2.8 Annex

SP Energy Networks 2015–2023 Business Plan

SPEN RIIO-ED1 review project

Smarter Grid Solutions

February 2013

SP ENERGY NETWORKS

Scottish Power Energy Networks

ED1 RIIO Review Project

FINAL REPORT

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2. INTRODUCTION

This report presents the outcomes of an assessment of Scottish Power Energy Networks (SPEN) investment proposals (IP1s) completed by Smarter Grid Solutions (SGS). This report documents the alternatives to conventional reinforcement and provides an outline justification for the use of the new solutions. Where alternative reinforcements have been indentified, the results of the work will be used to update the SPEN IP1 papers.

2.1. References

1. 200119-01B RIIO-ED1 Review Of IP1 Documents Proposal, Issued 9th January 2013
2. 200119 08A - RIIO ED1 IP1 Reviews Workshop Presentation, Issued 15th January 2013
3. DECC / Ofgem Smart Grid Forum Workstream 3, Developing Networks for Low Carbon, The Building Blocks for Britain's Smart Grids, Issued 7th October 2011
4. Energy Networks Association on behalf of Smart Grid Forum Workstream 3: Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Network, EA Technology, Issued 31st July 2012
5. Energy Networks Association on behalf of Smart Grid Forum Workstream 3: WS3 Phase 2 - SOLUTIONS ANNEX, A supporting document to "Assessing the Impact of Low Carbon Technologies on Great Britain's Power Distribution Networks", Issued 6th July 2012
6. 200119-07A SPEN RIIO ED1 Initial Assessment ,Issued 15th January 2013, Initial Version
7. 200119-07B SPEN RIIO ED1 Initial Assessment, Issued 21st January 2013, Updated Follow Design Meeting
8. SGS 200119 MM01A Minutes of Meeting 16th January 2013, Issued 21st January 2013
9. 200119-07C SPEN RIIO ED1 Initial Assessment, Issued 31st January 2013, Final Version
10. 200119-11A SPEN RIIO ED1 Detailed Assessment, Issued 31st January 2013

2.2. Background

Scottish Power Energy Networks (SPEN) own and operate the distribution networks in the South Scotland and Merseyside & North Wales areas of the UK. Under price control regulation SPEN plan and deliver investment in the distribution networks within price control periods. The new price control regulation mechanism (RIIO) places a greater emphasis (and incentive) on distribution network operators to invest in innovative solutions as alternatives to conventional reinforcement type solutions. The intention of the RIIO mechanism is to bring forward the deployment of innovative solutions that have been trialled and demonstrated under the IFI, RPZ and LCNF mechanisms that have been in place in recent years[1].

SPEN has engaged SGS to assist in the identification and appraisal of alternative network investments under this 'RIIO ED1 IP1 Reviews' project. IP1 documents contain individual proposed network investments and constitute the first stage in developing a capital project towards implementation by SPEN.

The aim of the project is to review the IP1 documents and identify opportunities where smart solutions could be deployed instead of conventional reinforcement approaches. The project aligns with but is independent to the ongoing work within SPEN exploring conventional and innovative

[1] IFI and RPZ have been in place since 2005 and the LCNF mechanism since 2010.

network solutions for potential investment. These activities by SPEN and SGS are undertaken in the context of the collaborative Ofgem/DECC/DNO activities in the Smart Grid Forum. Specifically, there is strong alignment and relevance in the WS3 project led by EATL to assess smart distribution solutions and to quantify the investments required by DNOs in smart grids. This project uses the classifications and titles of smart solutions and enablers from that WS3 activity and refers to the indicative costs for comparative purposes.

This report gives a brief summary of the methodology used to assess the investment cases and the conclusions and recommendations from the assessment.

3. PROJECT METHODOLOGY

The review of the SPEN IP1 documents started with two initial scoping and kick-off meetings with SPEN innovation and system design personnel. From these meetings a four-stage method was developed, proposed [1] and initiated as follows:

1. Initial Assessment of all received IP1 documents
2. Workshop to select IP1 cases for further detailed assessment
3. Detailed Assessment of select IP1 cases through further exploratory meetings with SPEN design personnel
4. Final report with conclusions and recommendations

The first three project phases are outlined in the following two sub-sections with the fourth phase consisting of the delivery of this report.

