Flexible Plug and Play Low Carbon Networks

Project Progress Report December 2014

UK Power Networks
Delivering your electricity

Contents

1 Executive Summary

The Flexible Plug and Play (FPP) project has demonstrated how, through the integration of innovative technological and commercial solutions, a cost effective connection of Distributed Generation (DG) to constrained parts of the distribution network can be achieved.

The FPP project was awarded funding of £6.7million by Ofgem, under the Low Carbon Networks Fund (LCNF) scheme, on 19 December 2011 and the project started on 1 January 2012.

The main focus of the final reporting period of the project following the successful delivery of the FPP technical platform and the development and offer of FPP flexible connections, is to finalise the technical trials, connect the DG customers who have accepted flexible connections allowing them to be commissioned and to deliver the Strategic Investment Model (SIM).

This six monthly reporting period (July 2014 – December 2014) is the sixth and final for the project and has seen the project focus on finalising the delivery of the technical trials and continuing the delivery process of the 14 accepted flexible connections. The detail of this work and the key learning has been captured and will be disseminated within the three Successful Delivery Reward Criteria (SRDC) reports that the project will submit in December 2014. Also as can be seen throughout the report, particularly in Sections 2 (Project Managers report) and 7 (Learning outcomes), significant knowledge continues to be generated and disseminated through various channels for use by other Distribution Network Operators (DNOs).

As of 12 December 2014, the project has commissioned four flexible connections, totally 2.75MW, which is a combination of Photovoltaic (PV), wind and Combined Heat and Power (CHP) generators. The commissioning the four flexible connections since April 2014 has continued to provide significant new learning that will be valuable in improving the end-to-end commissioning process to become more efficient and effective for embedding flexible connections into business-as-usual.

The FPP project continues to engage and recruit customers and as of 12 December 2014 39 flexible connection offers have been issued, 14 of which will be connected onto the distribution network using the FPP methods. These 14 accepted customers represent a total of 35.88MW across wind, PV and Anaerobic Digestion (AD), these generators will be connecting at different voltage levels on the distribution network (33kV, 11kV and LV) throughout 2014 and 2015. The technical diversity of the connections for this portfolio of projects continues to provide UK Power Networks' teams with extensive experience and rich knowledge that will be valuable for the business-as-usual roll out of flexible connections. This provides valuable learning and real life examples which have been include within SDRC 9.7 (Facilitation of faster and cheaper connection of DG to the distribution network), proving the flexible connections reflect an attractive offer to customers.

The final reporting period of the project has seen it complete the technical platform trials in accordance with the FPP Use Cases. Both simulated and operational data has been collected and analysed to provide conclusions and key learning which has been captured in SDRC 9.6 (Implementation of active power flow and voltage management within FPP trial area) and trial reports.

Finally the SIM, developed by Imperial College London as part of SDRC 9.5 (Strategic Investment Model) has been fully validated and used to carry out a number of studies to demonstrate its functionalities and draw conclusions on the impact of DG on network investment.

Risks

The FPP project recognised from the bid stage that a key risk to demonstrating the technical and commercial innovation developed by the project was the lack of customer participation to its trials (Bid risk R004). This has been successfully managed with excellent stakeholder engagement since the beginning of the project and mitigated by signing up fourteen customers for the FPP flexible connections, which has proved the commercial arrangements are acceptable to DG customers.

The project is managing the risk that commissioning dates may fall after December 2014 when trials are complete. This has been mitigated through the commissioning of the first flexible connection in April 2014 and will be supported by extensive simulated trials where required.

Learning outcomes

The key areas where the project has seen significant learning outcomes related to connecting DG customers through the flexible connections, the design and delivery of the FPP technical trials and the on-going engagement with DG customers. The main areas are outlined below:

Learning Area	Overview	FPP Document
Flexible DG contracts	Commercial development, feedback from customers	SDRC 9.7
Connection of DG customers	Design, testing and commissioning of Flexible Connection customers	SDRC 9.7
Active Network Management (ANM)	Design, implementation and integration with smart devices	SDRC 9.4 and SDRC 9.6
Quadrature-booster	Design, protection, testing and commissioning	SDRC 9.8 and Quadrature-booster trial report
Dynamic Overhead Line Rating	Design, implementation, commissioning and evaluation	SDRC 9.4 and SDRC 9.6

All of the knowledge and learning generated including that from the delivery of flexible connections delivered in quarter one 2015 will continue to be disseminated. The learning will be captured in the FPP Project Close Down Report to be submitted in March 2015, with any further learning generated to be added as an addendum to the Close Down Report in December 2015. Please refer to sections 2.1 and 7.1 for further learning and more detail.

Knowledge Dissemination

The FPP project team has continued to disseminate the learning generated, which can be evidenced by the five SDRC learning reports, with a further three to be published at the end of 2014. These are supported by presentations, papers and videos presented in various industry events that are available in the public domain.

In the final reporting period, internal knowledge dissemination has continued to play a significant role in transferring the knowledge into business-as-usual. The project is continuing to work alongside a number of internal departments and stakeholders to both deliver the FPP project activities, but also importantly transfer and embed all knowledge generated by the project to support and ensure business readiness for delivery of the flexible connections in 2015.

Full details of the learning dissemination activities can be found in section 7.2.

2. Project Manager's report

2.1 Progress in current reporting period

2.1.1 Customer engagement

Customer Recruitment

The project has continued to offer flexible connections in the 700km² trial area in the East of England since March 2013. The offers in the FPP trial area enable the curtailment of the generators export at times when the network is reaching its operational limits. The flexible connection offers are supported by an estimated curtailment amount based on the likely yearly export of the generator.

Since the introduction of the flexible connections in March 2013 there has been significant interest, which has seen the project receive 45 DG connection requests, make 39 connection offers for a total of 176MW of generation, with 14 customers (totalling 35.88MW) accepting their flexible connection offer. As of 12 December 2014, four customers have been commissioned, totalling 2.75MW, which has given the project the opportunity to generate and implement new learning, which is detailed in Section 7, for future flexible connections that are to be commissioned.

The project has seen continued interest in the flexible connection offer, despite curtailment levels increasing, currently at over 15%, due to the 14 accepted connection offers within the trial area. The table below details the connection offers made so far and the current status.

Table 1: A summary of the DG customers have received an FPP connection offer

Generator	MVA	Tech	Status
Generator 01	**8.00**	**Wind (33kV)**	**ACCEPTED**
Generator 02*	**0.5**	**Wind (11kV)**	**Re-requested and ACCEPTED**
Generator 03	**10.00**	**Wind (33kV)**	**ACCEPTED**
Generator 04	5.00	Wind (33kV)	Expired
Generator 05	**1.50**	**Wind (11kV)**	**ACCEPTED AND COMMISSIONED**
Generator 06*	**1.00**	**Wind (11kV)**	**Re-requested and ACCEPTED**
Generator 07	10.25	Wind (33kV)	Expired
Generator 08	0.50	CHP/AD (11kV)	Expired
Generator 09	2.40	PV (33kV)	Expired
Generator 10	**0.50**	**CHP/AD (11kV)**	**ACCEPTED AND COMMISSIONED**
Generator 11	6.60	PV (33kV)	Expired
Generator 12	**0.50**	**Wind (LV)**	**ACCEPTED AND COMMISSIONED**
Generator 13	7.00	PV (33kV)	Expired
Generator 14	**4.00**	**PV (33kV)**	**ACCEPTED**
Generator 15	**0.25**	**PV (11kV)**	**ACCEPTED AND COMMISSIONED**
Generator 16	1.50	CHP (33kV)	Expired
Generator 17	**6.93**	**PV (33kV)**	**ACCEPTED**
Generator 18	0.50	CHP (33kV)	Expired
Generator 19	9.48	Wind (33kV)	Expired
Generator 20	**1.20**	**PV (11kV)**	**ACCEPTED**
Generator 21	**0.50**	**Wind (11kV)**	**ACCEPTED**
Generator 22	18.00	PV (33kV)	Expired
Generator 23	5.00	PV (33kV)	Expired
Generator 24	5.00	PV (33kV)	Expired
Generator 25	15.00	PV (33kV)	Expired
Generator 26	2.00	PV (11kV)	Expired
Generator 27	5.00	PV (33kV)	Expired
Generator 28	15.00	PV (33kV)	Expired
Generator 29	**0.50**	**CHP/AD (11kV)**	**ACCEPTED**
Generator 30	**0.50**	**Wind (11kV)**	**ACCEPTED**
Generator 31	2.00	PV (11kV)	Expired
Generator 32	1.50	PV (11kV)	Expired
Generator 33	0.99	PV (11kV)	Expired
Generator 34	18.45	Wind (33kV)	Offer valid until Jan 2015
Generator 35	4.00	PV (11kV)	Offer valid until Jan 2015
Generator 36	4.00	PV (11kV)	Offer valid until Feb 2015
Generator 37	4.95	PV (11kV)	Customer has requested offer, due Jan/14

*Generators 02 and 06 re-requested the FPP offer based on the same amount of generation connecting and so have not been shown as separate offers within the table

Figure 1 below shows that as of the 12 December 2014, there have been 14 connection offers accepted, equating to a total capacity of 35.88MW. Two of these schemes will connect to Peterborough Central grid on a Last In First Off (LIFO) basis and 12 will connect to March Grid on a pro-rata basis.

