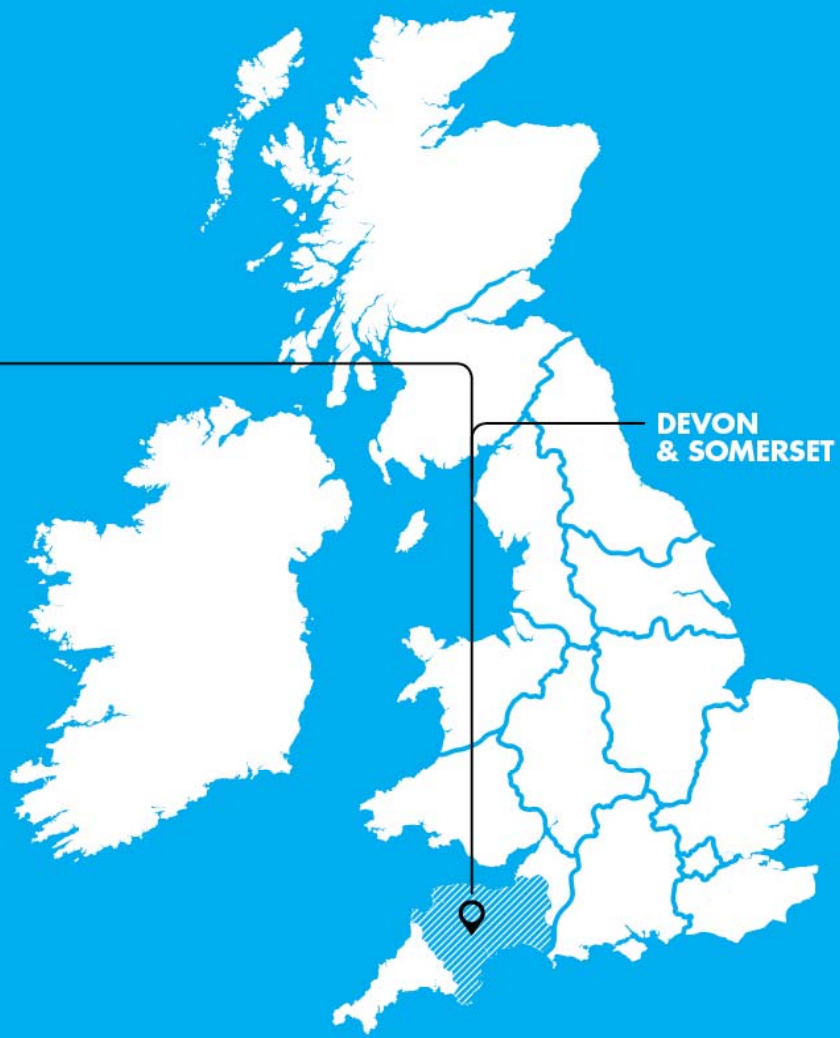
WESTERN POWER DISTRIBUTION

NETWORK EQUILIBRIUM

BALANCING GENERATION AND DEMAND



PROJECT PROGRESS REPORT

REPORTING PERIOD:
June 2018 to November 2018

LCN Fund
Low Carbon Networks

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Prepared by:	Jonathan Berry	07.12.2018
Reviewed by:	Roger Hey	10.12.2018
Approved by:	Nigel Turvey	12.12.2018

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Contents

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1 Executive Summary

Network Equilibrium is funded through Ofgem's Low Carbon Networks Second Tier funding mechanism. Network Equilibrium was approved to commence in March 2015 and will be complete by 14th June 2019. Network Equilibrium aims to develop and trial an advanced voltage and power flow control solution to further improve the utilisation of Distribution Network Operators' (DNO) 11kV and 33kV electricity networks in order to facilitate cost-effective and earlier integration of customers' generation and demand connections, as well as an increase an customers' security of supply.

This report details progress of the project, focusing on the last six months, May 2018 to November 2018.

Business Case

The business case for Network Equilibrium remains unchanged. The benefit of creating additional system capacity for the connection of load and generation, as well as the increases in security of supply to all customers is still valid.

Project Progress

This is the eighth progress report. The period covered in this report has focussed on the continued operation of the System Voltage Optimisation (SVO) system and the Flexible Power Link (FPL).

The operation of the SVO has enabled significant data to be captured and learning to be gathered regarding the performance of the complete system. In this period we have been able to understand the operational performance of the SVO system and its wider applicability based on the needs of the network.

This period has seen the operation of the FPL, following the commissioning and energisation, and learning has been gathered both regarding the performance of the FPL technology and the Control Module (CM) to calculate the real and reactive power to ensure the FPL operates appropriately to suitably manage the network voltage and power flows. This period also saw the submission of SDRC 6, which detailed the Trialling and Demonstrating of the FPL.

These activities described above have provided significant progress towards the completion of the next SDRC, 7.

Project Delivery Structure

Project Review Group

The Network Equilibrium Project Review Group met once during this reporting period. The main focus of this meeting was the initial learning from the trials of the SVO and FPL on the system.

Resourcing

The resourcing of the project remains as described in the previous reporting period, where the design team is led by WPD engineers and supported by WSP engineers.

Procurement

The procurement activities for Network Equilibrium focus on the SVO and FPL methods. Throughout the project supporting procurement activities will take place in order to facilitate the successful delivery of all project methods; however, there are two formal procurement activities as part of the project.

Table 1-1: Procurement Activities

Manufacturer	Technology	Applicable Substations	Anticipated Delivery Dates
Siemens	SVO System	16 Substations	Completed
ABB	FPL	Exebridge	Completed

Installation

Construction and installation activities related to the SVO and FPL have been completed in the previous reporting period:

- 16 complete SVO relay site installation; and
- FPL device installed and commissioned.

Project Risks

A proactive role in ensuring effective risk management for Network Equilibrium is taken. This ensures that processes have been put in place to review whether risks still exist, whether new risks have arisen, whether the likelihood and impact of risks have changed, reporting of significant changes that will affect risk priorities and deliver assurance of the effectiveness of control.

Contained within Section 8.1 of this report are the current top risks associated with successfully delivering Network Equilibrium as captured in our Risk Register along with an update on the risks captured in our last six monthly project report. Section 8.2 provides an update on the most prominent risks identified at the project bid phase.

Project Learning and Dissemination

Project lessons learned and what worked well are captured throughout the project lifecycle. These are captured through a series of on-going reviews with stakeholders and project team members, and will be shared in lessons learned workshops at the end of the project. These are reported in Section 6 of this report.

A key aim of Network Equilibrium is to ensure that significant elements of the work carried out for network modelling, monitoring, design and installation are captured and shared within WPD and the wider DNO community. During this period the main focus has been to capture the learning from the design, testing, installation and commissioning of the FPL in SDRC 6.

In addition to this we have shared our learning (where applicable), through discussions and networking at a number of knowledge sharing events; principally the 2018 Low Carbon Networks Innovation Conference.

2 Project Manager's Report

2.1 Project Background

The focus of Network Equilibrium is to balance voltages and power flows across the distribution system, using three Methods to integrate distributed generation within electricity networks more efficiently and delivering major benefits to distribution customers.

The Problem that Network Equilibrium addresses is that electricity infrastructure in the UK was originally designed and developed for passive power distribution requirements. As a result, the integration of significant levels of low carbon technologies (LCTs) within our present electricity networks can cause voltage management and thermal issues. For business as usual (BAU) roll-out we need to develop solutions, which take a strategic engineering approach, considering the whole system and not solving constraints on a piecemeal basis. The Problem will be investigated using three Methods, and their applicability to 33kV and 11kV distribution networks assessed. Each will involve testing within South West England:

(1) Enhanced Voltage Assessment (EVA);
(2) System Voltage Optimisation (SVO); and
(3) Flexible Power Link (FPL).

