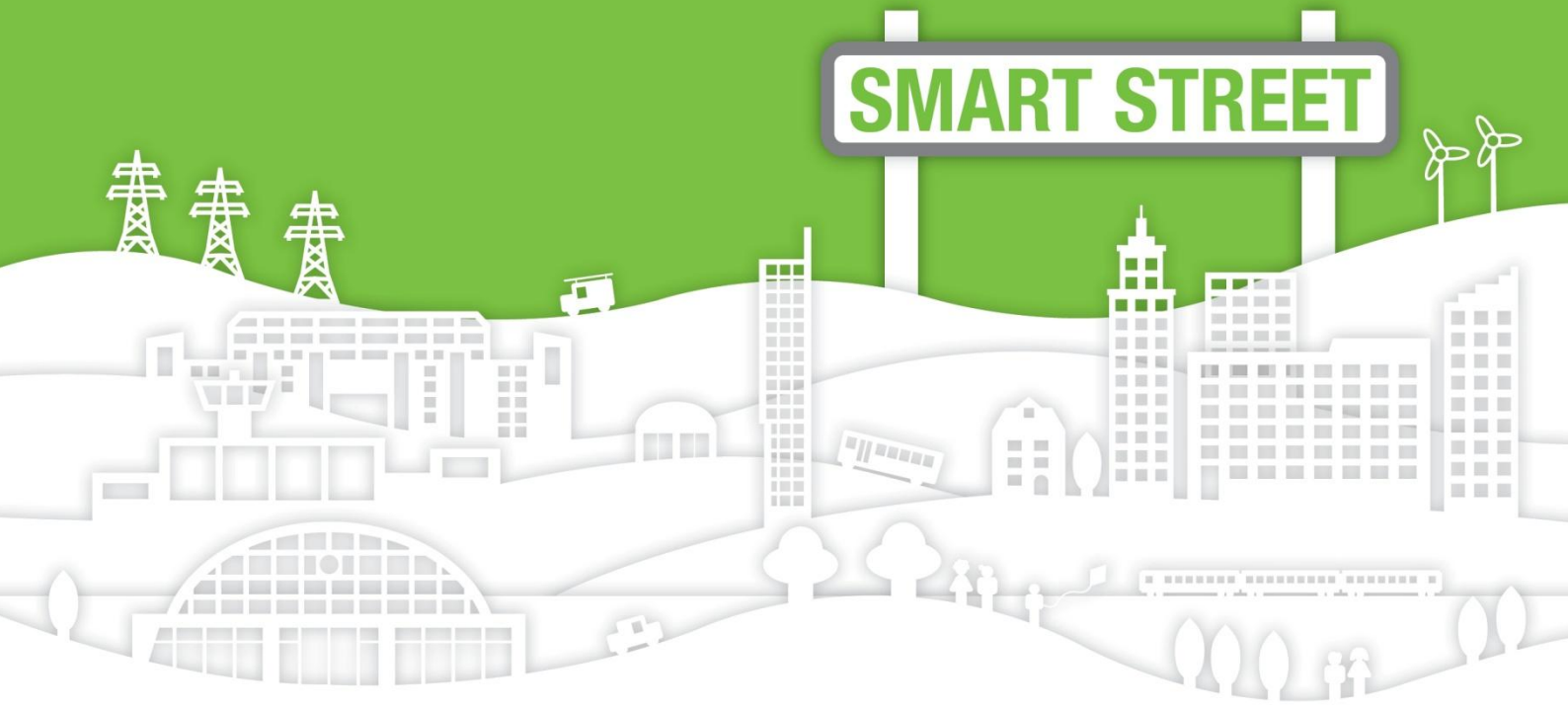
electricity north west

Bringing energy to your door

Smart Street
Circuit Selection Methodology

31 July 2014



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VERSION HISTORY

Version	Date	Author	Status	Comments
1.0	31/7/2014	Electricity North West	1st issue	

GLOSSARY OF TERMS

Abbreviation	Term
C_2C	Capacity to Customers
CLASS	Customer Load Active System Services
DG	Distributed Generation
EHV	Extra High Voltage (33kV-132kV)
HV	High Voltage (6.6kV / 11kV)
IFI	Innovation Funding Incentive
LCN	Low Carbon Network
LCT	Low Carbon Technology
LV	Low Voltage (230V / 415V)
NMS	Network Management System
Ofgem	Office of Gas and Electricity Markets
SDRC	Successful Delivery Reward Criteria

1 EXECUTIVE SUMMARY

The Ofgem Project Direction for the Smart Street Project (ref: ENWL/ eta /19 December 2013) 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 per the list below).

This report is to deliver evidence for the first 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 by July 2014
- Contracts for the supply of networks equipment signed by July 2014
- Publish network equipment specifications and installation reports by September 2015
- Publish NMS, interface and optimisation configuration and commissioning reports by September 2015
- Publish new LV network management protocols by June 2015
- Electricity North West operational personnel, including control engineers briefed and/ or trained on LV network management protocols by June 2015.

This report describes the methodology and the process for selecting the high voltage (HV) and low voltage (LV) circuits that will be investigated within the Smart Street Trial.

The selection of HV and LV circuits for the Smart Street Trial was undertaken in four main stages; initial circuit screening, circuit classification, preliminary circuit selection and circuit simulation for refined circuit selection.

Initial circuit screening involved considering the full portfolio of HV and LV circuits within the three area classes (rural, urban and dense urban). Preference was given to those HV and LV circuits which are fed from a primary substation that has been involved in either of the C_2C or CLASS Project Trials to optimise the use of assets already installed.