Figure 1 – Summary of Customer Engagement to Date

Offers at March Grid currently cover the whole of the capacity quota (33.5MW) as well as a number of offers being made on a LIFO basis after the quota was filled. As of 12 December 27.63MW of the capacity quota is in accepted offers.

Figure 2 below shows the range of estimated worst-case curtailment levels that are currently expected for the March Grid quota. Curtailment levels increase significantly after the quota due to the size of the next generator (18MW). This effectively renders all DG schemes that are outside of the quota unviable, as curtailment levels of over 20% will not give financers of DG schemes the returns required to carry out the investment.

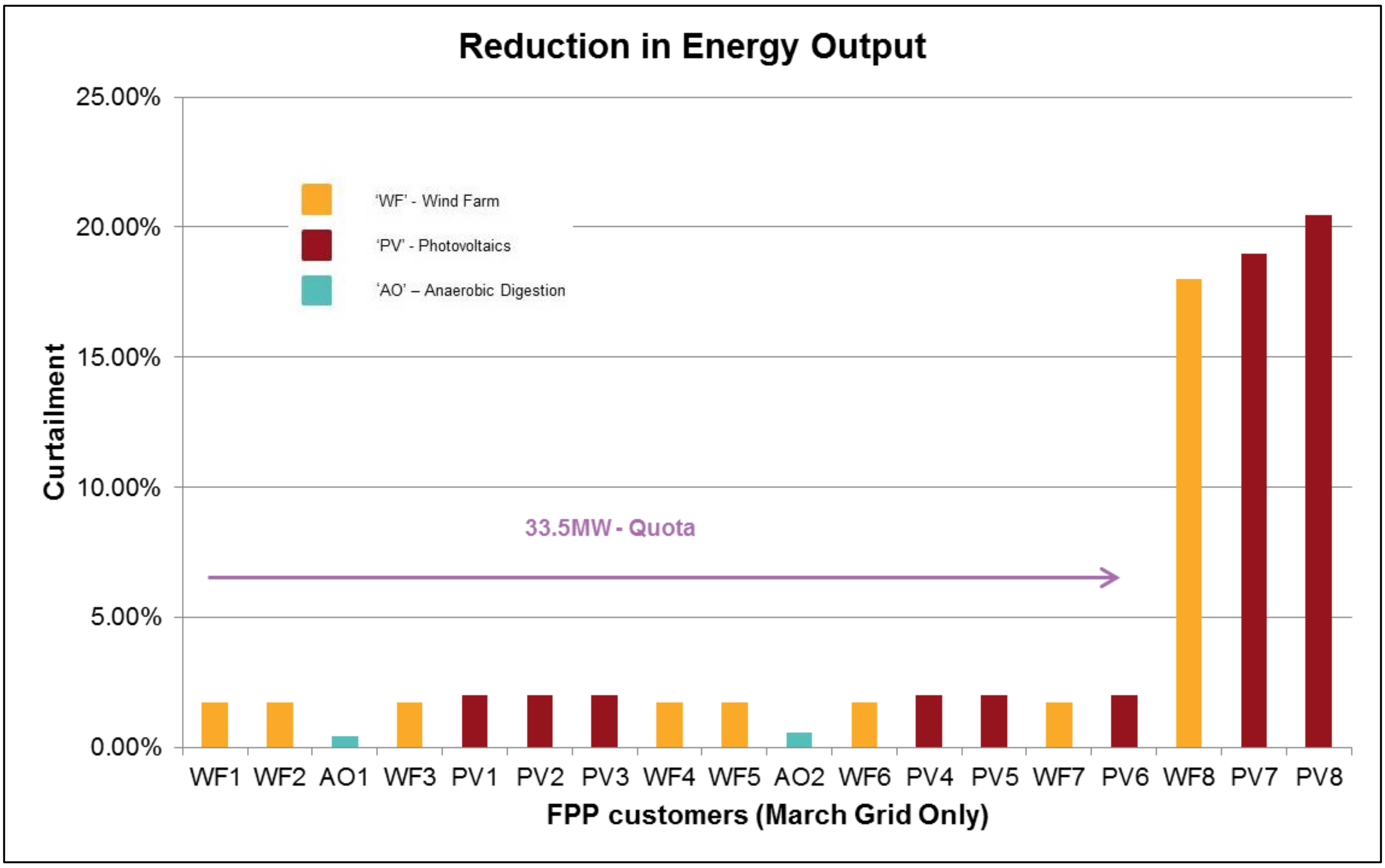


Figure 2 – Principles of Access Assessment March Grid quota followed by LIFO

Connections Delivery

During this reporting period, further progress has been made with a further three more customers being connected within the March Grid area. giving a total of four DG customers utilising the flexible connection methods in the FPP trial area.

The FPP team has been working closely with the customers to meet their requested connection dates. Some of the power on dates have been delayed due to re-planning of these projects and events outside the DNO control. There are currently four generators connected prior as at 12 December 2014, with the remaining 10 connections to be delivered by the business-as-usual teams in 2015.

Below are the connected offers and currently expected connection dates.

Table 2: Status of accepted connection offers

Generator	MVA	Tech	Status	Estimated Connection Date	Curtailment Level
Generator 01	8.00	Wind (33kV)	ACCEPTED	Q1 2015	2.82%
Generator 02	0.50	Wind (11kV)	ACCEPTED	September 2015	1.84%
Generator 03	10.00	Wind (33kV)	ACCEPTED	Q1 2015	1.84%
Generator 05	1.50	Wind (11kV)	ACCEPTED	Connected	1.84%
Generator 06	1.00	Wind (11kV)	ACCEPTED	H1 2015	1.84%
Generator 10	0.50	CHP (11kV)	ACCEPTED	Connected	0.59%
Generator 12	0.50	Wind (LV)	ACCEPTED	Connected	1.84%
Generator 14	4.00	PV (33kV)	ACCEPTED	Expected December 2014	2.3%
Generator 15	0.25	PV (11kV)	ACCEPTED	Connected	7.93%
Generator 16	0.5	CHP (11kV)	ACCEPTED	H2 2015	0.59%
Generator 17	6.93	PV (33kV)	ACCEPTED	H2 2015	2.3%
Generator 20	1.2	PV (11kV)	ACCEPTED	Q1 2015	2.3%
Generator 21	0.5	Wind (11kV)	ACCEPTED	H2 2015	1.84%
Generator 30	0.5	Wind (11kV)	ACCEPTED	H2 2015	1.84%

The accepted curtailment levels have reduced since the previous six monthly report as the curtailment analysis has been re-run to assess the curtailment levels for already accepted generators. Many of the earlier generators to connect did so at around a 5.3% curtailment level within the March Grid capacity quota, this was on the assumption that only wind generators would be connecting to March Grid. As the generators requesting and subsequently accepting flexible connection offers had become more diverse in the trial area, the subsequent estimated curtailment has reduced. The below graph show the difference between the curtailment levels at acceptance for each accepted customer in the March Grid area to the curtailment levels expected in December 2014.

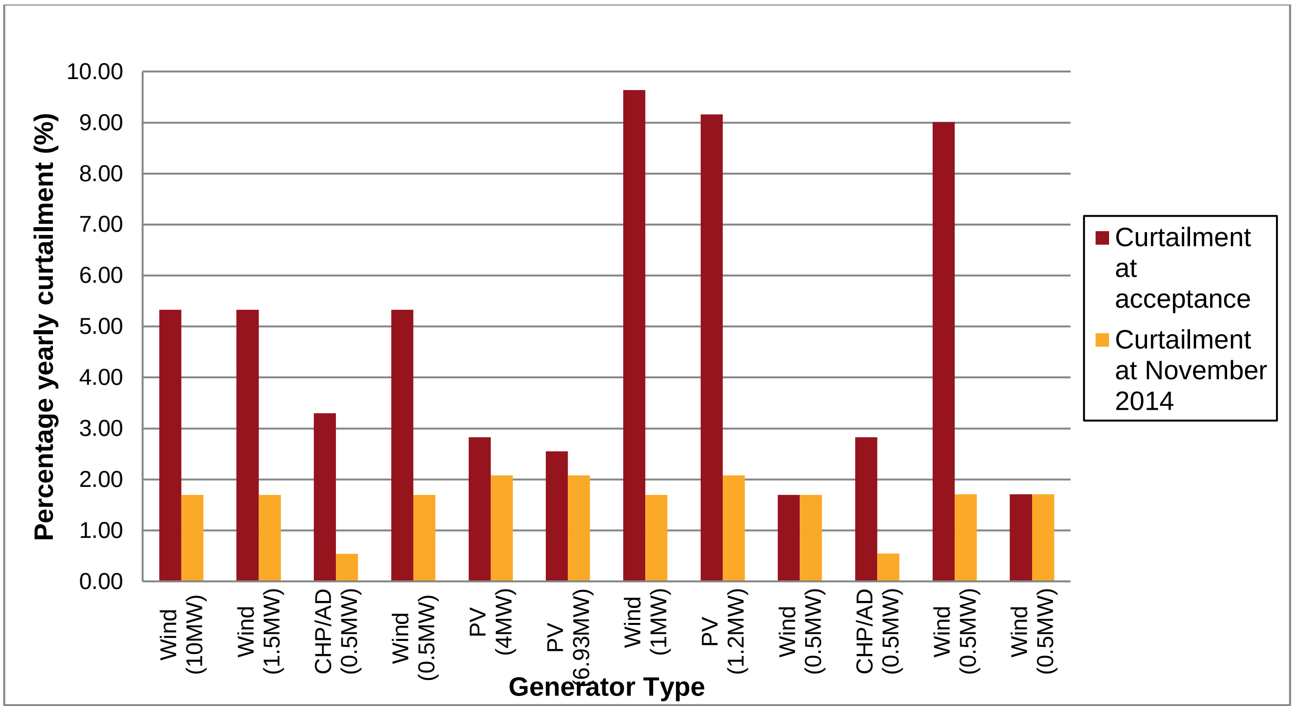


Figure 3: Comparison between curtailment level at acceptance and in November 2014