The aims of Equilibrium are to:

- Increase the granularity of voltage and power flow assessments, exploring potential amendments to ENA Engineering Recommendations and statutory voltage limits, in 33kV and 11kV networks, to unlock capacity for increased levels of low carbon technologies, such as distributed generation (DG);
- Demonstrate how better planning for outage conditions can keep more customers (generation and demand) connected to the network when, for example, faults occur. This is particularly important as networks become more complex, with intermittent generation and less predictable demand profiles, and there is an increased dependence on communication and control systems;
- Develop policies, guidelines and tools, which will be ready for adoption by other GB DNOs, to optimise voltage profiles across multiple circuits and wide areas of the network;
- Improve the resilience of electricity networks through FPL technologies, which can control 33kV voltage profiles and allow power to be transferred between two, previously distinct, distribution systems; and
- Increase the firm capacity of substations, which means that the security of supply to distribution customers can be improved during outage conditions, leading to a reduction in customer interruptions (CIs) and customer minutes lost (CMLs).

2.2 Project Progress

This is the eighth progress report. The period covered in this report has focussed on the continuing operation of the SVO and the initial network learning of the FPL following commissioning.

The operation of the SVO has enabled a substantial amount of data to be gathered both from the performance of the SVO's central system, Siemens' SP5, and the network data, principally the effect on voltage and the wider network impacts. This data has been, and will continue to be, used to assess the impact of the complete SVO system, the value and benefit of implementation at future locations based on technical and economic factors and to provide important learning for further development towards business as usual adoption.

As discussed in the previous reporting period the FPL has now been installed on site, fully tested and commissioned and is now operational, following the production and approval of the required operation and safety policies and procedures. The initial learning has focussed on the updated system capacity released through the implementation of the device and its wider effect on the network. This learning has been robustly captured in SDRC 6, submitted in October 2018.

2.3 System Voltage Optimisation

The SVO method of Network Equilibrium aims to dynamically manage the voltages in the network to maximise the level of LCTs that can be connected to network while maintaining statutory limits.

In this reporting period work has focused on the operational trials of SVO and the capturing of the learning produced.

2.3.1 Operational Learning

2.3.1.1 Alarm exchanges between SVO and NMS

Through the trials, valuable learning and confidence in the system has been gained which enabled the simplification of the alarm exchanges between SVO and the Network Management System (NMS) and significantly reduced the time that had to be spent by Control Engineers to react to alarms.

The SVO system, Spectrum Power 5 (SP5), has been designed to send alarms to the NMS that indicate the status of the optimisation at each site but also the status of the system. The alarms were grouped following a traffic light system, where the status of the optimisation of each site could be red, amber or green depending on the highest priority alarm raised for that site. Similarly, the status of the system could be red, amber or green, reflecting the highest priority system alarm raised by SP5. Each category of alarms required a different action, with red site alarms for example, requiring the site to be disabled automatically and the Distribution System Operator (DSO) Technology team (the system owner) to be notified of the alarm by the Control team, amber alarms also required notification while green alarms required no action. This ensured that Control Engineers could easily understand the operational status of SVO without the need of having to interpret a large list of technical alarms and that the action that had to be taken was clear. Additionally, it reduced the traffic between the NMS and SP5, ensuring that the visibility of existing network alarms is not affected by the new SVO alarms. An example of the Green System Status is shown in Figure 2-1 and an example of the Green Site Status is shown in Figure 2-2.

Figure 2-1: System Status Example

Figure 2-2: Site Status Example

The trials have shown that the alarms were successfully exchanged between SP5 and the NMS and as they progressed increased our confidence in the system operation. Through the running of the technology in the first few months, it was proved that the optimisation at each site is correctly reported and that the correct action is taken by the system when required (for example automatic disabling when red alarm is raised). Therefore, we updated our operational procedures to remove the requirement for the Control Engineers to be reporting any optimisation alarms to the DSO technology team. Additionally, the criticality of the majority of the amber optimisation alarms was reduced and those alarms were given green (lowest) priority since the trials have shown that they don't require attention.

2.3.1.2 Automatic Restoration

With the stable operation of the system being proven in the trials, certain operational procedures have been automated, making the day-to-day operation of the technology more efficient and independent of manual intervention from Control Engineers.

Originally, the system had been designed such that when a red optimisation alarm (highest priority) was sent from SP5 to the NMS, SVO would be automatically disabled on that site. This was done through a logic that was implemented in the NMS which would send a control to the SVO system to disable SVO on that site once that site's optimisation status turned red. After investigating the issue that caused the red alarm, the Control team had to be contacted over the phone in order to request the re-enabling of SVO on that site.

The numerous investigations that were done following this procedure have shown that in most cases the reason the site's status turned red was transient due to issues with communications. In all the occasions, the site could be safely re-enabled straight after the event with no operational implications as the various safety checks that were added to SP5 ensure that no action is taken that could compromise the network.

Therefore, additional logic was then added in the NMS in order to re-enable the site automatically an hour after it was disabled due to a red optimisation alarm. This increased the on-time of the technology, reduced the amount of time spent by Control Engineers to manually re-enable sites and also provided additional learning by making it easier to see how long each site would maintain green optimisation status. Figure 2-3, shows the automatic enabling / disabling behaviour at Tiverton Moorhayes Primary with 2 indicating that the site is enabled and 1 that the site is disabled. As can be seen in the figure, SVO was automatically disabled on the 13th of November for 1 hour, then it got re-enabled automatically again with no further switching taking place after that. It can also be observed that while the site was being re-enabled, its status dropped to zero for a few seconds. This is because of the state changing, with the zero showing the transition.