3.1. Initial Assessment & Workshop

On receipt of a set of one hundred and one (101) SPEN IP1 documents for the SPM and SPD territories, the SGS project team undertook an Initial Assessment to identify any cases where an alternative (i.e. non-conventional) solution looked feasible or where further information was required to make such a judgement. The complete list of reviewed IP1 cases is provided in the appendix in section 7. The proposed smart solutions and enablers adopt the same titles and definitions that have been set out by the Smart Grid Forum (see appendix in section 6). The following criteria were used for the Initial Assessment and these are captured for each IP1 case in a spreadsheet.

- Proposed Conventional Investment/Reinforcement
- Driver for Investment
- Proposed Investment cost
- Assumptions
- Proposed Start Date
- Smart Solutions Considered
- Smart Enablers Required
- Smart Solution Justifications
- Estimated Cost of Smart Solution
- Smart solution Technology Proven Date

The Initial Assessment spread sheet (200119-07A SPEN RIIO ED1 Initial Assessment) [6] was reviewed at a workshop with SPEN innovation, RIIO business planning and system planning/design personnel on 16th January 2013. Each IP1 in the SPM and SPD areas was reviewed at the workshop and

discussed with a decision made to either progress to Detailed Assessment, not to proceed to Detailed Assessment or to seek further information from other SPEN system design personnel.

The workshop outcomes were captured in a revision of the Initial Assessment spread sheet (200119-07B SPEN RIIO ED1 Initial Assessment) [7] and meeting notes [8].

Following the workshop the highlighted IP1 cases in the SPM area were discussed with SPEN system design engineers to confirm the decision to undertake the Detailed Assessment and to obtain further more detailed information:

- Crewe
- Anglesey
- Chester
- Coedpoeth
- Llanilar
- Tarvin
- Bootle - Litherland
- Graig Fawr
- Bryn Blaen & Mynydd Y Gwynt Wind Farm (alternative solutions discounted during Detailed Assessment phase)
- Whitchurch(alternative solutions discounted during Detailed Assessment phase)
- Lostock (alternative solutions discounted during Detailed Assessment phase)
- Beaumaris (alternative solutions discounted during Detailed Assessment phase)
- Runcorn (alternative solutions discounted during Detailed Assessment phase)
- Gateacre_Huyton_Prescot_Kirkby (alternative solutions discounted during Detailed Assessment phase)
- Orford-Padgate (alternative solutions discounted during Detailed Assessment phase)
- Bold-Prescot-Widnes (alternative solutions discounted during Detailed Assessment phase)
- Ince (alternative solutions discounted during Detailed Assessment phase)

Following the workshop the highlighted IP1 cases in the SPD area were discussed with SPEN system design engineers to confirm the decision to undertake the Detailed Assessment and to obtain further more detailed information:

- Crookston 'A' Fault Level Resolution
- Ayr
- Kilmarnock South
- Portobello
- Norham GSP (Berwick_Eccles)
- Ecclefechan
- Govan 6.6kV (Phase 2)
- Langholm Primary Substation Voltage Reinforcement
- Govan 6.6kV (Phase 1)
- Partick
- Yair Bridge
- Berwick Ring Voltage Support

- Berwick (North Road_Loaning Relief)
- Stranraer
- Girvan
- Bowhill_Kelty
- Langside

3.2. Detailed Assessment

The methodology for the Detailed Assessment of the potential alternative solutions for IP1 cases was to generally develop the initial Assessment further in and specifically to consider the following issues for each case:

- Drivers for Reinforcement
- Cost of Conventional Reinforcement
- Description of Alternative Smart Solution Opportunity
- Smart Grid Forum WS3 Solutions Reference
- Smart Grid Forum WS3 Enablers Reference
- Solution Maturity (trialled by SPEN, deployed by SPEN, deployed by other DNO, trialled by other DNO, SPEN IFI project, IFI project of other DNO, etc.)
- Operational Considerations
- Risks
- Additional Benefits
- Solution Costs (CAPEX and OPEX)
- Enabler Costs (CAPEX and OPEX)
- Total Solution Costs (TOTEX)

The results of the Detailed Assessment are contained in a spreadsheet (200119-011A SPEN RIIO ED1 Detailed Assessment) [10] with a tab for each IP1 case that was subject to a detailed assessment undertaken.

3.3. Inputs and Assumptions

SGS applied various assumptions to the consideration of the viability of alternative solutions and through discussion with SPEN these assumptions were developed and various system planning and RIIO ED1 strategic issues were identified and are captured below:

AS1. ***RIIO ED1 bid strategy*** will include the level of investment in innovative solutions. This will have an impact on a 'fast tracking' outcome and SPEN are aiming to be innovative.

AS2. SPEN would ideally like to manage the ***number of different innovative solutions*** in their bid to avoid undue complexity and risk.

