WESTERN POWER DISTRIBUTION

FLEXDGRID

HEAT AND POWER FOR BIRMINGHAM

PROJECT PROGRESS REPORT
REPORTING PERIOD:
DECEMBER 2013 – MAY 2014

LCN Fund Low Carbon Networks · THE UNIVERSITY OF WARWICK · PARSONS BRINCKERHOFF

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Contents

Glossary

Term	Definition
BaU	Business as Usual
CBD	Central Business District
CHP	Combined Heat and Power
DG	Distributed Generation
DNO	Distribution Network Operator
EU	European Union
FLM	Fault Level Monitor
FLMT	Fault Level Mitigation Technology
HV	6.6kV or 11kV
ITT	Invitation To Tender
KPI	Key Performance Indicator
SDRC	Successful Delivery Reward Criteria
SoW	Scope of Work
ST	Standard Technique
UoW	University of Warwick
WPD	Western Power Distribution

1 Executive Summary

FlexDGrid is funded through Ofgem's Low Carbon Networks Second Tier funding mechanism. FlexDGrid was approved to commence in January 2013 and will be complete by 31st March 2017. FlexDGrid aims to develop and trial an Advanced Fault Level Management Solution to improve the utilisation of Distribution Network Operators' (DNO) 11kV (HV) electricity networks while facilitating the cost-effective and early integration of customers' generation and demand connections.

This report details the progress of FlexDGrid, focusing on the last six months, December 2013 to May 2014.

1.1 Project Progress

Significant progress has been made in this report period in respect of the installation of the technologies on to the 11kV network area. Following the procurement of all the required Fault Level Monitor (FLM) and Fault Level Mitigation Technology (FLMT) devices, construction activities have now begun at the FlexDGrid primary substations.

Progress has also been made in understanding the variations, fluctuations and causes of changes of fault level at 11kV in real-time. Section 2.8 provides detail on the work carried out to both model and measure the fault level over an historic real-time basis. This work has enabled the potential benefits of enhanced fault level assessment to be further quantified and verified.

In this reporting period significant progress has also been made in working towards the delivery of other project SDRCs, specifically SDRCs 7 - 11.

1.2 Project Delivery Structure

1.2.1 Project Review Group

The FlexDGrid Project Review Group met twice during this reporting period. The first Project Review Group was also a Gateway Review in order to gain approval for the transition from the project's design phase to construction. This review was approved.

1.2.2 Resourcing

There have been no significant resourcing changes during this reporting period.

Contracted construction staff are now being employed on a site by site basis to support WPD with the delivery of the technology installation activities.

1.3 Procurement

Following the approval of SDRC-5 (Fault Level Mitigation Technology Procurement Report) the competitive procurement activities for five FLMTs and 10 FLMs was carried out. The procurement process was completed in the last reporting period and now all the technology devices for FlexDGrid have signed contracts in place. Table 1-1 below provides an overview of the technologies, manufacturers and expected delivery dates.

Manufacturer	Technology	Applicable Substations	Anticipated Delivery Dates
S&C Electric	Fault Level Monitors	10 Sites	Phased throughout 2014 and 2015
GridON	Fault Current Limiter – Pre-saturated Core	Castle Bromwich	January 2015
Nexans	Fault Current Limiter - Resistive Superconducting	Chester Street Bournville	June 2015 August 2015
Alstom	Fault Current Limiter - Power Electronic	Kitts Green Sparkbrook	January 2016 April 2016

Table 1-1 - FL Technology Contracts

1.4 Installation

The designs for the installation of the 10 FLMs are complete and construction activities started in April for their installation. Civil and Electrical elements of the construction activities are being carried out separately in order to minimise the installation periods and to de-risk and reduce project costs by ensuring that each site is available to accept the technologies as soon as they are manufactured.

The finalisation of design and construction activities for the installation of the five FLMTs is being staggered in order to meet the manufacturers' delivery timescales. The first FLMT to be installed is the GridON device in to Castle Bromwich Primary Substation. The construction activities for this installation are currently underway. The designs for the other FLMTs have been finalised, following approved designs for each device being submitted following contract award and construction activities are being planned.

1.5 Project Risks

A proactive role in ensuring effective risk management for FlexDGrid 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 FlexDGrid, as captured in our Risk Register along with an update on the risks captured in the last six monthly project report. Section 8.2 provides an update on the most prominent risks identified at the project bid phase.

1.6 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.

During this reporting period we have shared our learning from FlexDGrid through the following events:

- DNO workshop on Fault Level Mitigation Operation (14th May 2014); and
- Published paper (Sensitivity Analysis of Fault Level Assessments in HV Networks – Paper 0200) at the CIRED, Rome, 11-12th June 2014 within the workshop, Challenges of implementing active distribution management.

In addition to this we have shared our learning through discussions and networking at a number of knowledge sharing events hosted by other organisations.

2 Project Managers Report

2.1 Project Background

The FlexDGrid Low Carbon Networks Fund project aims to develop and trial an Advanced Fault Level Management Solution to improve the utilisation of Distribution Network Operators’ (DNO) 11kV (HV) electricity networks while facilitating the cost-effective and early integration of customers' generation and demand connections. The FlexDGrid project was awarded funding through Ofgem’s Low Carbon Networks Second Tier funding mechanism and commenced on the 7th January 2013.

The Carbon Plan aims to deliver carbon emission cuts of 34% on 1990 levels by 2020. This national target is devolved, in part, through local government carbon emission reduction targets as set out in their strategy planning documents. The Carbon Plan sets out ways to generate 30% of the UK's electricity from renewable sources by 2020 in order to meet the legally binding European Union (EU) target to source 15% of the UK's energy renewable sources by 2020. The UK Government has identified distributed generation (DG) as a major low carbon energy enabler and an important part of the future electricity generation mix.

Fault level is a measure of electrical stress when faults occur within networks. It is a growing issue in the connection of Distributed Generation (DG), especially in urban networks, as the majority of DG increases the system fault level. Conventional solutions to manage Fault Level often entail significant capital costs and long lead times.

In order to address the Fault Level Management Problem, three methods will be trialled and evaluated within the Central Business District (CBD) of Birmingham. The findings from these three methods will be extrapolated in order to understand the wider applicability to GB urban networks.

These Methods are:

Method Alpha (α)	-	Enhanced Fault Level Assessment;
Method Beta (β)	-	Real-time Management; and
Method Gamma (γ)	-	Fault Level Mitigation Technologies.

These three methods aim to defer or avoid significant capital investment and create a wider choice of connection options for customers who can accept a flexible connection to the network. These benefits will be provided to customers through advanced and modified generation connection agreements. Each method on its own will help customers to connect DG more flexibly. The three methods used together will aim to create greater customer choice and opportunities for connection.

2.2 Project Update

This is the third reporting period and in the previous two the focus of the project was on carrying out design, development and procurement activities. During this reporting period the focus has move to finalising the procurement and design of both the FLMs and FLMTs, whilst moving in to the construction phase for the installation activities. Supporting work, including the production of equipment and methodology policies has also been undertaken.

In the previous reporting period the FLMs and FLMTs were selected, through a competitive procurement process. All the contracts for these technologies have now be finalised and signed by all required parties. This has allowed the design of the devices to be finalised. Also, factory visits to all manufacturers have taken place and laboratory tests for the FLMs have been successfully completed.

Detailed designs for the inclusion of the technologies into the 10 sites are now complete. The construction activities in order to connect the technologies to the existing 11kV network are on-going and scheduled with the delivery programme of the units.

An integral factor in the success of FlexDGrid is ensuring that the learning and processes used as part of the project are robustly captured. This capture is taking the form of documented policies for the installation, operation and maintenance of the new technologies connected to the network along with procedural policies on modelling fault more robustly. An indicative timetable of go-live dates for the policies to be produced as part of FlexDGrid is show in Table 2-1.

