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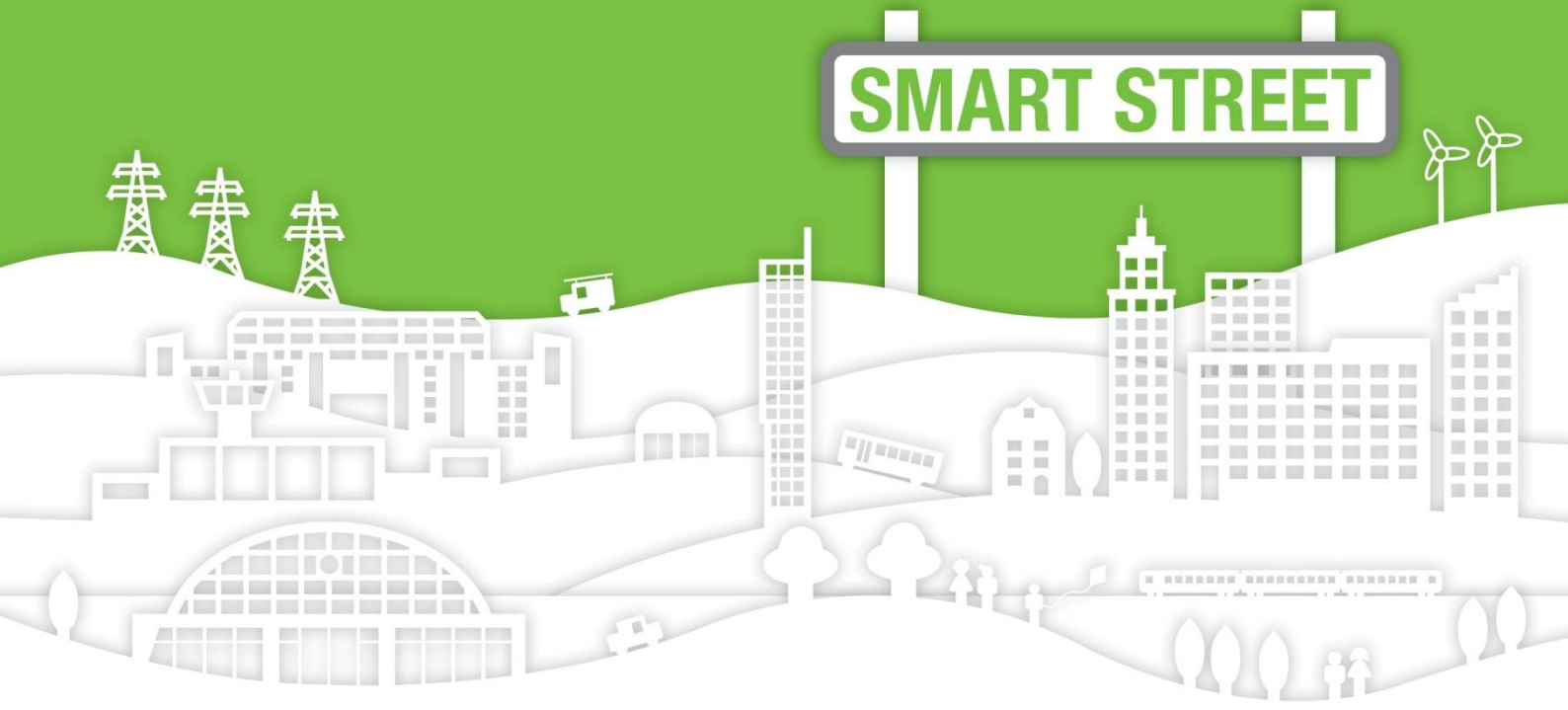
Bringing energy to your door

Smart Street Equipment Specification and Installation Report

29 January 2016



CONTENTS

VERSION HISTORY

Version	Date	Author	Status	Comments
1.0	29/1/2016	D Coyle	Approved	Final

EXECUTIVE SUMMARY

The Ofgem project direction for the Smart Street project outlines certain successful delivery reward criteria (SDRC), against which the success of the project will be assessed. For each criterion, the project direction defines the evidence that is required to demonstrate successful delivery.

There are six discrete SDRC evidence required for the technology build workstream of the Smart Street project (as listed below).

This report delivers evidence for the third SDRC on the list.

- Publish on the Smart Street website a report detailing the site selection methodology and a map of Smart Street trial areas. This was completed in July 2014.
- Contracts for the supply of networks equipment to be signed. Completed July 2014.
- ***Publish network equipment specifications and installation reports by January 2016. Change from original submission as date reflects four-month project extension.***
- Publish NMS, interface and optimisation configuration and commissioning reports. Completed January 2016.
- Publish new LV network management protocols. Completed June 2015.
- Electricity North West operational personnel, including control engineers briefed and/ or trained on LV network management protocols Completed June 2015.

The following equipment has been installed and commissioned as part of the Smart Street trials over the last 18 months.

- Weezap
- Lynx
- LV capacitors
- HV capacitors
- Distribution transformers with on-load tap changers
- End point monitors.

The next step in the project is go-live in January 2016, with the trial period lasting two years until January 2018.

1 INTRODUCTION

The anticipated changes in consumer behaviour and electricity demand on the low voltage (LV) network coupled with the reduction in the carbon footprint associated with the electrification of heat, transport and electricity generation through to 2050 will pose a significant challenge to electricity distribution network operators (DNOs) who historically employed traditional reinforcement to address the problems created by new low carbon technologies (LCTs) but can no longer adopt this option due to the high cost and associated disruption.

The substantial increase in new electricity loads from LCTs such as heat pumps for heating and electrical vehicles for transport coupled with the take up of micro-generation will create thermal and voltage challenges for the management of the network. DNOs must connect the new LCTs to facilitate customers' transition to a low carbon future, while maintaining statutory voltages, reducing network losses, managing power quality and, against a backdrop of increasing energy bills, help reduce costs to customers.

DNOs must therefore adapt the design and operation of their networks via efficient intervention techniques, alternative to traditional reinforcement, to enable the networks to

facilitate efficient connection of LCTs, while maintaining power quality and network voltage within statutory limits.

As such, the key business drivers relating to the Smart Street project that may determine the design of the future distribution networks due to the changes imposed, but not limited to, the increasing distributed generation and LCT penetration, and UK's decarbonisation are:

- Reinforcement cost reduction
- Carbon efficiency improvement
- Ability for faster connection of LCTs
- Energy cost reduction to customers.

1.1 Report scope and objectives

The purpose of this report is to review the specification, installation and configuration of the technology deployed as part of the project.

2 BACKGROUND AND TECHNIQUES

Distribution networks should be designed to deliver electricity to the customer in an efficient and cost effective manner.

The general objective in managing the voltage on distribution networks is to improve the quality and reliability of the supply provided, to increase effectiveness of circuit ratings, reduce network losses and therefore reduce the carbon footprint of the distribution network as a result of the changes imposed by the increasing distributed generation and LCT penetration.

Smart Street will optimise network voltages and configurations in real time to simultaneously manage high voltage (HV) and LV network assets to respond to customers' changing demands in the most efficient end-to-end manner.

The three key methods that the Smart Street project considers appropriate for the quality improvement of the supply provided, to reduce losses associated with transporting energy across the distribution networks, release significant network capacity and control network voltages and harmonics within designated limits are:

- Co-ordinated voltage control, using transformers with on-load tap changers and capacitors, across HV and LV networks
- Interconnecting traditionally radial HV and LV circuits through optimisation software and assuming control of these networks within the control room
- Real-time co-ordinated configuration and voltage optimisation of HV and LV networks.

2.1 HV and LV voltage control

Energy flows on LV networks are predicted to become more complex and less predictable due to the penetration of new LCTs over the coming years. Traditional LV electricity networks designed and operated without voltage control capability, will therefore face significant voltage challenges unless addressed accordingly.

Smart Street suggests the use of capacitors on HV and LV networks and distribution transformers with on-load tap changers to allow supply voltages to customers to be sustained at the optimum level for energy efficient operation of appliances, reducing the energy consumed by customers and, on the HV network, simultaneously reducing network losses.

2.2 LV network management and interconnection

Existing networks are not designed to cope with the highly variable power flows that will be caused by the introduction of LCTs, such as vehicle charging, and generation. Interconnection of LV networks is one means by which voltage, thermal and harmonic problems created by LCT loads and generation connected to LV networks can be significantly reduced.

Smart Street proposes using intelligent switching devices (Weezap – vacuum circuit breaker and Lynx – link box vacuum switch) that can be remotely controlled, sense feeder flows and offer dynamic reconfiguration of the LV network to safely transform radial networks into interconnected networks providing a centralised LV network management and automation system.

2.3 Network configuration and voltage optimisation

Smart Street will be able to optimise the network configuration and voltage profiles in real time in response to customers' needs. For this, Smart Street will dynamically analyse network loads and generation levels and will alter both interconnected configurations and voltage profiles across HV and LV networks. The software that will be used for voltage optimisation and network configuration will also allow carbon reductions to be optimised. In this regard the software will directly compare and balance network losses and customers' energy consumptions.

Additionally Smart Street proposes to optimise network voltages by using CVR on the LV trial networks.

CVR on a distribution network is defined as a reduction of energy consumption resulting from a decrease in feeder voltage. Smart Street proposes to optimise the voltage by utilising on-load tap changing (OLTC) transformers in conjunction with shunt capacitors to optimise the voltage profile. The OLTC transformer will regulate the sending voltage on the feeder while the capacitors will create a voltage boost at the end of the circuit. This will produce a flatter voltage profile and allow a reduced, more uniform voltage to be supplied to customers while maintaining statutory limits.

3 SMART STREET EQUIPMENT

The equipment deployed to enable the Smart Street methods and techniques comprise of:

3.1 Weezap

The Weezap (Figure 1) is a retrofit design LV vacuum circuit breaker (VCB) supplied by Kelvatek, which can be installed onto existing LV fuse boards in replacement of the traditional high rupturing capacity (HRC) fuses.

