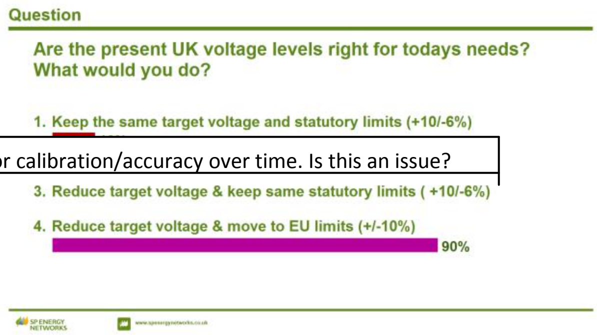
17	**Are you planning to adjust the spreadsheet model to better match the actual temperature?**
18	**For the areas where the calculated and actual circuit temperatures are seen to differ, do we know why the difference is there?**
19	**How often do you feel that this load growth scenario will be required?**
20	**In respect of the network topology reconfigurations, were Fault Level changes (as result of network toplology changes) taken into account?**
21	**Is there a special design team to consider load shedding and telecomms configuration?**
22	**Is the Bi-directional opperational mode suitable for "Active Networks" which may see a sudden shift in Load and Source sides ? Especially if looking to implement AVR into complex interconnected networks with differing generation sources and complex interactions between load and generation power flows.**
23	**How does the load growth tool cope with embedded generation and the reduction in apparent peak demand?**

Audience Feedback on Multiple Choice Questions

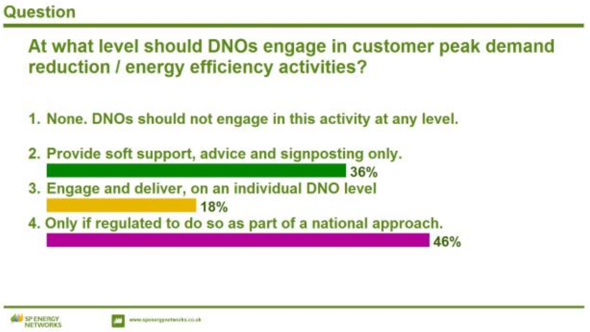


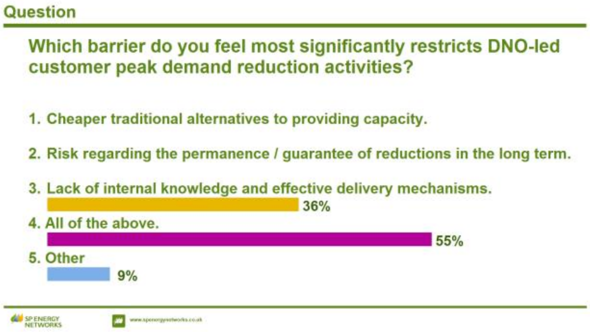


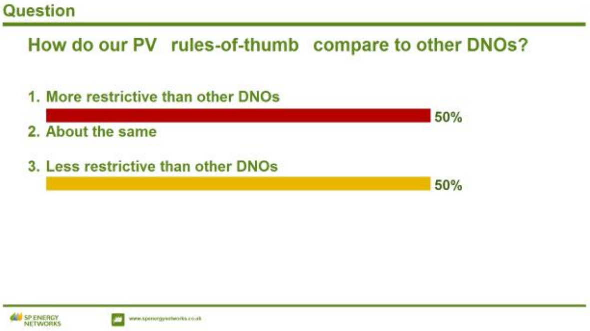


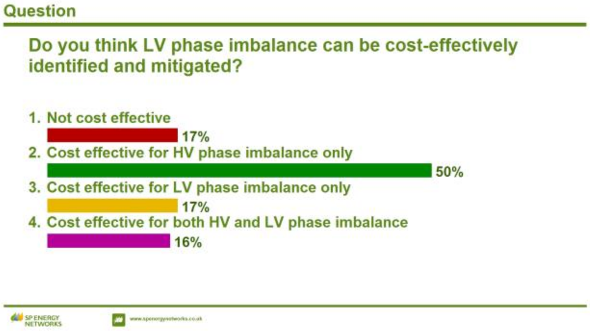


Re overhead line rttr---re weather station sensor calibration/accuracy over time. Is this an issue?