Policy Type	Name	Go-live Date
Engineering Specification	FLM Engineering Specification	July 2014
Engineering Specification	FLMT Engineering Specification	August 2014
Standard Technique	Application and Connection of 11kV FLMs	July 2014
Standard Technique	Application and Connection of 11kV FLMTs	August 2014
Standard Technique	Determination of Short Circuit Duty for Switchgear on the WPD Distribution System	August 2014

Table 2-1 - Policy Timetable

Using the extensive FlexDGrid network that has been produced during the two previous reporting periods, real-time fault levels for each primary substation have been produced. This is a process of understanding the actual network configuration over a 12 month period, rather than a snapshot of network configurations (current DNO wide standard), to understand the fluctuations and therefore potential fault level headroom that can be accessed using enhanced fault level assessment.

The University of Warwick are progressing with both their workstreams, engineering and socio-economic. The engineering work has been and is currently focussed on understanding the fault level infeed to aggregated load on the system. Tests have been carried out on domestic appliances to understand a homes' contribution to fault level and work is progressing to recommend changes and updates to 11kV fault level infeed values. Following the approval by Ofgem of the Customer Communications and Data Protection Plan the UoW have carried out a survey to understand peoples understanding and willingness to be involved in district heating schemes. The learning from this survey is to be used to further understand the potential societal benefits of FlexDGrid.

2.3 Project Reporting Progress

Due Date	Type	Description	Status
28.02.2014	Ofgem Approval Document	Customer Communications and Data Protection Plan	Completed and Approved
30.03.2014	KPI	Construction activities to start	Completed
30.03.2014	KPI	First technology factory visit	Completed
30.04.2014	KPI	All technology contracts signed	Completed
16.05.2014	KPI	Hold 3rd DNO FLMT Workshop	Completed
13.06.2014	KPI	Present CIRED paper	Completed

Table 2-2 - Progress to date - Key Outputs and Milestones

2.4 Substation Selection Update

FlexDGrid originally identified 18 sites to install the FLMs and FLMTs. At the end of the design phase 10 sites were selected to be used and five sites were identified as key reserve sites. It has now proven beneficial to change one of the originally selected 10 sites, Winson Green, due to interaction with business as usual work that is currently being undertaken.

After instigating a selection process for the replacement substation, Shirley 132/11kV substation was identified as the most suitable replacement. Shirley 132/11kV substation is within the capture area of FlexDGrid, has similar fault level restrictions to Winson Green and has existing infrastructure capability and available space for the installation of the FLM device.

2.5 FLM Construction Phase – Method Beta

The previous progress report for the period June 2013 to November 2013 gave a summary of the design work that was being completed for the FLM and FLMT installations.

Further work has taken place during the period between December 2013 and May 2014 to finalise the designs ready for construction. Of the ten substations for installation of FLMs, eight designs have been completed (where the remaining two are integrated with FLMT designs) with contracts now awarded for these sites. Table 2-3 below lists the sites that been issued for contract with the expected installation start dates.

Substation	Installation start date
Elmdon	28/04/2014
Hall Green	19/05/2014
Chad Valley	02/06/2014
Castle Bromwich	02/06/2014
Shirley	23/06/2014
Kitts Green	07/07/2014
Chester Street	21/07/2014
Perry Barr	28/07/2014

Table 2-3 - Substations for FLM Installation

The FLM installation work at each substation has been split into civil and electrical elements, as reflected in the designs and Scope of Work (SoW) documentation. This solution was chosen as the contracts were tailored towards the existing civil and electrical framework contracts already used by WPD.

Examples of the typical FLM designs are shown in Figure 2-1.

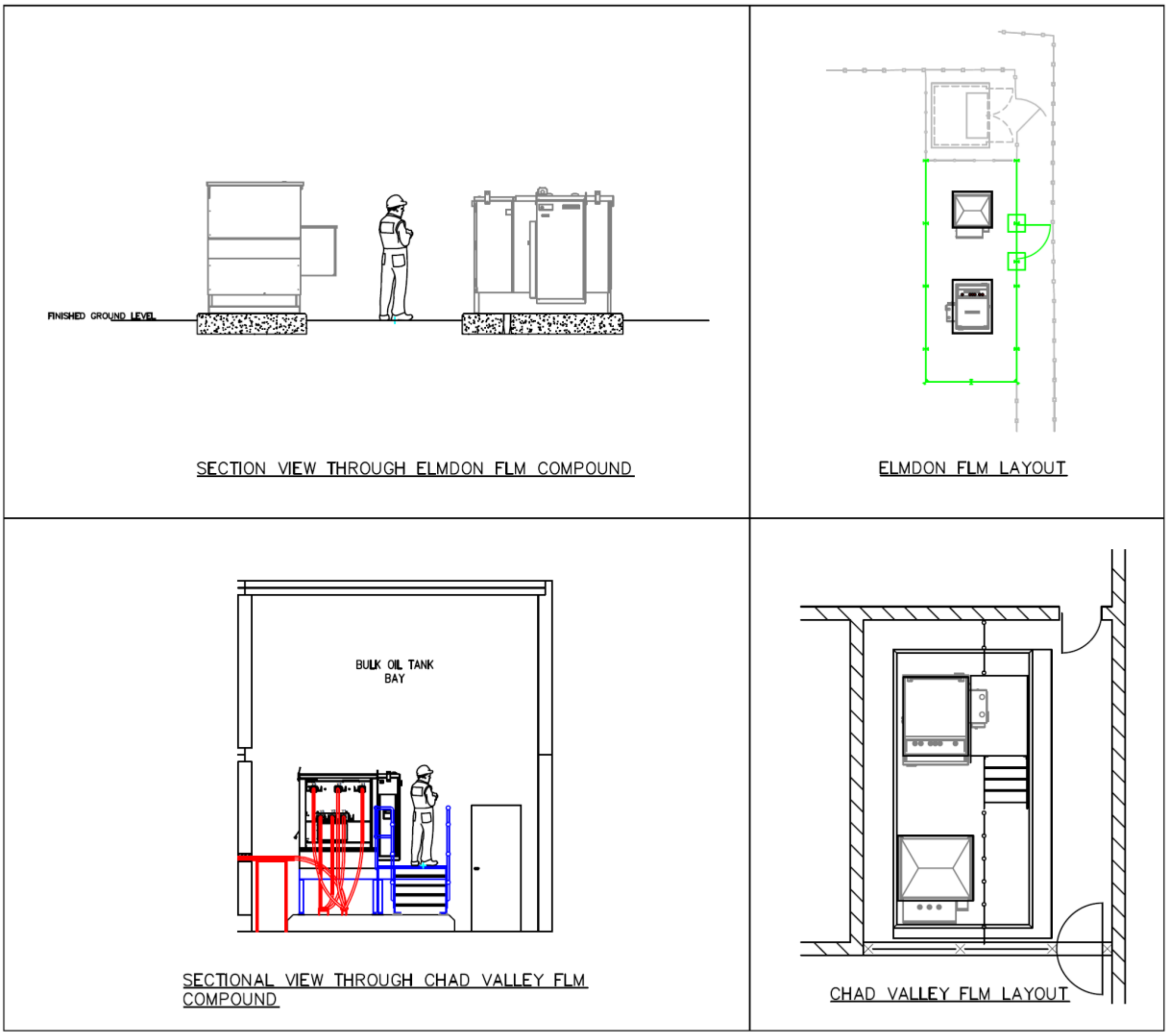

Figure 2-1 - Elmdon and Chad Valley FLM Installations

FLM installations at Bournville and Sparkbrook substations have not yet gone out to tender. This is due to the integration of the FLM being dependent on the final requirements for switchgear and FLMT footprint dimensions. Discussions are currently on-going with Alstom and Nexans to finalise the design of the FLMTs for these sites, after which, designs for the integration of FLMs shall be completed.

2.6 FLMT Construction Phase – Method Gamma

Since the last progress report there have been a number of design reviews between WPD and the manufacturers to establish the integration and connection of the technologies into the five method gamma substations. The scheduled delivery dates for the technologies have been phased so that the installation process can be managed carefully.

The first of the FLMT installations will be GridON's Pre-saturated Core FLMT at Castle Bromwich substation, due to be delivered in January 2015. A combined electrical and civil installation tender for the FLM, FLMT and switchgear was issued in April 2014 and following scoring and post tender negotiations the contractor has now been selected. Work started on-site on 2 June 2014. The final arrangement of the FLMT, FLM and switchgear are indicated in the designs show in Figure 2-2 below.