The Weezap is installed in conjunction with the Kelvatek Gateway device (Figure 2). The Gateway is the remote terminal unit (RTU) that communicates with Electricity North West's supervisory control and data acquisition (SCADA) system and relays the various controls and monitoring to and from the Weezap devices. The Gateway also acts as the onsite user interface for installation, configuration and control. Each Gateway can manage up to 15 devices. Two gateways can be installed at any one substation therefore a maximum of 30 devices can be installed at any one site.

For Weezap specification and installation locations please see Appendix A and Appendix B respectively.

Figure 1: The Weezap

Figure 2: Gateway device

3.2 Lynx

The Lynx is an LV switch designed to fit into existing underground link boxes (LB) enabling the interconnection of LV circuits as well as providing advanced monitoring capabilities. The Lynx is fitted directly to LV link boxes in replacement of the solid link or fuse. The Lynx has the ability to close and open the circuit at the link box either locally or remotely.

Figure 3: Lynx devices

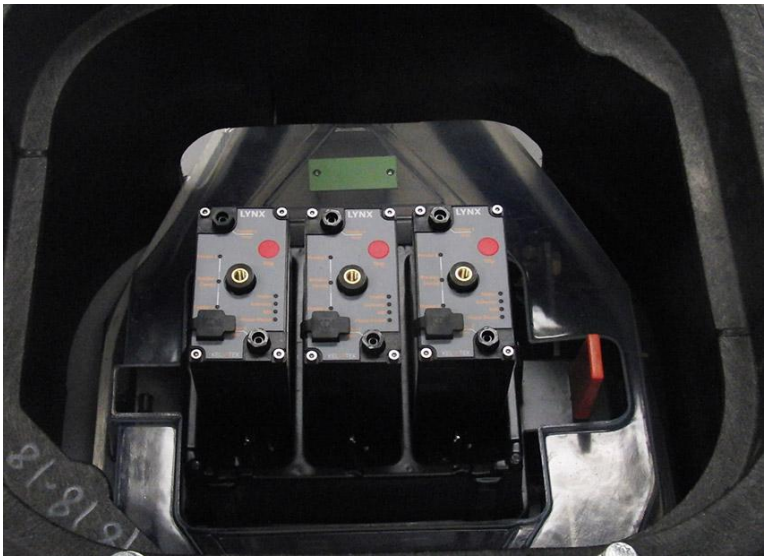
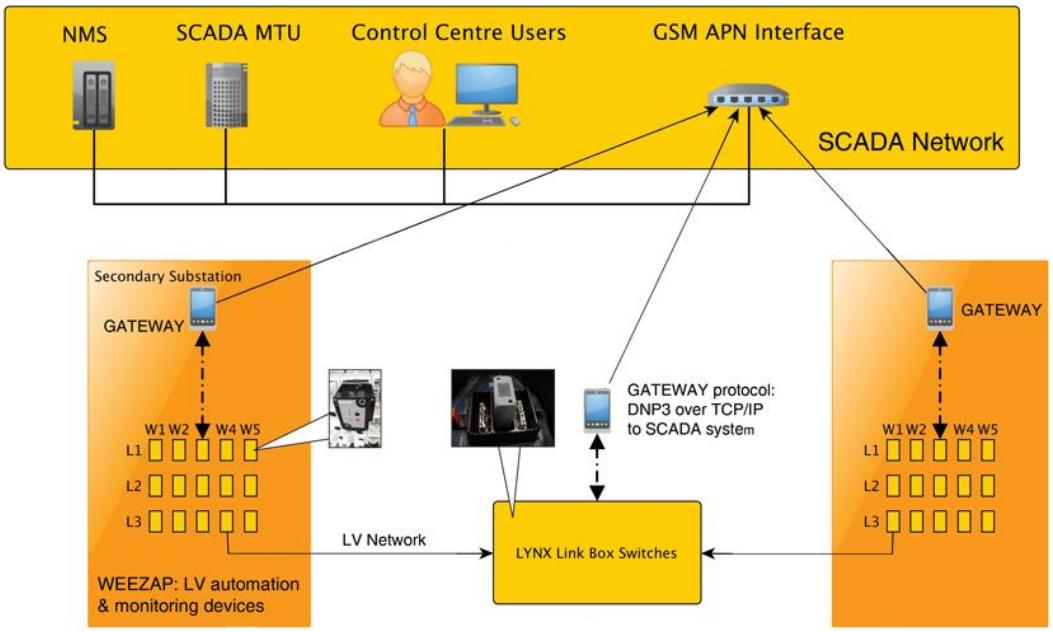


Figure 4: Lynx with Gateway installed, Denton East.

The Lynx communicates with the Gateway device (Figure 4), which provides a remote connection to the installed devices. This enables remote monitoring and control via the NMS. Figure 5 shows a typical Weezap and Lynx configuration on Smart Street including the connectivity.

Figure 5: Weezap and Lynx connectivity



For Lynx specification and installation locations please see Appendix C and Appendix D respectively.

3.3 LV capacitor

Figure 6: LV capacitor installation on Millbrook Ave, Denton East.

There are 84 LV capacitors (Figure 6) in total deployed on Smart Street trial circuits. These capacitors will provide a voltage boost at the point of connection; this allows the control system to optimise the voltage along the LV feeders depending on the load.

Figure 7: The CQ930 capacitor controller.

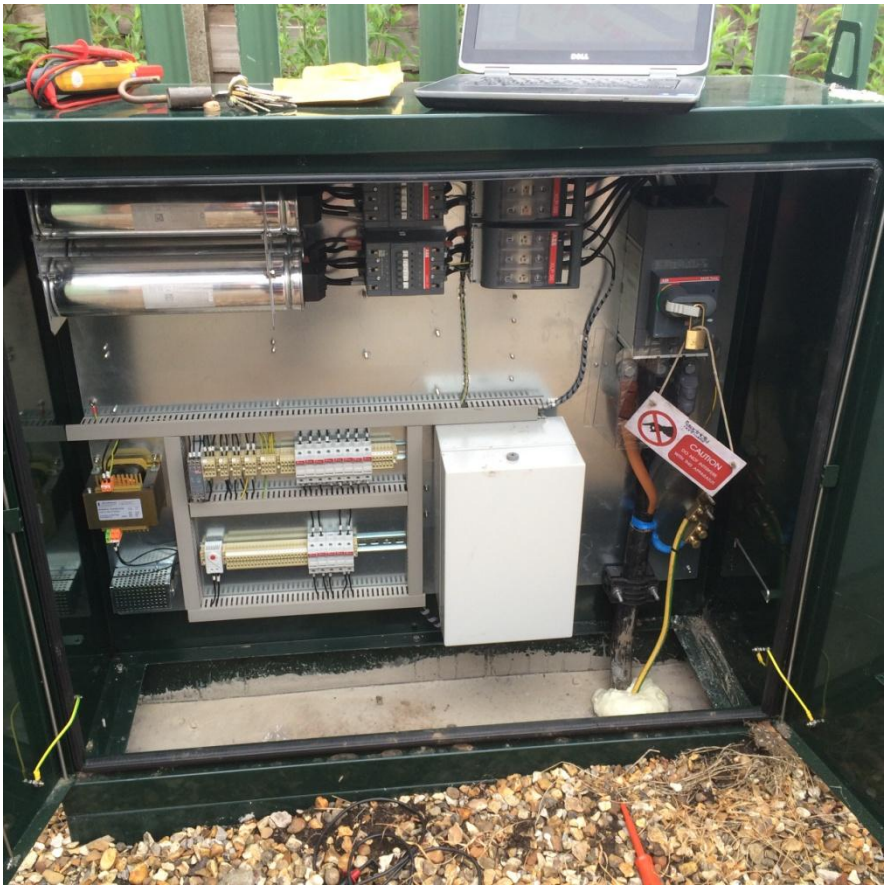
The capacitors were supplied by ABB and are fitted with an ABB RTU controller, the CQ930 (Figure 7). This controller allows three modes of operation: auto, local and remote. For Smart Street these units will remain in remote mode. Three different sizes of capacitors have been installed: 100kvar, 150kvar and 200kvar. During the design stage all trial circuits were modelled for the optimum size and point of connection of the capacitors, with the intention that the capacitor would simply have an on/off operation. However, due to advances in software on the CQ930 we have been able to introduce multi-stage switching.

Three different configurations of LV capacitor installed:

- One stage: 100 kvar
- Two stages: 100 + 50 kvar
- Three stages: 100 + 50 + 50 kvar

The multi-stage switching increases the control we have on the voltage on the feeder and therefore improves the optimisation ability.

Figure 8: LV capacitor internal components



For LV capacitor specification and installation locations please see Appendix D and Appendix E respectively.

3.4 HV capacitors

HV capacitors are deployed to enable voltage control and management. The Smart Street trial area covers dense urban, urban and rural networks to gain a better understanding of the benefits, and to be more representative, of GB networks. Due to differing network types two styles of HV capacitor have been deployed: ground-mounted (GM) in urban networks and pole-mounted (PM) on rural networks.

3.5 Ground-mounted HV capacitor

Three GM HV capacitors (Figure 9) are installed as part of Smart Street, two in the Manchester trial area which is classed as a dense urban network and one in Wigan trial area on an urban network. The GM HV capacitor banks are supplied by ABB. The three banks are as follows:

- 2 x 200kvar, at a nominal 6.6kV, 50Hz
- 1x 400kvar, at a nominal 11kV, 50Hz.

Figure 9: Ground-mounted HV capacitor installation, Longsight.