2.1.2 Communications Platform

The FPP communication platform consists of a Vodafone Wide Area Network (WAN) and Silver Springs Radio Frequency (RF) mesh network. During this reporting period a key focus was to undertake the communication trial to investigate the performance of the communication platform under all possible scenarios and the ability of supporting an increase in the volume of data and connected customers.

Before the commencement of the trial network, site surveys were carried out in order to identify improvements in the performance of the RF Mesh. The surveys identified equipment requiring replacing and also highlighted some recommended reinforcement work. New relays were deployed in three new locations, primarily to improve service to the nodes at the edge of trial area and where some customers will be connecting.

The communication trial, initiated in the previous reporting period, was designed to provide further learning in terms of network performance and ability to cope the an increasing volume of data in the perspective of the connection of new customers, but also the handover the solution to business-as-usual. The trial was set up by installing IEC 61850 server simulators on a small number of points of the communication infrastructure and then sequentially increasing the amount of data introduced into the system to assess the capability communication platform.

The communication trial started in July 2014, but due to an issue detected on the communications platform following the investigation of a curtailment event on the first connected customer, the trial was paused. It was identified that a number curtailment events were a result of a communication failure, which was affecting all of the communication nodes across the network. This was not previously discovered as both individual performance reports from WAN and RF mesh solutions did not highlight any issues. An end-to-end performance monitoring and notification system has since been implemented to identify any failures

The peculiar nature of this fault posed a number of challenges for the project team and the project partners to correctly identify the cause of the problem. This fault had the following characteristics:

- It was not possible to anticipate which device would fail and for how long; and
- It was not possible to ascertain if the issue was on the WAN or on the RF mesh infrastructure as both systems were found to be performing well on their own.

Both Vodafone and Silver Spring Networks undertook comprehensive investigation and testing in order to identify the actual cause of the failures. A number tests and solutions, such as hardware upgrades and routing improvements were deployed, however these failed to resolve the underlying issue. In order to investigate the issue, a number of tests were conducted only using one backhaul site at a time. When March Grid was disabled the Peterborough Central connection showed comparatively improved performance with minimal failures compared to March Grid when the reverse was implemented. The performance seen when only using Peterborough Central backhaul site was improved compared to the scenario with both backhaul sites or just March Grid. However, it was still suffering from performance issues due to the long distances involved for some of nodes which resulted on some failures.

During the interim solution period, stress tests were, carried out, using only the Peterborough Central backhaul[1] site, though the test result were not 100% conclusive due to the impact of the on-going communication platform issue. Instead the main focus has been to actively monitor the network to support end-to-end assessment the system performance.

The fault investigation identified a number of factors contributing to the suboptimal performance. The main cause of the issue was related to the synchronisation between the master nodes at Peterborough Central and March Grid across the WAN. This resulted in intermittent failures and higher latencies. A number of corrective actions were taken to resolve this issue and improve the performance of the communication platform. The corrective actions led to a stable performance of the RF mesh network and was further improved by network optimisation exercise which involved replacement and re-location of under-performing relays and reinforcement of additional relays in parts of the network with lower signal quality.

Regardless of the communication issue detailed above, the communication trial was progressed to evidence the capability to expend the network to connect additional devices and also to cope with other application protocols such as DNP3.

2.1.3 Smart Devices

Each of the smart devices have been evaluated in accordance with the trial designs, the results of which have been included as part of individual trial schedules. These documents provide an overview of the learning obtained through the delivery of each smart device trial, with particular reference to the initial learning outcomes, as defined within the project Use Cases. In addition to the above, a high level overview of additional trial activities undertaken during the reporting period are outlined below.

Quadrature-booster

The performance of the Quadrature-booster has been evaluated using 'live' network data from power quality monitors (PQMs), DR-C50 equipment[2] installed as part of the Quadrature-booster enhanced monitoring scheme, and PI historian[3]. The PQMs enabled the collection of ten minute averaged load flow data for each of the three circuits (Northwold No.1, Downham Market No.2 and Southery No.3) that emanate from the Wissington 33kV substation. The initial results of this evaluation indicates that the Quadrature-booster has achieved the primary of objective of balancing power flows on the Northwold No.1 and Downham Market No.2 parallel circuits, and has been successful in enabling greater utilisation of the two feeder circuits.

In addition, the project undertook further simulated trials to demonstrate an enhanced Quadrature-booster control philosophy that would enable control of the target set-point within the Quadrature-booster control system, which is otherwise set to evenly share the load 50/50 between the Northwold No.1 and Downham Market No.2 parallel circuits. In this trial, the Active Network Management (ANM) platform hosts an algorithm which receives circuit loading inputs from remote measurement points to determine the appropriate set-point target to be used by the Quadrature-booster control system in balancing the load flows. This revised target set-point is communicated to the Quadrature-booster control system via IEC

[1] The back-haul network is the communications connection between the RF Mesh Network and Active Network Management (ANM) solution for data exchange. Also, the management connection between the RF Mesh Network and GridScape management application
[2] DR-C50 is an comprehensive transformer online monitoring and management equipment that is configurable to provide an economical solution for monitoring, control and communication. It was installed for enhanced monitoring on the Quadrature-booster.
[3] PI historian is a database that stores half-hourly network data that can be retrieved for historical analyses.

61850 communications. With this revised control philosophy it is expected that the additional capacity headroom created by the Quadrature-booster at the Wissington 33kV network boundary could be made available to potential connections on this 33kV network.

Dynamic Line Rating (DLR)

The review of the performance of the DLR has been completed. Over a years' weather station data was recorded at three separate DLR trial sites, and this was used to identify any correlation between local and remote weather conditions. From this information it was established generic settings can be configured to provide assurance that a single weather station can be used to evaluate the DLR over a range of approximately 10km. Considering these settings, the ampacity has been calculated for comparison with the seasonal conductor rating so as to identify the additional 'headroom' available through the deployment of the DLR scheme. Based on the assessment of the systems, and the network on which they have been deployed, it has been established that the overhead line can support peak gains of up to 130%, which is then limited by the rating of other equipment on the line. With this peak increase in ampacity, and the weather information we collected over the course of the year, we anticipate an additional capacity of approximately 5%.

The process for integrating the DLR system into business as usual practices has started. The first stage of this process, which was completed in October, has been to develop an Engineering Operating Standard (EOS) specific to the systems deployed as part of the DLR trial. The purpose of this document is to provide guidance to UK Power Networks staff on the assessment, installation, operation and maintenance requirements of the DLR equipment installed as part of the Flexible Plug and Play trial so that it can be supported as necessary. The final stage of the trial will be to create a more comprehensive guide to the implementation of weather based DLR systems so as to enable their integration into UK Power Networks practices and procedures.

Novel Protection Relay

The aim of the novel protection relay trial was to evaluate alternatives to directional overcurrent protection, which provides back-up protection to intertripping, for 132kV circuits. Directional overcurrent protection limits the amount of reverse power that can be supported by the substation to below that which could be supported by the thermal capacity of the network. Two alternative systems were deployed at each of the grid substations within the trial area, namely March Grid and Peterborough Central.

The first of the systems deployed was the combined directional negative phase sequence and voltage dependent overcurrent scheme, which were implemented in an alarm only configuration for a year, with the aim of proving the stability of the scheme during normal and abnormal network conditions. In addition to this, PQMs were installed so as to better understand the base negative phase sequence and the voltages on the network. Following the review the scheme was found to be stable, although there were a number of alarms generated by the voltage dependant element of the scheme, which would suggest that this would require further review and consideration should the scheme be put into operation. There were no recorded alarms for the directional negative phase sequence element of the scheme.

The second of the systems deployed, which was implemented in July 2014, was the directional overcurrent with load blinding and voltage drop scheme, which was also implemented to in an alarm only configuration. To prove the stability of this scheme the settings were reduced so as to enable simulation of normal and abnormal network conditions. This system was proved to remain stable and also generated appropriate alarms during what the relay should have considered to be abnormal conditions.