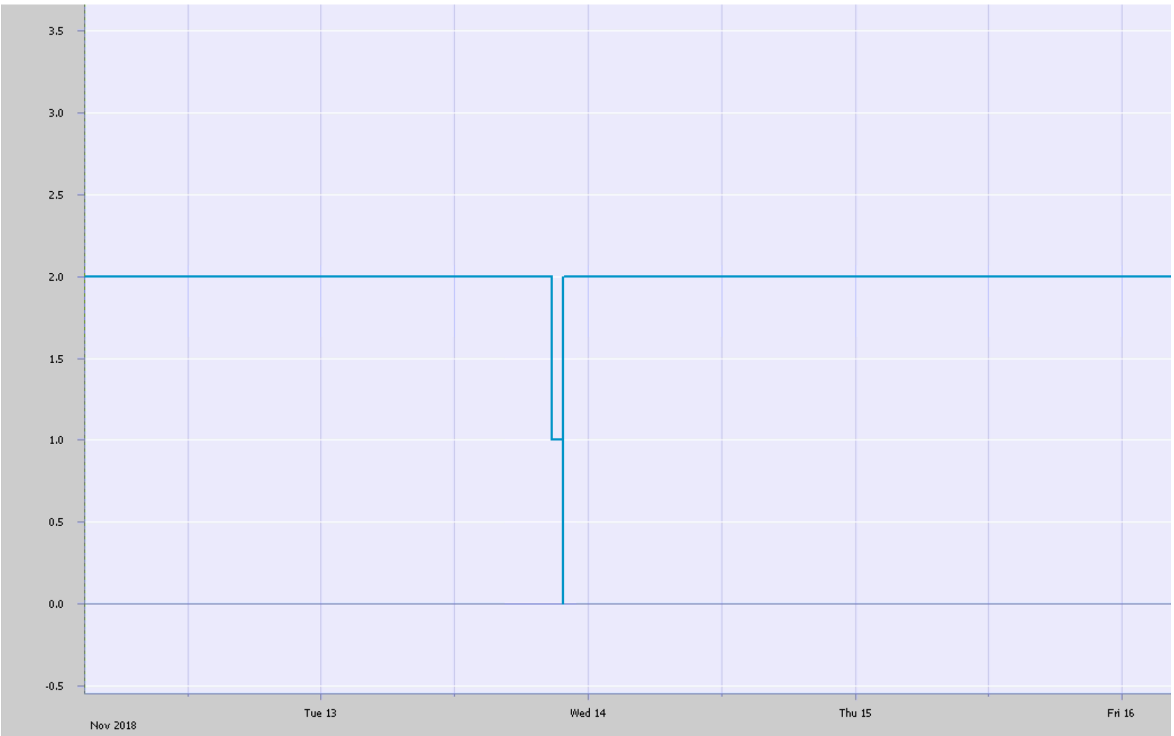


Figure 2-3: Automatic enabling-disabling at Tiverton Moorhayes Primary

The indication that was added to the NMS to show whether automatic restoration was active at each site is shown in Figure 2-4.

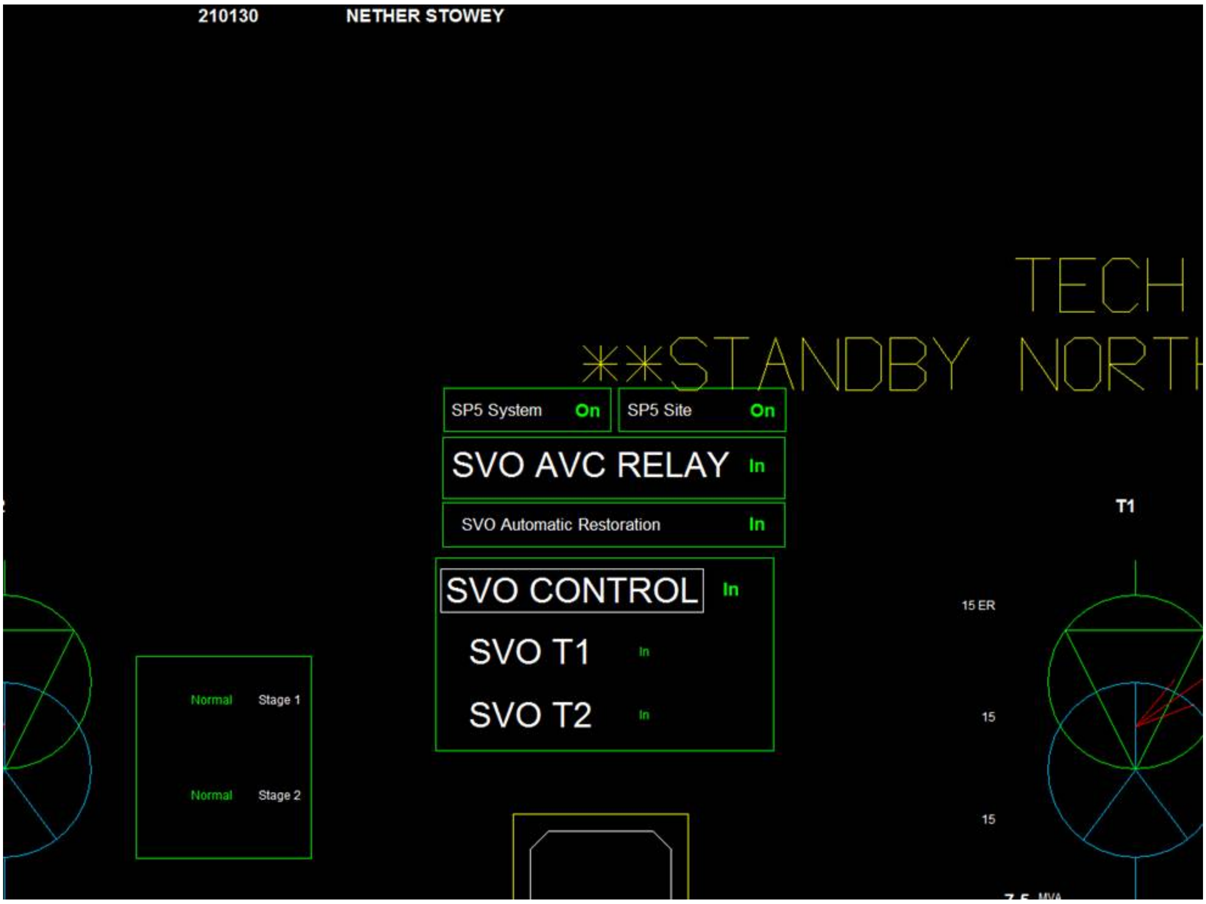


Figure 2-4 Automatic Restoration Indication in the NMS for Nether Stowey Primary

2.3.1.3 Set Point Resolution

Transmitting analogue set points through the existing Supervisory Control And Data Acquisition (SCADA) infrastructure is one of the main functionalities of the SVO system but something that was not done previously as part of the Business As Usual (BAU) operation of the network. Therefore, through the implementation and trial of SVO, significant learning was gained on the main challenges that need to be overcome when sending analogue settings to equipment on the network and how that can be done.

The biggest challenge is that resolution is lost while the analogue set point is travelling from the SVO system to site, which means that the target voltage set point that reaches the Automatic Voltage Control (AVC) relay on site differs slightly to the set point that was sent by the SVO system. This is because of the conversions that are taking place along the way as the set point is travelling through the SCADA system. To demonstrate this, let's consider the example where the SVO system is sending the target voltage setting of 33.45kV to Bowhays Cross BSP. After SVO calculates the set point, it sends the value of 33.45kV to the NMS which performs the following translation before sending the value to the Remote Terminal Unit (RTU) on site:

$$SetPoint = \frac{SVOsetpoint \times 1000}{33} = 1013.63 = 1013$$

As can be seen from the above equation, all decimal places are dropped in order to send the value to the RTU. This is because only 16-bit integers are sent from the NMS to the RTU in the implementation of the IEC60870-5-101[1] that is used in the NMS-RTU communications. Therefore, the NMS then sends the value of 1013 to the RTU on site which in turn sends the value to the relay. The relay then applies the value which can be translated into a kV voltage using the equation below:

$$AppliedSetPoint = \frac{SetPoint \times 33}{1000} = 33.429kV = 33.43kV$$

This demonstrates that the initial set point of 33.45kV sent by SP5 is applied as 33.43kV by the relay and even though this difference is small, it can have an impact on the way the optimisation system works. In some cases we have observed that SP5 was sending the same set point sequentially a number of times and that was because it continued trying to achieve the mathematical optimal solution which differed slightly to what was applied on site. This is very valuable learning as it shows the requirement of adjusting optimisation tools to take into account actual operational constraints when finding the "best" solution.

2.3.1.4 Correlation Analysis

Significant learning was also gained from the analysis of the trial results that was performed so far. In this analysis, the aim was to see whether the SVO system was dropping the network voltages as expected and if it was possible to identify any trends in the target voltage set points that were sent to the SVO sites.

As part of this work, all of the SVO sites graphs are produced on a weekly basis that show the SVO target voltage set points, the voltage on site and the total power flow at that site. An example is shown in Figure 2-5, where the voltage, set points and total MW for GT1 at Tiverton BSP is shown. The green and red squares indicate when SVO was enabled / disabled in that period.