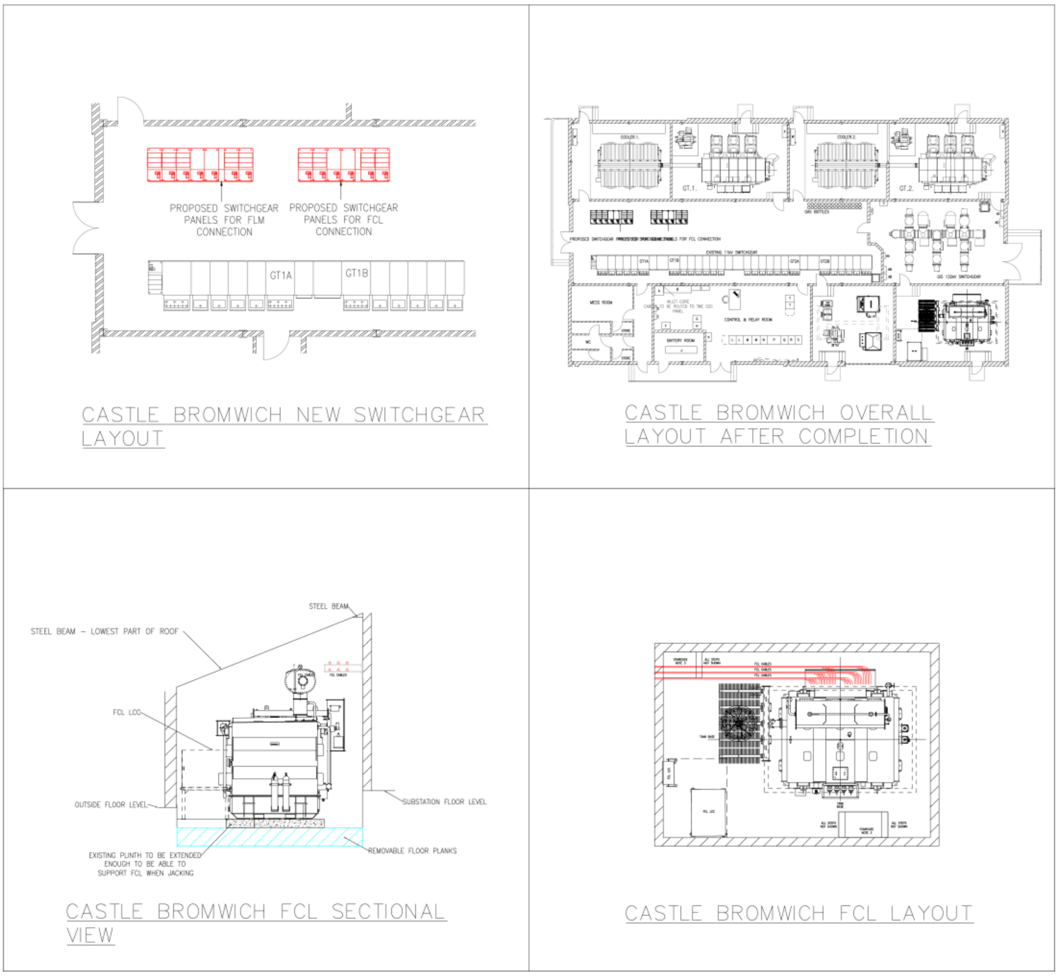

Figure 2-2 - FLMT and FLM installation at Castle Bromwich

The Resistive Superconducting FLMT by Nexans is due to be installed at Chester Street in July 2015 and Bournville in August 2015. Design meetings with Nexans have helped to develop slightly different FLMT solutions for Chester Street and Bournville. At Chester Street the installation will be outdoors and as such the FLMT will be delivered in a purpose built enclosure. For Bournville, the solution is to install the FLMT and the component parts within the substation switch house.

The Alstom Power Electronic FLMTs for Kitts Green and Sparkbrook substations are due to be delivered in January 2016 and April 2016 respectively. Following an initial design review meeting, Alstom are working on WPD's requirements. Further design meetings are scheduled over the coming months to develop the final design of the FLMTs.

2.7 Policy Documents – All Methods

One of the main aims of FlexDGrid is to ensure that important elements of the work carried out for network modelling, monitoring, design and installation is captured and shared within WPD and the wider DNO community. During this period one of the objectives was to capture learning in the form of WPD policy documents. The sections below provide further detail on the policy documents that have been produced and also those planned for the future.

2.7.1 11kV Fault Level Modelling Standard Techniques

Two Standard Technique (ST) policy documents have been produced to provide Primary System Design engineers and 11kV planners with a comprehensive reference, and consistent guidance on the modelling of fault levels within 11kV electricity networks. The Standard Techniques build on the information published in SDRC-4 and support WPD's business-as-usual (BaU) customer connection application assessment processes.

The first Standard Technique provides engineers and planners with guidance on how to consistently assess the fault level for customers' connections when the available network model represents the electricity from National Grid in-feeds to the 11kV busbars in Primary Substations. In this case, the appropriate data sources and process for modelling the equivalent network from the customer's point of connection to the 11kV busbar of the Primary substation is given.

The second Standard Technique provides engineers and planners with guidance on how to consistently assess the fault level for customers' connections when the electricity network model has already been built to represent the 11kV network (as described in SDRC-1 and SDRC-4).

2.7.2 FLM and FLMT Application and Connection Standard Techniques

Two WPD standard technique (ST) policy documents have been produced. These documents will provide WPD engineers with information which will help inform the decision of when and where to install FL technologies on the network.

The FLM ST provides an overview of the operation of the device, the arrangements in which it can be connected and how it should be protected. Similarly, the FLMT ST details the background behind FLMT installations, how each different FLMT technology functions, the arrangements in which they can be connected, factors to be considered when selecting technologies and protection of the devices.

2.7.3 FLM and FLMT Engineering Specifications

WPD have a suite of Engineering Specifications for equipment such as switchgear, transformers, cables etc. Using these existing specifications as examples, new Engineering Specifications have been developed for the FLM and FLMT devices.

The FLM Engineering Specification has been built upon the functional requirements that were highlighted in the original ITT for FlexDGrid along with relevant WPD equipment requirements such as device construction, connections and testing.

As the FLMT Engineering Specification covered three separate technologies; Resistive Superconducting, Pre-Saturated Core and Power Electronic, the document was split into sections which covered general requirements and those specific to the technologies.

2.7.4 FLM and FLMT Operation and Maintenance Procedures

Prior to the installation of the FLM and FLMT devices, operation and maintenance standard techniques shall be produced. This will ensure that these devices can be serviced and operated in line with WPD’s current practices for existing plant and equipment on the network.

2.8 Comparing modelled and monitored fault level values

2.8.1 PM7000 logger locations

PM7000 fault level measurement devices have been installed at six (of the ten) Primary substation sites as part of FlexDGrid:

- Castle Bromwich;
- Kitts Green;
- Chester Street;
- Bournville;
- Sparkbrook; and
- Hall Green.

These devices record the magnitude of faults, if they occur during the course of the project, and the results can be compared to modelled fault magnitude values. The devices also record background (termed "natural") disturbance data which is used for calculation of the prospective fault level. This allows the electricity network to be characterised, based on fault activity and natural disturbances, prior to the installation of active FLM devices, as part of Method Beta.

An illustration of PM7000 logger installations at Chester Street Primary substation is given in Figure 2-3. The natural disturbances in voltage and current waveforms of Grid Transformer 2 (GT2) are monitored by the PM7000 logger with the serial number (SN) SN694. In a similar way, the natural disturbances in voltage and current waveforms of GT3 are monitored by PM7000 SN698.