The directional overcurrent with load blinding and voltage drop has been configured and commissioned at both March Grid and Peterborough Central as a legacy to the project.

Automatic Voltage Control (AVC)

The aim of the trial is to assess the potential to enhance voltage control on 33kV and 11kV networks by integrating the standard voltage regulation relay, deployed during the delivery phase of the project, with the ANM platform. Distinct solutions have been developed for the 33kV network and for the 11kV network as these two types of network present different challenges and specific voltage control issues.

To improve the AVC scheme, and therefore the ability to maintain statutory voltage limits in areas of the network with significant penetration of DG, the ANM platform has been used to provide real-time information about the load and generation to provide a more accurate estimation of the conditions.

For the 33kV network, the ANM system has been configured to calculate the required voltage target by comparing transformer and feeder measurements at the grid substation (March Grid) with remote measurements at the Point of Common Coupling (PCC) at a number of DG sites. This calculated optimum voltage target will be communicated to the voltage regulation relay at the Grid Substation using the IEC 61850 protocol.

For the 11kV network, a load ratio is determined using remote measurements at points of common coupling at a number of generation sites. This load ratio is a measure of the load and DG output/export on the network and is dynamic. Under current design philosophies the load ratio is fixed at the design stage of the AVC implementation. The ANM system has been configured to systematically update the load ratio on the AVC system via IEC 61850 communication such that any errors in generation estimation will be significantly reduced.

Both trials began in June 2014 and were completed in November 2014. Each has a natural fall back to the current existing set point in the event of lost communications.

Frequent Use Switches

Ring Main Units (RMUs), which were installed as part of business-as-usual activities, are being used in place of Frequent Use Switches, and has resulted in a refund of the funding associated with the supply/design/installation and commissioning costs for the Frequent Use Switches. The RMUs were originally scheduled to be energised in August 2014, but issues with wayleave consents delayed the delivery until November 2014.

These RMUs are remotely controllable and allow the flexibility of Whittlesey Primary substation to be supplied from either March Grid or Peterborough Central. The RMUs are controlled through ENMAC, and the switch status indications are relayed to ENMAC as part of business-as-usual. The ANM pick up the switch indications from ENMAC to determine the running arrangement at any time.

It is expected that under winter maximum network load conditions, Whittlesey Primary will be supplied from Peterborough Central and under summer minimum load Whittlesey Primary supply will be shifted to March Grid.

2.1.4 Smart Applications

The approach undertaken to trial the smart applications as well as the analysis of the trial activities to demonstrate the capability of ANM applications to address power flow and voltage issues have been captured and documented in the SDRC 9.6 report – “Implementation of active voltage and active power flow management within FPP Trial area”.

The smart applications consist of a set of centralised functions forming the ANM system developed to deliver flexible connection by monitoring constraint points of the distribution network and controlling the output of non-firm generators.

During this last reporting period, the smart applications activities have been focused on trialling the various functionalities of the ANM system. The objectives of the ANM trial were to prove the applicability and the efficiency of the the ANM system to manage power flows and voltage levels in the FPP trial area. The activities also aimed to demonstrate the feasibility to use a dynamic rating application as alternative or additional approach to standalone DLR devices. The trials illustrated how the ANM solution can also interact closely with smart devices to develop innovative network management strategies. In order to deliver the ANM trial, twelve hypotheses were developed, each focussing on a particular set of functionalities of the ANM solution. The following three steps have been carried out to evidence the hypothesis:

1. The monitoring of current and voltage on the various substations impacted in the area and under various operating conditions

2. The simulation of scenarios to validate the hypothesis

3. The analyses of power flow, voltage level and other data during the simulation and operating phase when possible to cover the ANM trial hypotheses

Initially, the ANM trial phases were heavily dependent on the connection of generators to demonstrate the ANM hypothesis. As most of the expected generators have postponed or delayed their connection, the trial design adopted a strategy to simulate the connection of DG and to use the FPP technical solution to model particular network conditions. During this process the DG customers were simulated and using the real time values coming from the trial area, the behaviour and the functionalities of the ANM solution were assessed. Various scenarios have been implemented for each hypothesis. For more detail of the ANM trial, please see SDRC 9.6 – ‘Implementation of active power flow and voltage management within FPP trial area’

To support the ANM system a technical description document has been produced to cover the key technical aspects of the ANM solutions, such as the design, implementation, configuration and operation. In turn this document will be used to support the development of an Engineering Design Standard for the ANM. The technical description document also includes the DG connection interface design documents, which is a key element of the connection design process.

Active Power Flow Management Application

As part of the ANM trial, the active power flow management application has been trialled to manage reverse power flow and thermal constraints on the distribution network. The application was designed to actively manage the flow of real power and current measurements at key constraint points. Using the benefit of real time network visibility of the ANM system, this application calculates and issues control instructions to generators in order to maintain network loading within its capacity limits.

It was demonstrated using a combination of simulated generators and real time measurements that the ANM system can manage both the reverse power flow and thermal loading constraint by issuing set points consistent with the theoretical calculations. Proving the application can manage the thermal constraint using dynamic thresholds to manage power export of DG.

Voltage Management Application

As part of the ANM trial an active voltage management application was deployed to manage multiple voltage constraints on the distribution network in conjunction with the power flow management. The application was designed to monitor system parameters using real time network measurements and also to interact with the AVC relay. The smart application was trialled to mainly explore its capability to interact with the AVC.

It was demonstrated that the philosophy of generator control to mitigate voltage constraint was also relevant. The experiment was simulated as a real voltage constraint was not found in the network. In addition to the main objective of mitigating voltage constraints on the network by curtailing DG, the trial also addressed the challenges to optimise voltage control profile and minimise circulating current flow on the 33kV and 11kV distribution networks in interaction with the tap changer relays. New algorithms were developed for this purpose and hosted in ANM platform. The results of the trial showed that the voltage profile could be optimised on the 33kV and 11kV network by coordinating ANM with the tap changer relays.

ANM operational envelope

A key outcome of this reporting period was the development of the operational envelope for the ANM application. The effective deployment of ANM application is dependent upon the setting of its configuration parameters as they pertain to the unique conditions associated with a given constraint. These parameters ultimately define the activation thresholds, time delays and response magnitudes associated with an ANM action. The ANM actions that may be triggered due to the breach of a particular current/power flow magnitude include trim, sequential trip and global trip.

Given that some of the conditions can change over time as well as the fact that initial settings should be conservative to ensure operability, it was established that the parameter settings should be regularly reviewed and revised both to improve performance and address the dynamic nature of the network and devices connected to it. The project undertook a thorough study of the trial network in order to establish firm threshold settings, system parameter and identified the factors that need to be considered during the process. The study involved an iterative process of parameter adjustment and validation of the result in order to achieve an optimal system performance. Two set of configuration parameters were developed, measurement point and generator controller. A explanation of this work is detailed in SDRC 9.6.

Smart application and energy storage

In order to explore the potential capabilities of the energy storage in the FPP trial area, a desktop study was carried out. The objective of the study was to prove that energy storage can offer additional flexibility used with an ANM system to manage interruptible distributed generations and potentially reduce the level of their overall curtailment. The 5-year simulation showed that energy storage was able to reduce the curtailment of FPP generators. In the best case, the energy storage was found to reduce the curtailment about 43.48%.

2.1.5 System Integration

The system integration activities have mainly focused on the following two activities

1. Identifying potential IT security issues that may that may represent cyber security threats and requiring to carry out targeted penetration testing

2. Specifying how UK Power Networks Remote Terminal Unit (RTU) could be connected to the sgs connect in order to operate the UK Power Networks circuit breaker and disconnect the DG customer.

A security risk assessment identified the potential for unauthorised access to UK Power Networks equipment as some customers require that their control system to be connected to the public internet. To prevent the unauthorised access and the mitigation of potential cyber security threats, additional hardware was installed and further penetration testing was conducted on the specific element of the FPP solution to ensure the issue had been mitigated.

Where the DG control system fails to respond to ANM instructions, the ANM instructs the UK Power Networks on-site RTU to carry out breaker control and disconnect the DG customer. In order to avoid potential conflict of simultaneous control messages coming from RTU and ANM, further security functionalities were developed on the UK Power Networks RTU to ensure the Supervisory Control an Data Acquisition (SCADA) control message was given a priority should there be a simultaneous control instruction from SCADA and ANM.

2.1.6 Strategic Investment Model (SIM)

The SIM, developed by Imperial College London, aims at optimising smart-grid technology investment options and analysing the cost and benefit of alternative distribution network planning strategic decisions investigated by the project. The SIM has been fully developed, validated, and used to carry out a number of studies that demonstrate its functionalities and applications.