The classification stage involved assessment and ranking of HV and LV circuits based on a number of criteria, listed below:

- Voltage levels
- Circuit types
- Customer types
- Low carbon technology (LCT) uptake
- Physical and electrical constraints
- LV interconnection

Following the classification of the circuits, a preliminary circuit selection was made in order to obtain a representative set of circuits for the Project Trial.

These preliminary circuits were then modelled to identify any power flow, voltage, fault level or protection issues that arise as a result of operating two radial feeders as an interconnected network. Circuits where none of these issues were found were selected to form part of the final suite.

Using this approach, 163 LV circuits have been selected. These are spread over 38 distribution substations, 11 HV feeders, and six primary substations. To maximise the representation of the selection, two primary substations have been selected in each area class (rural, urban and dense urban). This is summarised in Table 1: Smart Street circuit summary below.

The final selection is representative of Electricity North West's network and provides confidence that the learning from the Trial could be applied to other distribution networks.

Table 1 - Smart Street circuit summary

Primary	CLASS Site	C_2C Ring	Circuit Type	Voltage	HV Feeders	Distribution Substations	LV Circuits	Customers
Denton East	Yes	Yes	Dense Urban	6.6kV	2	7	20	3039
Longsight	Yes	Yes	Dense Urban	6.6kV	2	5	16	3020
Green Street	No	Yes	Urban	6.6kV	2	7	30	3179
Hindley Green	No	Yes	Urban	11kV	2	9	49	4374
Egremont	Yes	No	Rural	11kV	2	7	34	3766
Wigton	No	No	Rural	11kV	1	3	14	452

2 INTRODUCTION

Funded via Ofgem's Low Carbon Networks Second Tier funding mechanism, Smart Street is being undertaken by Electricity North West in partnership with Kelvatek, Siemens, Impact Research, Manchester University and Queens University Belfast. The Smart Street Project was authorised to commence in December 2013 and is due to complete in December 2017.

Smart Street will demonstrate a step change in the co-ordination and integrated operation of distribution networks in Great Britain. Utilising the most advanced technology developed today for LV network management, Smart Street challenges the current operational practices and demonstrates how to optimise HV and LV networks in real time.

The Smart Street Method combines the concepts of interconnection of networks, developed within one of Electricity North West's previous LCN Second Tier Funded Project, the Capacity to Customers (C_2C) Project, and elements of the voltage control technologies developed within our LCNF First Tier programme. The Capacity to Customers Project focused on EHV and HV networks, Smart Street will extend these technologies and their benefits down the voltage levels to encompass HV and LV networks. The Project utilises advanced real time optimisation software to simultaneously manage all HV and LV network assets to respond to customers changing demands in the most efficient end to end manner. The three key incremental steps in the Smart Street Method are the application of:

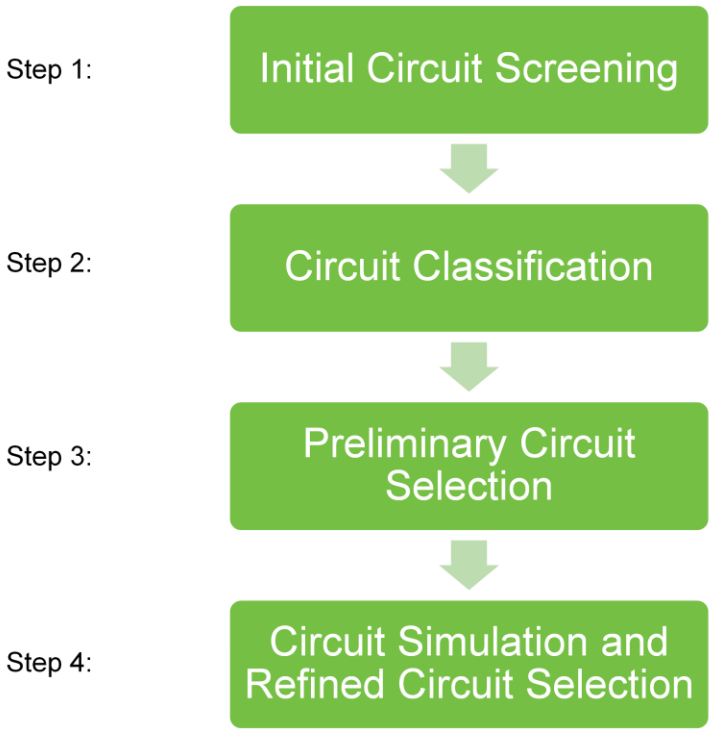
- Co-ordinated voltage control, using transformers with on load tap changers and capacitors, across HV and LV networks
- Interconnecting traditionally radial HV and LV circuits and assuming control of these networks within the control room
- Real-time co-ordinated configuration and voltage optimisation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

The four year Smart Street Project, which started in January 2014, will employ these techniques to demonstrate that a network operator can quickly release capacity and voltage headroom to facilitate the connection of low carbon technologies and at the same time operate a cost, carbon and energy efficient distribution network. The themes of LV network management and interconnection, HV and LV voltage control, and network configuration and voltage optimisation are the key interlinking aspects of the Smart Street Method.

3 DESCRIPTION OF CIRCUIT SELECTION METHODOLOGY

The steps of the circuit selection methodology are shown below.

