1. SCOPE

This document details the SP Energy Networks approach to facilitate Independent Connection Providers (ICPs) determining Point of Connections (POCs) and self-approving the design of new networks for adoption by SP Distribution plc and SP Manweb plc for new and additional load to the network. It relates to Low Voltage and High Voltage networks.

2. ISSUE RECORD

This is a Controlled document. The current version is held on the EN Document Library.

It is your responsibility to ensure you work to the current version.

Issue Date	Issue No.	Author	Amendment Details
October 2015	1	A Scott A Peacock	Initial Issue
March 2016	2	Gary Barnes	Changes due to revision of the Code of Practice, including insertion of standard matrices. Amendment to Low Voltage Design Assessment Matrix
May 2020	3	Sofia Cobo de Guzman Stephen Jones	General review and update.
August 2024	4	Michael Burgan / Paul Dynes	General review and update.

3. ISSUE AUTHORITY

Author	Owner	Issue Authority
Michael Burgan Lead Design Engineer Network Planning & Regulation	Sofia Cobo de Guzman SPM Major Connections Manager	Kailash Singh Head of Distribution Network Connections  p.p. I Divers, Head of Distribution Networks Date:13/08/2024

4. REVIEW

This is a Controlled document and shall be reviewed as dictated by business / legislative change, but at a period of no greater than three years from the last issue date.

5. DISTRIBUTION

This document is part of the SP Distribution and SP Manweb System Design Virtual Manuals but does not have a maintained distribution list. It is also published on the SP Energy Networks website.

SP Distribution DOC-00-206
SP Manweb DOC-00-310

6. CONTENTS

7. DEFINITIONS AND ABBREVIATIONS

ADMD	After Diversity Maximum Demand
CDM	The Construction (Design and Management) Regulations 2015
Customer	The recipients of the power supply being a tenant or owner of a new building or premises
Developer	One who builds on land or alters the use of an existing building for some new purpose
DNO	Distribution Network Operator – Companies that own and operate electrical distribution network
GIS	Geographical Information System; SPEN IT mapping tool that provides geographical locations, sizes of underground cables, overhead lines and transformers and plant and ancillary apparatus details
GND	Geo schematic circuit diagrams for LV networks with open points indicated where available
High Voltage	6,000 Volts, 6,300 Volts, 6,600 Volts or 11000 Volts
ICP	Independent Connection Provider, a Company assessed and accredited through NERS to design and build electrical distribution networks
IDNO	Independent Distribution Network Operator
Interconnector	A cable that runs directly between two or more substations to provide interconnection to provide an alternative supply to a substation
Low Voltage	230V single-phase or 400V three-phase
N.E.R.S	National Electricity Registration Scheme, a scheme run by Lloyds Accreditation on behalf of UK DNOs to assess service providers who request and hold accreditation for contestable works associated with the design and installation of electrical connections
PME	Protective multiple earthing
Point of Connection (POC)	The physical connection between the extended network and the DNOs existing Distribution System
PowerOn	SP Energy Networks HV circuit schematic operational circuit diagrams
PTE	Pole mounted transformer
RAdAR	Register of Adopted Asset Requests system used for the Registration of Connection Enquiries and Management Process for Contestable Connection Projects
SPEN	SP Energy Networks, operator of network assets on behalf of the SP Distribution plc and SP Manweb plc

SP Distribution plc (SPD)	The Distribution Licence Holder for the Distribution Service area formerly known as ScottishPower
SP Manweb plc (SPM)	The Distribution Licence Holder for the Distribution Service area for Merseyside and North Wales formerly known as Manweb
The Company	A term used throughout this document to refer to both SP Distribution plc and SP Manweb plc including all associated design and planning practices
UMV	SPEN IT mapping tool that provides access to GIS, GND and PowerOn

8. RELATED DOCUMENTS

This document forms part of a suite of specifications and guidance relating to this subject including, but not limited to, the following:

a) Statutory Legislation

- Health and Safety at Work Act 1974
- Electricity Supply Quality Continuity Regulations 2002 and subsequent Amendments
- Electricity at Work Regulations 1989
- Management of Health and Safety Regulations 1999
- IEE Wiring Regulations (Latest Edition)
- Memorandum of guidance on the Electricity at Work Regulations
- Reporting of Injuries, Diseases, Dangerous Occurrences regulations 1995
- Construction (Health, Safety and Welfare) Regulations 1996
- Provision and Use of Work Equipment Regulations 1998
- Supply of Machinery (Safety) Regulations1992
- IEE Code of Practice on In-Service Inspection and Testing of Electrical Equipment
- The Construction (Design and Management) Regulations 2015
- New Roads and Street Works Act 1991
- HSE GS6 Avoiding danger from overhead power lines
- HSG47 Avoiding danger from underground services