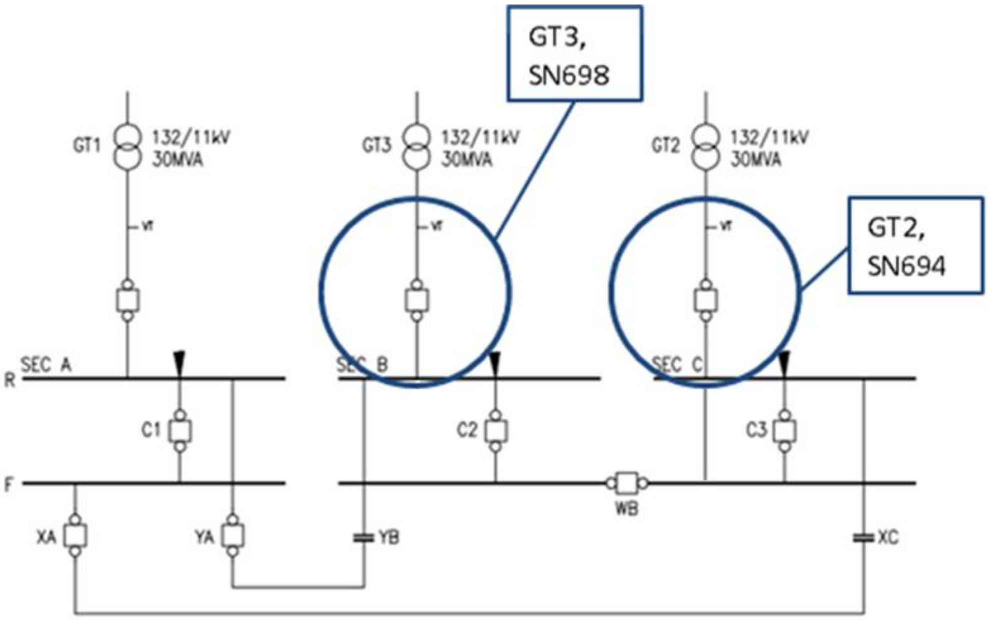

Figure 2-3 - PM7000 logger locations in the Chester Street Primary substation

2.8.2 Monitoring prospective fault levels

Based on the PM7000 loggers installed in the FlexDGrid demonstration area, to date, the granularity of prospective fault level assessments has increased from a single set of the most onerous case (as part of the present connection assessment planning processes) to monitoring prospective fault level in real-time. This allows modelled fault level values to be compared with monitored fault levels.

Example results for the prospective Break fault level (rms at 90ms) are given in Figure 2-4, corresponding to PM7000 logger SN694 installed on GT2 at Chester Street, for the period 16/09/2013 – 30/09/2013.

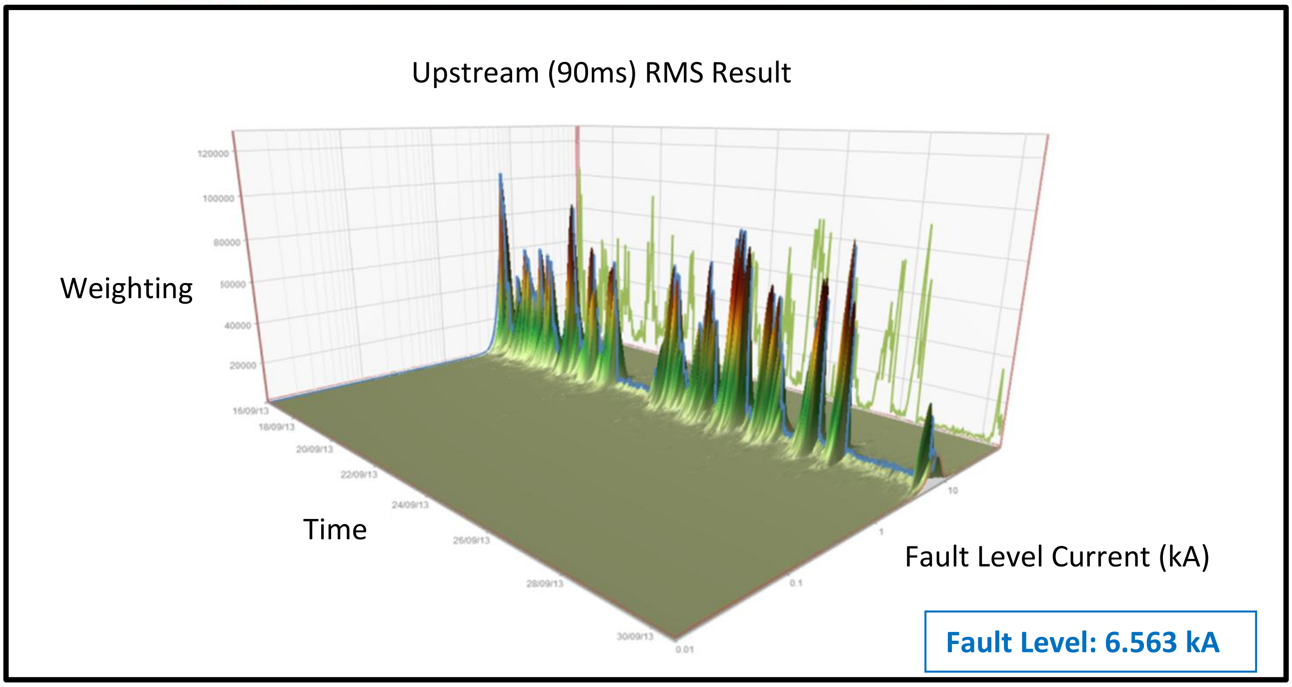

Figure 2-4 - Prospective Break fault level results for Chester Street Primary substation

The prospective fault level is plotted in 3-D to represent the variation of fault level with time and the variation of the weighting / confidence of the prospective fault level calculation. Three dimensions are used in order to understand the confidence factor of the results provided, the greater the disturbance on the network (change in voltage and current due to a naturally occurring network event) the more significant the spike and therefore the greater confidence of the result.

From Figure 2-4 it can be seen that the fault level is relatively consistent in the region of 6.6kA (on the Z-axis), however at certain points the weighting (on the X-axis) is very low. There are significant periods when the weighting is low for short periods, the troughs between the peaks, and also longer periods of time. These points in time are characterised by the monitored Primary substation having mainly industrial load connected and the low weighting results being evenings and weekends, when the industrial facilities aren't operating.

These results have provided important learning and further business case for the installation of active fault level monitors. Having the ability to, at a controlled point, cause a non-network effecting disturbance to the system, to provide a fault level result with a high weighting / confidence factor, means that all the troughs and long periods of low weighting can be removed. This data can then be used reliably to optimise the operation of the network and provide flexible connection to both demand and generation customers.

2.8.3 Analysis of modelled and monitored fault level values

Using the real-time fault level analysis process described in SDRC-4, the time-based variation of fault level at the Primary Substation sites has been modelled and can be directly compared with PM7000 logger data which, at this stage in the project, represents the prospective fault level based on natural disturbances in the electricity network.

The PM7000 loggers have the capability to report back fault levels with a one-minute granularity. For the purposes of an initial analysis, fault level values have been averaged over periods of a fortnight and directly compared with the modelled fault level, corresponding to the same fortnightly period.

An illustrative comparison is given in Figure 2-5 for the Break fault level (rms at 90ms), corresponding to PM7000 logger SN694 and the fault level at GT2 in Chester Street for the period 16/09/2013 – 31/12/2013.