In this reporting period, Imperial College has carried out the following activities:

- The DLR formulation in the SIM has been validated against the data obtained from the trial in four sites (Farcet 1, Farcet 2, Funtham Lanes, and March Grid). It is observed that the applied model tends to mimic accurately the characteristics of DLR. However, the results of comparing the model and the field trial data show that the Institute of Electrical and Electronic Engineers (IEEE) steady-state heat balance formulation used in the SIM, in some occasions, tends to overestimate the thermal capacity improvement. In order to be conservative, the DLR capacity improvement in the SIM has been offset down by 15%-30%.
- A number of realistic case studies were developed and simulation studies ran in order to demonstrate the functionalities and applications of the SIM. The studies were based on the real network data and scenarios focusing on a spectrum of applications of smart-grid technologies including DLR, Quadrature-boosters, novel protection relays and ANM in order to improve the economic and technical efficiency of DG integration into the present UK Power Networks distribution network. The objectives of the studies were:
  - Identification of network constraints caused by DG connections in various future development scenarios and to identify plausible solutions by coordinating and optimising the planning and operation of distribution networks;

- Quantification of the economic and carbon costs and benefits associated with various smart alternatives to network reinforcements;
- Analysis of strengths and weaknesses of individual alternative solutions and identification of the most cost effective solutions for renewable generation connections; and
- Identification of optimal timing for future network reinforcements.

Following these objectives, the SIM has been used to determine the smart grid investment decisions and answer a number of the project Use Cases.. The investment proposition by the SIM is in agreement with the one proposed in the use cases, which formally demonstrates the cost-effectiveness of adopted FPP solutions.

Another set of studies has demonstrated the application of the SIM to find the optimal DG connection and the associated network connection and reinforcement costs. The studies show that connecting a new DG to the closest network point may not be the least cost solution as it may trigger demand for network reinforcement if the closest connection point is already in the constrained part of the network. The studies demonstrate that the least cost connection point can be determined by the SIM which takes into consideration many factors including DG technology, rating of DG, type of network access, system constraints at the candidate connection points, and the expected DG and load growth.

The SIM has also been employed to assess the cost performance difference between the incremental and strategic investment approaches. The former focuses on the short-term objectives while the latter ensures the long-term least cost development of the system, but subject to increased uncertainty due to longer planning time horizon. The results of the studies demonstrate that the decisions taken using the incremental approach may be sub-optimal in the future system and the cost of these sub-optimal decisions tend to exceed the short-term benefits. On the other hand, the strategic investment approach ensures that any investment or operating decisions taken will also be suitable in the future and therefore the overall long-term cost is minimal. However, the short-term cost in the second approach may exceed the short-term cost in the first approach.

The modelling of the SIM, the results of the validation studies, and the analysis of the simulation studies to demonstrate the SIM's functionalities and capabilities have been recorded and documented in the SDRC 9.5 report – "Strategic Investment Model for Future Distribution Network Planning".

2.1.7 Technical Trials

This reporting period has been heavily focussed on the analysis and evaluation of the trial experiments results against the trial objectives set out in the project Use Cases. Each trial hypothesis was subjected to a structured testing and analysis process that involved either experiments on actual network or desktop studies

Trial evaluation

The objective of the evaluation process was to review each hypothesis results to provide confidence and ensure the conclusions reached answer the Use Case learning outcomes and are supported by sufficient data. The trial outcomes and results were presented to internal expert panels at various stages of the trial. This enabled the project team to utilise the expertise of the internal UK Power Networks stakeholders to validate the approach as well as to obtain recommendations to enhance the quality of the trial outcomes.

Engagement of the relevant business stakeholders during the trial evaluation process also assisted in the business-as-usual embedding process of project solutions at the end of the project.

In additional to expert panel reviews, an external consultant undertook an independent assurance review of the DLR trial focusing on the approach, results and analysis. A key output of this was to provide guidance on determining a wind speed correction factor for the DLR system, which is determined by a period of site assessments and comparison with a trusted wind speed measurement.

2.2 Key challenges during this reporting period

The key challenges the project has faced during this reporting period have focused around the connection of the FPP customers, the delivery of the technical trials and transferring the knowledge into business-as-usual.

The demand for flexible connections has continued to remain at a high level, which is much higher than originally anticipated, with flexible connection request still being received. This high demand for flexible connections quotations has continued to created additional work within the team, which is being managed carefully to ensure that does not have a negative impact upon the projects deliverables.

As mentioned in Section 2.1.1 (Project Managers Report), a number of the accepted flexible connections have faced delays, which has impacted the final commissioning dates. This has resulted in less operational data being gathered for the technical trials as original anticipated. To ensure the project is still able to provide meaning for conclusions, where operational data has not been available, test simulations have taken place.

As a result of the delayed customer connections, the project expects to deliver the remaining nine flexible connections in 2015. These connections will be delivered by business-as-usual within UK Power Networks, who the project has been working with closely to transfer the knowledge from the project.

As mentioned in Section 2.1.2. (Project Managers Report), the project experienced issues with the communication platform, which affected the progress of the trial. The trial tests were postponed, due to the complex nature the fault and it was not resolved before the full suite of tests was completed. Regardless of the issue, the project were able to evidence the capability to expand the RF Mesh network to connect additional devices because of new generators and cope with DNP3 protocols to collect measurements from remote sites.

Further tests were conducted following the resolution of the fault, which were able to clearly demonstrate that the corrective actions led to a stable performance with higher level of availability and lower latencies. The performance of the RF mesh network was further improved by network optimisation exercise which involved replacement and re-location of under-performing relays and reinforcement of additional relays in parts of the network with lower signal quality.

A key challenge, as with any other project, has been the transferring of knowledge developed from the complex FPP solution and designing effective processes suitable for integration into the current business-as-usual processes. The project has continued to transfer activities into business-as-usual by working closely with numerous parts of the business ensure that have to good working level understanding of technical requirements and process to enable a smooth transition.

The design and delivery of the trials and flexible connections has involved a number of project workstreams, the majority of the project partners, as well as resources from a number of different directorates within UK Power Networks, including Network Operations, Asset Management, Capital Programme and IT. To ensure a coordinated approach across the multiple activities, the project continued with the process followed during the successful delivery of the technical platform, holding weekly trial plan and risk review meetings with the Trial Managers and Design Authority in attendance to identify, review, manage the risk and issues and review the project plan to track and monitor the dependencies between all of the trials.

2.3 Outlook for next reporting period

In the next reporting period the project will be focusing on three key activities; finalising the Close Down report, the project learning dissemination Close Down event and delivering the flexible connections that have been delayed to 2015.

2.4 Key challenges for next reporting period

Please see Section 2.3.

3. Business case update

Through the trials, the project has successfully designed and implemented a methodology for offering flexible connections that have provided DG customers within the FPP trial area a cheaper and faster alternative method of connecting to a heavily constrained area of the distribution network compared to the normal business-as-usual approach. As highlighted in SDRC 9.7, the flexible connection has enabled an average saving of 87% for DG customers in the trial area and reduced connection lead times by over 59%, or an average of 29 weeks. This has also led to higher acceptance levels for flexible connection offers, compared to business-as-usual offers.

The flexible connection gives the customer an option for a different type of connection, which is usually at a cheaper price, but with the likelihood of generation curtailment at peak generation times. Each customer must then assess this against the business-as-usual alternative and decide which option provides the best solution for their project. FPP has proven that when taking account of the calculated level of curtailment the flexible connection is a viable option for the majority of customers. In the FPP trial area DG schemes have seen an average saving of ~65% over the business as usual offer. In total the project has saved DG customers within the trial area approximately £38 million on their connection offers, or £32 million, when including the cost of the ANM and curtailment.

Flexible connection offers have been made to thirty-four schemes within the FPP trial area. The main benefit of the project is that DG customers within this area are able to connect more quickly, mainly due to the reduction in the cable routes from the site to the point of connection, and also more cheaply, for the same reason.

Table 3: Comparison between a business-as-usual connection offer and FPP 'interruptible' connection offer

Generator	MVA	Tech	Savings
Generator 01	**8.00**	**Wind (33kV)**	**77.5%**
Generator 02	**0.5**	**Wind (11kV)**	**89.8%**
Generator 03	**10.00**	**Wind (33kV)**	**87.8%**
Generator 04	5.00	Wind (33kV)	45.2%
Generator 05	**1.50**	**Wind (11kV)**	91.9%
Generator 06	**1.00**	**Wind (11kV)**	83.4%
Generator 07	10.25	Wind (33kV)	69.8%
Generator 08	0.50	CHP/AD (11kV)	84.0%
Generator 09	2.40	PV (33kV)	77.7%
Generator 10	**0.50**	**CHP/AD (11kV)**	**95.2%**
Generator 11	6.60	PV (33kV)	80.7%
Generator 12	**0.50**	**Wind (LV)**	**92.2%**
Generator 13	7.00	PV (33kV)	91.3%
Generator 14	**4.00**	**PV (33kV)**	**89.6%**
Generator 15	**0.25**	**PV (11kV)**	**98.4%**
Generator 16	1.50	CHP (33kV)	98.0%
Generator 17	**6.93**	**PV (33kV)**	90.4%
Generator 18	0.50	CHP (33kV)	95.7%
Generator 19	9.48	Wind (33kV)	77.4%
Generator 20	**1.20**	**PV (11kV)**	**96.4%**
Generator 21	**0.50**	**Wind (11kV)**	**96.5%**
Generator 22	18.00	PV (33kV)	93.7%
Generator 23	5.00	PV (33kV)	95.9%
Generator 24	5.00	PV (33kV)	91.8%
Generator 25	15.00	PV (33kV)	93.3%
Generator 26	2.00	PV (11kV)	90.5%
Generator 27	5.00	PV (33kV)	88.4%
Generator 28	15.00	PV (33kV)	72.2%
Generator 29	**0.50**	**CHP/AD (11kV)**	**96.4%**
Generator 30	**0.50**	**Wind (11kV)**	**96.9%**
Generator 31	2.00	PV (11kV)	86.5%
Generator 32	1.50	PV (11kV)	95.4%
Generator 33	0.99	PV (11kV)	93.6%
Generator 34	18.45	Wind (33kV)	57.7%
Generator 35	4.00	PV (33kV)	86.3%
Generator 36	4.00	PV (33kV)	88.38%

Please note; generators 20 onwards, have been charged for the ANM equipment, as the initial eight ANM units were funded through the project have now been allocated to the first eight projects to accept.