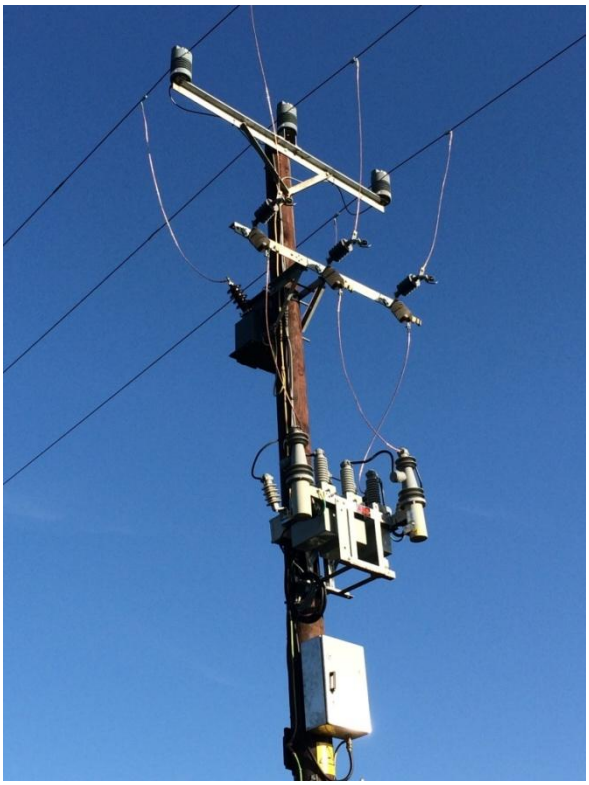
These capacitors are also controlled by the CQ930 RTU (Figure 7) that is used with the LV capacitor. The only difference in operation is that the HV capacitors do not use multi-stage switching. Each GM capacitor bank system comprises of one incoming stage and one switched power stage.

The capacitor is supplied with an ABB VCB that is rated for capacitive load switching. In order to reduce disruption to the network in the event of a fault, a standard main unit (RMU) has been installed in line with the capacitor. This enables a more robust method of isolating the capacitor from the network and provides a rated earth for the cable feeding the capacitor.

To ensure the ABB VCB is used for the capacitive load switching and not the RMU, a new interlocking system was developed with ABB to ensure correct operation by any operator.

3.6 Pole-mounted HV capacitor

Figure 10: HV pole-mounted capacitor Hockery Brook, Hindley.



Three pole-mounted HV capacitors are installed as part of Smart Street, two in the Egremont trial area and one in the Wigan trial area. The pole-mounted HV capacitor banks are supplied by ABB and are:

- 400kvar, at a nominal 11kV, 50 Hz.

These capacitors are also controlled by the CQ930 RTU (Figure 7) and are comprised of one incoming stage and one switched power stage.

The pole-mounted capacitor is supplied with a voltage transformer (VT); this is to supply the local RTU with power and to provide a voltage measurement from the network. The VT is normally mounted on the main body of the capacitor bank, however the decision was made to alter the standard arrangement by moving the VT away from the capacitor bank, higher up the pole above the isolating fuses. The reason for this was to ensure the RTU and measurement data would remain online in the event that the capacitor needed to be isolated for any reason ie testing, failure or a system abnormality.

For HV capacitor specification and installation locations please see Appendix F and Appendix G respectively.

3.7 Distribution transformers with on-load tap changers

Figure 11: Vauxhall Rd OLTC Transformer, Wigan.

As part of Smart Street, Electricity North West has installed five distribution transformers with an on-load tap changer (Figure 11). These transformers are a standard distribution transformer with the addition of:

- A Gridcon iTap internal tap changer, manufactured by MR. The tap changer is a reactor type with vacuum diverter switches
- Motor-drive unit mounted on top of the transformer
- Control/regulation unit mounted on the side of the transformer which contains the following:
    - An error signal lamp
    - A tap position indicator
    - A status OK lamp
    - An operations counter
    - Rotary switch for operating mode (manual/auto)
    - Tap lower key
    - Tap raise key
- A mechanical tap position indicator which can be viewed through a sight glass on top of the transformer next to the motor
- An oil conservator which shall be filled to the required level
- A Buchholz relay fitted in the pipe to the conservator. The relay alarms are disconnected and are not operational. No surge trip or gas alarms are fitted
- LV auxiliary supply isolator
- A Siemens autonomous substation controller (ASC) is located at each site. This unit provides the communications link between the transformer and the distribution system management centre (DSMC).

For OLTC specification and installation locations please see Appendix H and Appendix I respectively.

3.8 End-point monitors

49 Gridkey monitoring units are installed at the end of radial LV feeders at the point of the highest calculated voltage drop, to record circuit measurements for both voltage optimisation purposes and to validate network modelling results during the research phase of the project. They will be solely used to measure voltage. These devices are business as usual monitoring units that were also deployed in our previous First Tier LCN Fund project LV network Solutions and in the Second Tier project CLASS.

Figure 12: End-point monitor installation at Town Lane, Denton.

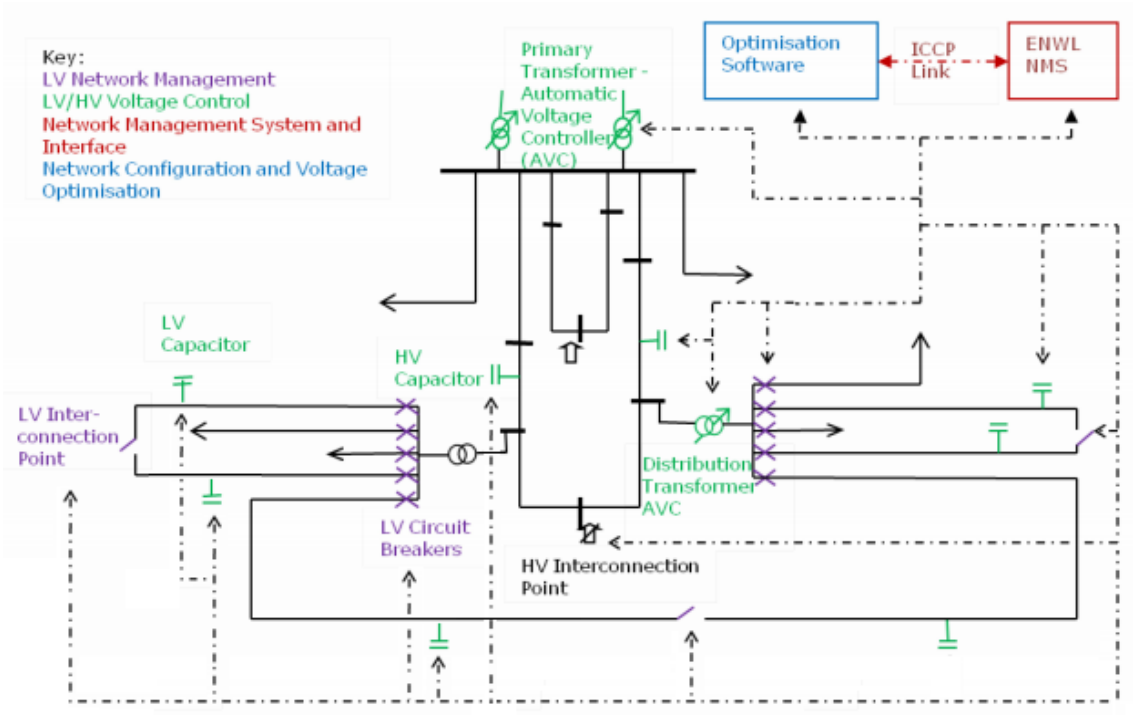
For installation locations please refer to Appendix K.

4 SYSTEM OVERVIEW

4.1 Smart Street deployment

The Smart Street trials are expected to run from January 2016 to January 2018. The technologies described in Section 3 are deployed on the network in line with the diagram presented in Figure 13.

Figure 13: System design



Deployment of the Weezap in conjunction with the Lynx enables LV network interconnection and facilitates dynamic reconfiguration either locally or remotely from Electricity North West's control room.

In addition to remote operation the Weezap will provide both network monitoring (voltages, currents, power flow and harmonics) and advanced adaptive protection coupled with network fault detection capability and automatic fault reclose functions.

Smart Street will simultaneously manage the primary transformer automatic voltage control (AVC) system, the HV and LV network capacitors, the distribution transformer ASC and HV and LV interconnection points in order to deliver the optimal network configuration and voltage profiles for carbon, losses and energy savings in real time.

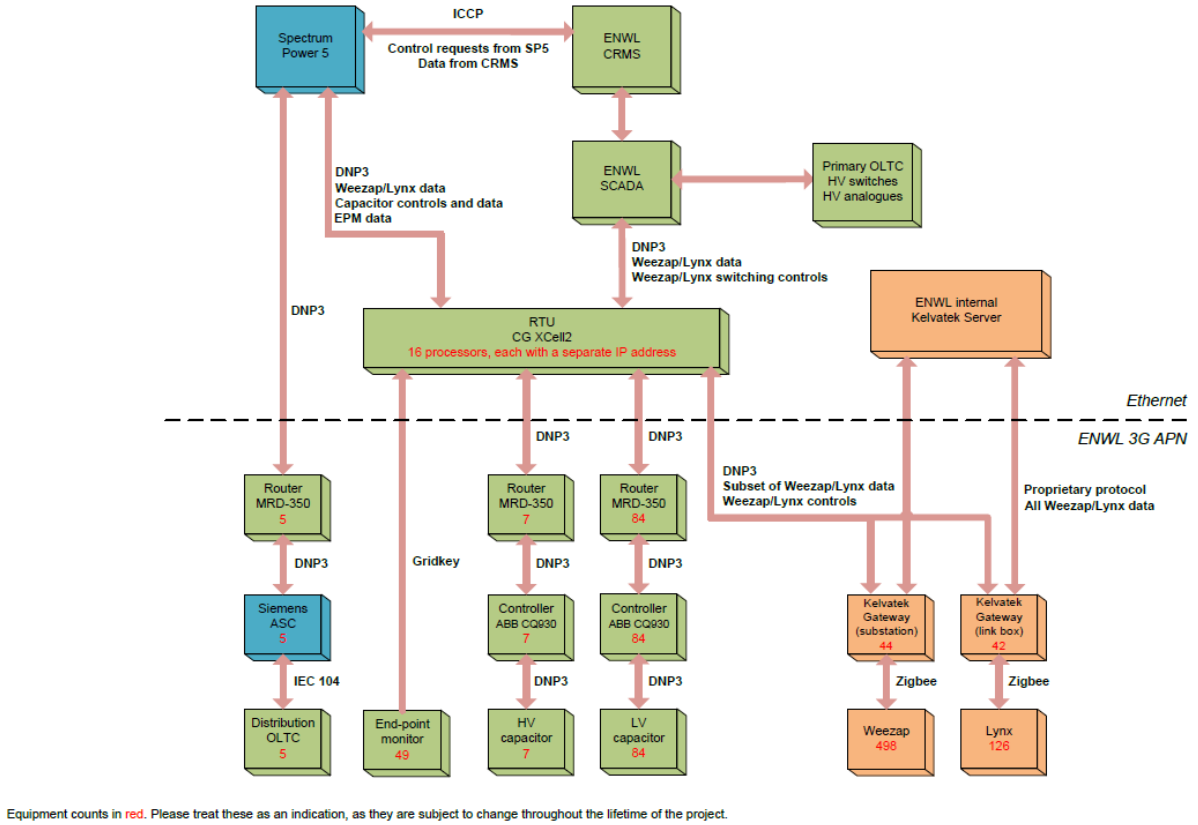
The operation of the HV and LV capacitors will be based on voltage set-points rather than power factor control.