AS3. ***Investment deferral*** would be considered in some cases to await an alternative solution. The value of deferral of reinforcement is buying time while a more enduring solution with a longer development time (e.g. new substation) is progressed.

AS4. The ***pathway*** and ***timeline*** for implementation of alternative solutions needs to be considered along with alternative solution availability and implementation.

AS5. ***Assessment of the degree of confidence and risk*** in innovative solutions is necessary so that this can be robustly traded off against the available rewards and incentives.

AS6. ***Thresholds for reinforcement*** (e.g. projected peak demand as % of substation firm capacity, fault level % of switchgear rating) are key components of the RIIO ED1 investment portfolio.

SPEN has traditionally taken an outlying position on reinforcement with higher thresholds than other DNOs and is under pressure from Ofgem to adopt a more central position on investment triggers.

AS7. SPEN ***stakeholders*** are seeking ***reinforcement ahead of need*** to avoid lack of network capacity acting as a hindrance to their activities.

AS8. Solutions need to ***endure*** for a reasonable timescale to avoid repetitive design and mobilisation effort.

AS9. Alternative solutions need to present a ***clearly favourable cost benefit assessment*** so in comparison with conventional solutions.

AS10. The next round of RIIO ED1 ***stakeholder engagement*** proceeds in February 2013 and SPEN assessment of smarter, alternative solutions will become a feature of these engagement activities.

AS11. ***Smart Enabling*** of asset replacement investments would be acceptable if customer benefit can be clearly evaluated over the lifetime of the asset (e.g. automation, service monitoring, ANM, EV/microGen integration). Future proofing of asset replacements is a driver for investment by SPEN. The investment case for smart enabling and the budget heading (replacement, renewal, load related, etc.) is an issue of ongoing consideration within the RIIO ED1 team in SPEN.

AS12. ***Generation Connections***: SPEN are seeking to apply the learning from their own and other DNO LCNF projects in deploying smarter solutions in the ED1 period.

AS13. ***Voltage Support***: SPEN have a good degree of confidence in advanced voltage support solutions such as D-Statcom.

AS14. ***Real Time Thermal Ratings***: SPEN would consider their use but would like to achieve a consistent application of weather correction of loading levels where this is the trigger for reinforcement.

AS15. ***Fault level***: Fault limiting technologies considered too immature to provide lasting solutions in early ED1 period. Where fault level exceeds the equipment rating, no smart solution. Where fault level approaches the equipment rating then fault level monitoring can be considered.

4. SUMMARY OF PROPOSED ALTERNATIVE SOLUTIONS FOR IP1 CASES

The Initial and Detailed Assessments yielded a proposed alternative solution for each of the IP1 cases where one was thought viable according to the criteria of those assessments. **Error! Reference source not found.** presents summarises the proposed alternative solution for each IP1 case (full detail can be found in the '200119-011A SPEN RIIO ED1 Detailed Assessment' spread sheet) [10] and provides a commentary on each solution and case where smart solutions are thought to be viable.

Table 1: Alternative Solutions for the IP1 Cases

IP1 case	Conventional solution	Alternative solution	Commentary
Coedpoeth	New 33/11kV Transformer + new 11kV Board to resolve anticipated thermal capacity headroom issue	Real Time Thermal Rating (RTTR) Transformer + Monitoring	The RTTR Transformer solution is in demonstration in two LCNF projects and it is expected that this solution will be available in a robust form by 2015 ahead of the need in this IP1 case (2018). The modest expected solution costs provide a low regret opportunity to deploy earlier than need to monitor the transformer and appraise the solution ahead of actual need.
Llanilar	New 33/11kV Transformer + new 33kV board + new 11kV board to resolve voltage regulation issue	Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM	SPEN already confident in maturity, performance, risk and cost of this solution. Additional power system analysis is required to verify solution.
Tarvin	New 33/11kV Transformer, new 33kV board, replace 11 kV board to resolve thermal capacity issue	Real Time Thermal Rating (RTTR) Transformer + Monitoring	The RTTR Transformer solution is in demonstration in two LCNF projects and it is expected that this solution will be available in a robust form by 2015 ahead of the need in this IP1 case (2018). The modest expected solution costs provide a low regret opportunity to deploy earlier than need to monitor the transformer and appraise the solution ahead of actual need.
Graig Fawr	Upgrade existing 33/11kV Transformer to resolve thermal capacity issue	Real Time Thermal Rating (RTTR) Transformer + Monitoring	The RTTR Transformer solution is in demonstration in two LCNF projects and it is expected that this solution will be available in a robust form by 2015 ahead of the need in this IP1 case (2018). The modest expected solution costs provide a low regret opportunity to deploy earlier than need to monitor the transformer and appraise the solution ahead of actual need.
Bootle - Litherland	New 33kV cable to interconnect and resolve thermal capacity issue	Real Time Thermal Rating (RTTR) Transformer + Monitoring	The RTTR Transformer solution is in demonstration in two LCNF projects and it is expected that this solution will be available in a robust form by 2015 ahead of the need in this IP1 case (2018). The modest expected solution costs provide a low regret opportunity to deploy earlier than need to monitor the transformer and appraise the solution ahead of actual need.
Crewe	New 132kV circuit to resolve thermal capacity issue	Phase Shifting Transformer	The application of phase shifting transformers is relatively novel in distribution networks but is common in transmission networks and can be regarded as a mature solution. The cost savings from this solution in this case are very significant. Additional power system analysis is required to verify solution.