Figure 1: Smart Street selection methodology



4 INITIAL CIRCUIT SCREENING

An initial screening process was applied to the total population of 363 primary substations within the Electricity North West network to avoid locations where the system configuration or system operation could affect the implementation of the Trial or the Trial results. The criteria below were used to either give preference to or exclude specific HV circuits:

- CLASS[1] sites
- C_2C rings
- System works.

4.1 CLASS sites

Smart Street intends to control the voltage at the primary substations using Siemens' autonomous substation controller that has been developed under Electricity North West's LCN Second Tier Project CLASS. Therefore any sites that will best demonstrate the Smart Street Method and also fall under the CLASS Trial area will optimise the use of assets already installed. There are a total of 60 CLASS primaries and these where highlighted as preferred sites.

[1] CLASS is an LCN Second Tier Project being undertaken by Electricity North West to assess the relationship between voltage and demand. There are 60 primary substations included in the CLASS Trials.

4.2 C_2C Rings

Capacity to Customer (C_2C) is Electricity North West's first LCN Second Tier funded Project. It aims to release capacity on the HV network through a number of different techniques. One of these approaches is by running closed ring circuits. A similar arrangement will be utilised for Smart Street. By incorporating C_2C rings in the Smart Street Trial, benefits and efficiencies will be realised as system studies have been already carried out. This will negate any power flow, voltage and fault level issues that may be caused through interconnection. Furthermore we will utilise automation already installed as part of C_2C, thus reducing expenditure for Smart Street.

There are a total of 105 primary substations running closed rings as part of the C_2C Project, 29 of which overlap with the 60 CLASS sites.

4.3 System works

Primaries where outages are expected due to works planned during the Trial period were excluded to minimise any disruption to the Smart Street Trial programme.

As part of the RIIO ED1 asset replacement programme Electricity North West has planned 88 primary transformer replacements and 45 primary HV switchgear replacements. The affected primaries were excluded from the Smart Street circuit selection.

4.4 Initial circuit screening summary

The initial circuit screening exercise reduced the total number of preferred primary substations from 363 to 59. From these 59 primary substations, there were 574 HV circuits that required classifying and comparing to select the circuits that best demonstrate the Smart Street Methods on the HV and LV networks.

5 CIRCUIT CLASSIFICATION

A key requirement is that the selected HV and LV circuits for the Trial should be representative of the range of circuits on Electricity North West's network, in order to maximise the learning outcomes of the Trial and ensure transferability to other UK distribution networks. The circuits short listed by the initial screening were classified according to the following criteria to check their suitability for selection:

- Voltage levels
- Circuit types
- Customer types
- Low carbon technology (LCT) uptake
- Physical and electrical constraints
- LV interconnection

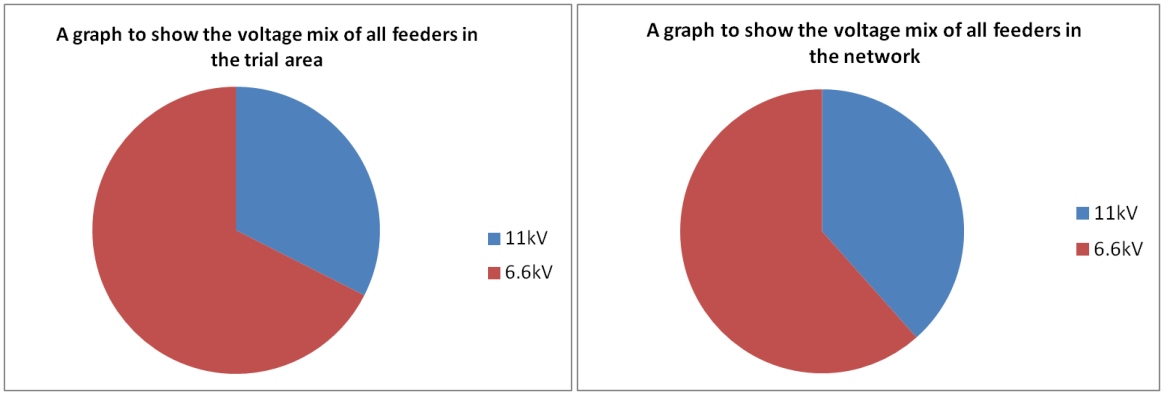
5.1 Voltage levels

The following voltage levels are considered in the circuit selection methodology, in order to maximise the learning outcomes and applicability to other GB distribution networks:

- 11kV & 6.6kV
- 415 V

Figure 2 below highlights the voltage mix of the feeders selected for the Smart Street Trial areas relative to Electricity North West's network.

Figure 2 – Voltage mix of HV feeders in Trial areas compared to the entire Electricity North West's network.



5.2 Circuit types

The following categories of circuit type are considered in the circuit selection methodology and are defined as:

- Dense urban – all underground cable
- Urban – mainly underground cable with some overhead
- Rural – mainly overhead with some underground.

5.3 Customer types

The type of customers connected to the circuits was considered as part of the Trial selection process to ensure that learning is obtained on how customer groups are affected to by Smart Street techniques. Electricity North West maintains a record of the numbers of customers connected to each primary substation by profile classes, as shown in Table 2 below.

Table 2 – Profile class description

Profile Class	Description
Profile Class 1	Domestic Unrestricted Customers
Profile Class 2	Domestic Economy 7 Customers
Profile Class 3	Non-Domestic Unrestricted Customers
Profile Class 4	Non-Domestic Economy 7 Customers
Profile Class 5	Non-Domestic Maximum Demand (MD) Customers with a Peak Load Factor (LF) of less than 20%
Profile Class 6	Non-Domestic Maximum Demand Customers with a Peak Load Factor between 20% and 30%
Profile Class 7	Non-Domestic Maximum Demand Customers with a Peak Load Factor between 30% and 40%
Profile Class 8	Non-Domestic Maximum Demand Customers with a Peak Load Factor over 40%

The customer profile class for the complete Trial area was cross referenced with Electricity North West's distributed generation database to categorise customers into the following groups, as shown in the table 3 below.