[1] Transmission Protocols – companion standards especially for basic telecontrol tasks

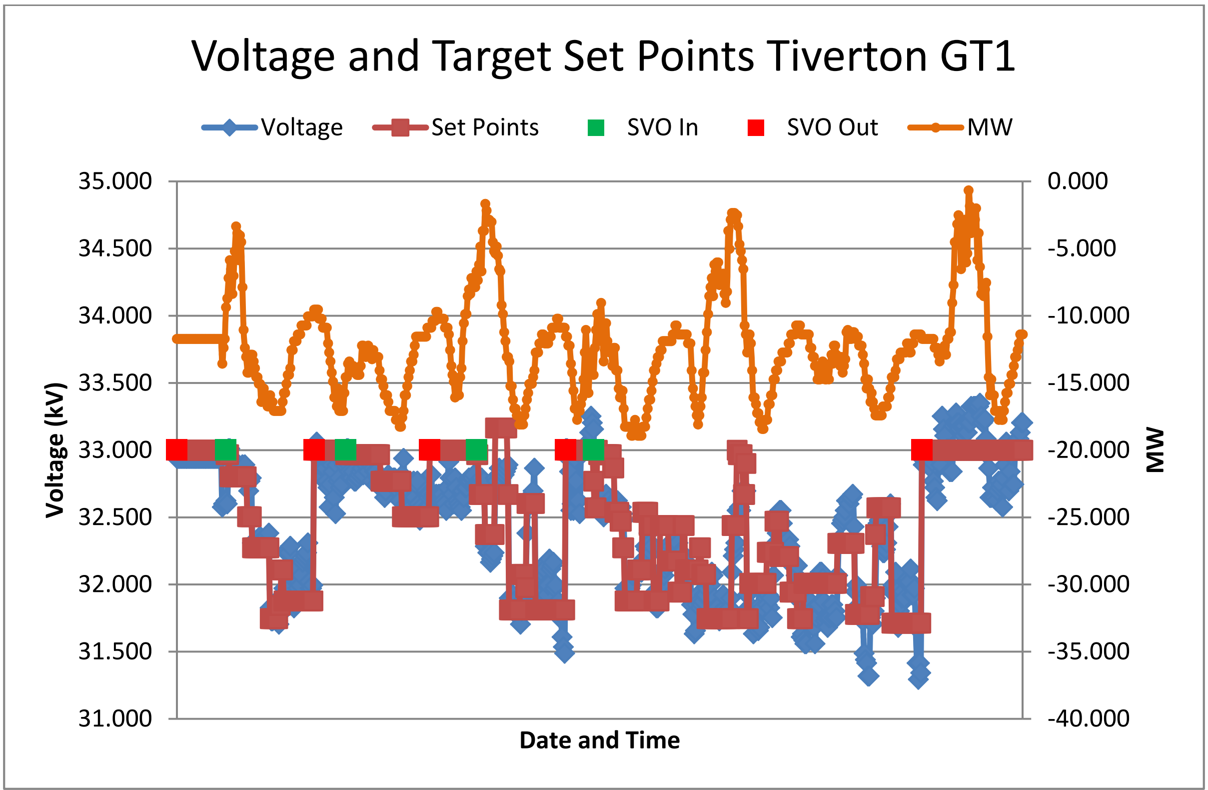


Figure 2-5: Tiverton BSP GT1 Weekly Graph for 03.09.2018-09.09.2018

In order to understand better if the SVO set points are affected by the total substation flow or if there are any other trends that cannot be easily identified from the graph, we performed some statistical analysis on the trial data. This analysis was done automatically using a Python script, making it easy to apply this analysis on the additional data that are extracted every week. As part of this analysis, the voltages, set points, MW and the way all these parameters change were processed outputting a measure of the relationship between the parameters. This is called a correlation coefficient and is a number between -1 and 1, showing how strong the relationship between two parameters is. Zero indicates no relationship, while 1 shows a strong relationship where if one parameter increases the second will increase too and if it decreases the second will decrease too. -1 shows a strong relationship where if one parameter increases the other will decrease. The results for Tiverton BSP, for a week (03.09.2018-09.09.2018) are shown in the table below:

Table 2-1: Correlation Analysis Results for Tiverton BSP

SVO Site	Correlation Set point-MW	Correlation Set point-MW Change	Correlation Set point change-MW	Correlation Set point change-MW change	Correlation Set point-Max V	Correlation Set point-Min V
Tiverton BSP	0.19	0.12	0.059	0.25	-0.33	0.42

The table shows that there is almost no relationship between the set point change and the substation MW and there is little relationship between Set Point and MW, Set Point and MW change and Set Point change and MW change. However, there is some relationship between the set point and the maximum and minimum voltages in the network.

This shows that it is not currently possible to provide generalised rules on what the best target voltage in the network is, since it does not get affected by the total substation flow or follow a specific trend. In fact, the distribution of the loads and generation in the network mean that the operation of the network is complex and requires a control system that is able to perform power flow analysis, in order to understand how the constraints change in real time and therefore how voltage control should adapt accordingly. It reinforces the case for the need to have a control system that can understand the complex network we now have and then perform control actions or even optimise it accordingly.

This analysis is ongoing on a weekly basis and the next steps will be to determine whether there are any similarities in the behaviour of the various SVO sites that could group them into categories to benefit future implementations.

2.4 Flexible Power Link

Successful testing in the previous period enabled the FPL to be energised and operate both in real and reactive power (P and Q) models to manage voltage and thermal limits on the network.

The analysis of the FPL has focused on the effect of these power transfers, P and Q, on each BSP network, the reliability and availability of both systems. Power System studies, using network and FPL operation data, have been carried out to improve previous estimates regarding the additional generation capacity that can be released by the FPL.

2.4.1 Performance

In order to fully test the operation of the FPL the system violation limits of the network assets were reduced compared to what they would be on a business as usual implementation; this allowed the FPL to be driven in to operation and present the following information.

The operational performance seen from the FPL has predominately focussed on the real power (P) transfer at this stage. This is principally due to the volume of generation located on the Barnstaple side of the FPL network and the load dominated network on the Taunton side. Due to this the transfer of real power has generally aligned with large load utilisation of the system; Figure 2-6 shows the performance of the FPL. It can be seen that the utilisation of the FPL centres on morning and evening peak demands when considering the loads at both Barnstaple and Taunton BSP as indicated in Figure 2-7 and Figure 2-8.

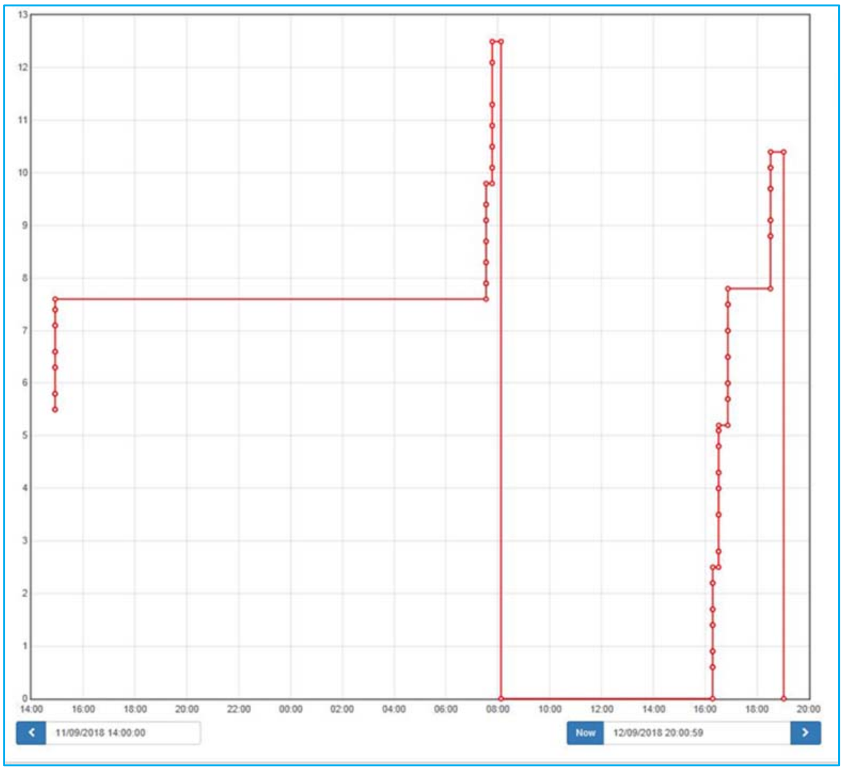


Figure 2-6: Real Transfer Performance of FPL (MW)