IP1 case	Conventional solution	Alternative solution	Commentary
Anglesey	Various 33kV system reinforcement and new BSP options to resolve general capacity issues on island	Various smart solutions possible as part of overall reinforcement scheme to be rolled out.	While it is clear that smart solutions are not only possible but desirable to address the load and generation related reinforcement requirements on Anglesey there are many interacting factors that make scheme designs with smart solutions complementing conventional a challenging task. There are potentially significant gains from a combined smart + conventional solution as has been demonstrated in other rural/island/renewable rich areas of the UK.
Chester	RMU Replacement to resolve fault level issues stemming from new Grid Transformer	Active Network Management - Dynamic Network Reconfiguration	The proposed type of smart solution is well supported by available technology and demonstration activities - particularly from the US where the main drivers of automation in the smart grid are for security and reliability through automated switching schemes. The enabling technologies include: IEC 61580 Compliant Substation Devices (inc protection devices); RMUs Fitted with Actuators; Link boxes fitted with remote control; Advanced control systems; Monitoring flow energy at primary substation; Communications to and from devices; Design tools; and Dynamic Network Protection at 11kV.
Ayr	New 33kV switchgear to resolve high fault level issue	Fault Level Monitoring	Fault level monitoring would be deployed only to underpin the planning assessment on fault level and to more accurately track the development of fault level towards switchgear ratings. SPEN has gained appreciable experience in fault level monitoring through IFI projects. The costs are modest compared to switchgear upgrade and prospective investment deferral value.
Crookston 'A'	New 33kV switchgear to resolve high fault level issue	Fault Level Monitoring	Fault level monitoring would be deployed only to underpin the planning assessment on fault level and to more accurately track the development of fault level towards switchgear ratings. SPEN has gained appreciable experience in fault level monitoring through IFI projects. The costs are modest compared to switchgear upgrade and prospective investment deferral value. Further investigation required to confirm source of increased fault level.

IP1 case	Conventional solution	Alternative solution	Commentary
Kilmarnock South	New 33kV switchgear to resolve high fault level issue	Fault Level Monitoring	Fault level monitoring would be deployed only to underpin the planning assessment on fault level and to more accurately track the development of fault level towards switchgear ratings. SPEN has gained appreciable experience in fault level monitoring through IFI projects. The costs are modest compared to switchgear upgrade and prospective investment deferral value.
Portobello	New 11kV switchgear to resolve high fault level issue	Smart Enabling of new switchgear	It is proposed that the required switchgear replacement/upgrade plan take into account the possibility to 'smart enable' the new switchgear units and associated substation and field equipment to provide the foundation of additional smart functionality in future. The technology is considered mature at the transmission level. The smart enablers proposed are: IEC 61580 Compliant Substation Devices (including protection devices); Dynamic Network Protection at 11kV; RMUs Fitted with Actuators; Link boxes fitted with remote control; Communications to and from devices.
Norham GSP (Berwick_Eccles)	New 132/33kV GSP with a capacity of 60MVA to enhance network capacity for both demand and generation development.	Smart Enabling of new substation	It is proposed that the new substation plan take into account the possibility to 'smart enable' the new equipment in the substation and in the field to provide the foundation for additional smart functionality in future. The solutions are the subject of demonstration in other DNO LCNF projects and in the SPEN ARC LCNF project. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 33 kV; Frequent Use Switches; 33 kV Circuit Monitoring including State Estimation.
Ecclefechan	New 132/33kV GSP with a capacity of 90MVA to enhance network capacity for both demand and generation development.	Smart Enabling of new substation	It is proposed that the new substation plan take into account the possibility to 'smart enable' the new equipment in the substation and in the field to provide the foundation for additional smart functionality in future. The solutions are the subject of demonstration in other DNO LCNF projects and in the SPEN ARC LCNF project. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 33 kV; Frequent Use Switches; 33 kV Circuit Monitoring including State Estimation.