Table 3 – Customer type description

Customer Type	Description
1	Generation connections
2	Domestic load demand connections
3	Combined domestic load and generation connections
4	Commercial load demand connections
5	Industrial load demand connections
6	Combined commercial or industrial load and generation connections

By cross referencing customers in this way and categorising them by customer type, we can see what proportion of the Trial area is domestic, industrial or commercial. Furthermore we can establish where these customers are exporting to the network ie generation connections.

From the results the two primaries that have been included in the Trial where there has been a large uptake in LCT's (primarily photovoltaic solar panels) can easily be seen by the substantial proportion of customer type 3 (shown in figure 3 and 4).

The customer type results were divided up by primary level and can be found in appendix A.

5.4 Low carbon technology (LCT) uptake

Those circuits with known LCT's connected (either distributed generation (DG) or new LCT demands eg heat pumps and/or electric vehicles) were identified and this was further refined to networks with cluster of LCT's in order to show how these networks can be operated by the Smart Street Method.

13 primaries were identified that had substantial clusters of LCT uptake. Two of these primaries were included in the final selection.

5.5 Physical and electrical constraints

Consideration was given to the following when selecting the sites:

- Physical space for installation of new equipment
- Indoor or outdoor site, with indoor the preference for security reasons
- Ability to backfeed or connect a generator to limit supply interruptions during the installation phase
- LV feeders fuse size is limited by the 400A rating of the WEEZAP[2].

[2] The WEEZAP is an LV vacuum circuit breaker combined with an advanced measurement and protection processing unit jointly developed between Kelvatek and Electricity North West under an IFI project.

5.6 LV interconnection

At this stage in the process the availability of LV circuit interconnection was considered. This is a key element of the Smart Street Method. Circuits where possible points of interconnection already exist ie link boxes, benefit the Project as this will minimise network reinforcement work and disruption to customers. LV interconnection can be categorised in to three groups:

- Ring – two LV feeders that connect fed from the same distribution transformer
- Parallel – two LV feeders fed from different distribution transformers
- Radial - no interconnection.

6 PRELIMINARY CIRCUIT SELECTION

By collating and analysing all the data gathered in the previous two steps, a preliminary selection of 18 HV circuits was made.

7 CIRCUIT SIMULATION AND REFINED CIRCUIT SELECTION

The circuits in the preliminary list were simulated (using the IPSA network planning design tool) to identify any thermal, voltage or fault level issues that may arise as a result of operating the two radial HV feeders as a closed loop.

This allowed us to refine the short list of HV circuits down to ten.

Once the short list had been derived, we modelled the HV and LV system as a whole to establish load flows and volt drop, ideal interconnection points at LV and to where it would be most beneficial to install the various HV and LV capacitors. An example model of Green Street primary can be found in Appendix B.

8 SUMMARY AND SELECTION RESULTS

As stated in the Smart Street bid submission, the intended Trial area was to cover approximately 160 LV circuits, 40 distribution substations, ten HV circuits spread over five primary substations.

During the preparation of the Smart Street bid, some initial studies were undertaken to identify three geographical areas at which the Smart Street Methods can be applied. Manchester (dense urban), Wigan (urban) and Wigton (rural) were identified as the most suitable areas to best represent the entire Electricity North West's network.

Unfortunately Wigton primary is due to have one of the two 33kV /11kV primary transformers replaced during the Smart Street Trial period, which would have a negative impact on the Trial results at the HV level. However it is possible to apply the LV Trials and test regimes to a small Trial area on one of the feeders out of Wigton primary and we included this into the site selection

The decision was therefore made to expand the rural Trial area to incorporate Egremont primary resulting in the Trial area now covering six primary substations and 11 HV circuits.

From these 11 HV circuits, 163 LV circuits were identified spread over 38 distribution substations.

A detailed list of the Trial area selected for the Smart Street Trial can be found in Appendix C.