In order to regulate the HV and LV network voltage using the above described configuration, the optimisation software will assimilate voltage measurements from key points on the HV network, distribution substation LV busbars and along LV circuits and will make the decision to ensure that optimum voltage is delivered to the customer and end-to-end carbon is minimised.

4.2 Control principles

The Smart Street project will use multiple communications routes as shown in Figure 2.

Figure 14: Smart Street connectivity



Equipment counts in red. Please treat these as an indication, as they are subject to change throughout the lifetime of the project.

- All switching commands for the Lynx and Weezap devices will be instructed from the Electricity North West NMS while the control commands, ie change of voltage set-points and the switching of the capacitor banks, will be issued directly from the Siemens Spectrum Power software.
- Monitoring information from field devices will be picked up by the Spectrum Power 5 software via the CG RTUs and ICCP.

For further information on the network management system, Spectrum Power 5 and the optimisation functions please refer to the Smart Street NMS interface, optimisation, configuration and commissioning report on the key documents page of our website.

5 SUMMARY AND LESSONS LEARNT

Over 775 new installations of new technologies have taken place over an 18-month period.

The new technologies discussed in the sections above were identified and investigated prior to the project bid submission and therefore the requirements and specifications of the equipment were defined at a high level. This provided direction for the project delivery team to procure the necessary technologies to realise Smart Street and stay true to the scope of the bid document.

Development work has taken place throughout the design, specification, procurement, installation and commissioning of the equipment deployed. Some of the key developments are discussed in the below section on lessons learnt.

The relationship between Electricity North West and the Smart Street project partners has been key to meeting project milestones and to further develop the technologies involved. The commitment and buy-in from project partners has been essential to realise Smart Street.

Electricity North West expects to continue to work with project partners and manufacturers to further develop the technologies deployed throughout the project life.

5.1 Lesson learnt

Street furniture design

Due to concerns raised by customers regarding youths congregating around LV capacitors, Electricity North West worked with ABB to redesign the LV capacitor cabinet to try to prevent members of the public sitting on the units. The new design incorporates a peaked top to discourage people from sitting on the units. See Figure 6 in Section 3.3 for the original design and see Figure 15 for the re-design.

Figure 15: Peaked LV capacitor cabinet.

Weezap firmware upgrade

The software within the Weezap has been upgraded a number of times within the project to meet project specific requirements. The original Weezap required a power cycle after downloading the latest firmware; this would mean opening the breaker. On circuits without a backfeed this was not possible as it would mean taking customers off supply. Once this was identified Kelvatek developed a new method of updating the firmware remotely while the device was still in service and customers' supplies remained on.

HV GM capacitor

As these capacitors are more commonly utilised for power factor correction on large industrial sites, it was recognised that the deployment of these units on Smart Street would be in dense urban networks, therefore they would be more exposed to the public and there would be an increased risk of vandalism. Electricity North West worked with ABB to implement a number of design enhancements to the capacitor's standard specification to ensure the safety of the public and that of the operator. As the capacitors are a new technology being deployed on the Electricity North West network, we have to ensure the highest standards of health and safety are maintained. Therefore although the banks are suitable for outdoor installation the decision was made to house each unit in a secure glass reinforced plastic housing. Other design changes included:

- Additional micro switches applied to ensure emergency trip if any access doors of enclosure are inadvertently opened
- A unique interlocking system to ensure correct operation of the unit in line with the Electricity North West network
- Anti-vandal screws applied to external panels of the unit.

Communications

All the field devices deployed on Smart Street connect into the central control system via the 3G network. In some areas it has been found that signal strength varies throughout the day and can result in the loss of communications for long periods. A number of high gain antennae have been fitted to equipment in problematic areas. We are currently monitoring signal strength and communications reliability of this equipment and we are working with project partners and network providers on a number of solutions to further improve the reliability of 3G communications.

6 APPENDICES

6.1 Appendix A – Weezap technical specification

Specification	Value
Rated voltage	440VRMS, 50Hz
Rated load current	400 ARMS
Reclose delay range	30 seconds to 10 minutes
Maximum fault current breaking capacity	VCB: 6kARMS @ 415VAC
Series fuse	7 kARMS
Maximum fault making capacity	27 kARMS
Fault making /breaking life @ 6kARMS	40 operations
Maximum rating of fuses	500A Class j
Nominal Gateway radio range	15m
Communications	Via Kelvatek Gateway (GPRS)
Dimensions	115 x 160 x 183 mm
Weight	6 kg
Temperature range	-20 to 50°C
Replaceable fuse type	Type J Fuselink, 500A 415V

6.2 Appendix B – Weezap installation locations

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
DENTON EAST	1.1. CIRCULAR RD	171383	1.1.4	235044358	1	1713831LS11
					2	1713831LS12
					3	1713831LS13
			1.1.5	235044359	1	1713831LS21
					2	1713831LS22
					3	1713831LS23
			1.1.6	235044360	1	1713831LS31
					2	1713831LS32
					3	1713831LS33
	1.2. HODNET WALK	171823	1.2.1	235030014	1	1718231LS11
					2	1718231LS12
					3	1718231LS13
			1.2.3	235030013	1	1718231LS31
					2	1718231LS32
					3	1718231LS33
	1.3. KENNEDY WAY	172165	1.3.2	235029724	1	1721651LS21
					2	1721651LS22
					3	1721651LS23
			1.3.3	235029725	1	1721651LS31
					2	1721651LS32
					3	1721651LS33
			1.3.4	235029726	1	1721651LS41
					2	1721651LS42
					3	1721651LS43
			1.3.5	235029730	1	1721651LS51
					2	1721651LS52
					3	1721651LS53
	1.4. SCOTT RD	172175	1.4.2	235029629	1	1721751LS21
					2	1721751LS22
					3	1721751LS23
			1.4.3	235029630	1	1721751LS31
					2	1721751LS32
					3	1721751LS33
			1.4.4	235029633	1	1721751LS41
					2	1721751LS42
					3	1721751LS43
			1.4.5	235029635	1	1721751LS51
					2	1721751LS52
					3	1721751LS53
	1.5. TOWN LN (NO 52)	172371	1.5.2	235030181	1	1723711LS21
					2	1723711LS22
					3	1723711LS23
			1.5.3	235030178	1	1723711LS31
					2	1723711LS32
					3	1723711LS33
			1.5.4	235030180	1	1723711LS41
					2	1723711LS42
					3	1723711LS43
			1.5.5	235030179	1	1723711LS51
					2	1723711LS52
					3	1723711LS53
	1.6. VICTORIA ST	172181	1.6.1	207040437	1	1721811LS11
					2	1721811LS12
					3	1721811LS13
			1.6.3	207040439	1	1721811LS31
					2	1721811LS32
					3	1721811LS33
	1.7. PENDLE RD	172187	1.7.3	235029901	1	1721871LS31
					2	1721871LS32
					3	1721871LS33
			1.7.4	235029898	1	1721871LS41
					2	1721871LS42
					3	1721871LS43

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
LONGSIGHT	5.1. BIRCH LANE NURSING HOME	172399	5.1.3	232041436	1	1723991LS31
					2	1723991LS32
					3	1723991LS33
			5.1.4	232041440	1	1723991LS41
					2	1723991LS42
					3	1723991LS43
	5.2. BRYNTON RD (NO.70)	171281	5.2.2	238051923	1	1712811LS21
					2	1712811LS22
					3	1712811LS23
			5.2.3	238051920	1	1712811LS31
					2	1712811LS32
					3	1712811LS33
			5.2.4	238051917	1	1712811LS41
					2	1712811LS42
					3	1712811LS43
			5.2.5	238051915	1	1712811LS51
					2	1712811LS52
					3	1712811LS53
	5.3. BRYNTON RD (NO.8)	171279	5.3.3	232043785	1	1712791LS31
					2	1712791LS32
					3	1712791LS33
			5.3.4	232043775	1	1712791LS41
					2	1712791LS42
					3	1712791LS43
			5.3.5	232043767	1	1712791LS51
					2	1712791LS52
					3	1712791LS53
			5.3.6	??	1	1712791LS61
					2	1712791LS62
					3	1712791LS63
	5.4. DALTON ELLIS HALL ANSON RD	171059	5.4.2	231049284	1	1710591LS21
					2	1710591LS22
					3	1710591LS23
			5.4.4	231049299	1	1710591LS41
					2	1710591LS42
					3	1710591LS43
			5.4.5	231049315	1	1710591LS51
					2	1710591LS52
					3	1710591LS53
	5.5. GREVILLE ST	171625	5.5.2	232042897	1	1716251LS21
					2	1716251LS22
					3	1716251LS23
			5.5.3	232042864	1	1716251LS31
					2	1716251LS32
					3	1716251LS33
			5.5.4	232042866	1	1716251LS41
					2	1716251LS42
					3	1716251LS43
			5.5.5	232042903	1	1716251LS51
					2	1716251LS52
					3	1716251LS53
			5.5.6	232042894	1	1716251LS61
					2	1716251LS62
					3	1716251LS63