IP1 case	Conventional solution	Alternative solution	Commentary
Govan 6.6kV (Phase 1)	New 11kV substations – phasing out of 6.6kV	Smart Enabling of new substation	It is proposed that the required switchgear replacement/upgrade plan take into account the possibility to 'smart enable' the new switchgear units and associated substation and field equipment to provide the foundation of additional smart functionality in future. The technology is considered mature at the transmission level. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 11kV; RMUs Fitted with Actuators; Link boxes fitted with remote control; Communications to and from devices.
Govan 6.6kV (Phase 2)	New 11kV substations – phasing out of 6.6kV	Smart Enabling of new substation	It is proposed that the required switchgear replacement/upgrade plan take into account the possibility to 'smart enable' the new switchgear units and associated substation and field equipment to provide the foundation of additional smart functionality in future. The technology is considered mature at the transmission level. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 11kV; RMUs Fitted with Actuators; Link boxes fitted with remote control; Communications to and from devices.
Partick	New 11kV substations – phasing out of 6.6kV	Smart Enabling of new substation	It is proposed that the required switchgear replacement/upgrade plan take into account the possibility to 'smart enable' the new switchgear units and associated substation and field equipment to provide the foundation of additional smart functionality in future. The technology is considered mature at the transmission level. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 11kV; RMUs Fitted with Actuators; Link boxes fitted with remote control; Communications to and from devices.
Yair Bridge	New 11kV substations – phasing out of 22kV	Smart Enabling of new substation	It is proposed that the required switchgear replacement/upgrade plan take into account the possibility to 'smart enable' the new switchgear units and associated substation and field equipment to provide the foundation of additional smart functionality in future. The technology is considered mature at the transmission level. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 11kV; RMUs Fitted with Actuators; Link boxes fitted with remote control; Communications to and from devices.

IP1 case	Conventional solution	Alternative solution	Commentary
Berwick (North Road_Loaning Relief)	New 33/11kV substation to resolve capacity issue	Smart Enabling of new substation	It is proposed that the required switchgear replacement/upgrade plan take into account the possibility to 'smart enable' the new switchgear units and associated substation and field equipment to provide the foundation of additional smart functionality in future. The technology is considered mature at the transmission level. The smart enablers proposed are: IEC 61580 Complaint Substation Devices (including protection devices); Dynamic Network Protection at 11kV; RMUs Fitted with Actuators; Link boxes fitted with remote control; Communications to and from devices.
Bowhill_Kelty	New 33/11kV transformers to resolve capacity issue	Real Time Thermal Rating (RTTR) Transformer + Monitoring	The RTTR Transformer solution is in demonstration in two LCNF projects and it is expected that this solution will be available in a robust form by 2015 ahead of the need in this IP1 case (2018). The modest expected solution costs provide a low regret opportunity to deploy earlier than need to monitor the transformer and appraise the solution ahead of actual need.
Langside	Dynamic Network Reconfiguration scheme to resolve network capacity issues	Active Network Management - Dynamic Network Reconfiguration	The proposed type of smart solution is well supported by available technology and demonstration activities - particularly from the US where the main drivers of automation in the smart grid are for security and reliability through automated switching schemes. The enabling technologies include: IEC 61580 Compliant Substation Devices (inc protection devices); RMUs Fitted with Actuators; Link boxes fitted with remote control; Advanced control systems; Monitoring flow energy at primary substation; Communications to and from devices; Design tools; and Dynamic Network Protection at 11kV.
Girvan	Dynamic Voltage Support +10MVAr deployment to resolve voltage issues	Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM	SPEN already confident in maturity, performance, risk and cost of this solution.
Stranraer	Dynamic Voltage Support +12MVAr deployment to resolve voltage issues	Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM	SPEN already confident in maturity, performance, risk and cost of this solution.
Berwick Ring Voltage Support	Dynamic Voltage Support +20MVAr deployment to resolve voltage issues	Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM	SPEN already confident in maturity, performance, risk and cost of this solution.

IP1 case	Conventional solution	Alternative solution	Commentary
Langholm	Dynamic Voltage Support +20MVAr deployment to resolve voltage issues	Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM	SPEN already confident in maturity, performance, risk and cost of this solution.