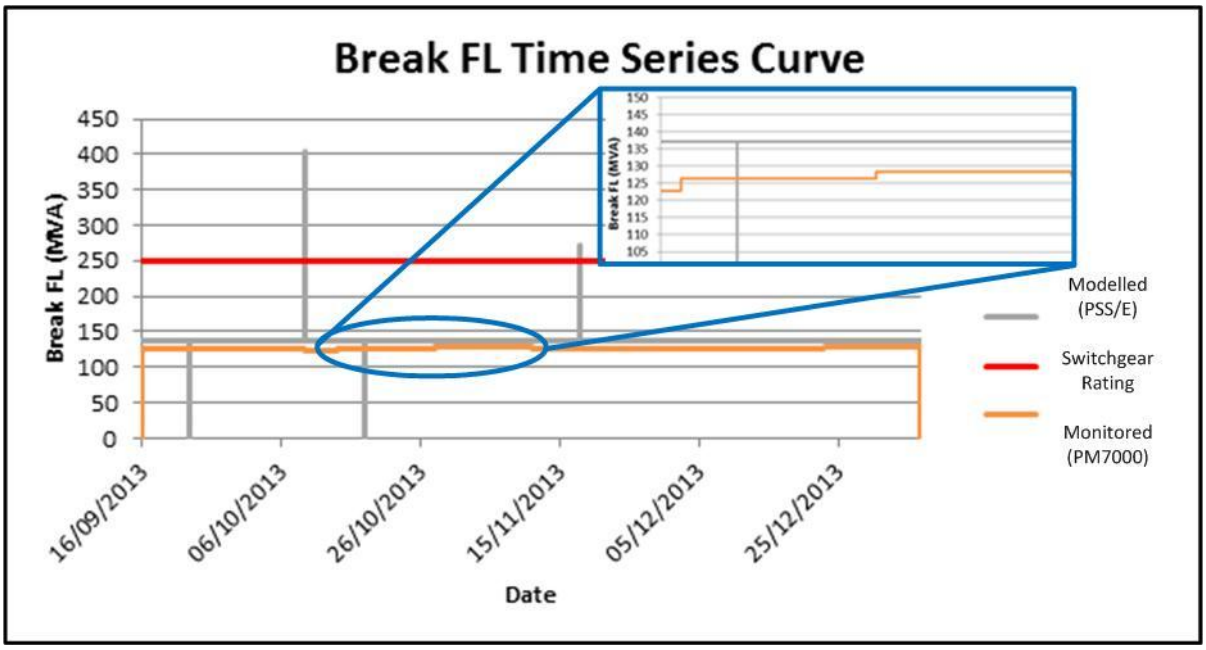

Figure 2-5 - Comparison of modelled and monitored fault level at GT2 in Chester Street Primary substation

Based on the plot of modelled and monitored fault level values, the data was analysed to establish the maximum difference between the data sets during normal operation of the network. A summary of results is given in Table 2-4 for the Break fault level (rms at 90ms) at GT2 and GT3 in Chester Street Primary substation. A similar analysis was conducted to compare prospective Make fault level (peak at 10ms) from the loggers with the corresponding modelled fault level.

Location	Modelled Break fault level (rms at 90ms)	Monitored Break fault level (rms at 90 ms)	Difference (MVA)	Difference (%)
GT2	137.1	126.2	-10.1	-8.0
GT3	150.3	148.0	-2.3	-1.6

Table 2-4 - Comparison of modelled and monitored fault level at Chester Street

Considering Table 2-4 it can be seen that the PM7000 logger is predicting a lower prospective fault level with respect to the modelled fault level at both GT2 and GT3 with 8% and 2% differences for the two locations, respectively.

This supports the assertion that the fault level model derived from the Engineering Recommendation G74 could be leading to conservative estimations of fault level. During 2014, the consistency of variations between the modelled and monitored fault levels at the various FlexDGrid demonstration sites will be quantified.

2.9 Fault current limiter modelling

This work has been carried out to develop computer models of the three FLMT technologies that will be trailed in FlexDGrid. The aim of developing these models is to provide WPD planning engineers with tools and methodologies for desktop studies to determine the fault level headroom that can be unlocked by using different FLMT technologies. In addition, these models will be incorporated into fault level study processes carried out for the connection application assessment.

As one of the outcomes of a previous workshop with UK DNO delegates, it was recognised that a static model of an FLMT that can be used for calculating making and breaking fault current is what is required for the purpose of the desktop system studies and generation connection assessments. Therefore, the developed models will simulate the FLMTs' performance in two snapshots of post-fault network conditions: fault making time and fault breaking time.

2.9.1 Data requirements

In order to accurately model the performance of an FLMT in WPD's PSS/E model a static model of each device is required; this is where the FLMT's effect on the network pre and post fault can be modelled. FLMT manufacturers routinely have a transient model of their FLMT, which allows the performance of the device to be characterised during the fault. The manufacturers are currently in the process of providing the impedance of the FLMTs during different network conditions that will allow us to develop FLMT static models in the next reporting period.

2.9.2 FLMT Excel model

An Excel based FLMT model has been developed to provide WPD engineers with a tool for calculating the fault levels as well as fault level headroom for a given two bus system. In particular, this Excel based model is designed for the users that do not have access to advanced power system analysis software such as PSS/E or IPSA. This will be captured in the 11kV Fault Level Modelling Standard Technique (Section 2.7.1). In this Excel based model following the options are taken into account:

- Network location of FLMT– users can study the effect of an FLMT on fault levels when the FLMT is installed within the interconnectors or in parallel with the transformers.

- FLMT Specific – users can select different FLMTs. The performance and the fault level reduction level of each FLMT can be different.

- Upstream fault contribution – users can update the upstream fault contribution. For most of the primary substations the upstream fault contribution can be obtained from Long Term Development Statements.

- Downstream fault contribution – users can update the downstream fault contribution. Downstream fault contribution may be due to generators connected to the HV network and the dynamic loads (rotating machines) connected to HV and LV networks.

Figure 2-6 shows the dashboard designed for the Excel based FLMT model.

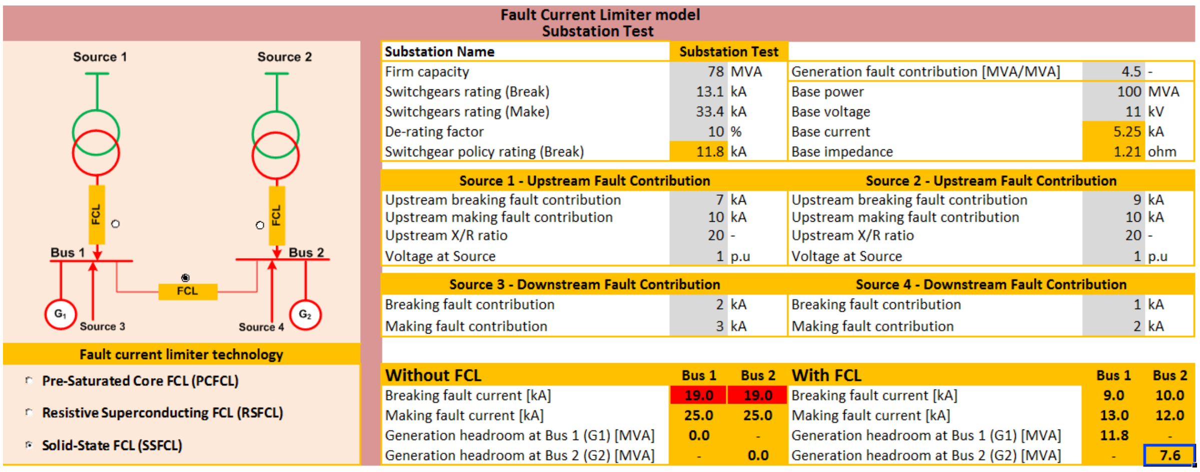

Figure 2-6 - FLMT Excel model

2.10 HV network fault level survey report

The HV networks of the 13 primary substations (increase from 12 to include Shirley Primary Substation – see section 2.4) in the Birmingham area have been modelled in FlexDGrid. In total the modelled HV network comprises of 2658 distribution substations. The geographical area covered by the modelled HV network is shown in Figure 2-7. In Figure 2-7, the black dots represent the distribution substations.