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
HINDLEY GREEN	4.1. ASHBOURNE AVENUE	212730	4.1.2	69053043	1	2127301LS21
					2	2127301LS22
					3	2127301LS23
			4.1.4	69053051	1	2127301LS41
					2	2127301LS42
					3	2127301LS43
			4.1.5	69053077	1	2127301LS51
					2	2127301LS52
					3	2127301LS53
			4.1.6	69053087	1	2127301LS61
					2	2127301LS62
					3	2127301LS63
			4.1.7	69053095	1	2127301LS71
					2	2127301LS72
					3	2127301LS73
	4.2. BORSDANE AVENUE	212725	4.2.2	69053286	1	2127251LS21
					2	2127251LS22
					3	2127251LS23
			4.2.3	69053292	1	2127251LS31
					2	2127251LS32
					3	2127251LS33
			4.2.4	69053308	1	2127251LS41
					2	2127251LS42
					3	2127251LS43
			4.2.5	69053322	1	2127251LS51
					2	2127251LS52
					3	2127251LS53
	4.3. BRIDGEWATER STREET	212720	4.3.1	69077948	1	2127201LS11
					2	2127201LS12
					3	2127201LS13
			4.3.2	69077999	1	2127201LS21
					2	2127201LS22
					3	2127201LS23
			4.3.3	69078008	1	2127201LS31
					2	2127201LS32
					3	2127201LS33
			4.3.6	69078077	1	2127201LS61
					2	2127201LS62
					3	2127201LS63
			4.3.7	69078065	1	2127201LS71
					2	2127201LS72
					3	2127201LS73
			4.3.8	69078060	1	2127201LS81
					2	2127201LS82
					3	2127201LS83
			4.3.9	69078054	1	2127201LS91
					2	2127201LS92
					3	2127201LS93

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
HINDLEY GREEN	4.4. CASTLE HILL	212723	4.4.2	75039549	1	2127231LS21
					2	2127231LS22
					3	2127231LS23
			4.4.3	75039547	1	2127231LS31
					2	2127231LS32
					3	2127231LS33
			4.4.4	75039545	1	2127231LS41
					2	2127231LS42
					3	2127231LS43
			4.4.5	75039546	1	2127231LS51
					2	2127231LS52
					3	2127231LS53
			4.4.6	75039541	1	2127231LS61
					2	2127231LS62
					3	2127231LS63
			4.4.7	75039544	1	2127231LS71
					2	2127231LS72
					3	2127231LS73
	4.5. GIDLOW STREET	212711	4.5.1	538508910	1	2127111LS11
					2	2127111LS12
					3	2127111LS13
			4.5.2	538508911	1	2127111LS21
					2	2127111LS22
					3	2127111LS23
			4.5.3	538508912	1	2127111LS31
					2	2127111LS32
					3	2127111LS33
			4.5.4	538509173	1	2127111LS41
					2	2127111LS42
					3	2127111LS43
			4.5.5	538509174	1	2127111LS51
					2	2127111LS52
					3	2127111LS53
	4.6. GLOUCESTER CRESCENT	212727	4.6.2	69051964	1	2127271LS21
					2	2127271LS22
					3	2127271LS23
			4.6.3	69051974	1	2127271LS31
					2	2127271LS32
					3	2127271LS33
			4.6.4	69051989	1	2127271LS41
					2	2127271LS42
					3	2127271LS43
			4.6.5	69052002	1	2127271LS51
					2	2127271LS52
					3	2127271LS53
			4.6.6	69052016	1	2127271LS61
					2	2127271LS62
					3	2127271LS63

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
HINDLEY GREEN	4.7. VICARAGE	212716	4.7.1	69055636	1	2127161LS11
					2	2127161LS12
					3	2127161LS13
			4.7.2	69055647	1	2127161LS21
					2	2127161LS22
					3	2127161LS23
			4.7.3	69055655	1	2127161LS31
					2	2127161LS32
					3	2127161LS33
			4.7.4	69055677	1	2127161LS41
					2	2127161LS42
					3	2127161LS43
			4.7.5	69055702	1	2127161LS51
					2	2127161LS52
					3	2127161LS53
			4.7.6	69055712	1	2127161LS61
					2	2127161LS62
					3	2127161LS63
			4.7.7	69055716	1	2127161LS71
					2	2127161LS72
					3	2127161LS73
			4.7.8	69055736	1	2127161LS81
					2	2127161LS82
					3	2127161LS83
	4.8. VICTORIA FARM	212729	4.8.2	69058430	1	2127291LS21
					2	2127291LS22
					3	2127291LS23
			4.8.3	69058433	1	2127291LS31
					2	2127291LS32
					3	2127291LS33
			4.8.4	69058435	1	2127291LS41
					2	2127291LS42
					3	2127291LS43
			4.8.5	69058439	1	2127291LS51
					2	2127291LS52
					3	2127291LS53
			4.8.6	69058447	1	2127291LS61
					2	2127291LS62
					3	2127291LS63
	4.9. WALMER ROAD	212734	4.9.4	69080105	1	2127341LS41
					2	2127341LS42
					3	2127341LS43
			4.9.7	69080101	1	2127341LS71
					2	2127341LS72
					3	2127341LS73
			4.9.8	69080100	1	2127341LS81
					2	2127341LS82
					3	2127341LS83
			4.9.9	69080099	1	2127341LS91
					2	2127341LS92
					3	2127341LS93

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
GREEN STREET	3.1. CAMBERWELL CRESCENT	212410	3.1.2	70074453	1	2124101LS21
					2	2124101LS22
					3	2124101LS23
			3.1.3	70074488	1	2124101LS31
					2	2124101LS32
					3	2124101LS33
			3.1.4	70074492	1	2124101LS41
					2	2124101LS42
					3	2124101LS43
			3.1.5	70074495	1	2124101LS51
					2	2124101LS52
					3	2124101LS53
	3.2. CAUNCE ROAD	212512	3.2.1	74029055	1	2125121LS11
					2	2125121LS12
					3	2125121LS13
			3.2.2	74029056	1	2125121LS21
					2	2125121LS22
					3	2125121LS23
			3.2.4	74029054	1	2125121LS41
					2	2125121LS42
					3	2125121LS43
			3.2.5	74029057	1	2125121LS51
					2	2125121LS52
					3	2125121LS53
	3.3. LINNEY STREET	212510	3.3.2	74030474	1	2125101LS21
					2	2125101LS22
					3	2125101LS23
			3.3.3	74030475	1	2125101LS31
					2	2125101LS32
					3	2125101LS33
			3.3.4	74030476	1	2125101LS41
					2	2125101LS42
					3	2125101LS43
			3.3.5	74030477	1	2125101LS51
					2	2125101LS52
					3	2125101LS53
			3.3.7	74030479	1	2125101LS71
					2	2125101LS72
					3	2125101LS73
	3.4. MALDON CLOSE	212407	3.4.2	70067408	1	2124071LS21
					2	2124071LS22
					3	2124071LS23
			3.4.3	70067421	1	2124071LS31
					2	2124071LS32
					3	2124071LS33
			3.4.4	70067429	1	2124071LS41
					2	2124071LS42
					3	2124071LS43
			3.4.5	70067461	1	2124071LS51
					2	2124071LS52
					3	2124071LS53
			3.4.6	70067467	1	2124071LS61
					2	2124071LS62
					3	2124071LS63

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
GREEN STREET	3.5. MOAT HOUSE STREET	212529	3.5.2	543338982	1	2125291LS21
					2	2125291LS22
					3	2125291LS23
			3.5.4	543338983	1	2125291LS41
					2	2125291LS42
					3	2125291LS43
	3.6. PETTICOAT LANE	212531	3.6.2	411670754	1	2125311LS21
					2	2125311LS22
					3	2125311LS23
			3.6.3	411670755	1	2125311LS31
					2	2125311LS32
					3	2125311LS33
			3.6.4	411670756	1	2125311LS41
					2	2125311LS42
					3	2125311LS43
			3.6.5	411671227	1	2125311LS51
					2	2125311LS52
					3	2125311LS53
			3.6.6	411671228	1	2125311LS61
					2	2125311LS62
					3	2125311LS63
	3.7. VAUXHALL ROAD	212221	3.7.2	74029007	1	2122211LS21
					2	2122211LS22
					3	2122211LS23
			3.7.3	74029006	1	2122211LS31
					2	2122211LS32
					3	2122211LS33
			3.7.4	74029005	1	2122211LS41
					2	2122211LS42
					3	2122211LS43
			3.7.5	74029004	1	2122211LS51
					2	2122211LS52
					3	2122211LS53
			3.7.6	74029003	1	2122211LS61
					2	2122211LS62
					3	2122211LS63