5. DISCUSSION

This review has identified several (25 in total) IP1 cases where low to medium risk innovative solutions, which should be available in appropriate timescales, can offer an alternatives or complements to conventional reinforcement schemes. The solutions considered are:

- Real Time Thermal Rating (RTTR) Transformer + Monitoring
- Fault Level Monitoring
- Smart Enabling of new substations
- Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM
- Active Network Management - Dynamic Network Reconfiguration
- Phase shifting transformer

In a number of cases, the review has indentified opportunities to 'smart enable' new switchgear units, associated substation and field equipment to provide the foundation for additional smart functionality in future. Investing in smart solutions during this price control period will allow the enabled network nodes to participate in active network management to provide SPEN with the flexibility to integrate additional future demand and generators with minimum outages. Smart enabling will also allow the application of the learning from the SPEN LCNF ARC and Flexible Networks projects (as well as other DNO LCNF projects) in deployed smart solutions in the RIIO ED1 period.

In considering the application of real time ratings and fault level monitoring, SGS were cognisant of SPEN's desire to apply more conservative thresholds for reinforcement. This has limited the opportunity to deploy alternative solutions since the new thresholds effectively 'create' immediate threshold breach situations and it has been assumed that these will be resolved in a conventional manner with some urgency rather than to seek to deploy a smart solution.

In the application of real time thermal ratings SGS identified a number of criteria that must be met before the solution was considered. The demand must not have exceeded the firm capacity of the asset, the demand must be correlated with seasonal temperature and there should be some uncertainty of the evolution of demand over time. Each of these conditions creates the opportunity for a smarter solution to be considered.

Similarly, in the application of fault level monitoring SGS identified a number of criteria that must be met before the solution was considered. The fault must not have exceeded the rating of the switchgear and the increase in fault level must be due to 'organic' growth rather than a change of network running arrangement or generation connection.

Since the alternative solutions proposed in this exercise are relatively novel it will be necessary for SPEN to consider the appropriate method to develop these investment cases further and undertake the required engineering and commercial assessments of the solutions.

6. APPENDIX: SMART GRID FORUM (SGF) – SMART SOLUTIONS AND ENABLERS

6.1. SGF WS3: Smart Solutions

The following list provides the exhaustive set of smart solutions identified by the Smart Grid Forum [3]:

1. Temporary Meshing (soft open point) LV - maximising latent capacity
2. Temporary Meshing (soft open point) HV - maximising latent capacity
3. Temporary Meshing (soft open point) EHV - maximising latent capacity
4. Switched capacitors @ LV
5. Switched capacitors @ HV
6. Switched capacitors @ EHV
7. Real Time Thermal Ratings for LV UG cables
8. Real Time Thermal Ratings for LV OH lines
9. Real Time Thermal Ratings for HV/LV Tx
10. Real Time Thermal Ratings for HV OH lines
11. Real Time Thermal Ratings for EHV UG cables
12. Real Time Thermal Ratings for EHV OH lines
13. Permanent Meshing of Networks - LV Sub-Urban Networks
14. Permanent Meshing of Networks - LV Urban Networks
15. Permanent Meshing of Networks - HV Networks
16. Permanent Meshing of Networks - EHV Networks
17. New Types Of Circuit Infrastructure - Novel HV underground cable
18. New Types Of Circuit Infrastructure - Novel HV tower and insulator structures
19. New Types Of Circuit Infrastructure - Novel EHV underground cable
20. New Types Of Circuit Infrastructure - Novel EHV tower and insulator structures
21. Local smart EV charging infrastructure - Intelligent control devices
22. Generator Providing Network Support - e.g. PV Mode Generator support @ LV
23. Generator Providing Network Support - e.g. PV Mode Generator support @ HV
24. Generator Providing Network Support - e.g. PV Mode Generator support @ EHV
25. Generator Constraint Management, GSR (Generator Side Response) @ LV
26. Generator Constraint Management, GSR (Generator Side Response) @ HV
27. Generator Constraint Management, GSR (Generator Side Response) @ EHV GSR
28. Fault Current Limiters - HV Superconducting fault current limiters
29. Fault Current Limiters - HV Non-superconducting fault current limiters
30. Fault Current Limiters - HV reactors - mid circuit
31. Fault Current Limiters - EHV Superconducting fault current limiters
32. Fault Current Limiters - EHV Non-superconducting fault current limiters
33. Enhanced Automatic voltage Control (EAVC) - LV PoC voltage regulators
34. Enhanced Automatic voltage Control (EAVC) - LV circuit voltage regulators
35. Enhanced Automatic voltage Control (EAVC) - HV circuit voltage regulators
36. Enhanced Automatic voltage Control (EAVC) - EHV circuit voltage regulators
37. Enhanced Automatic voltage Control (EAVC) - HV/LV Transformer Voltage Control