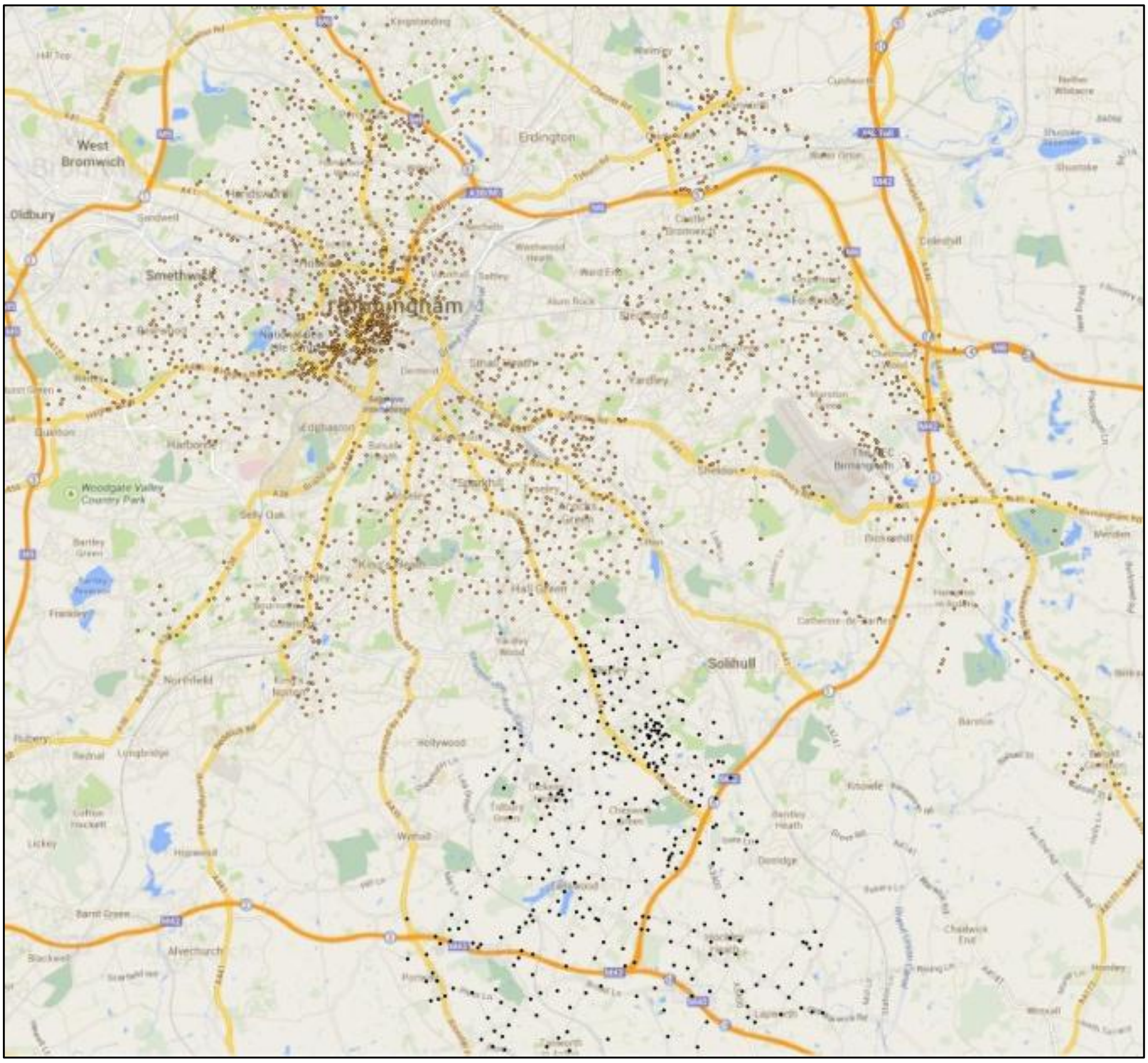

Figure 2-7 - Birmingham HV network modelled in FlexDGrid

As part of the enhanced fault level assessment process, a fault level survey report was produced for the HV network of all 13 primary substations. Figure 2-8 shows an example of the HV fault level survey report for Castle Bromwich. This report aims to:

- Enhance the knowledge of WPD HV planners regarding the fault levels in HV networks;
- Report the fault level headroom at each distribution substation by comparing the modelled fault levels and equipment ratings;
- Provide WPD engineers with equivalent network impedances which can be improve the accuracy of the fault level calculations;
- Reduce the time for connection application process time by providing updated network parameters; and
- Enable WPD engineers to conduct fault level assessments for new connection application more accurately without need of the advance power system analysis software.

In the HV fault level surveys the following parameters have been reported:

- Making and Breaking fault levels in normal operation and split operation: Normal and parallel operation is referred to the connection arrangement at the corresponding primary substation where 132/11kV transformers can be operated in split or in parallel arrangement;
- The short circuit rating of the equipment at the distribution substations and the short circuit ratings of the switchgear at the upstream primary substation; and
- The equivalent impedance (resistance and reactance) between a distribution substation and the upstream primary substation.

Site Number	Equipment breaking short circuit rating [kA]		Calculated fault levels in normal operation [kA]		Calculated fault levels in network parrallel operation [kA]		Equivalent impedance to Primary s/s	
	@ Distribution s/s	@ Primary s/s	Make	Break	Make	Break	R (ohm)	X (ohm)
229657	*	13.1	11.0	6.2	11.7	6.8	0.485	0.292
721364	20	13.1	10.1	5.7	10.7	6.2	0.525	0.384
721366	18.4	13.1	10.1	5.8	10.7	6.3	0.552	0.336
722067	*	13.1	12.2	6.3	13.7	7.4	0.361	0.276
722069	*	13.1	10.1	5.9	11.2	6.8	0.548	0.248
722071	16	13.1	14.9	6.9	17.4	8.5	0.225	0.223
722072	21	13.1	13.9	6.5	16.1	7.9	0.243	0.277
722073	13.1	13.1	15.9	7.1	18.9	8.8	0.187	0.207
722074	21	13.1	17.2	7.4	20.8	9.3	0.146	0.179
722131	16	13.1	14.7	7.5	16.0	8.6	0.305	0.176
722132	13.1	13.1	16.0	7.3	18.9	9.2	0.200	0.171
722134	16	13.1	14.6	7.5	15.8	8.5	0.310	0.181
722135	13.1	13.1	12.3	6.7	13.2	7.4	0.405	0.252
722165	16	13.1	22.0	8.5	22.0	8.5	0.062	0.032
722179	21	13.1	13.2	6.5	13.2	6.5	0.291	0.169
722193	21	13.1	11.9	6.5	12.7	7.2	0.430	0.264

Bournville | Castle Bromwich | Chad Valley | Chester Street | Elmdon | Hall Green | Kitts Green | Ladywood | Perry Bar | Sparkbrook | Summer Lane

Figure 2-8 - HV fault levels survey report

This HV fault level survey has formed the basis of the 11kV Fault Level Modelling Standard Technique for planners (Section 2.7.1) without access to power systems analysis software.

2.11 UoW Socio-Economic research

During the project, the University of Warwick will conduct research work on the socio-economic impact of Combined Heat and Power (CHP) integration and Fault Level Mitigation, with specific focus on low income households in the Birmingham area. Following this analysis, further research work will be done to assess the social and economic benefits of FlexDGrid.

2.11.1 Phase 1 - Literature Review

In order to evaluate the potential social and economic effects of the development of CHP installations in Birmingham a review of the literature on district heating, energy consumption and affordability has been undertaken, by the University of Warwick, to examine the main lessons learned from existing academic and policy studies on the subject.

The literature review presented and discussed the available evidence about the economic, environmental and efficiency gains that accrue to local communities from the deployment of district heating. It also discussed the potential wider social benefits arising from the alleviation of financial hardship and fuel poverty among households with low incomes and/or including vulnerable individuals.

It has revealed that not only income and energy expenditure, but socio-economic characteristics of the household and of the local area, cultural factors and individual perceptions of heat and comfort all play an important role in defining the conditions, under which it is possible, to evaluate the impact of changes in the technology used for the supply of energy and the costs associated with such technology.

It also emerged from the literature review that the quality and source of the information about different technologies and their costs can be key to the successful implementation of district heating and other local energy systems.

The evidence discussed in the literature review will be used to inform the research plan for the analysis of the potential socio-economic impact of FlexDGrid on final energy users in the local areas, with a particular focus on low-income and vulnerable individuals.

The evidence reviewed in this report shows that the specific choices on how to measure the causes of energy consumption and expenditure affect the reliability of the results of a quantitative analysis of the impact of district heating projects, and the ability to evaluate their implications for policy purposes.

2.11.2 Phase 2 - Customer Survey

The University of Warwick created a summary of socio-economic and demographic indicators to support the creation of a representative sample for the survey of Birmingham and to use postcodes that are most likely to contain vulnerable and/or fuel poor households. These indicators will help identify which postcode districts (3-digit postcodes) are most likely to contain households that are more likely to be at risk of fuel poverty.

Following Authority Approval of our Customer Communications and Data Protection Plan in March 2014, the University of Warwick (through the independent marketing company IFF Research) conducted a telephone survey of residential consumers in Birmingham.