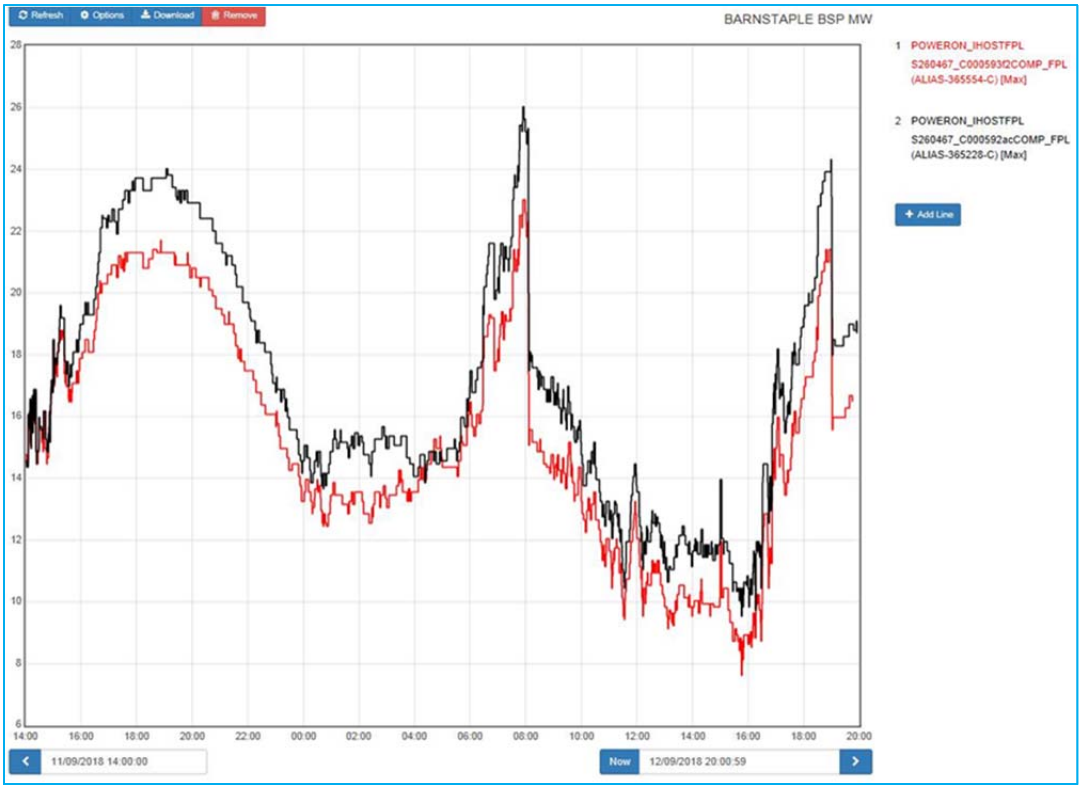


Figure 2-7: Barnstaple BSP Power (MW)

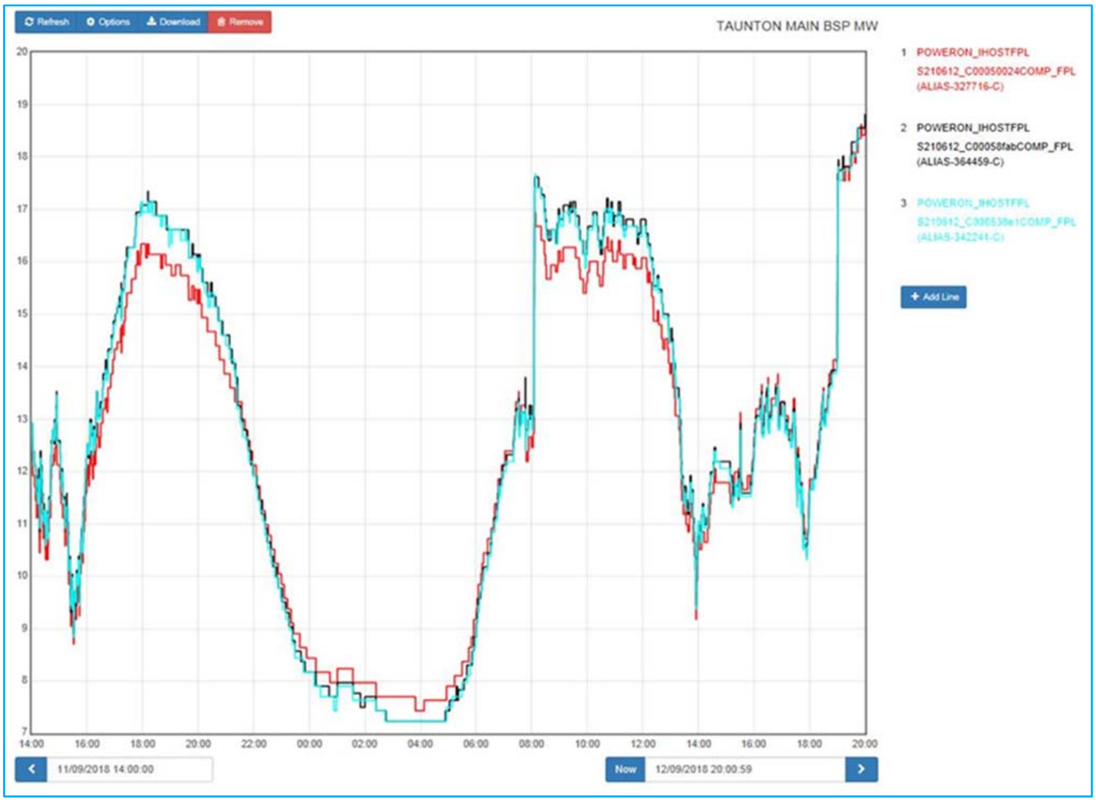


Figure 2-8: Taunton BSP Power (MW)

The graphs show that at times of high load on Taunton BSP, the FPL transfers between 10.5MW and 12.5MW from Barnstaple BSP.

Changes of the wider network operational limits are planned to enable other modes of the FPL to be suitably tested, specifically reactive power (Q) operation to control voltage and P and Q to ensure, beyond the testing previously carried out, that the device operates as expected and required for the network performance to be optimised.

2.4.2 Operational Experience

Through the open and closed loop testing of the FPL on the network, where the device operated without issue, the system was shown to be reliable and stable. Through the closed loop operation the FPL has been exposed to a number of external events that have caused its disconnection from the network.

On several occasions the device automatically shut down for a short period of time. Following analysis of the FPL, FPL CM and other network data the issue was identified as being caused by the trip operation and auto reclose of the 11kV switchgear at the FPL substation, Exebridge. This caused the loss of the LV supply that supplies the FPL's auxiliary systems including the cooling system. Further analysis showed that the trip events were a regular occurrence on the breaker supplying the LV substation for the FPL. Modifications were made the to the LVAC connections to transfer the critical FPL supplies onto the other distribution substation supplied by a section of network with a greater reliability. Since the change there has been no further period of unavailability of the FPL device.