38. Embedded DC Networks - Embedded DC@LV
39. Embedded DC Networks - Embedded DC@HV
40. Embedded DC Networks - Embedded DC@EHV
41. Electrical Energy Storage - LV connected EES - small
42. Electrical Energy Storage - LV connected EES - medium
43. Electrical Energy Storage - LV connected EES - large
44. Electrical Energy Storage - HV connected EES - small
45. Electrical Energy Storage - HV connected EES - medium
46. Electrical Energy Storage - HV connected EES - large
47. Electrical Energy Storage - EHV connected EES - small
48. Electrical Energy Storage - EHV connected EES - medium
49. Electrical Energy Storage - EHV connected EES - large
50. Electrical Energy Storage - EES - HV Central Business District (commercial building level)
51. Demand Side Response (DSR) - DNO to commercial DSR (direct with HV customers)
52. Demand Side Response (DSR) - DNO to commercial DSR (direct with EHV customers)
53. Demand Side Response (DSR) - DNO to aggregator led commercial DSR (HV customer)
54. Demand Side Response (DSR) - DNO to aggregator led commercial DSR (EHV customer)
55. Demand Side Response (DSR) - DNO led residential DSR
56. Demand Side Response (DSR) - DNO to Central business District DSR
57. Distribution Flexible AC Transmission Systems (D-FACTS) @ LV
58. Distribution Flexible AC Transmission Systems (D-FACTS) @ HV
59. Distribution Flexible AC Transmission Systems (D-FACTS) @ EHV
60. Distribution Flexible AC Transmission Systems (D-FACTS) - LV connected STATCOM
61. Distribution Flexible AC Transmission Systems (D-FACTS) - HV connected STATCOM
62. Distribution Flexible AC Transmission Systems (D-FACTS) - EHV connected STATCOM
63. Active Network Management - Dynamic Network Reconfiguration @ LV
64. Active Network Management - Dynamic Network Reconfiguration @ HV
65. Active Network Management - Dynamic Network Reconfiguration @ EHV

6.2. SGR WS3: Enablers [3]

The following list provides the exhaustive set of smart solution enablers identified by the Smart Grid Forum [3]:

1. Phase imbalance - HV circuit
2. Phase imbalance - LV connect customer, 3 phase
3. Phase imbalance - smart meter phase identification
4. Phase imbalance - LV circuit
5. Smart Metering infrastructure - DNO to DCC 2 way control
6. Smart Metering infrastructure - DNO to DCC 2 way A+D
7. Smart Metering infrastructure - DCC to DNO 1 way
8. Monitoring waveform quality (HV/LV Tx)
9. Monitoring waveform quality (EHV/HV Tx)
10. Weather monitoring
11. Dynamic Network Protection, 11kV

12. Communications to DSR aggregator
13. RMUs Fitted with Actuators
14. LV Circuit monitoring (along feeder) w/ state estimation
15. Link boxes fitted with remote control
16. HV Circuit Monitoring (along feeder) with State Estimation
17. HV Circuit Monitoring (along feeder)
18. EHV Circuit Monitoring
19. DSR - Products to remotely control EV charging
20. DSR - Products to remotely control loads at consumer premises
21. Design tools
22. Communications to and from devices
23. DNO Data Architecture
24. Advanced control systems

7. APPENDIX: SPEN IP1 PAPERS

Ayr 33kV Fault Level Resolution (IP1)
Bainsford 33kV Fault Level Resolution (IP1)
Berwick (North Road_Loaning Relief) Reinforcement (IP1)
Berwick Ring Voltage Support (IP1)
Bowhill_Kelty Reinforcement (IP1)
Broxburn GSP Network Reconfiguration (IP1)
Calais Reinforcement (IP1)
Chirnside Reinforcement (IP1)
Cockenzie 33kV Fault Level Resolution (IP1)
Crookston 'A' Fault Level Resolution (IP1)
Dalbeattie Reinforcement (IP1)
Deans Close Reinforcement
Dumfries 132_11kV Fault Level Resolution (IP1)
Dumfries 33kV Fault Level Resolution (IP1)
Duns Reinforcement (IP1)
Ecclefechan Reinforcement (IP1)
Erskine Reinforcement (IP1)
Gartferry Road Reinforcement (IP1)
Girvan Primary Substation Voltage Reinforcement (IP1)
Govan 6.6kV (Phase 1) Upgrade (IP1)
Govan 6.6kV (Phase 2) Upgrade (IP1)
Hillington Reinforcement (IP1)
Killermont 33kV Fault Level Resolution (IP1)
Kilmarnock South 33kV Fault Level Resolution (IP1)
Langholm Primary Substation Voltage Reinforcement (IP1)
Langside Reinforcement (IP1)
Lasswade Reinforcement (IP1)
Leven 33kV Fault Level Resolution (IP1)
Leven GSP Network Configuration (IP1)