The customers were asked about the socio-economic characteristics of the household and the property they inhabit. They were also asked about their views on district heating systems and their willingness to join local heating schemes. Information about energy expenditure and patterns of consumption were also collected to evaluate the potential benefits of joining a district heating scheme in terms of reduced bills or reduced rationing behaviour.

The full aggregated and analysed results of this survey will be reported in December 2016.

3 Business Case Update

There is no change to the business case. The business case was to facilitate the increased connection of DG, specifically combined heat and power (CHP), in urban HV networks. This is still applicable.

4 Progress against Budget

	Total Budget	Expected Spend to Date May 2014	Actual Expenditure to date	Variance £	Variance %
Labour	**1809.49**	**551.21**	**127.07**	**- 424.15**	**- 77%[1]**
WPD Project management	320	117.55	67.64	- 49.92	- 42%
Detailed Investigation of Substation for Technology Inclusion	71.26	71.26	0.00	- 71.26	- 100%
Detailed Investigation of Technologies	71.14	71.14	37.46	- 33.68	- 47%
Detailed design of substation modifications for Technology Inclusion	72.43	72.43	0.00	- 72.43	- 100%
Determine Enhanced Assessment Processes	71.88	71.91	0.00	- 71.91	- 100%
Create Advanced Network Model	72.32	72.48	0.00	- 72.48	- 100%
Installation of Fault Level Measurement Technology	5.75	-	0.00	0.00	0%
Installation of Fault Level Monitoring Technology	296.65	13.00	12.67	- 0.33	- 3%
Installation of Fault Level Mitigation Technology	445.1	2.00	1.99	- 0.01	- 1%
Installation of VCU Technology	148.11	-	0.00	0.00	0%
Capture, Analyse Data and performance	234.85	59.44	7.31	- 52.13	- 88%
Equipment	**9779.63**	**2,116.46**	**715.88**	**- 1,400.58**	**- 66%**
Procurement of Fault Level Measurement Technology	117.01	117.01	128.96	11.95	10%[2]
Installation of Fault Level Measurement Technology	9.58	8.58	8.52	- 0.06	- 1%

	Total Budget	Expected Spend to Date May 2014	Actual Expenditure to date	Variance £	Variance %
Procurement of Fault Level Monitoring Technology	1554.99	1,554.65	402.87	- 1151.78	- 74%[3]
Installation of Fault Level Monitoring Technology	494.52	282.00	21.13	- 260.87	- 93%[4]
Implementation of Real Time Modelling	3.76	1.60	0.18	- 1.42	- 89%[5]
Procurement of Fault Level Mitigation Technology	5830.14	155.00	154.00	- 1.00	- 1%
Installation of Fault Level Mitigation Technology	741.84	-	0.00	0.00	0%
Procurement of VCU technologies	777.86	-	0.00	0.00	0%
Installation of VCU Technology	246.85	-	0.00	0.00	0%
Equipment to enable modelling and technology installation	3.08	0.70	0.22	- 0.48	- 68%[6]
Contractors	**1927.36**	**827.81**	**796.40**	**- 31.41**	**- 4%**
PB Project Support	340.94	127.85	91.00	- 36.85	- 29%[7]
Detailed Investigation of Substation for Technology Inclusion	96.14	96.14	103.60	7.46	8%
Detailed Investigation of Technologies	102.89	102.89	107.98	5.09	5%
Detailed Design of Substation Modifications for Technology Inclusion	48.85	48.85	51.04	2.19	4%
Determine Enhanced Assessment Processes	64.85	64.81	65.88	1.07	2%
Create Advanced Network Model	51.38	51.38	52.00	0.62	1%
Implementation of Real Time Modelling	350.94	122.48	119.00	- 3.48	- 3%
Capture Monitored & Measured Data	49.61	8.50	8.91	0.41	5%

	Total Budget	Expected Spend to Date May 2014	Actual Expenditure to date	Variance £	Variance %
Analyse Monitored and Measured Data	157.49	24.37	25.35	0.98	4%
Verify and Modify Advanced Network Models	253.89	113.84	112.68	- 1.16	- 1%
Gather Performance of Mitigation Technologies	50.07	8.56	0.02	- 8.54	- 100%[8]
Knowledge Capture and Learning Dissemination	281.62	40.48	40.84	0.36	1%
Procurement & Installation Support	78.69	17.65	18.1	0.45	3%
IT	**57.73**	**52.98**	**9.17**	**- 43.81**	**- 83%**
IT Costs	57.73	**52.98**	9.17	- 43.81	- 83%[9]
IPR Costs	**3.29**	**0.27**	**0.25**	**- 0.03**	**- 10%**
IPR Costs	3.29	**0.27**	0.25	- 0.03	- 10%[10]
Travel & Expenses	**465.62**	**137.61**	**100.43**	**- 37.18**	**- 27%**
Travel & Expenses	465.62	137.61	100.43	- 37.18	- 27%[11]
Contingency	**1407.05**	**338.95**	**0.00**	**- 338.95**	**- 100%**
Contingency	1407.05	338.95	0.00	- 338.95	- 100%
Other	**27.21**	**9.94**	**1.83**	**- 8.11**	**- 82%**
Other	27.21	9.94	1.83	- 8.11	- 82%
TOTAL	**15,477.38**	**4,035.24**	**1,751.03**	**- 2284.21**	**- 57%**

Table 4-1- Progress against Budget

Note 1 *– All Labour costs to date are underspent due to previously documented change in split of activities between WPD internal staff and Parsons Brinckerhoff*
Note 2 *– Additional features were provided with the technology to ensure they were transferrable between substation sites*
Note 3 *– Staged payments for technology have been included to reduce the project risk*
Note 4 *– Work has been completed to this value, however, invoicing has not been completed*
Note 5 *– Equipment has not been required at this stage*
Note 6 – *This spend is now projected for Q4 during 1st FLMT installation*
Note 7 – *Additional WPD resource has taken up this element of work*
Note 8 *– FLMTs have not yet been installed*
Note 9 *– Existing WPD IT has been used to date – as technologies are installed additional IT will be required*
Note 10 *– Technology designs are currently being finalised – IPR costs will be realised following design completion*
Note 11 *– Local construction resource has been utilised*

5 Successful Delivery Reward Criteria (SDRC)

During this third reporting period there have been no additional SDRCs completed (none were planned).

The six previously completed SDRCs are available on WPD's Innovation website.

5.1 Future SDRCs

Table 5-1 captures the remaining SDRCs for completion during the project life cycle. Significant work and progress has been completed in this reporting period working towards all these SDRCs.

SDRC	Status	Due Date	Comments
SDRC-7 Open-loop test of FLMs	Green	31/12/2015	On track
SDRC-8 Open-loop test of FLMTs	Green	31/12/2016	On track
SDRC-9 Closed-loop test of FLMs & FLMTs	Green	31/12/2016	On track
SDRC-10 Analysis & Benefits	Green	31/12/2016	On track
SDRC-11 Novel commercial aggs	Green	31/03/2017	On track

Table 5-1 - SDRCs to be completed

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

Learning outcomes have been detailed in all six SDRCs submitted and approved to date (SDRC1-6).

Specific learning in relation to the technologies has centred on the production of a suite of policies to support the installation, operation and maintenance of the each device. This will ensure that the learning is comprehensively and appropriately communicated to all required WPD staff as well as being an appropriate format to share with other DNOs.

Significant learning in this period has been captured in relation to enhanced fault level assessment analysis. The use of real-time fault level modelling has provided a step change in the granularity of fault levels provided for the 11kV network. This is supported by background fault level monitoring, as reported in Section 2.8, to further understand the real-time variations due to load, generation and network configuration changes. The next stage of learning is to further understand the relationship between the changeable parameters and their effects on fault level.

In this reporting period learning has been shared in one FlexDGrid organised DNO workshops on the 14th May 2014 and in the form of a CIRED workshop 2014 paper, Sensitivity Analysis of Fault Level Assessments in HV Networks – Paper 0200.