The significant cost savings come from the reduced cable length required for FPP connections over the business-as-usual alternative. Often, business-as-usual connections for schemes within the trial area are required to connect at point a significant number of kilometres away from the site, up to 40km. The FPP offer can significantly reduce this cable length, often utilising existing connection points for already established sites.

A number of new projects have requested flexible connection over the last 6 months; this has changed the dynamics of the capacity queue, with less PV now accepting offers. This is likely to be due to the funding changes to the Renewable Obligation Certificates to be implemented from April 2015. Current estimates of curtailment at the end of the LIFO section of the queue at March Grid are ~20%, which is significantly more than the curtailment offers of 0.59% to 2.30% offered within the capacity quota at March Grid. This means that once the quota is filled with accepted connection offers, it is unlikely that more generation will wish to connect as generation on a LIFO basis after the quota is full is likely to be significantly curtailed, which will not prove viable for further connections.

4. Progress against budget

This section is provided as a confidential appendix.

5. Bank account

This section is provided as a confidential appendix.

6. Successful delivery reward criteria (SDRC)

Table 4: Delivery required in 2012

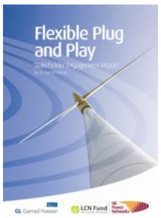
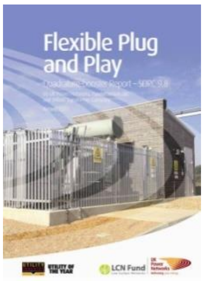
SDRC			Progress/Status
9.1	**Stakeholder Engagement Report 1** 	***Evidence*** • *Publication of a stakeholder engagement report ("Stakeholder Engagement report I").*	**Completed**. Stakeholder engagement report submitted to Ofgem on 28 September 2012. The report was written in collaboration with DVN GL (formerly GL Garrad Hassan) on behalf of the FPP project and it includes a foreword by Renewable UK. The report has been shared with GB DNOs and other key stakeholders. It is available in the learning zone of the FPP website, www.flexibleplugandplay.co.uk
9.2	**Development of smart commercial arrangements** 	***Criterion*** *Development of smart commercial arrangements, which will provide a number of options that can be tested and implemented in new types of connection agreements with generation developers. These will be established in conjunction with key stakeholders. The development of smart commercial arrangements will be completed by the end of December 2012 in accordance with agreed specifications.* ***Evidence*** • *Publication of a report on Principles of Access, which will determine the Principles of Access for smart commercial arrangements.* • *Connection agreements templates (new model forms) for actively managed generator connections, to be established in conjunction with key stakeholders.*	**Completed**. Principle of Access report submitted to Ofgem on 28 December 2012. The report was written in collaboration UK Power Networks and Baringa Partners. The deliverable to Ofgem included: • Report on smart commercial arrangements for generators connecting under the FPP project, including a regulatory analysis on underwriting curtailment risk. The Principles of Access report has been shared and published and can be found in the learning zone on the FPP website: www.flexibleplugandplay.co.uk • UK Power Networks Connection Offer and Connection Agreement templates for implementing non-firm generation connections. • Report on international experience of the use of smarter connection arrangements for DG by the University of Cambridge.

Table 5: Delivery Required in 2013

SDRC			Progress/Status
9.3	**IP (Internet protocol) Communications Platform – Go Live**  	***Criterion*** *Full deployment of an Internet Protocol (IP) communications platform across the FPP trial area to support open standards communication protocols. This will be completed by the end of March 2013.* ***Evidence*** • *Installation and commissioning documentation of Vodafone Multi-Service Platform (MSP) network and Silver Spring Networks Radio Frequency mesh network in the FPP trial area and in accordance with the specification included in the contracts with the relevant partners.* • *Recorded results of IEC 61850 communication trials using IEC 61850 simulators at installed locations in the FPP trial area.*	**Completed**. The project successfully installed and commissioned an IP-based communications solution across the FPP trial area by end of March 2013. It also demonstrated through IEC 61850 trials that the end-to-end communications solution was and is capable of acting as a bearer for IEC 61850 traffic. The Communications Platform SDRC 9.3 Report was delivered to Ofgem on 28 March 2013. The report was written in conjunction with Vodafone *(formally Cable & Wireless Worldwide)*, Silver Spring Networks and UK Power Networks. The report has been shared with GB DNOs and other key stakeholders. It is available in the learning zone of the FPP website: www.flexibleplugandplay.co.uk

SDRC			Progress/Status
9.8	**Deployment of Quadrature-Booster within trial area** 	***Criterion*** *Successful deployment of a Quadrature-booster within the FPP trial area. This will be completed by 9 August*[4] *2013.* ***Evidence*** • *Installation and commissioning of a Quadrature-booster and in accordance with the specification included in the contracts with the relevant partners.* • *Demonstration of improved balance between the circuits allowing increased power flow headroom of approximately 10MW*	**Completed.** The Quadrature-booster was successfully installed and commissioned in July 2013. The Quadrature-booster SDRC 9.8 Report was delivered to Ofgem on 9 August 2013. The report was written in conjunction with Fundamentals Ltd, Wilsons Transformer Company and UK Power Networks. The report provides an overview of the deployment phase of the project from concept through to commissioning and includes initial analysis demonstrating the improved balancing between the circuits. The report has been shared with GB DNOs and other key stakeholders. It is available in the learning zone of the FPP website, at: www.flexibleplugandplay.co.uk

[4] This was agreed under change request https://www.ofgem.gov.uk/ofgem-publications/83108/sdrc9.4and9.8changesdecisionletter150813.pdf

SDRC			Progress/Status
9.4	**Demonstrate FPP technical characteristics of FPP solution** 	***Criterion*** *Demonstration of Flexible Plug and Play capabilities of the overall FPP technical solution following completion of the FPP installation phase. This will be completed by the end of September 2013.* ***Evidence*** • *IEC 61850 certification for all relevant Remote Terminal Units (RTUs), Intelligent Electronic Devices (IEDs) and other IEC 61850 field devices.* • *Installation and commissioning documentation of IEDs and other field devices necessary to support the trials and in accordance with the specification included in the contracts with the relevant partners.* • *Installation and commissioning documentation of production of Smart Applications in accordance with the specification included in the contracts with the relevant partners.* • *Pre-production interoperability test results for FPP's Smart Devices and Smart Applications.*	**Completed.** The FPP solution was successfully installed and commissioned in September 2013. The SDRC 9.4 Report was delivered to Ofgem on 30 September 2013. The report has been shared with GB DNOs and other key stakeholders. It is available in the learning zone of the FPP website, at: www.flexibleplugandplay.co.uk This milestone has seen the delivery of the following key outcomes : • The IEC 61850 conformance of the overall components. • The commissioning and the acceptance of the ANM production platform. The integration of the Smart devices including the Dynamic Line Rating system, the Quadrature-booster Control system, the Automatic Voltage Control units and the upgraded RTUs into the ANM production platform. • The field commissioning of the smart devices to the ANM production platform via the RF mesh infrastructure.

Table 6: Delivery Required in 2014

SDRC			Progress/Status
9.5	**Strategic Investment Model**	***Criterion*** *Delivery of the FPP strategic investment model including validation and testing of the model utilising data captured within the FPP trials. This will be completed by the end of December 2014.* ***Evidence*** • *Completion documentation for the strategic investment model development and build phase.* • *Recorded validation and test results.* • *Delivery of the strategic network investment model in a fully usable and external issue format.*	**Completed.** The SIM was designed, built and delivered in December 2014. The SIM has been developed, tested and fully validate through a number of a case studies including the utilisation of data captured within the FPP trials. The full test results are recorded in the report. The SIM has been completed in a fully usable and external issue format using commercial software (i.e. Microsoft Excel, Fico Xpress) and proprietary code from Imperial College London. Report to be submitted to Ofgem by 31 December 2014.
9.6	**Implementation of active power flow and voltage management within FPP trial area**	***Criterion*** *Deployment of active power flow management and active voltage management within the FPP trial area. This will be completed by the end of December 2014.* ***Evidence*** • *Pre-production functional test results for active power flow management and active voltage management applications.* • *Installation and commissioning documentation of production active power flow management and active voltage management applications in accordance with the specification included in the contracts with the relevant partners.* • *Suitable agreements with generators in place (if required).* • *Trial results for the active power flow management and active voltage management trials*	**Completed.** The active power flow and the active voltage management was trialled within the FPP trial area and the report completed in December 2014. The report provides an overview of the trials conducted to demonstrate the capability of active power flow and active voltage management applications to overcome a number of constraints. The results analysed have come from a combination of both simulation and operational experiments. Report to be submitted to Ofgem by 31 December 2014.