9 APPENDICES

APPENDIX A - TRIAL AREA CUSTOMER TYPES

Figure 3 – Hindley Green Trial feeders customer type mix

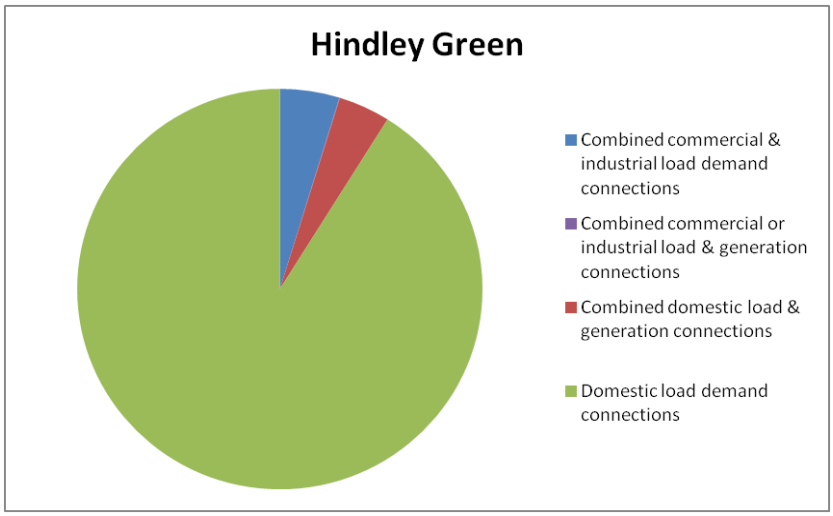


Figure 4 – Green Street Trial feeders customer type mix

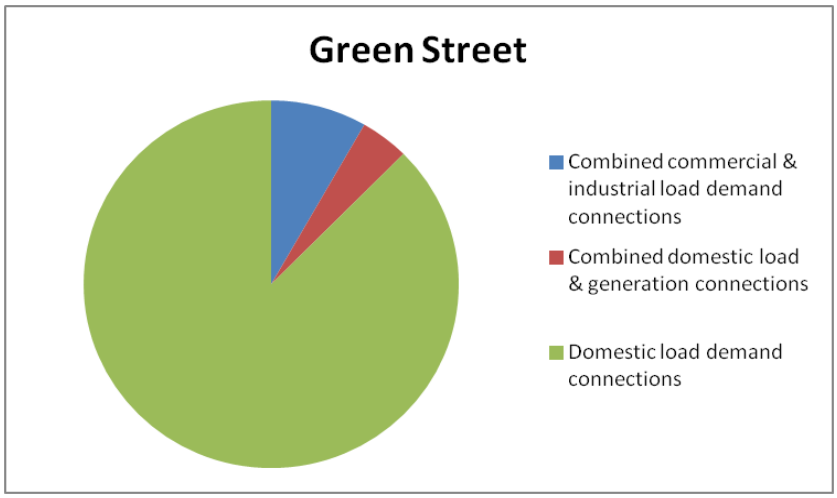


Figure 5 – Denton East Trial feeders customer type mix