The FPL has also operated twice for external faults on the remote system of which it connects. In each case there was a single-phase to earth fault on the network. In both these instances the FPL identified the fault and disconnected from the system within 600 milliseconds. This can be seen in the events log for one of these events in Figure 2-9.

2018-10-28 13:57:58.301,1X1_ARU_SWG,612,E6312_E,FPL1 CB is open,Opened
2018-10-28 13:57:58.301,1X2_INU_SWG,612,E1312_E,FPL2 CB is open,Opened
2018-10-28 13:57:58.273,1X2_GEN,623,E0123_E,Ctrl. 800PEC transient recorder B recording,Active
2018-10-28 13:57:58.273,1X2_GEN,621,E0121_E,Ctrl. 800PEC transient recorder A recording,Active
2018-10-28 13:57:58.273,1X2_GEN,611,E0111_E,Group warning control,Active
2018-10-28 13:57:58.251,1X2_INU,602,E1102_E,Converter FPL2 pulses are blocked,On
2018-10-28 13:57:58.230,1X2_GEN,26,G0123_CH16_W,Protection-PEC has set TRIP MATRIX channel(s),Warning reset
2018-10-28 13:57:58.218,1R2_GEN,15,G0124_CH05_W,Control-PEC has set TRIP MATRIX channel(s),Warning reset
2018-10-28 13:57:58.217,1R2_GEN,625,E8125_E,Prot. 800PEC transient recorder C recording,Active
2018-10-28 13:57:58.217,1R2_GEN,623,E8123_E,Prot. 800PEC transient recorder B recording,Active
2018-10-28 13:57:58.217,1X1_ARU,1,A0026_W,FPL1 grid fault causes pulse blocking,Warning reset
2018-10-28 13:57:58.215,1X2_GEN,16,G0123_CH06_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.215,1X2_GEN,15,G0123_CH05_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.215,1X2_GEN,12,G0123_CH02_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.215,1X2_GEN,26,G0123_CH16_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.215,1X2_GEN,25,G0123_CH15_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.215,1X2_GEN,24,G0123_CH14_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.215,1X2_GEN,11,G0123_CH01_W,Protection-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:58.214,1R2_GEN,621,E8121_E,Prot. 800PEC transient recorder A recording,Active
2018-10-28 13:57:58.213,1R1_ARU_PRIM,430,A0006_T,FPL1 XFMR primary side earth fault,Trip
2018-10-28 13:57:57.752,1X1_ARU,602,E6102_E,Converter FPL1 pulses are blocked,On
2018-10-28 13:57:57.704,1R2_GEN,15,G0124_CH05_W,Control-PEC has set TRIP MATRIX channel(s),Warning
2018-10-28 13:57:57.703,1X1_ARU,1,A0026_W,FPL1 grid fault causes pulse blocking,Warning

Figure 2-9: FPL Event Log for External Trip

The FPL CM has been available and operational throughout the open and closed loop testing period. On two occasions during open loop testing, due to maintenance activities on the network, the FPL CM triggered a stage 2 alarm caused by the closure of a remote normally open point. Following this, further guidance information was produced for control and operational engineers to ensure that switching operations at defined locations are completed within a defined time, or ensures the FPL is disabled prior to starting work. Figure 2-10 provides a snapshot of the FPL CM interface. The availability for the project team and wider support staff to visualise the status and operational performance has been particularly useful, especially the capturing of data at 10 second internals for the purpose of detailed analysis.

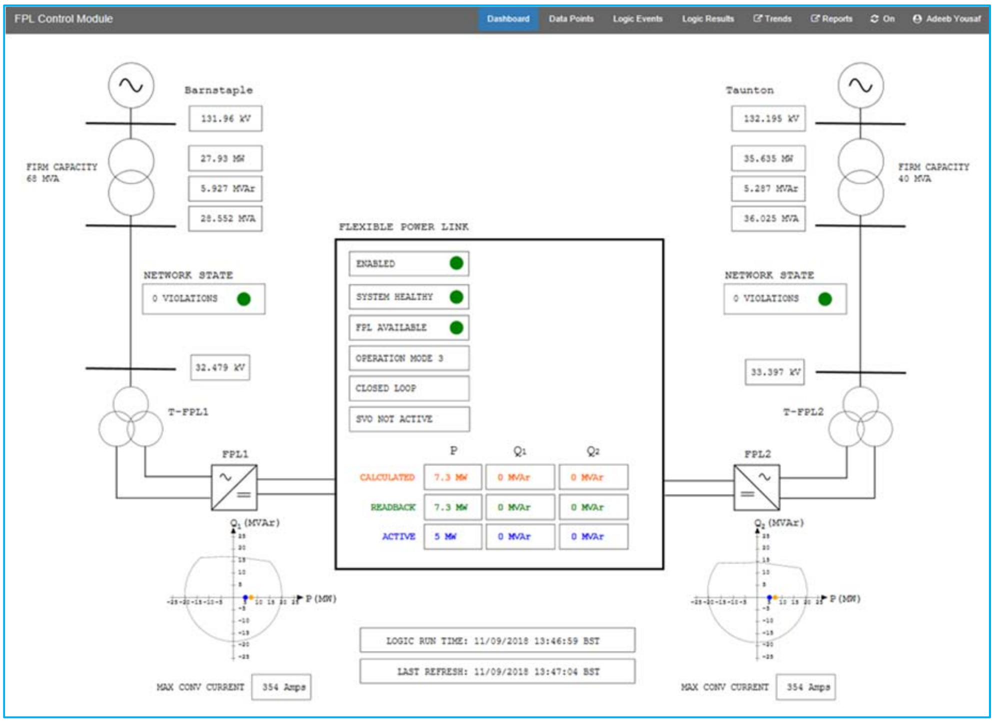


Figure 2-10: FPL CM Screenshot

2.4.3 Capacity Release

Previous analysis of the capacity released from the implementation of an FPL was presented in SDRC-4, whereby for the specific implementation between Barnstaple and Taunton was completed. Figure 2-11 shows the analysis carried out in SDRC-4, the Barnstaple-Taunton 2 analysis relates directly to the FPL install at Exebridge primary substation.