Moffat Reinforcement (IP1)
Norham GSP (Berwick_Eccles) 33kV Network Integration (IP1)
North Berwick Reinforcement (IP1)
North Road 11kV Fault Level Resolution (IP1)
Oakfield (Kelso) Reinforcement (IP1)
Partick 6.6kV Upgrade (IP1)
Penpont Reinforcement (IP1)
Portobello 11kV Fault Level Resolution (IP1)
Queensway_Warout Road Reinforcement (IP1)
Sighthill Reinforcement (IP1)
Stranraer Primary Substation Voltage Reinforcement (IP1)
Strathleven 33kV Fault Level Resolution (IP1)
Tongland 132_33kV GSP 33kV Network Integration (IP1)
West George Street 33kV Fault Level Resolution (IP1)
Westburn Road 33kV Fault Level Resolution (IP1)
Yair Bridge 22kV Voltage Uprating (IP1)
Yoker Ferry Road Reinforcement (IP1)
Aintree 33kV switchboard replacement IP1-Concept_Approval _1_
Anglesey Reinforcement IP1 Concept Approval _1_
Bangor - Caernarfon Reinforcement IP1-Concept_Approval
Blundell Street 33kV RMU Fault leve replacementIP1-Concept_Approval _1_
Bold-Prescot-Widnes 33kV reinforcement IP1-Concept_Approval _1_
Bootle - Litherland 33kV Reinforcement v3
Bootle-Lister Drive-Burlington St 33kV reinforcement IP1-Concept_Approval _1_
Brymmbo_Legacy_Marchwiel IP1-Concept_Approval _1_
Bryn Blaen & Mynydd Y Gwynt Wind Farm SRG IP2 version B
Chester Reinforcement IP1-Concept_Approval _1_
Crewe 132kV Reinforcement IP1 Concept Approval _1_
Fault level Mitigation Gateacre_Huyton
Flint Reinforcement IP1-Concept_Approval _1_
Gateacre_Huyton_Prescot_Kirkby IP1-Concept_Approval _1_
Hoylake-Heswall-Prenton 33kV reinforcement IP1-Concept_Approval _1_
Ince 33kV reinforcement IP1-Concept_Approval _1_
Kirkby-Gillmoss-Simonswood 33kV reinforcement IP1-Concept_Approval _1_
Legacy 132kV (3rd cct running arrangement clarification) IP1-Concept_Approval (2)
Legacy 132kV _3rd cct running arrangemenet clarification_ IP1-Concept_Approval _2_
Lostock Reinforcement IP1-Concept_Approval _1_
Mid Wales Reinforcement IP1-Concept_Approval (2)
Mobil Oil 33kV RMU Fault leve replacementIP1-Concept_Approval _1_
Prenton 33kV switchboard replacement IP1-Concept_Approval _1_
Runcorn 33kV Reinforcement IP1-Concept_Approval
Speke 33kV switchboard replacement IP1-Concept_Approval _1_
Wallasey 33kV switchboard replacementIP1-Concept_Approval _1_
Warrington 33kV Network Fault Level Reinforcement IP1-Concept_approval(Signed)
Whitchurch Reinforcement IP1-Concept_Approval _1_

Abergele-Pensarn IP1
Anderton IP1 Paper
Beaumaris IP1 Paper
Bowater Ellesmer Port IP1 Paper
Caergwrle IP1 Paper
Cheshire Oaks IP1 Paper
Chowley IP1 Paper
Civic Centre IP1 Paper
Cledford IP1 Paper
Coedpoeth IP1Paper
Duckington IP1 Paper
Fairbourne IP1 Paper
Forden IP1 Paper
Frodsham IP1 Paper
Graig Fawr IP1 Paper
Ifton IP1Paper
Llandrinio IP1 Paper
Llandyfrydog IP1 Paper
Llandyrnog IP1 Paper
Llanidloes IP1 Paper
Llanilar IP1 Paper
Orford-Padgate IP1
Pen-y-Groes IP1 Paper
Ringway IP1 Paper
Runcorn IP1 Paper
Tarvin IP1 Paper
Wistaston Hall IP1 Paper