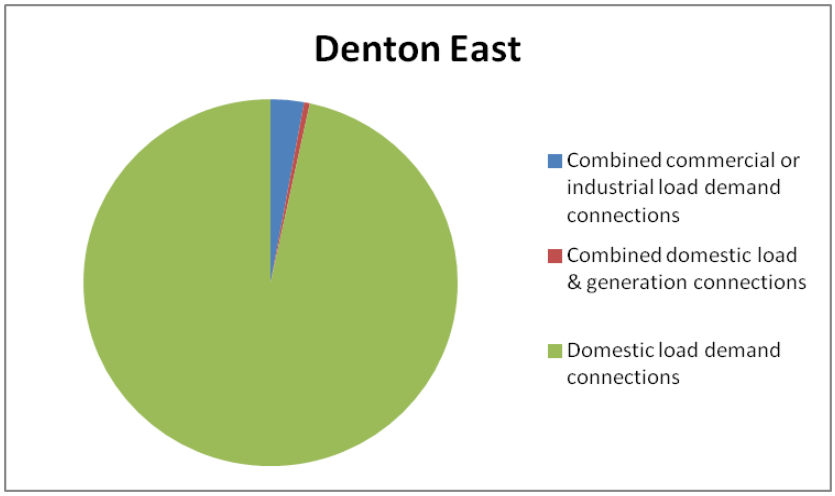


Figure 6 - Longsight Trial feeders customer type mix

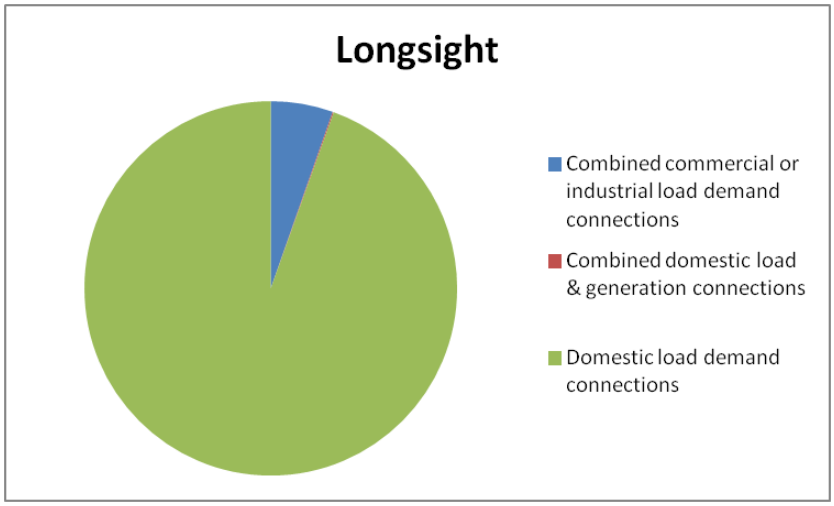


Figure 7 - Egremont Trial feeders customer type mix

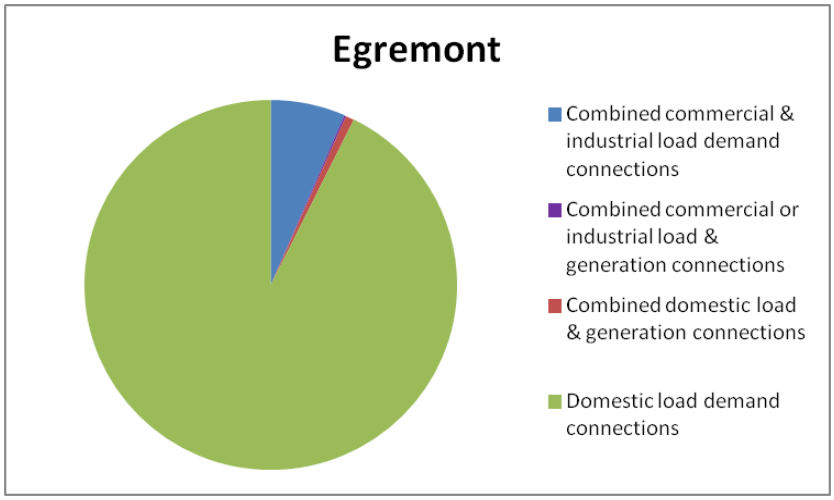
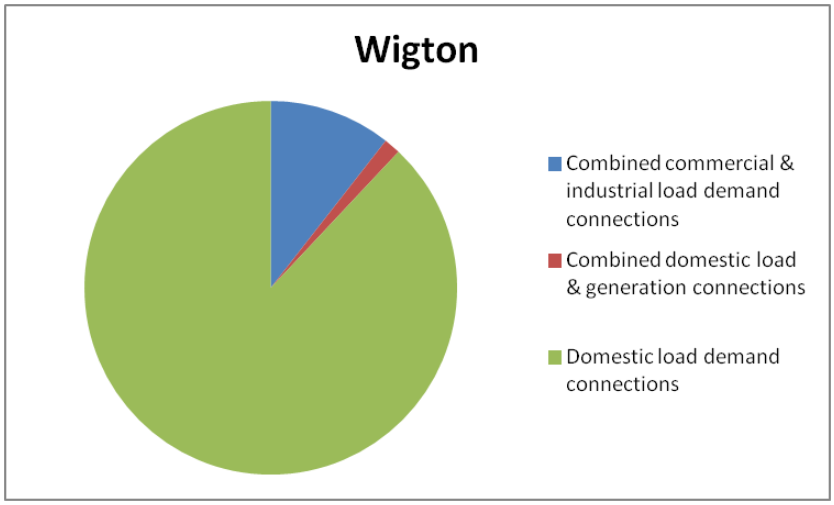
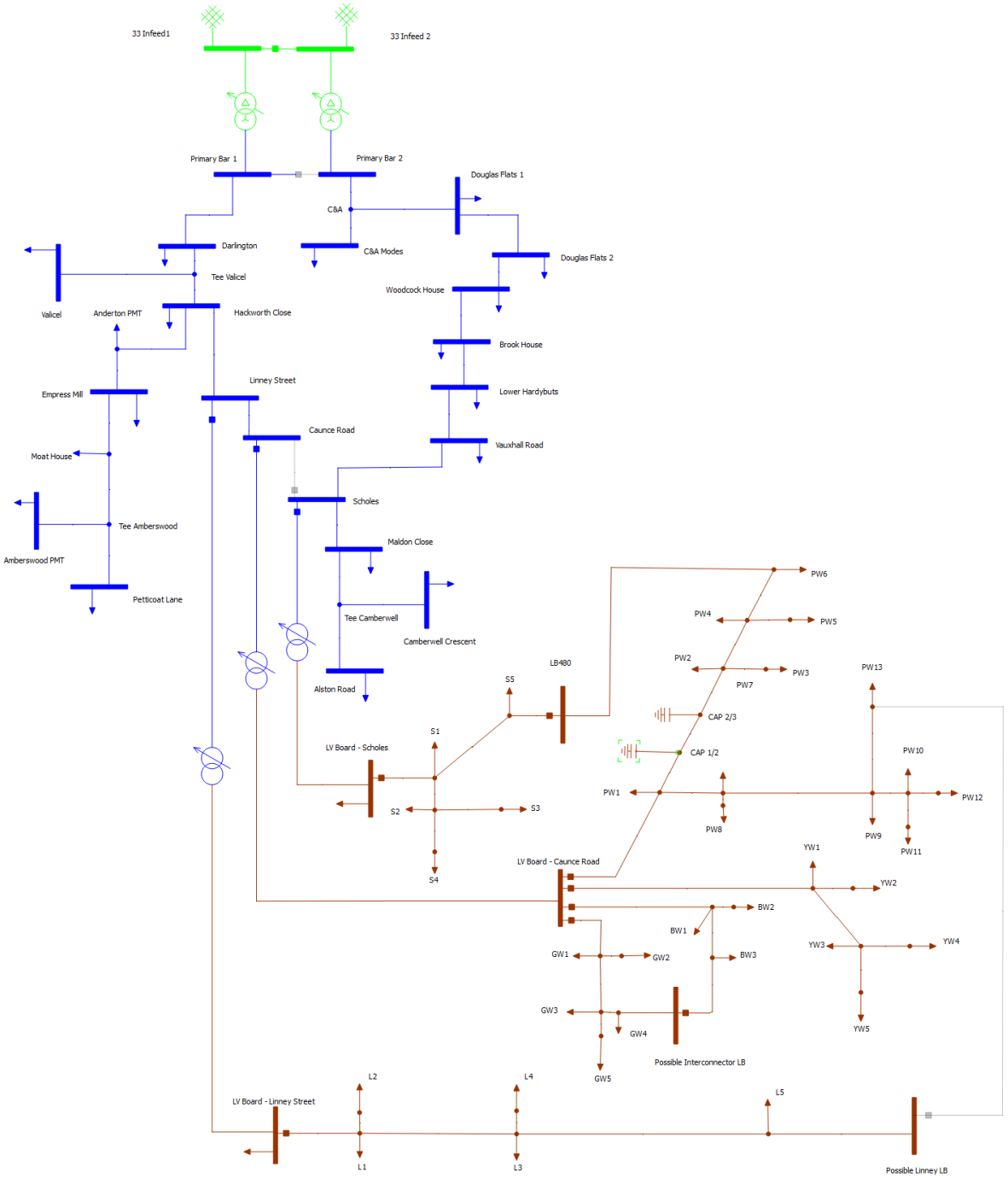