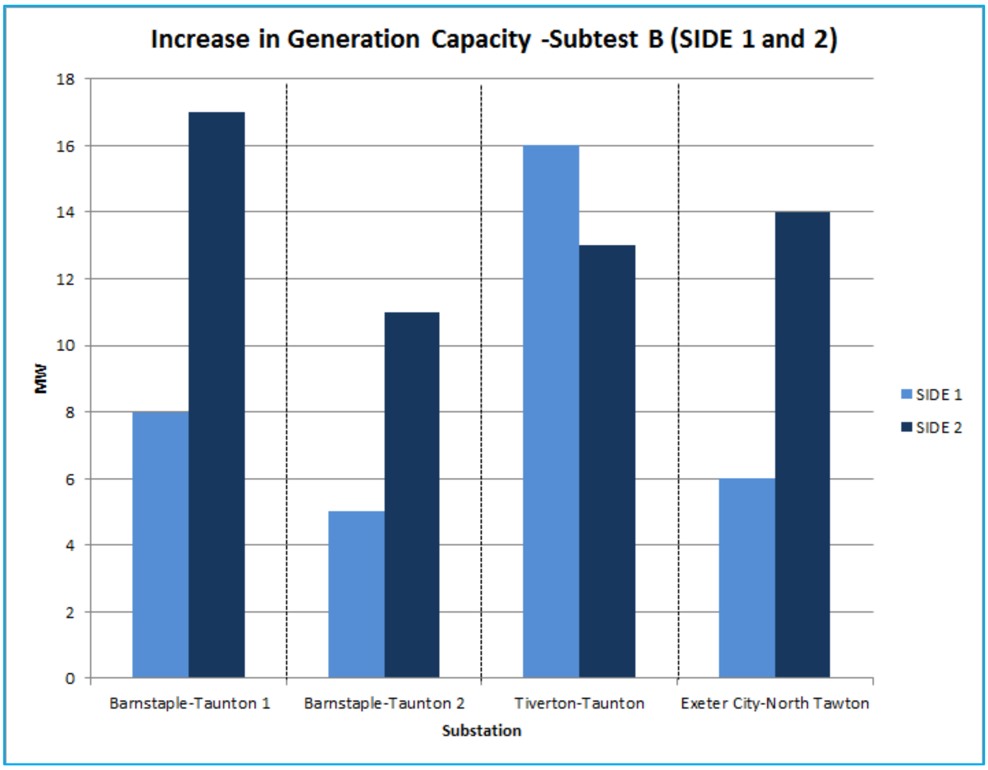


Figure 2-11: Increase in generation capacity flexibility using FPL

Following the implementation of the FPL and the development of a Power System Analysis (PSA) FPL tool updated capacity release figures have been generated. The figures presented in SDRC-4 have now increased from 5MW to 6.5MW and 11MW to 13.5MW; these values represent a transfer between Barnstaple and Taunton and Taunton and Barnstaple respectively.

The operation of the FPL will continue to be monitored and analysed, which will provide the opportunity to further understand the performance characteristics and capacity release capability of the device. This information will be captured in SDRC-7.

3 Business Case Update

There is no change to the business case. The business case to further facilitate the connection of low carbon loads and generation in the project area, on both the 11kV and 33kV are still applicable.

4 Progress against Budget

Table 4-1: Progress against budget

	Total Budget	Spend to Date November 2018	Actual Spend to date	Variance £	Variance %
Labour	**1262**	**833**	**814**	**(19)**	**-2%**
WPD Project Management & Programme office	510	380	371	(9)	-2%
Project Kick Off & Partner / Supplier Selection	33	33	33	-	0%
Detailed design & modelling	101	101	92	(9)	-8%[1]
Installation of Equipment - 11kV & 33kV	290	56	55	(1)	-3%
FPL Technologies - Substation Installation 33kV	241	220	221	1	0%
Capture, analyse & verify data for EVA, SVO & FPL	58	29	28	(1)	-4%
Dissemination of lessons learnt	29	14	13	(1)	-4%
Equipment	**6691**	**6021**	**6064**	**43**	**1%**
Project Kick Off & Partner / Supplier Selection	2	2	2	-	0%
Procurement of SVO Equipment	1540	1045	1038	(7)	-1%
Procurement of FPL Technologies 33kV	4550	4375	4408	33	1%
FPL Technologies - Substation equipment 33kV	599	599	616	17	3%
Contractors	**3339**	**2412**	**2374**	**(38)**	**-2%**
Detailed design & modelling	804	804	799	(5)	-1%
Delivery of SVO Technique - 11kV & 33kV	392	330	312	(18)	-5%
Installation of Equipment - 11kV & 33kV	650	125	119	(6)	-5%
Implementation of Solution	46	46	46	0	1%
Implementation of Solution	139	95	90	(5)	-5%

FPL Technologies - Substation Installation 33kV	740	695	687	(8)	-1%
Capture, analyse & verify data for EVA, SVO & FPL	445	295	300	5	2%
Dissemination of lessons learnt	123	22	21	(1)	-5%
IT	**396**	**318**	**309**	**(9)**	**-3%**
1. WPD - Advanced Network Modelling and Data Recovery	130	125	114	(11)	-9%[2]
1. WPD - Procurement of SVO Equipment	60	39	40	1	4%
Installation of Equipment - 11kV & 33kV	60	8	8	0	5%
6. WPD - Implementation of Solution	46	46	46	0	1%
FPL Technologies - Substation Installation 33kV	100	100	100	(0)	0%
Travel & Expenses	**159**	**125**	**125**	**(0)**	**0%**
Contingency	**1190**	**-**	**-**	**-**	**0%**
Other	**53**	**25**	**25**	**0**	**0%**
TOTAL	**13091**	**9734**	**9711**	**(23)**	**0%**

Notes on line item changes and variations

1 – Efficiencies in detailed design and the production of standard designs enabled savings.

2 – Cost savings were enabled through the use of an existing advanced network modelling methodology created as part of the previous FlexDGrid project.

5 Successful Delivery Reward Criteria (SDRC)

5.1 Future SDRCs

Table 5-1 captures the remaining SDRCs for completion during the project life cycle.

Table 5-1 - SDRCs to be completed

SDRC	Status	Due Date	Comments
7 - Trialling and demonstrating the integration of the EVA, SVO and FPL Methods	Green	28/12/2018	On track
8 - Knowledge capture and dissemination	Green	12/04/2019	On track

Status Key:	
Red	Major issues – unlikely to be completed by due date
Amber	Minor issues – expected to be completed by due date
Green	On track – expected to be completed by due date

6 Learning Outcomes

Significant learning has been generated and capturing in this reporting period, specifically in SDRC-6 regarding the trialling and demonstrating the FPL. Several key learning elements have also been generated during the operation and analysis of the SVO and FPL; this learning will be robustly reported in SDRC-7.

7 Intellectual Property Rights

A complete list of all background IPR from all project partners has been compiled. The IP register is reviewed on a quarterly basis.

No relevant foreground IP has been identified and recorded in this reporting period.

8 Risk Management

Our risk management objectives are to:

- Ensure that risk management is clearly and consistently integrated into the project management activities and evidenced through the project documentation;
- Comply with WPD's risk management processes and any governance requirements as specified by Ofgem; and
- Anticipate and respond to changing project requirements.

These objectives will be achieved by:

- ✓ Defining the roles, responsibilities and reporting lines within the Project Delivery Team for risk management
- ✓ Including risk management issues when writing reports and considering decisions
- ✓ Maintaining a risk register
- ✓ Communicating risks and ensuring suitable training and supervision is provided
- ✓ Preparing mitigation action plans
- ✓ Preparing contingency action plans
- ✓ Monitoring and updating of risks and the risk controls

8.1 Current Risks

The Network Equilibrium risk register is a live document and is updated regularly. There are currently 27 live project related risks. Mitigation action plans are identified when raising a risk and the appropriate steps then taken to ensure risks do not become issues wherever possible. In Table 8-1 we give details of our top five current risks by category. For each of these risks, a mitigation action plan has been identified and the progress of these are tracked and reported.

Table 8-1 - Top five current risks (by rating)

Details of the Risk	Risk Rating	Mitigation Action Plan	Progress
Optimal FPL violation limits for operation cannot be determined	MODERATE	Robust cold-commissioning and testing of the system and its suitability	Further analysis required to enable both P and Q to operate appropriately
Required data from several WPD systems in to the Siemens SVO system to enable it to function is unmanageable and non-updatable	MODERATE	Develop a team structure and a process to enable the required timely updates to be carried out	Data is currently being kept up to date, however, process is labour intensive and larger networks will be difficult
Analogue data is not suitable to support the SVO and FPL real-time system decisions	MODERATE	Ensure that quality and quantity of analogue data is suitable for the project	All available analogues have been ratified and their granularity of data reporting has been increased to support the project. Trialling of the system further will reduce this risk
Correct level of network data can't be gathered to benchmark SVO and FPL performance	MODERATE	Carry out detailed analysis of data retrieved during trial phase of the FPL / FPL CM to establish credible violation limits that can be implemented after trial phase.	Pre-trial data has been gathered but as network operation and arrangements change this will be monitored
Voltage complaints	MODERATE	Carry out detailed analysis of data retrieved during trial phase of the FPL / FPL CM to establish credible violation limits that can be implemented after trial phase.	A fault on the wider network causing the FPL to trip then caused voltage issues on the wider network

Table 8-2 provides a snapshot of the risk register, detailed graphically, to provide an on-going understanding of the projects' risks.