b) British Standards

- BS 7671 Requirements for Electrical Installations – IEE Wiring Regulations
- BS 7430 Code of practice for Earthing

c) National Joint Utilities Group (NJUG) Publication

- Guidelines on the positioning and colour coding of Utilities' apparatus

d) Energy Networks Association (ENA) Documents

- Engineering Recommendation G81 – Framework for design and planning, materials specification and installation and record for low voltage housing development installations and associated new, HV / LV distribution substations
  - Part 1: Design and Planning
  - Part 2: Materials Specification
  - Part 3: Installation and Records
  - Part 4: Design and Planning
  - Part 5: Materials Specification
  - Part 6: Installation and Records
- Engineering Recommendation G12 (as amended): Requirements for the application of protective multiple earthing to low voltage networks
- Engineering Recommendation P2 (as amended): Security of Supply

- Engineering Recommendation P28 (as amended): Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom
- Engineering Recommendation P29 (as amended): Planning limits for voltage unbalance in the UK for 132kV and below
- Engineering Recommendation G5 (as amended) Planning Levels for Harmonic Voltage Distortion & the Connection of Non-Linear Equipment to Transmission Systems & Distribution Networks in the United Kingdom
- Engineering Recommendation ER G74 (as amended) Procedure to Meet the Requirements on IEC909 for the Calculation of Short-Circuit Currents in Three-Phase AC Power System
- Engineering Recommendation G88 (as amended) Principles For The Planning, Connection And Operation Of Electricity Distribution Networks At The Interface Between Distribution Network Operators (DNOs) And Independent Distribution Network Operators (IDNOs)
- Engineering Recommendation ER G99 Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019
- Engineering Recommendation ER G98 Requirements for the connection of fully type tested micro-generators (up to and including 16A per phase) in parallel with public low voltage distribution networks on or after 27 April 2019.
- Engineering Recommendation ER S34 (as amended). A guide to assessing the rise of earth potential at substation sites
- Competition in Connections Code of Practice

e) SP Energy Networks Policies:

- Materials Specification Framework for Low Voltage Housing Development Installations and Associated New HV/LV Distribution Substations (Ref: EPS-03-027)
- Installation and Record Framework for Low Voltage Housing Estate Developments, Underground Networks and Associated new HV/LV Distribution Substations (Ref: EPS-02-005)
- Secondary Substation Installation and Commissioning Specification (Ref: SUB-02-006)
- General Specification for the Civil Engineering and Building Design and Construction of Secondary Substations (SUB-03-017)
- Approved Equipment Register (available on SP Energy Networks website – https://www.spenergynetworks.co.uk/userfiles/file/Approved_Equipment_Register.xlsx)
- New Connections Independent Connection Provider (ICP) Approval Policy (ASSET-01-015)
- Framework for Design and Planning of LV Housing Developments, Including U/G Networks and Associated HV/LV S/S (Ref: ESDD-02-012)
- Equipment Ratings (Ref: ESDD-02-007)
- Calculation of System Fault Levels (Ref: ESDD-02-006)
- Overhead Line Protection and Switchgear Standard (Ref: ESDD-02-011)
- Low Voltage Earthing Policy and Application Guide. (EART-01-002)
- Low Voltage Connection Arrangements in Residential Developments (ESDD-02-003)
- Site Responsibility Agreement Template (CON-09-005)
- Sample of a Completed Site Responsibility Agreement (CON-09-006)

f) SP Energy Networks Operating Regime Document
- Safety Instruction-7, 'Addition to and Removal from the System'

g) SP Energy Networks Quality Document
- Recording of Electrical Assets by Contractors (Ref. BUPR-22-015)

h) SP Energy Networks Auditing Document
- Inspection and Monitoring of Networks Constructed by Independent Connection Providers (Ref: ASSET-04-020).

i) SP Energy Networks Completion Process
- Project Completion Process For Contestable Works (Ref: CON-04-006)

j) SP Energy Networks Associated RAdAR Processes
- Process for Contestable 132kV Connection Projects (Ref: CON-04-010)
- RAdAR Process for Contestable Connection Projects (Ref: CON-04-005)
- RAdAR Process for Self-Determined and Dual Offer Connection Projects (Ref: CON-04-009)

All designs must comply with both the requirements described within this document and those detailed above.

9. INTRODUCTION

This document sets out the principles and requirements to enable ICPs to self-determine POCs and self-Design Approval in accordance with Energy Networks Association Competition in Connections Code of Practice (as amended).