Figure 8 – Wigton Trial feeders customer type mix



APPENDIX B - IPSA TRIAL AREA SIMULATION MODEL

Green Street IPSA model



APPENDIX C – TRIAL AREA

Legend for Trial area tables

	Primary substation
	Distribution substation
	LV circuit

Table 4 – Denton East primary

DENTON EAST	CIRCULAR RD	LV Way 2 - Towards Pendle Road
		LV Way 4 - Standish Walk
		LV Way 5 - Towards Town Lane
	HODNET WALK	LV Way 1 - Towards Circular Rd
		LV Way 3 - Yew Tree Road
	KENNEDY WAY	LV Way 3 - Millbrook Ave & Ruskin Ave S/S
		LV Way 4 - Warren Close to Ruskin Ave S/S
		LV Way 5 - Tomcroft Lane to X851
	SCOTT RD	LV Way 2 - Scott Rd Nearside
		LV Way 3 - Stockport Rd Nearside to x865 & Stockport Rd Farside towards Stockport
		LV Way 4 - Wakeling Rd Farside to X866
		LV Way 5 - Wakeling Rd Nearside to X866
	TOWN LN (NO 52)	LV Way 2 - Town Lane to X643
		LV Way 3 - Town Lane to X471
		LV Way 4 - Acre St Near Side to Birch Grove S/S
		LV Way 5 - Longmeadow Grove
	VICTORIA ST (DENTON)	LV Way 1 - Victoria St x232
		LV Way 3 - Victoria St x132
	PENDLE RD	LV Way 3 - Pendle to Smith Street
		LV Way 4 - Pendle Rd to Stockport rd X952

Table 5 – Longsight primary

LONGSIGHT	BIRCH LN NURSING HOME	LV Way 3 - Nursing Home
		LV Way 4 - Grenville St
	BRYNTON RD (NO 70)	LV Way 2 - Brynton Rd BE
		LV Way 3 - Brynton Rd X48
		LV Way 4 - Birchfields Rd X705
		LV Way 3 - Brynton Rd North to X850
		LV Way 4 - Brynton Rd South to X48
		LV Way 5 - X705 Birchfields Rd
	DALTON ELLIS HALL ANSON RD	LV Way 2 - Farside Anson Rd
		LV Way 4 - Delta Box
		LV Way 5 - Walton Hall
	GREVILLE ST	LV Way 2 - Longford Place
		LV Way 3 - Tagore Close Nearside
		LV Way 4 - Tagore Close Farside & X6123
		LV Way 5 - Greton Close Nearside
		LV Way 6 - Greton Close Farside

Table 6 – Wigton primary

WIGTON	WESTERN BANK(WIGTON)	LV Way 2 - Green Acres LB R398
		LV Way 3 - Green Acres 6-18A, 18-36 61-67
		LV Way 4 - Green Acres 17-59 AND 82-92
		LV Way 5 - Longhead Farm
		LV Way 6 - LB Wampool Place
	WIZA CRES	LV Way 2 - Burnside Farside
		LV Way 3 - WaverLn/Burnside Nearside
		LV Way 4 - Park Rd Via Waver Ln
		LV Way 5 - Waver Ln/Wiza Ava/Throstle Ave
		LV Way 6 - LB R263 Throstle Ave direct
	EDEN CL	LV Way 3 - Industrial estate
		LV Way 5 - Box Wampool Place
		LV Way 6 - Ellen Close
		LV Way 7 - Wasdale and Langdale

Table 7 – Egremont primary

EGREMONT	ELECTRIC HS	LV Way 2 - Jordan Engineering
		LV Way 3 - North Rd
		LV Way 4 - Windrigg Cl
		LV Way 5 - Main St West
		LV Way 6 - Main St East
	FELL VIEW DR	LV Way 2 - Fell View Dr/ Queensgate
		LV Way 3 - Bookwell LB111
		LV Way 4 - Hagget end LB110
		LV Way 5 - Greendykes/Dale View Gardens
	SMITHFIELD	LV Way 2 - Greenmoor Rd LB105
		LV Way 3 - Copeland Ave Lb104
		LV Way 4 - Smithfield Rd / Howbank Rd
		LV Way 5 - Howbank Rd / Beach Ln
		LV Way 6 - Gillfoot Rd West
		LV Way 7 - Howbank Rd West
		LV Way 8 - The Crescent
	CROFT TERR	LV Way 2 - South St LB113
		LV Way 3 - Beck Green LB116
		LV Way 4 - Cross Side
	DRYDENWAY	LV Way 2 - Chaucer Ave
		LV Way 3 - Milton Place
		LV Way 4 - Keats Drive / Spencer Close to LB108
		LV Way 5 - Croadalla Ave / Coleridge Drive to LB107
		LV Way 6 - Dryden Way to Castlecroft
		LV Way 7 - Infants School
	SHAKESPEARE AVE	LV Way 2 - Shakespeare Ave Interconector Castle Croft SS
		LV Way 3 - Tennyson Dr /Shakespeare ave/ Croadella to LB107
		LV Way 4 - Southey Dr / Tennyson Dr to LB 108
		LV Way 5 - Southey Dr/Southey Walk/Orgill Junior School to LB
		LV Way 6 - Wordsworth Cl / Goldsmith Rd
		LV Way 7 - Shakespeare Ave/Wordsworth CL/Broadfield HSE/LB138
	BRIDGE END IND EST	LV Way 2 - Industrial Est South
		LV Way 3 - Industrial Est North
		LV Way 4 - Cringlewaithe SS