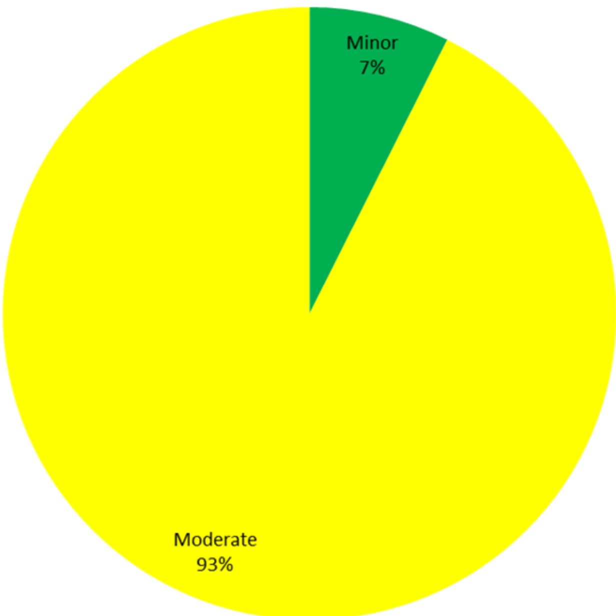
Table 8-2 - Graphical view of Risk Register

Likelihood = Probability x Proximity						
	Certain/Imminent (21-25)	0	0	0	0	0
	More likely to occur than not/Likely to be near future (16-20)	0	0	0	0	0
	50/50 chance of occuring/ Mid to short term (11-15)	0	0	0	0	0
	Less likely to occur/Mid to long term (6-10)	0	0	19	0	0
	Very unlikely to occur/Far in the future (1-5)	0	0	2	2	4
		1. Insignificant changes, re-planning may be required	2. Small Delay, small increased cost but absorbable	3. Delay, increased cost in excess of tolerance	4. Substantial Delay, key deliverables not met, significant increase in time/cost	5. Inability to deliver, business case/objective not viable
		Impact				

	Minor	Moderate	Major	Severe	
Legend	2	25	0	0	**No of instances**
Total	27				No of live risks

Table 8-3 provides an overview of the risks by category, minor, moderate, major and severe. This information is used to understand the complete risk level of the project.

Table 8-3 - Percentage of Risk by category



8.2 Update for risks previously identified

Descriptions of the most significant risks, identified in the previous six monthly progress report are provided in Table 8-4 with updates on their current risk status.

Table 8-4 - Risks identified in the previous progress report

Details of the Risk	Previous Risk Rating	Current Risk Rating	Mitigation Action Plan	Progress
Analogue data is not suitable to support the SVO and FPL real-time system decisions	MAJOR	MODERATE	Ensure that quality and quantity of analogue data is suitable for the project	All available analogues have been ratified and their granularity of data reporting has been increased to support the project. Trialling of the system further will reduce this risk
Design and Protection methodology employed for FPL is unsuitable	MAJOR	MINOR	Ensure standardised protection is employed where possible and run extensive models prior to commissioning	Real system faults have successfully been protected
Optimal FPL violation limits for operation cannot be determined	MAJOR	MODERATE	Robust cold-commissioning and testing of the system and its suitability	Further analysis required to enable both P and Q to operate appropriately
Voltage complaints	MAJOR	MODERATE	Carry out detailed analysis of data retrieved during trial phase of the FPL / FPL CM to establish credible violation limits that can be implemented after trial phase.	A fault on the wider network causing the FPL to trip then caused voltage issues on the wider network
Correct level of network data can't be gathered to benchmark SVO and FPL performance	MAJOR	MODERATE	Carry out detailed analysis of data retrieved during trial phase of the FPL / FPL CM to establish credible violation limits that can be implemented after trial phase.	Pre-trial data has been gathered but as network operation and arrangements change this will be monitored

Descriptions of the most prominent risks, identified at the project bid phase, are provided in Table 8-5 with updates on their current risk status.

Table 8-5 - Risks identified at the Bid Phase

Risk	Previous Risk Rating	Current Risk Rating	Comments
Project team does not have the knowledge required to deliver the project	Minor	Minor	Risk is being tracked but operation of SVO and FPL is now in place and performance being analysed
No SVO available from the contracted supplier	Closed	Closed	The SVO system procurement activity is now complete
Project cost of high cost items are significantly higher than expected	Minor	Closed	All major items are now procured
No FPL available from the contracted supplier	Minor	Closed	FPL is now live and operational
Selected sites for technology installations become unavailable	Minor	Closed	Construction activities on all sites are now complete

9 Consistency with Full Submission

During this reporting period a core team of both WPD and WSP|PB engineers has been formed, which has and will continue to ensure that there will be consistency and robust capturing of learning moving forwards. This has ensured that the information provided at the full submission stage is still consistent with the work being undertaken in the project phase.

The scale of the project has remained consistent for all three methods:

- **EVA** – Develop and demonstrate an Advanced Planning and Operational tool for 33kV and 11kV networks;
- **SVO** – Install and trial advanced voltage control schemes at 16 substations; and
- **FPL** – Install and trial a Flexible Power Link at a 33kV substation.

10 Accuracy Assurance Statement

This report has been prepared by the Equilibrium Project Manager (Jonathan Berry), reviewed by the Future Networks Manager (Roger Hey) and approved by the Network Strategy and Innovation Manager (Nigel Turvey).

All efforts have been made to ensure that the information contained within this report is accurate. WPD confirms that this report has been produced, reviewed and approved following our quality assurance process for external documents and reports.

Glossary

Term	Definition
ABSD	Air Break Switch Disconnector
AC	Alternating Current
AIS	Air Insulated Switchgear
APT	Advanced Planning Tool
AVC	Automatic Voltage Control
BAU	Business as usual
BSP	Bulk Supply Point
CB	Circuit Breaker
CT	Current Transformer
DC	Direct Current
DG	Distributed Generation
DNO	Distribution Network Operator
EHV	Extra High Voltage
ENA	Energy Networks Association
ER	Engineering Recommendation
EU	European Union
EVA	Enhanced Voltage Assessment
FPL	Flexible Power Link
FTP	File Transfer Protocol
GB	Great Britain
GIS	Gas Insulated Switchgear
HSOC	High Set Overcurrent
HV	High Voltage
IDMT	Inverse Definite Minimum Time
IPR	Intellectual Property Register
ITT	Invitation to Tender
LCT	Low Carbon Technologies
LV	Low Voltage
LVAC	Low Voltage Auto Changeover
NMS	Network Management System
NOP	Normal Open Point
OCEF	Overcurrent Earth Fault
OHL	Overhead Line
OLTC	On Load Tap Changer
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition

SDRC	Successful Delivery Reward Criteria
SLD	Single Line Diagram
SVO	System Voltage Optimisation
TSDS	Time Series Data Store
UK	United Kingdom
VLA	Voltage Level Assessment
VT	Voltage Transformer
WG	Working Group
WPD	Western Power Distribution

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