SDRC			Progress/Status
9.7	**Facilitation of faster and cheaper connection of DG to the distribution network, as compared to timescales and costs of connection utilising traditional approaches.**	***Criterion*** *Facilitation of faster and cheaper connection of* DG *to the distribution network, as compared to timescales and costs of connection utilising traditional approaches. To be completed by end of December 2014.* ***Evidence*** ▪ *Demonstration that* DG *connection offers are: 1 - Cheaper; and 2 - Offer faster project connection timescales, than offers based traditional reinforcement. The evidence for this criterion will be met through the provision of one connection offer to generators using the FPP methods. If during the duration of the FPP project other generators are in a position to accept a connection offer, then we will use that as evidence supporting this criterion.*	**Completed.** The flexible connections that have been offered, accepted and commissioned have all been used to demonstrate that flexible connections are a cheaper and faster method for connecting DG to the network compared to conventional business-as-usual. Since 1 March 2013 39 flexible connection offers have been delivered to DG customers in the FPP trial area. Fourteen of these offers have been accepted. Report to be submitted to Ofgem by 31 December 2014.

7. Learning outcomes and knowledge dissemination

This section will focus on the specific learning that has been captured, provide information on the internal and external knowledge dissemination activities, as well as provide a summary of formal published materials that are available relating to each of our key topic areas.

Set out in Table 7 is a summary demonstrating the project's knowledge dissemination activities since the start of the project; with the key activities/materials are available at the FPP learning zone on the UK Power Networks innovation website: www.ukpowernetworks.co.uk/innovation

Table 7: FPP Knowledge dissemination activities

Activity	Volume since 2011
FPP learning reports generated and published	5
FPP learning events open to the industry	4
Published papers	12
National and international speaking slots	56
Internal dissemination/training activities	32
PR activity (press releases, articles, features)	27

7.1 Main learning Outcome from this reporting Period

7.1 .1 Customer Connection

Treatment of other onsite generation

A number of schemes connecting under FPP already have exporting and non-exporting generation onsite. This needs to be captured under the connection agreement as theoretically the customer can generate from any piece of generating equipment as long as the combined on site generation does not exceed the export capacity that has been approved. The other onsite generation needs to be controllable, if this is the case, so that if the distribution network is unable to accept generation, all onsite generators can be switched off until it is safe to generate.

A pre-defined 'worst case' quota level doesn't always provide the most optimal economic network efficiency

The initial assumption made for the flexible connection curtailment offers was that the capacity quota at March Grid would be wholly filled with wind generation. This made the best 'worst case' scenario for all generators requesting a connection offer initially. However, the resulting generation mix of PV, wind and CHP has meant that by capping the quota at 33.5MW, the project has not made the best possible utilisation of the network as the quota could have accepted more generation with the current technology mix at a curtailment level of 5.33%. Although at the beginning of the project this gave customers a worst-case scenario to work with to finance their projects, their position has become much more favourable since the generation mix has changed, resulting in the most economic network utilisation not being achieved. This will be reviewed as part of any roll out to other part of the network.

7.1.2 Customer Connection Delivery

The connections delivery process highlighted the need to ensure that the all details regarding the interface between the ANM system and the DG control system must be agreed and implemented before beginning commissioning. The following four key learning outcomes were generated and were implemented for the future commissioning procedure:

1) To minimise the possibility of any technical issues that could affect commissioning, where feasible bench testing of all interfaces need to be carried out prior to final commissioning onsite with the generator's control unit. Where bench testing is not possible, cold commissioning should be undertaken prior to full commissioning. This is an activity that can be completed remotely, and could identify any potential issues that could be fixed prior to the full generation commissioning day;
2) To ensure any potential technical issues that are raised during the final commissioning day can be resolved on the day, the DG customers control unit engineer needs to be present on site for the whole commissioning day. This ensures any issues with their control equipment can be dealt with it quickly and preferably on the same day; and
3) Following initial discussions with DG control system providers it was identified there was a need to standardise the communications protocols that are used for interfacing with the generators control system. Based on these discussions it was concluded that the following three options would suffice,
    1. Distributed Network Protocol 3 (DNP3),
    2. Hardwire and
    3. MODBUS
4) To further mitigate security risks associated with generator controller via ethernet, an additional layer of security between the ANM local controller (sgs connect) and the customer's generator controller is required. This has been achieved by the deployment of an industrial ethernet switch with security controls designed to isolate networks and restrict traffic to specific protocols and pre-defined IP addresses.

7.1.3 Communication Platform

The communication fault, as described in 2.1.2 provided a number of key learning points regarding the approach taken to designing and implementing a communication platform. The key learning points are as follows:

- The significance of active monitoring of the end-to-end communication infrastructure was highlighted to enable a full understanding the performance of the individual communication solutions, as their performance individually does not necessarily represent the overall performance of the communications network. As a result the project designed an automatic email notification process to ensure full visibility of any communication issues.
- For communications technology, a standard acceptance test should also include soak testing period of a minimum of two weeks, to ensure the network/solution is stable for longer periods.
- With a sparse RF mesh deployment such as the FPP project, it is important to monitor the network for any performance variations and carry out on-going network optimisations. This may involve relocation of relays or reinforcement with strategically placed additional relays where required.
- Adding additional nodes through new generators also improves the network performance by increasing routes and density. This highlights that on an RF mesh network the more devices, the better the performance.

7.2 External communications and knowledge dissemination activities

FPP continues raising the profile of the project through conferences and PR:

Table 8: FPP conferences and formal dissemination activities

Conferences and formal dissemination activities	Main Messages/presentation title	Date
CIGRE Paris (Poster Session)	ANM – Flexible Plug and Play Low Carbon Networks: an open and scalable Active Network Management solution for a faster and cheaper Distributed Generation connections (P.0284)	August 2014
East of England Energy Group (EEGR) Awards	A demonstration of the key successes, benefits and learning generated during the project. Entry (P0.389) and Presentation (P.0395)	September 2014
National Business Awards	A demonstration of the key successes, benefits and learning generated during the project. Entry (P0.393) and Presentation (P.0394)	September 2014
Telecoms for Smart Grids	Telecoms for Smart Grids (SMi) (P.0357)	September 2014
Low Carbon Network Fund 2014	Innovative DG Connections Systems and Security (P.0396)	October 2014

Awards

Since January 2014 FPP have entered seven external awards, which has seen the project being short-listed for five awards. During this report period the project was successful in winning two awards; the Energy Institute Innovation category and the Low Carbon Innovation Award at the EEGR awards ceremony, receiving the following positive feedback from Simon Grey, chief executive of EEEGR.

'*It's a fantastic and very innovative concept that provides a really useful and low-cost way of connecting renewable generation developments to the electricity network. It was widely lauded by all the judges which is why it won the category.*'

Sotiris Georgiopoulos, FPP Project Director (front left), at the awards ceremony

7.3 Learning and Dissemination activities in the next reporting period

In the first six-monthly report to Ofgem in June 2012, the project issued the FPP Knowledge Dissemination Roadmap, which is a plan to inform stakeholders what knowledge the project would share, how it would be shared, with whom and at what stages. The FPP Knowledge Dissemination Roadmap is a live document and has been updated during the project to provide the project team with more detail of dissemination activities. The final event for the project will be the 'FPP Final Learning Event', which disseminate all of the key learning generated by the project over the past three years.

All of the learning generated from flexible connections delivered in quarter one 2015 will be captured in the FPP Project Close Down Report to be submitted in March 2015, with any further learning generation to be added as an addendum to the Close Down Report in December 2015.