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:

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

These objectives will be achieved by:

- ✓ defining the roles, responsibilities and reporting lines within the 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
- ✓ regular monitoring and updating of risks and the risk controls

8.1 Current Risks

The FlexDGrid risk register is a live document and is updated regularly. There are currently 68 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. Table 5-1 details the top five current risks by rating. For each of these risks, a mitigation action plan has been identified and the progress of these are tracked and reported.

Risk	Risk Rating	Mitigation Action Plan	Progress
Cost of the technologies increase after contract signature	Moderate	Rigorous tendering process and prescriptive contract	All contracts for the technology are signed with determined requirements. However, technologies are new to the market and unforeseen issues could occur

Risk	Risk Rating	Mitigation Action Plan	Progress
FlexDGrid FLMT or FLM fails and confidence is lost in the project	Major	Extensive work to be undergone with operational and control staff to ensure detailed understanding of the technologies and their performance / requirements. Policy documents will be produced prior to the energisation of technologies for FlexDGrid	Factory visits and inspections and laboratory testing of equipment has or will be carried out to ensure product reliability. All equipment policies are either drafted or finalised, where the policy must be in place prior to energisation
The operation of FLMTs cannot be validated	Major	Rigorous Factory Acceptance Tests	Fault Level Mitigation Technologies can only be validated by operating successfully under a fault condition. As part of the manufacture and installation process of all FLMTs there will be a laboratory test to confirm its performance under a fault condition. Work has been undertaken to understand the fault frequency at each of the five Primary Substations chosen for FLMT inclusion. The operation of the FLMTs also involves the ability to be energised and operational on the system for a significant period of time
Injury to third party from property, equipment or site activities	Major	Secure compounds and buildings. Procedures will be developed to ensure working environments and technology are appropriately secured and identified.	Following the start of construction activities this is a significant risk. All activities are carried out under a defined and documented work instruction and RAMS are also in place
Sites become unavailable due to other business requirements	Moderate	Specific reserve sites have been identified and all equipment ordered is suitable for more than one site	Significant work has been carried out to ensure that the sites are currently not planned to have any significant work carried out.

Table 8-1 - Top five current risks

The FlexDGrid risk register is a live document updated on a weekly basis in formal project meetings. Table 8-2 provides a snapshot of the risk register, detailed graphically, to provide an on-going understanding of the projects' risks.

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**	**1**	**0**	**0**	**0**
	50/50 chance of occuring/ Mid to short term (11-15)	**2**	**3**	**3**	**1**	**0**
	Less likely to occur/Mid to long term (6-10)	**0**	**6**	**8**	**14**	**1**
	Very unlikely to occur/Far in the future (1-5)	**1**	**1**	**11**	**12**	**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	**21**	**27**	**20**	**0**	**No of instances**
Total	**68**				No of live risks

Table 8-2- Graphical view of Risk Register

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 FlexDGrid. There are currently no severe project risks.

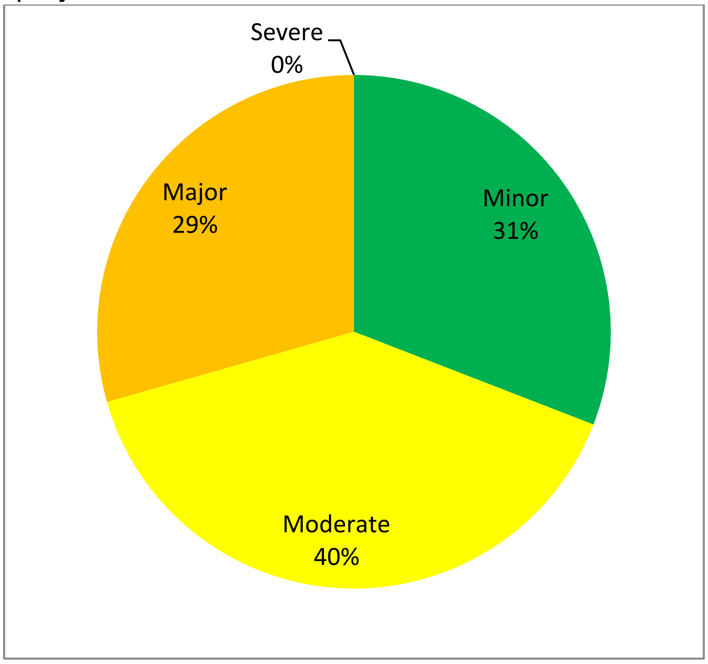

Table 8-3- Percentage of Risk by category

8.2 Update for risks previously identified

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

Risk	Previous Risk Rating	Current Risk Rating	Comments
We do not meet the deadline for gaining Ofgem approval for the 'Customer Communications Plan'	Major	Closed	The Customer Communications and Data Protection Plan was submitted to Ofgem in February 2014 and Authority Approval was received on 18/03/2014
The operation of FL Mitigation Technologies cannot be validated	Major	Major	Fault Level Mitigation Technologies can only be validated by operating successfully under a fault condition. As part of the manufacture and installation process of all FLMTs there will be a laboratory test to confirm its performance under a fault condition. Work has been undertaken to understand the fault frequency at each of the five Primary Substations chosen for FLMT inclusion. The operation of the FLMTs also involves the ability to be energised and operational on the system for a significant period of time
Outage conflicts with network services to install equipment arise	Moderate	Moderate	Work has been undertaken to ensure that the required outages for 2014 and 2015 can be obtained
Fault level calculations produce a fault level value that is significantly different than the monitored value	Moderate	Minor	Evidence documented in section 2.8 has significantly reduced this risk
We are unable to evidence a quicker response to customers' connection applications	Moderate	Closed	Evidence provided in SDRC-4. Risk will be re-opened if customer connection applications take place in the trial area during the project duration

Table 8-4 - Top five risks identified in previous six monthly report

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.

Risk	Previous Risk Rating	Current Risk Rating	Comments
Insufficient WPD resource for project delivery	Minor	Minor	Specific WPD staff have been assigned to manage and deliver the construction aspects of the project
Partners and supporter perception of the project changes	Minor	Minor	Detailed schedules of work (SoW) have been produced for the complete project activities with both PB and UoW. These SoWs are the basis of the contractual collaboration agreements between each party
Cost of high costs items are significantly higher than expected	Closed	Closed	Closed as per previous 6 monthly report
No suitable FLMTs will be available	Closed	Closed	Contract negotiations with all the FL technology suppliers have been completed and signed contracts are in place for the equipment. Table 1 (section 1.3) provides an overview of the technologies, manufacturers and expected delivery dates
No suitable FLMs will be available	Closed	Closed	
The overall project scope and costs could creep	Minor	Minor	The scope of the project has been well defined in the initial delivery phase of FlexDGrid, which has been represented and documented in the SoWs with each party. This has significantly controlled this risk and therefore the cost of delivery. All potential scope creep is managed at project management level, where a decision is made as to the viability of inclusion and/or recommendation for future work
A partner may withdraw from the project or have oversold their solution	Moderate	Minor	A contractual collaboration agreement is in place with both PB and UoW for the project. Delivery of six SDRCs to date has delivered confidence that project partners can provide the required solution
The project delivery team does not have the knowledge required to deliver the project	Minor	Minor	Project partners have provided personnel with significant experience in all project areas. A review of individual's CVs takes place prior to their engagement with the project. Construction also have significant experience in the activities to be undertaken as part of the project

Table 8-5 - Most prominent risks identified at the project bid phase

9 Consistency with Full Submission

During this reporting period the same core team from both WPD and PB have been used, which has ensured that there has been consistency and robust capturing of learning from the previous reporting period. 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:

- **Alpha** – Build advanced network model of FlexDGrid network;
- **Beta** – Install ten Fault Level Monitors at Birmingham Primary Substations; and
- **Gamma** – Install five Fault Level Mitigation Technologies at Birmingham Primary Substations.

Each of the six completed SDRCs to date have been completed on, or before, schedule, ensuring that the proposed delivery plan at the full submission state is still applicable in project delivery.

10 Accuracy Assurance Statement

This report has been prepared by the FlexDGrid Project Manager (Jonathan Berry), reviewed by the Future Networks Team Manager (Roger Hey), recommended by the Policy Manager (Paul Jewell) and approved by the Operations Director (Philip Swift).

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.