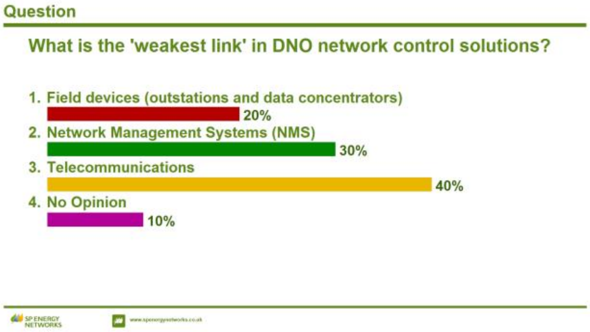

Question
At what level should DNOs engage in customer peak demand reduction / energy efficiency activities?
1. None. DNOs should not engage in this activity at any level.
2. Provide soft support, advice and signposting only.
36%
3. Engage and deliver, on an individual DNO level
18%
4. Only if regulated to do so as part of a national approach.
46%

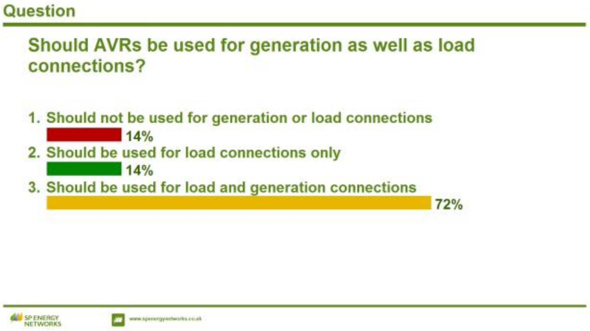

Question
Which barrier do you feel most significantly restricts DNO-led customer peak demand reduction activities?
1. Cheaper traditional alternatives to providing capacity.
2. Risk regarding the permanence / guarantee of reductions in the long term.
3. Lack of internal knowledge and effective delivery mechanisms.
36%
4. All of the above.
55%
5. Other
9%

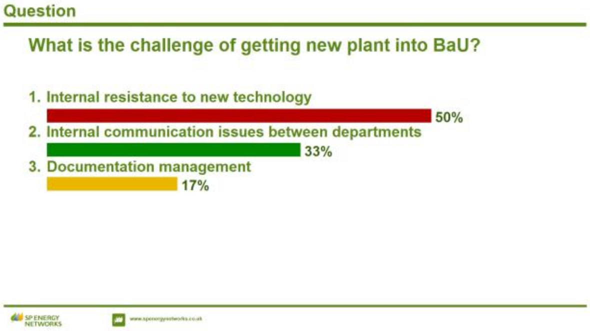

Question
How do our PV rules-of-thumb compare to other DNOs?
1. More restrictive than other DNOs
50%
2. About the same
3. Less restrictive than other DNOs
50%

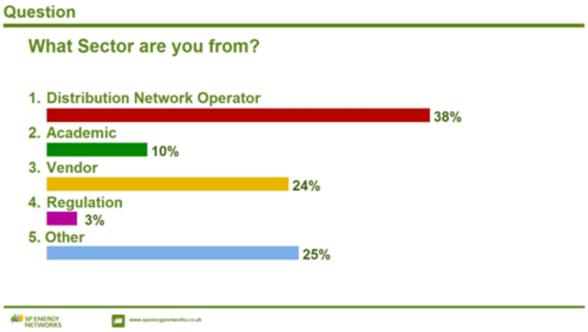

Question
Do you think LV phase imbalance can be cost-effectively identified and mitigated?
1. Not cost effective
17%
2. Cost effective for HV phase imbalance only
50%
3. Cost effective for LV phase imbalance only
17%
4. Cost effective for both HV and LV phase imbalance
16%

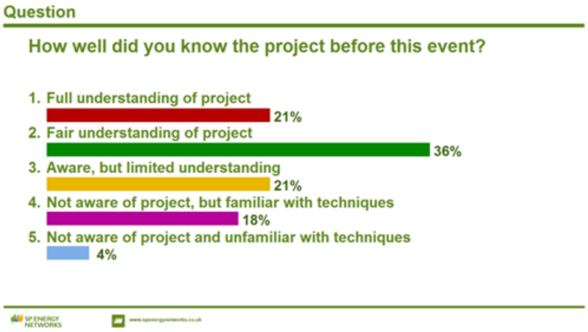

Question
Does FNC have a role to play in deferring reinforcement?
1. No role
2. Only very limited application
3. Limited application
89%
4. Could be widely applied
11%


Question
What is the 'weakest link' in DNO network control solutions?
1. Field devices (outstations and data concentrators)
20%
2. Network Management Systems (NMS)
30%
3. Telecommunications
40%
4. No Opinion
10%