Table 8 – Hindley Green primary

HINDLEY GREEN	ASHBOURNE AVE	LV Way 2 - Claremont Ave (LB 581)
		LV Way 4 - Nearside Lancaster Rd LB598/599
		LV Way 5 - Farside Lancaster Rd LB598/599
		LV Way 6 - Ashbourne Ave Farside (LB576A)
		LV Way 7 - Ashbourne Ave Nearside (x7474)
	BORSDANE AVE	LV Way 2 - Rear of Shops to LB
		LV Way 3 - Borsdane Ave LB576
		LV Way 4 - Far Side Borsdane Ave
		LV Way 5 - Unit 1 + L/L
	BRIDGEWATER ST	LV Way 2 - Lancaster Rd (5c .1)
		LV Way 3 - Lancaster Rd / Lincoln Rd / New Flats Opp S/S
		LV Way 4 - Lancaster Rd to Bridge St & Bridgewater St (LB565/LB563)
		LV Way 5 - BridgeWater St Both Sides North (LB570)
		LV Way 6 - Castle Hill Rd Nearside to LB570
		LV Way 7 - Castle Hill Rd Farside to LB565
		LV Way 8 - Bell St to Glouster Cres (LB572)
	CASTLE HILL	LV Way 2 - Hindley Mill Lane (LB584)
		LV Way 3 - Castle Hill to LB 570 (B)
		LV Way 4 - Gloucester Cres to LB572
		LV Way 5 - Sandy Lane to LB577
		LV Way 6 - Castle Hill South to LB570 (D)
		LV Way 7 - Castle Hill North to LB585
	GIDLOW ST	LV Way 2 - Oldbridge Dr/Prodesse Ct
		LV Way 3 - Ladies Lane Evens South X7150
		LV Way 4 - Margret St/Deansgate
		LV Way 5 - Ladies Lane Evens North Lb551
		LV Way 6 - Ladies Ln LB550 & Lb 553
	GLOUCESTER CRES	LV Way 2 - Smithwood Ave & Dodhurst Rd
		LV Way 3 - Sandy Lane towards Castle Hill
		LV Way 4 - Sandy Lane towards Long Lane
		LV Way 5 - Gloucester Cres To LB572/LB575
		LV Way 6 - Worchester Ave
	VICARAGE	LV Way 2 - Atherton & George St
		LV Way 3 - Atherton Rd towards Platt Lane
		LV Way 4 - Wenlock St
		LV Way 5 - Atherton Rd (EvenNo's) To Dickenson St Sub
		LV Way 6 - Odd No's George St To Lb
		LV Way 7 - To Lord St LB
		LV Way 8 - Odd No's Park Rd To Lord St
		LV Way 9 - Park Rd Even No's
	VICTORIA FM	LV Way 2 - Atherton Rd Nearside Tee
		LV Way 3 - Atherton Rd Farside towards Atherton
		LV Way 4 - Atherton Rd (farside) To Hindley LB562
		LV Way 5 - Kenilworth Dr to LB564 & LB563A
		LV Way 6 - Askwith Rd To LB 456338
	WALMER RD	LV Way 2 - LB598 Broadway
		LV Way 3 - Brookdale Rd
		LV Way 4 - To LB580 Belmont Rd
		LV Way 5 - Bedford Gardens

Table 9 – Green Street primary

GREEN STREET	CAMBERWELL CRES	LV Way 2 - Nearside Camberwell Crescent North
		LV Way 3 - Farside Camberwell Crescent North & Link Box
		LV Way 4 - Farside Camberwell Crescent South & Link Box
		LV Way 5 - Nearside Camberwell Crescent South
	CAUNCE RD	LV Way 2 - Blocks 12/16 -20/22/23
		LV Way 3 - Blocks
		LV Way 4 - Blocks to LB480 Scholes Street (assumed)
		LV Way 5 - Blocks
	LINNEY ST	LV Way 2 - Scholes B2
		LV Way 3 - Scholes B2
		LV Way 4 - Linney St
		LV Way 5 - LB Schofield Ln
		LV Way 7 - Lorne St
	MALDON CL	LV Way 2 - Link Box Shildon Close
		LV Way 3 - Link Box Wilston Ave
		LV Way 4 - Link Box Camberwell Cres
		LV Way 5 - Link Box Bamford Dr
		LV Way 6 - New School
	MOAT HS ST	LV Way 2 - LB535 Manchester Rd
		LV Way 4 - Dobson Park Way
	PETTICOAT LN	LV Way 2 - Thirlmere Ave
		LV Way 3 - Link Box 528 Windermere Rd
		LV Way 4 - Link Box 526 Kendal Rd
		LV Way 5 - Coniston Ave/Derwent Ave
		LV Way 6 - Haweswater Ave
	VAUXHALL RD	LV Way 2 - Vauxhall Rd Flats
		LV Way 3 - LB480 Belvoir Court (Hackworth Cl (RR30))
		LV Way 5 - Shopping Precinct
		LV Way 6 - School
		LV Way 7 - Vauxhall Rd