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
EGREMONT	2.1. ELECTRIC HOUSE	621431	2.1.2	36064568	1	6214311LS21
					2	6214311LS22
					3	6214311LS23
			2.1.3	36064570	1	6214311LS31
					2	6214311LS32
					3	6214311LS33
			2.1.4	36064572	1	6214311LS41
					2	6214311LS42
					3	6214311LS43
			2.1.5	36064574	1	6214311LS51
					2	6214311LS52
					3	6214311LS53
			2.1.6	36064576	1	6214311LS61
					2	6214311LS62
					3	6214311LS63
	2.2. FELL VIEW DRIVE	621932	2.2.2	36078570	1	6219321LS21
					2	6219321LS22
					3	6219321LS23
			2.2.3	36078572	1	6219321LS31
					2	6219321LS32
					3	6219321LS33
			2.2.4	36078573	1	6219321LS41
					2	6219321LS42
					3	6219321LS43
			2.2.5	36078574	1	6219321LS51
					2	6219321LS52
					3	6219321LS53
	2.3. SMITHFIELD	622111	2.3.2	515383205	1	6221111LS21
					2	6221111LS22
					3	6221111LS23
			2.3.3	515383206	1	6221111LS31
					2	6221111LS32
					3	6221111LS33
			2.3.4	515383207	1	6221111LS41
					2	6221111LS42
					3	6221111LS43
			2.3.5	515383208	1	6221111LS51
					2	6221111LS52
					3	6221111LS53
			2.3.6	515383209	1	6221111LS61
					2	6221111LS62
					3	6221111LS63
			2.3.7	515383210	1	6221111LS71
					2	6221111LS72
					3	6221111LS73
			2.3.8	515383211	1	6221111LS81
					2	6221111LS82
					3	6221111LS83

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
EGREMONT	2.4. CROFT TERRACE	622326	2.4.2	36045175	1	6223261LS21
					2	6223261LS22
					3	6223261LS23
			2.4.3	36045178	1	6223261LS31
					2	6223261LS32
					3	6223261LS33
			2.4.4	36045194	1	6223261LS41
					2	6223261LS42
					3	6223261LS43
	2.5. DRYDENWAY	622521	2.5.2	36070376	1	6225211LS21
					2	6225211LS22
					3	6225211LS23
			2.5.3	36070384	1	6225211LS31
					2	6225211LS32
					3	6225211LS33
			2.5.4	36070391	1	6225211LS41
					2	6225211LS42
					3	6225211LS43
			2.5.5	36070396	1	6225211LS51
					2	6225211LS52
					3	6225211LS53
			2.5.6	36070402	1	6225211LS61
					2	6225211LS62
					3	6225211LS63
			2.5.7	36070413	1	6225211LS71
					2	6225211LS72
					3	6225211LS73
	2.6. SHAKESPEARE AVENUE	622605	2.6.2	36080211	1	6226051LS21
					2	6226051LS22
					3	6226051LS23
			2.6.3	36080215	1	6226051LS31
					2	6226051LS32
					3	6226051LS33
			2.6.4	36080216	1	6226051LS41
					2	6226051LS42
					3	6226051LS43
			2.6.5	36080217	1	6226051LS51
					2	6226051LS52
					3	6226051LS53
			2.6.6	36080219	1	6226051LS61
					2	6226051LS62
					3	6226051LS63
			2.6.7	36080220	1	6226051LS71
					2	6226051LS72
					3	6226051LS73
	2.7. BRIDGE END INDUSTRIAL ESTATE	623096	2.7.2	36085591	1	6230961LS21
					2	6230961LS22
					3	6230961LS23
			2.7.3	36085589	1	6230961LS31
					2	6230961LS32
					3	6230961LS33
			2.7.4	36085592	1	6230961LS41
					2	6230961LS42
					3	6230961LS43

Primary Substation	Distribution Substation	Sub No	Circuit No	LV Way Feature No	Phase	CRMS Ref
WIGTON	6.1. WESTERN BANK	636033	6.1.2	402818773	1	6360331LS21
					2	6360331LS22
					3	6360331LS23
			6.1.3	402818774	1	6360331LS31
					2	6360331LS32
					3	6360331LS33
			6.1.4	402818775	1	6360331LS41
					2	6360331LS42
					3	6360331LS43
			6.1.5	402818777	1	6360331LS51
					2	6360331LS52
					3	6360331LS53
			6.1.6	402818778	1	6360331LS61
					2	6360331LS62
					3	6360331LS63
	6.2. WIZA CRESCENT	636035	6.2.2	402819269	1	6360351LS21
					2	6360351LS22
					3	6360351LS23
			6.2.3	402819268	1	6360351LS31
					2	6360351LS32
					3	6360351LS33
			6.2.4	402819267	1	6360351LS41
					2	6360351LS42
					3	6360351LS43
			6.2.5	402819266	1	6360351LS51
					2	6360351LS52
					3	6360351LS53
			6.2.6	402819270	1	6360351LS61
					2	6360351LS62
					3	6360351LS63
	6.3 EDEN CLOSE	638005	6.3.3	33093377	1	6380051LS31
					2	6380051LS32
					3	6380051LS33
			6.3.5	33093383	1	6380051LS51
					2	6380051LS52
					3	6380051LS53
			6.3.6	33093381	1	6380051LS61
					2	6380051LS62
					3	6380051LS63
			6.3.7	33093379	1	6380051LS71
					2	6380051LS72
					3	6380051LS73

6.3 Appendix C – Lynx specification

Specification	Value
Rated voltage	**440V , 50Hz**
Rated load current	**400 A**
Reclose delay range	**30 seconds to 10 minutes**
Making capacity	**1000A**
Breaking capacity	**1000A**
Rated short-time withstand current (I_{cw})	**10 kA for 100ms**
Rated service short-circuit making capacity (I_{cm})	**10kA$_{peak}$**
Temperature range	**-20 to 55°C**

6.4 Appendix D – Lynx installation locations

Primary Substation	Distribution Substation	Sub No	Circuit No	Link Box Type	Link Box Use	Phase	CRMS Ref
DENTON EAST	1.1. CIRCULAR RD	171383	1.1.5	2 WAY	Interconnector	1	1787211LS11
						2	1787211LS12
						3	1787211LS13
	1.3. KENNEDY WAY	172165	1.3.4	4 WAY	Interconnector	1	1787121LS11
						2	1787121LS12
						3	1787121LS13
	1.4. SCOTT RD	172175	1.4.5	2 WAY	Interconnector	1	1787301LS11
						2	1787301LS12
						3	1787301LS13
	1.5. TOWN LN (NO 52)	172371	1.5.2	2 WAY	Interconnector	1	1787231LS11
						2	1787231LS12
						3	1787231LS13
			1.5.4	2 WAY	Monitor	1	1787181LS11
						2	1787181LS12
						3	1787181LS13
	1.7. PENDLE RD	172187	1.7.3	2 WAY	Interconnector	1	1787271LS11
						2	1787271LS12
						3	1787271LS13

Primary Substation	Distribution Substation	Sub No	Circuit No	Link Box Type	Link Box Use	Phase	CRMS Ref
LONGSIGHT	5.1. BIRCH LN NURSING HOME	172399	5.1.4	2 WAY	Interconnector	1	1787331LS11
						2	1787331LS12
						3	1787331LS13
	5.2. BRYNTON RD (NO.70)	171281	5.2.3	2 WAY	Interconnector	1	1787381LS11
						2	1787381LS12
						3	1787381LS13
			5.2.4	4 WAY	Interconnector	1	1787411LS41
						2	1787411LS42
						3	1787411LS43

Primary Substation	Distribution Substation	Sub No	Circuit No	Link Box Type	Link Box Use	Phase	CRMS Ref
HINDLEY GREEN	4.1. ASHBOURNE AVENUE	212730	4.1.4	2 Way	Interconnector	1	2189291LS11
						2	2189291LS12
						3	2189291LS13
			4.1.5	2 Way	Interconnector	1	2189321LS11
						2	2189321LS12
						3	2189321LS13
			4.1.6	4 Way	Interconnector	1	2189361LS21
						2	2189361LS22
						3	2189361LS23
	4.2. BORSDANE AVENUE	212725	4.2.4	4 Way	Interconnector	1	2189431LS11
						2	2189431LS12
						3	2189431LS13
				2 Way	Interconnector	1	2189301LS11
						2	2189301LS12
						3	2189301LS13
	4.3. BRIDGEWATER STREET	212720	4.3.1	2 Way	Interconnector	1	2189391LS11
						2	2189391LS12
						3	2189391LS13
			4.3.3	4 Way	Interconnector	1	2189311LS21
						2	2189311LS22
						3	2189311LS23
			4.3.6	4 Way	Interconnector	1	2189501LS31
						2	2189501LS32
						3	2189501LS33
			4.3.9	4 Way	Interconnector	1	2189441LS31
						2	2189441LS32
						3	2189441LS33
	4.4. CASTLE HILL	212723	4.4.5	2 Way	Interconnector	1	2189351LS11
						2	2189351LS12
						3	2189351LS13
	4.7. VICARAGE	212716	4.7.2	2 Way	Monitor	1	2189631LS11
						2	2189631LS12
						3	2189631LS13
	4.9. WALMER RD	212734	4.9.7	2 Way	Interconnector	1	2189401LS11
						2	2189401LS12
						3	2189401LS13

Primary Substation	Distribution Substation	Sub No	Circuit No	Link Box Type	Link Box Use	Phase	CRMS Ref
WIGTON	6.1. WESTERN BANK	636033	6.1.6	2 Way	Interconnector	1	6393771LS11
						2	6393771LS12
						3	6393771LS13
	6.2. WIZA CRES	636035	6.2.4	2 Way	Interconnector	1	6393841LS11
						2	6393841LS12
						3	6393841LS13
			6.2.6	4 Way	Interconnector	1	6393971LS11
						2	6393971LS12
						3	6393971LS13

6.5 Appendix E – LV capacitor specification

Voltage range	415V at 50Hz
Working ambient temperature	Maximum = 40^{o}C Highest mean over 24 hours = 30^{o}C Highest mean over 1 year = 20^{o}C Lowest ambient temperature = - 20^{o}C
Power rating	100/150/200 kvar
Installation	Ground-mounted, bottom cable entry
Connection	Three-phase electrical network (Neutral not compulsory
Degree of protection	IP43 (door closed) Protected against direct and accidental contact (door open)
Execution	Outdoor
Enclosure	Stainless steel painted to BS14C40 Moss Green
Ventilation	Natural air cooling
Control	ABB CQ930 automatic capacitor bank controller
Losses at 415V	Less than 1.5W/kvar
Capacitors – QCap type	Dry type self healing according to IEC 60831- 1 & 2
Standards	Generally as per EN 61921
Incoming protective device	ABB Tmax T5H three pole MCCB rated 400A
Capacitor protection	• Through main DIN NH00 fuses fitted in ABB XLP00 fuse switch disconnector • Overpressure disconnection within the QCap capacitor unit
Safety	Discharge resistors fitted to the capacitor terminals to safely discharge the capacitor to 50V in one minute.
Dimensions(W x D x H mm)	Enclosure 1250 x 430 x 1125 (from ground level); Base frame 1250 x 430 x 300
Approximate weight (kg)	Gross = 192 (with pallet); Net = 166