Table 9: Learning and Dissemination activities in the next reporting period

Conferences and formal dissemination activities	Date
FPP Final Learning Event to disseminate all of the key learning and messages from the FPP Close Down Report.	February 2014
Hold bi-lateral with other DNO's to discuss specific areas of interest to each DNO .	February 2014
A knowledge sharing workshop with ERDF and EDF R&D to share all key learning from the project.	February 2014

8. Intellectual Property Rights (IPR)

During the current reporting period the following IPR (foreground or relevant foreground) has been generated (June 2014 – December 2014):

Workstream	IPR description	IPR Owner
2	P0374.AVC.11kV Voltage control algorithm	Fundamentals
2	P0372.AVC.11kV Voltage control offline test schedule and validation tool	Fundamentals
2	P0376.DLR.DLR calculation tool	UK Power Networks
2	P0375.AVC.33kV Voltage control algorithm	Fundamentals
2	P0373.AVC.33kV Voltage control offline test schedule and validation tool	Fundamentals
2	P0377.DLR.DLR Assurance report	UK Power Networks
2	P0378.FPP.EOS 09-0070 Dynamic Line Rating (DLR) Monitoring Equipment on 33kV Distribution Lines	UK Power Networks
Design Authority	P0379.FPP.Quadrature-booster Trial Schedule	UK Power Networks
Design Authority	P0380.FPP.Quadrature-booster Trial Report	UK Power Networks
Design Authority	P0381.FPP.Dynamic Line Rating Trial Schedule	UK Power Networks
Design Authority	P0382.FPP.Dynamic Line Rating Trial Report	UK Power Networks
Design Authority	P0383.FPP.Modern Protection Relay Trial Schedule	UK Power Networks
Design Authority	P0384.FPP.Modern Protection Relay Trial Report	UK Power Networks
Design Authority	P0385.FPP.AVC Trial Schedule	UK Power Networks
Design Authority	P0386.FPP.AVC Trial Report	UK Power Networks

9. Risk management

The FPP project has established a risk management process, as described in detail in the FPP Project Handbook. Please see Appendix 1 for an extract of the risk management process. It allows for the communication and escalation of key risks and issues within the project, and defines where decisions will be made and how these will be communicated back to the workstream where the risk or issue has arisen. Risks are reviewed weekly at workstream level and fortnightly at project level by the Project Board. Key project risks are then escalated to the Project Steering Committee for review and approval of the mitigation on a six week cycle basis.

Ref#	W/S	Risk & Impact Description	BID Mitigation	Mitigation (update)	Status
BID R0001	WS1	The Communications platform may not meet the smart applications' performance requirements leading to system incompatibilities and unsatisfactory trial results	The Communications platform should be subject to performance testing using smart devices or simulators under various operating conditions. Communications requirements to be defined at design stage and suitable Communications technology chosen for the purpose of the trials. UK Power Networks to agree Service Level Agreements for Communications platform.	As part of the acceptance tests performed for the communications platform, IEC 61850 communication trials were included both in the lab and in the field using IEC 61850 traffic simulators. By implementing various system optimisation techniques and upgrading the network, it was proven that the network was capable of supporting the ANM requirement. Further corrective actions were taken to increase the performance levels	

Ref#	W/S	Risk & Impact Description	BID Mitigation	Mitigation (update)	Status
BID R0002	WS1	Failure to secure suitable mounting positions/space for the communications equipment due to limited space in UK Power Networks-owned premises or assets e.g. poles – leading to lengthy negotiations with property owners resulting in programme delays	Optimise design and minimise mounting positions/space required. Investigate alternative options for mounting such as a third party provider. Carry out detailed site surveys early in the project.	Suitable mounting locations for the communications equipment, relays, have been identified at UK Power Networks Low Voltage (LV) distribution pole infrastructure. All installs at LV distribution poles were completed.	Closed
BID R0003	WS1	Silver Spring Networks may have to use an unlicensed spectrum if they are unable to get a trial licence on time leading to possible adverse perception from other project stakeholders	Establish whether trial licenses would be available by Q1 2012.	Silver Spring Networks was awarded an Ofcom development licence on 19 December 2012 for the duration of the project.	Closed

Ref#	W/S	Risk & Impact Description	BID Mitigation	Mitigation (update)	Status
BID R0004	WS3	Insufficient levels of Renewable Generation (RG) connecting – Generators may not want to participate (if for example the project interferes with their normal operations) during the FPP project timescales leading to failure to fully trial the FPP in the planned timescales	Engage with generators as early as possible to understand the risks and issues likely to impact their (generators) normal operations in order to actively manage/mitigate them	FPP has successfully engaged with thirty-seven developers that have now been offered connections. Fourteen customers have now accepted their FPP connection offers, one customer has been connected, this is expected to increase to six by the end of the year with a further five customers to be connected in 2015. The project is continuing to make connection offers despite currently high curtailment estimates at the end of the queue.	Closed
BID R0005	DA	Different vendor protocols/ characteristics could potentially compromise the interoperability trials which may cause delays during system integration and trials	Ensure that ALL communications application is based on international standards, and all devices and systems are tested and certified to these standards Ensure that ALL devices are subject to testing in pre-production environment	Interoperability tests have been successfully completed and all certification achieved.	Closed

Ref#	W/S	Risk & Impact Description	BID Mitigation	Mitigation (update)	Status
BID R0006	PM	Project Partner(s) withdrawing their participation in the FPP project at a late stage leading to lengthy programme delays to institute their replacement(s) and in the worst case the collapse of the FPP	Issue principles of collaboration and request official Letters of Intent from Partners to reduce probability of partners withdrawing from the project – Reduce dependency on specific partners – this is a vendor agnostic project	All contracts with Partners have now been completed with clear technical and commercial scope. Relevant exit clauses have been incorporated to ensure project continuity in the event of an early withdrawal of one of the parties.	Closed

Ref#	W/S	Risk & Impact Description	BID Mitigation	Mitigation (update)	Status
BID R0007	DA	If actual MWh or hours of DG operation diverge (adversely) significantly from results within smart grid application feasibility assessment then this may lead to possible complaints from generators.	Ensure that DG developers are made aware in advance that the curtailment assessment results are based on estimates and that the actual levels of curtailment are likely to change year on year. Data used in studies should be as accurate as possible and assessment methods agreed by all stakeholders as being suitable. Develop suitable commercial and legal framework for making such connections offers.	Technical Mitigation unchanged – data used in studies should be as accurate as possible and assumptions used fully transparent. In addition, the project is working closely with the DG customers to support them through their due diligence process by providing additional information/analysis and clarifications as required. This will ensure better understanding of the mechanics of the curtailment and increased confidence in the curtailment analysis presented. This risk is also still valid for the implementation of flexible connections into business-as-usual and will be mitigated using the same approach as the FPP.	Closed

Ref#	W/S	Risk & Impact Description	BID Mitigation	Mitigation (update)	Status
BID R0008	PM	Delays in resourcing and negotiation/drafting of delivery contracts could result in delays in project delivery.	The resourcing process/production of job descriptions and contract drafting to start pre-contract award. UK Power Networks to partly resource project. Contracting resource has been allowed for key roles.	The team is now fully established, most resources are permanent UK Power Networks employees, but where key skills are not available internally, interim consultants have been engaged.	Closed
BID R0009	WS03	Local opposition to wind energy development contributing to negative publicity for UK Power Networks within the project area	UK Power Networks will proactively engage local stakeholders and promote the work the project is doing (looking at alternative to reinforcement and new lines/cables)	There has been no local opposition to date and therefore no further action is required.	Closed
BID R0010	WS8	System integration issues occurring due to inadequate testing in technical workstreams (WS) leading to delays	Ensure that the deliverables from each workstream are appropriately tested prior to system integration activities and allow sufficient time to develop test specifications and to conduct the testing	High-level test plan and detailed pre-production environment specification currently being developed. The relevant activities are being incorporated into the detailed project plan. Extensive lab and field testing will be carried out to ensure no issues in commissioning.	Closed

10. Other

There is no additional information to report.

11. Consistency with the full submission

The work currently being undertaken within the project is consistent with the bid submission as amended by change request approved by Ofgem on 15 August 2013.

12. Accuracy assurance statement

The project implemented a project governance structure, as outlined in the project handbook that effectively and efficiently manages the project and all its products. All information produced and held by the project is reviewed and updated when required to ensure quality and accuracy. This report has gone through an internal project review and a further review within UK Power Networks to ensure the accuracy of information.

We hereby confirm that this report represents a true, complete and accurate statement on the progress of the Flexible Plug and Play Low Carbon Networks project in its third reporting six monthly period and an accurate view of our understanding of the activities for the next reporting period.

Signed …………………………………………………………………

Date ………11/12/2014………………………………………………

Ben Wilson
Director of Strategy & Regulation and CFO
UK Power Networks

13. Appendix

Appendix 1 – Risk Management

To support the FPP Risk Management process each risk is given a RAG Status to provide visual representation and understanding of the risks current status. The RAG status is determined upon the probability of the risk occurring and the consequences if the risk eventuates. Please see below for the Probability and Consequence Table Calculator:

Probability and Consequence Table Calculator:

	1	2	3	4	5
Probability	Rare	Unlikely	Possible	Likely	Almost certain
Consequence	Minimal	Minor	Moderate	Major	Catastrophic

Probability
1. Rare – May occur in exceptional circumstances 0-10%
2. Unlikely – Uncommon but has been known to occur 10-20%
3. possible – Could occur 20-75%
4. Likely – May occur 75%-90%
5. Almost certain – Expected to occur with a likelihood 90-100%

Consequence
1. Minimal
2. Minor
3. Moderate
4. Major
5. Catastrophic

Once a rating has been determined for the probability and consequences the RAG status (high, medium and low) is calculated by multiplying the probability against the consequences, e.g. taking a probability of 4, which is classified as likely, and multiplying this against a consequence of 2, which is classified as a Moderate, would give you and overall risk rating of 8, which would be risk rated as a RAG status of GREEN (Low)

Probability	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
	Consequence					