Question
Should AVRs be used for generation as well as load connections?
1. Should not be used for generation or load connections
14%
2. Should be used for load connections only
14%
3. Should be used for load and generation connections
72%


Question
What is the challenge of getting new plant into BaU?
1. Internal resistance to new technology
50%
2. Internal communication issues between departments
33%
3. Documentation management
17%


Question
What Sector are you from?
1. Distribution Network Operator
38%
2. Academic
10%
3. Vendor
24%
4. Regulation
3%
5. Other
25%


Question
How well did you know the project before this event?
1. Full understanding of project
21%
2. Fair understanding of project
36%
3. Aware, but limited understanding
21%
4. Not aware of project, but familiar with techniques
18%
5. Not aware of project and unfamiliar with techniques
4%

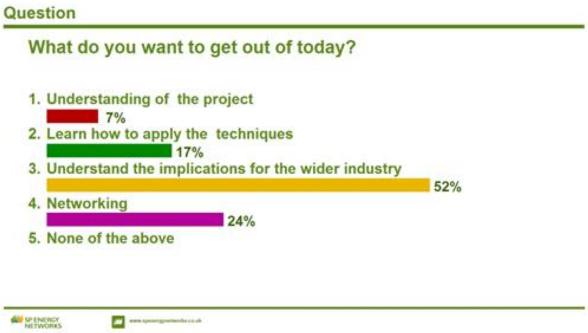

Question
What do you want to get out of today?
1. Understanding of the project
7%
2. Learn how to apply the techniques
17%
3. Understand the implications for the wider industry
52%
4. Networking
24%
5. None of the above

Table C.1: Summary of Other External Knowledge Dissemination

Key Stakeholders	Specific Stakeholders	Dissemination Activity
Other Distribution Network Operators	UK Power Networks	Provision of Enhanced Thermal Ratings Tool and response to any queries on use of the tool, as requested.
	Electricity North West	
	Scottish and Southern Energy	
Customers	University of St Andrews	Meetings were held with at the commencement of the project and correspondence throughout.
	Wrexham Borough Council	Meetings were held with at the commencement of the project and correspondence throughout including on installation of voltage monitors in customers residences. Provided a new list of properties on which solar PV can be installed without further intervention to the network.
	Shropshire Business Enterprise	Meetings were held with at the commencement of the project and correspondence throughout.
Equipment Suppliers	Nortech	Involvement as a project partner in Flexible Networks, informing future product development to meet low carbon network requirements.
	Monitor manufacturers	Learning for future product development to meet low carbon network requirements.
	Langley Engineering	Learning on automatic voltage regulator requirements for future flexible networks.
Academia	University of Strathclyde	Involvement as project partner in Flexible Networks, supporting a number of graduate students research.

Key Stakeholders	Specific Stakeholders	Dissemination Activity
	Aston University	Provision of Enhanced Thermal Ratings Tool and response to any queries on use of the tool, as requested
Wider Industry	Utility Week	Presentation at 2016 Utility Week Future Networks Conference in May 2016
	IET	Presentation at an IET event on Smart Grids, held in the Manchester Conference Centre in April 2015
	ENA	Presentations and exhibition stands at all LCNI Conferences from 2012 to 2015.
	CIRED	Four technical papers were presented at the CIRED Annual Conference in 2015.
	Energy Technology Partnership (ETP)	Presentation to the Energy Technology Partnership (ETP) in Dundee, Scotland, April 2013.
	BRE Trust	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. This should be publically available in June 2016.

Customer Feedback

"The University of St Andrews is happy to help this important flexible networks project, and overall electricity reduction and consumption displacement from peak hours use at the University can contribute to reduction of the infrastructure issues of the town. This may include Scottish Power transformer voltage reduction to our buildings, and other measures that consultants may come up with." David Stutchfield, Energy Officer, University of St. Andrews

IET Smart Grids Event 2015

"An excellent event ……." "I enjoyed hearing about the variety of techniques that Scottish Power are testing in particular."

Annex D – Timeline for Change Request

Table D.1: Timeline of Change Request

Event	Date
SP Energy Networks notified Ofgem of intention to raise a change request in 6 monthly progress report.	December 2013
Change request prepared and submitted.	14 February 2014
First set of Ofgem clarification questions received.	27 February 2014
SP Energy Networks response to first set of Ofgem clarification questions.	19 March 2014
Second set of Ofgem clarification questions received.	31 March 2014
SP Energy Networks response to second set of Ofgem clarification questions.	09 April 2014
Consolidated change request prepared and submitted.	02 May 2014
Change request approved by Ofgem with no modifications and revised project direction issued.	27 October 2014