6.6 Appendix F – LV capacitor installations

Primary Substation	Distribution Substation	Sub No	Circuit No	Cap Size	Cap Name	Cap No	CRMS Ref
DENTON EAST	1.1. CIRCULAR RD	171383	1.1.5	150kVAr	Foxdenton Walk Cap	178728	1787281RE01
			1.1.6	100kVAr	Circular Rd Cap	178735	1787351RE01
	1.2. HODNET WALK	171823	1.2.1	100kVAr	Essington Walk Cap	178745	1787451RE01
	1.3. KENNEDY WAY	172165	1.3.2	200kVAr	Kennedy Way Cap	178747	1787471RE01
			1.3.3	100kVAr	Millbrook Ave Cap	178749	1787491RE01
			1.3.5	100kVAr	Tomcroft Ln Cap	178771	1787711RE01
	1.4. SCOTT RD	172175	1.4.3	100kVAr	Stockport Rd Cap	178734	1787341RE01
			1.4.4	100kVAr	Wakeling Rd Cap	178760	1787601RE01
	1.5. TOWN LN (NO 52)	172371	1.5.2	100kVAr	Cooke St Cap	178743	1787431RE01
			1.5.3	100kVAr	Town Ln Cap	178766	1787661RE01
	1.7. PENDLE RD	172187	1.7.3	100kVAr	Stockport Rd Cap	178773	1787731RE01

Primary Substation	Distribution Substation	Sub No	Circuit No	Cap Size	Cap Name	Cap No	CRMS Ref
LONGSIGHT	5.1. BIRCH LN NURSING HOME	172399	5.1.4	100kVAr	Birch Ln Cap	178762	1787621RE01
	5.2. BRYNTON RD (NO. 70)	171281	5.2.2	100kVAr	Elsdon Rd Cap	178742	1787421RE01
			5.2.3	100kVAr	Meldon Rd (Opp 36) Ca	178777	1787771RE01
			5.2.5	200kVAr	Brynton Rd No70 Cap	178752	1787521RE01
	5.3. BRYNTON RD (NO.8)	171279	5.3.3	100kVAr	Birch Hall Ln Cap	178750	1787501RE01
			5.3.5	150kVAr	Birchfield Rd Cap	178737	1787371RE01
	5.4. DALTON ELLIS HALL ANSON RD	171059	5.4.2	100kVAr	Anson Rd Cap	178753	1787531RE01
	5.5. GREVILLE ST	171625	5.5.2	100kVAr	Longford Pl Cap	178748	1787481RE01
			5.5.3	100kVAr	Tagore Cl Cap	178756	1787561RE01

Primary Substation	Distribution Substation	Sub No	Circuit No	Cap Size	Cap Name	Cap No	CRMS Ref
HINDLEY GREEN	4.1. ASHBOURNE AVE	212730	4.1.2	100kVAr	Mornington Rd Cap	219009	2190091RE01
			4.1.4	100kVAr	Adj 31 Broadway Cap	218978	2189781RE01
	4.2. BORSDANE AVE	212725	4.2.4	150kVAr	Chapel Fields Ln Cap	219044	2190441RE01
	4.3. BRIDGEWATER ST	212720	4.3.1	100kVAr	Borsdane Ave Cap	219016	2190161RE01
			4.3.6	100kVAr	Scott Ave Cap	218986	2189861RE01
			4.3.8	100kVAr	Castle Hill Cap	218954	2189541RE01
	4.4. CASTLE HILL	212723	4.4.4	100kVAr	7 Herefold Rd Cap	218988	2189881RE01
			4.4.5	100kVAr	34 Herefold Rd Cap	218942	2189421RE01
			4.4.6	100kVAr	Castle Hill Rd Cap	218995	2189951RE01
	4.5. GIDLOW ST	212711	4.5.1	100kVAr	Oldbridge Dr Cap	219002	2190021RE01
			4.5.2	100kVAr	Ladies Ln Cap	218993	2189931RE01
			4.5.3	100kVAr	France St Cap	218971	2189711RE01
	4.6. GLOUCESTER CRES	212727	4.6.2	100kVAr	Smithwood Ave Cap	218951	2189511RE01
			4.6.4	100kVAr	Sandy Ln Cap	218960	2189601RE01
			4.6.5	100kVAr	Rutland Rd Cap	219000	2190001RE01
	4.7. VICARAGE	212716	4.7.1	100kVAr	Adj 209 Atherton Rd Cap	219011	2190111RE01
			4.7.2	100kVAr	Adj 153 Atherton Rd Cap	218949	2189491RE01
			4.7.4	100kVAr	Corsey Rd Cap	218974	2189741RE01
	4.8. VICTORIA FM	212729	4.8.3	100kVAr	Ashfield Ave Cap	219067	2190671RE01
			4.8.5	100kVAr	Kenilworth Dr Cap	218980	2189801RE01
			4.8.6	100kVAr	Askwith Rd Cap	219003	2190031RE01
	4.9. WALMER RD	212734	4.9.4	200kVAr	Walmer Rd Cap	218982	2189821RE01
				100kVAr	Bedford Gdns Cap	218952	2189521RE01
			4.9.7	150kVAr	94 Broadway Cap	218945	2189451RE01
			4.9.8	100kVAr	Castleway Cap	219008	2190081RE01

Primary Substation	Distribution Substation	Sub No	Circuit No	Cap Size	Cap Name	Cap No	CRMS Ref
GREEN STREET	3.1. CAMBERWELL CRESCENT	212410	3.1.2	100kVAr	Finchley Cres Cap	218941	2189411RE01
			3.1.3	100kVAr	Alston Rd Cap	218948	2189481RE01
	3.2. CAUNCE ROAD	212512	3.2.1	100kVAr	Stanley Pl Cap	218997	2189971RE01
			3.2.2	100kVAr	Golborne Pl Cap	218972	2189721RE01
	3.3. LINNEY STREET	212510	3.3.3	100kVAr	Linney Sq Cap	218989	2189891RE01
			3.3.7	100kVAr	Lorne St Cap	218953	2189531RE01
	3.4. MALDON CLOSE	212407	3.4.2	200kVAr	Maldon Cl Cap	218961	2189611RE01
			3.4.3	150kVAr	Whelley Cap	219010	2190101RE01
			3.4.4	100kVAr	Ashbourne Ave Cap	218970	2189701RE01
			3.4.5	150kVAr	Shildon Cl Cap	218983	2189831RE01
	3.5. MOAT HOUSE STREET	212529	3.5.2	100kVAr	Manchester Rd Cap	219020	2190201RE01
	3.6. PETTICOAT LANE	212531	3.6.2	100kVAr	Dovenby Fold Cap	219005	2190051RE01
			3.6.3	100kVAr	Grasmere Ave Cap	219013	2190131RE01
			3.6.4	100kVAr	Lakes Terr Cap	218946	2189461RE01
	3.7. VAUXHALL ROAD	212221	3.7.2	100kVAr	Collet Cl Cap	219022	2190221RE01
			3.7.6	100kVAr	Vauxhall Rd Cap	219051	2190511RE01

Primary Substation	Distribution Substation	Sub No	Circuit No	Cap Size	Cap Name	Cap No	CRMS Ref
EGREMONT	2.1. ELECTRIC HOUSE	621431	2.1.3	100kVAr	Green Moor Rd Cap	629378	6293781RE01
			2.1.6	100kVAr	Main St Cap	629386	6293861RE01
	2.2. FELL VIEW DR	621932	2.2.2	100kVAr	Fell View Dr (Adj 9) Cap	629505	6295051RE01
				200kVAr	Fell View Dr Cap	629425	6294251RE01
			2.2.4	100kVAr	Grove Rd (Adj 6) Cap	629400	6294001RE01
			2.2.5	100kVAr	Dale View Dr Cap	629391	6293911RE01
	2.3. SMITHFIELD	622111	2.3.6	100kVAr	Howbank Rd Cap	629417	6294171RE01
			2.3.7	100kVAr	Grillfoot Rd Cap	629380	6293801RE01
			2.3.8	100kVAr	The Crescent Cap	629420	6294201RE01
	2.4. CROFT TERR	622326	2.4.2	100kVAr	Croft Terr Cap	629387	6293871RE01
			2.4.3	100kVAr	Church St Cap	629409	6294091RE01
	2.5. DRYDENWAY	622521	2.5.2	100kVAr	Milton Rd Cap	629382	6293821RE01
			2.5.4	100kVAr	Spenser Cl Cap	629393	6293931RE01
			2.5.6	100kVAr	Croadalla Ave Cap	629414	6294141RE01
	2.6. SHAKESPEARE AVE	622605	2.6.3	100kVAr	Park View Cap	629402	6294021RE01
			2.6.5	100kVAr	Goldsmith Rd Cap	629381	6293811RE01
			2.6.7	100kVAr	Grove Rd (Opp 29) Cap	629395	6293951RE01
	2.7. BRIDGE END IND EST	623096	2.7.3	100kVAr	Bridge End Cap	629412	6294121RE01

Primary Substation	Distribution Substation	Sub No	Circuit No	Cap Size	Cap Name	Cap No	CRMS Ref
WIGTON	6.1. WESTERN BANK	636033	6.1.2	100kVAr	West Rd Cap	639379	6393791RE01
	6.2. WIZA CRES	636035	6.2.3	100kVAr	Burnside Cap	639394	6393941RE01
			6.2.4	100kVAr	Park Rd Cap	639404	6394041RE01
	6.3 EDEN CL	638005	6.3.5	100kVAr	Meadow Rd (Adj 33) Cap	639415	6394151RE01
			6.3.7	100kVAr	Brookfield Ave Cap	639388	6393881RE01

6.7 Appendix G – HV capacitor specification

Ground-mounted

ABBACUS Signature Q – Metal Enclosed capacitor Bank System

Model MECB12SI10-S

This capacitor bank system comprises one incoming stage and one switched power stage.

Incoming stage:

- HV terminal palms to connect main feeder cables
- Enclosure lighting
- Busbar system, non-insulated, tinned copper, designed to 31.5kA/1 sec
- ABB -type surge arresters
- ABB Voltage transformer for control reference voltage
- 3 x ABB line current transformers
- ABB VD4-type circuit breaker, 12kV, 400Amp, 31.5kA/1 sec
- ABB OWIII -type 'no-load' isolator, 12kV, 400Amp, 31.5kA/1 sec
- ABB -type interlocked earth switch, 12kV
- LV marshalling box containing control equipment (refer below)
    - 1 x ABB CQ930 RVT power factor controller
    - 1 x ABB unbalance relay
    - 1 x ABB REU 601 over- and under-voltage relay
    - 1 x ABB REF 601 overcurrent - earthfault relay
    - Live line indication
- YELLOW indication for signalling faults per step including:
    - Over-temperature
    - Unbalance protection
    - Fuse failure

Power stage

- 6 x 82/41kvar, 7.31/4.39kV, 50Hz, fused ABB capacitors connected in a YY configuration and manufactured in accordance with IEC60871. Discharge resistors are fitted for discharge to 75 Volts in 10 minutes
- 1 x 72.475/52.182mH, 19.2Arms, 3-phase, 7% detuned, iron core type reactor designed for a harmonic loading equivalent to v_1=106%, v_3=0.5%, v_5=3.5%, v_7=3.5% and linearity 29.8A
- 1 x ABB SACE VSC-S, 12kV, 250Arms, fixed, mechanically latched capacitor-switching vacuum contactor
- 3 x HRC fuses, with fuse failure indication
- 1 x X/1A , Class 1M, cast resin unbalance current transformer
- Fan forced cooling with externally removable filters
- Anti-condensation heating
- Enclosure lighting

Pole-mounted HV capacitor specification

The three PM HV capacitor banks are supplied by ABB and are:

Specification	Value
Power	400kvar
Voltage	11kV
Model	Three phase
Insulation level	125kV BIL
Frequency	50Hz
Arrangement	Delta
Number of capacitors	3
Control voltage	240Vac
Temperature range	-50 to +50 °C
Frame	Galvanised Steel
Discharge resistors	Built in
Dielectric	Polypropylene film
Impregnant	Faradol 810 non-PCB
Vacuum switch	PS15, 15.5kV
Surge arrestor	MWK

6.8 Appendix H – HV capacitor installation locations

Primary Substation	HV Cap Size	HV Cap Name	HV Cap No	CRMS Ref	Mount
Denton East	200kVAr, 6.6kV	Hodnet Walk Cap	178844	1788443RE01	Ground
Longsight	200kVAr, 6.6kV	Brynton Rd No.8	178908	1789083RE01	Ground
Hindley	400kVAr, 11kV	Bridgewater HV St Cap	219082	2190824RE01	Ground
Hindley	500kVAr, 11kV	Hockery Brook HV Cap	219055	2190554RE01	Pole
Egremont	500kVAr, 11kV	Carleton HV Cap	629455	6294554RE01	Pole
Egremont	500kVAr, 11kV	Dryhurst HV Cap	629432	6294324RE01	Pole

6.9 Appendix I – OLTC Specification

MR Gridcon iTap technical specification

Specification	Value
Number of phases	3
Transformer type	Free breathing with oil conservator
Transformer size	500kva, at 11kV & 6.6kV
Maximum rated through current	30 A
Rated short-time current	600 A
Rated duration of short circuits	3 s
Rated peak withstand current	1500 A
Maximum rated step voltage	600 V
Maximum rated tapping voltage	1200 V
Step capacity	9000 VA
Number of operating positions	9
Tapping range	+/- 8%
Rated frequency	50 Hz
Temperature range of transformer oil	-25°C – +105°C
Permissible absolute pressure during operation	minimum 0.7 bar, maximum 1.3 bar
Maximum number of tap-change operations	700,000
Protection class	IP 54
Operating site	Interior

6.10 Appendix J – OLTC installations

Primary Substation	Distribution Substation	Sub No.	Tx Size (KVA)	Primary Voltage (kV)
Denton East	Circular Rd	171383	500	6.6
Longsight	Brynton Rd (No 70)	171279	500	6.6
Green Street	Vauxhall Rd	212221	500	6.6
Hindley Green	Ashbourne Ave	212730	500	11
Egremont	Shakespeare Ave	622605	500	11

6.11 Appendix K – EPM installation locations

Primary Substation	Distribution Substation	Sub No	Circuit No	EPM Site No	Site Name
Denton East	1.1. CIRCULAR RD	171383	1.1.6	M100551MC001	Opposite 20 Blithfield Walk
	1.2. HODNET WALK	171823	1.2.1	M100561MC001	Opp 7 to 21 Benthall Walk
	1.3. KENNEDY WAY	172165	1.3.5	M100571MC001	O/S 162 Town Ln
	1.4. SCOTT RD	172175	1.4.3	M100581MC001	S/O 437 Stockport Rd
			1.4.4	M100591MC001	O/S the Lodge, Cemetery Rd
	1.5. TOWN LN (NO 52)	172371	1.5.3	M100601MC001	O/S 28 Westbourne Rd
Longsight	5.1. BIRCH LN NURSING HOME	172399	5.1.4	M100611MC001	O/S 50 Birch Ln
	5.2. BRYNTON RD (NO.70)	171281	5.2.2	M100621MC001	O/S 36 Elsden Rd
	5.3. BRYNTON RD	171279	5.3.3	M100631MC001	O/S 95 Birch Hall Ln
			5.3.5	M100641MC001	O/S 29 Birchfields Rd
	5.4. DALTON ELLIS HALL ANSON RD	171059	5.4.2	M100651MC001	Corner of Anson Rd / Denison Rd
	5.5. GREVILLE ST	171625	5.5.2	M100661MC001	S/O 45 Longford Place
Hindley Green	4.1. ASHBOURNE AVENUE	212730	4.1.2	M200601MC001	O/S 20 Silverdale Rd
	4.2. BORSDANE AVENUE	212725	4.2.4	M200611MC001	O/S 28 All Saints Grove
	4.3. BRIDGEWATER	212720	4.3.6	M200621MC001	O/S 40 Scott Ave
			4.3.8	M200631MC001	S/O 112 Castle Hill Rd
	4.5. GIDLOW STREET	212711	4.5.1	M200641MC001	O/S 16 Brayton Court
			4.5.2	M200651MC001	O/S 25 France St
			4.5.3	M200661MC001	Behind 1 Danes Brook Cl
	4.6. GLOUCESTER	212727	4.6.2	M200671MC001	O/S 31 Smithwood Ave
			4.6.4	M200681MC001	S/O 5 Sandy Park
			4.6.5	M200691MC001	O/S 37 Sailsbury Ave
	4.7. VICARAGE	212716	4.7.4	M200701MC001	O/S 1 Chatteris Cl
	4.8. VICTORIA FARM	212729	4.8.3	M200711MC001	O/S 58 Cinnamon Ave
			4.8.5	M200721MC001	O/S 60 Kenilworth Drive
			4.8.6	M200731MC001	O/S 17 Fenton Way
	4.9. WALMER ROAD	212734	4.9.4	M200761MC001	O/S 203 Sandy Ln
			4.9.7	M200741MC001	O/S 8 Brookdale Rd
			4.9.8	M200751MC001	O/S 16 Norfolk Close
Green St	3.1. CAMBERWELL	212410	3.1.2	M200511MC001	O/S 23 Bromley Cl
			3.1.3	M200521MC001	O/S 25 Finchley Cres
	3.2. CAUNCE ROAD	212512	3.2.1	M200531MC001	S/O 29 Stanley Place
	3.3. LINNEY STREET	212510	3.3.3	M200541MC001	O/S 130/132 Caunce Rd
			3.3.7	M200551MC001	O/S 71 Kirkless St
	3.4 MALDON CLOSE	212407	3.4.3	M200561MC001	O/S 281 Whelley
	3.5. MOAT HOUSE STREET	212529	3.5.2	M200571MC001	O/S 208 Manchester Rd
	3.6. PETTICOAT LANE	212531	3.6.2	M200581MC001	O/S 17 Doveny Fold
	3.7. VAUXHALL ROAD	212221	3.7.6	M200591MC001	O/S 15 Baldwin St
Egremont	2.1. ELECTRIC HOUSE	621431	2.1.3	M600081MC001	O/S 26 North Rd
	2.2. FELL VIEW DR	621932	2.2.4	M600091MC001	LV Pole 353803, S/O 14 Grove Rd
			2.2.5	M600101MC001	O/S 25 Dale View Dr
	2.3. SMITHFIELD	622111	2.3.7	M600111MC001	O/S 23 Grillfoot Rd
	2.4. CROFT TERR	622326	2.4.3	M600121MC001	S/O 53/54 Beck Green
	2.5. DRYDENWAY	622521	2.5.2	M600131MC001	Grass verge O/S 9 Chaucer Ave
	2.6. SHAKESPEARE AVE	622605	2.6.7	M600141MC001	O/S 7 Goldsmith Rd
	2.7. BRIDGE END IND EST	623096	2.7.3	M600151MC001	O/S 40 Sycamore Lea
	6.2. WIZA CRES	636035	6.2.3	M600171MC001	O/S 1 Burnside
	6.3. EDEN CL	638005	6.3.5	M600181MC001	O/S 9 Langdale
			6.3.7	M600191MC001	O/S 8 Langdale