This document is aimed at organisations who have the appropriate Lloyds NERS Accreditation, and have staff competent in electrical distribution network design and a working knowledge of SPEN's collaborative IT system for ICPs, RAdAR.

- Our website provides guidance on access to and use of RAdAR, training can be provided for new users and contact details are available on our website.

  https://www.spenergynetworks.co.uk/pages/radar_training_materials.aspx

- Competency of staff to design and work on electrical networks is covered by the Regulation 16 of The Electricity at Work Regulations 1989 (Statutory Instruments, 1989, No. 635).

This document is structured as follows:

- **Section 10** reminds ICPs of their duty of care to both SPEN's assets and those who may come into contact with these assets or who may be affected by the acts or omissions of ICPs. This section also reminds ICPs of our underlying network principles.

- **Section 11** details our requirements for an ICP to attend an initial workshop with SPEN prior to starting self-determinations to ensure there is a full understanding of the information available and how to access it within the ICP organisation. Once attended, or subsequently undertaken a review of the "presentation pack" to ensure a full understanding of this document, ICPs can brief their own and any new staff on these details. Once started all ICPs will be subject to sample audits.

- **Section 12** details the checks to be followed to determine LV and HV POCs it also includes guidance to assess if going forward assets are in a suitable location with suitable access. There is a matrix for LV POCs which in certain circumstances reduces the volume of checks required. This section also details the information to be uploaded to RAdAR following the assessments. Please note this section is for guidance only does not inform how to complete the checks just what checks are required and the information to be shared in RAdAR as a result.

- **Section 13** provides guidance on the completion of Design Approvals and the preparation of the Construction and Adoption Agreement, Connection Agreement and Site Responsibility Agreements.

- **Section 14** summarises the information exchanges.

- The Appendices hold tables of equipment ratings and characteristic and examples of the format of information to be loaded into RAdAR.

This document is for guidance and will not cover every circumstance. When an ICP is in any doubt, they shall contact SPEN; it is in all parties' interest to get the correct solution first time.

SPEN will continue to provide, on request, an indicative Point of Connection onto the Company network based on the load information provided by an ICP, developer or other party carrying out the necessary system design to specify the lowest cost practical point(s) of connection to the existing distribution system. The Point of Connection will normally be either an existing low voltage cable, the outgoing fuseway(s) of an existing secondary substation or an existing high voltage cable (requiring a secondary substation) and/or existing extra high voltage cable (requiring a primary substation).

When requested to complete the point of connection determination, SPEN will design high voltage or high voltage / low voltage systems as appropriate and will advise:

(a) The characteristics of the high / low voltage system at the point(s) of connection.

(b) Any additional requirements for low voltage and high voltage Mains cables through the site and any diversionary works required to accommodate the site.

(c) Where appropriate and if provided with sufficient information, the type and approximate preferred location of substation(s).

DNOs have an obligation to design and extend the various networks to form a safe, reliable, economic, efficient, and coordinated system. These networks will operate with a high utilisation factor, low maintenance, and low losses, using standard equipment, voltages and phase relationships.

The use of standard equipment leads to reductions in operating costs, equipment stocks and strategic spares. Standardised equipment also leads to improvements in the levels of safety by reducing the range of equipment and consequential training needs for operational staff. New standard equipment will be engineered and implemented where it will have wide application and provide significant benefits such as lower cost, reduced losses or improved customer service.

10. GENERAL

The data and guidance contained within this document remains the property of SPEN and may not be used for purposes other than that for which it has been supplied and may not be reproduced either wholly or in part, in any way whatsoever, nor may it be used by, or its contents divulged to, any other person whosoever, without the prior written permission of SPEN.

This document applies to new installations and is not to be applied retrospectively.

SPEN reserves the right to change the data contained within this document without notification. Although specific network extensions will be designed by ICPs, SPEN retains the overall responsibility for the design of the distribution system and since the guidance cannot cover every eventuality, reserve the right to apply other criteria where necessary. SPEN accepts no responsibility for any inaccuracies in, or omissions from the document.

The ICP is responsible for ensuring they have all relevant information to undertake the design. Only ICPs possessing the appropriate licence, skills, training, and experience shall use the data and guidance contained within this document.

10.1 Duty of Care

ICP's have a duty of care to work with the developers to ensure that the developers and their contractors are fully aware of any risks on site. ICPs should advise developers of the process they need to follow to remove these risks and ensure a safe system of work is in place. For example:

- Recording the issue of any Health and Safety guidelines issued to the developer with regard to any DNO electrical plant or apparatus in the vicinity or on the site prior to works commencing.
- The removal of existing underground cables / overhead lines and substations from sites prior to the developer's work commencing in their vicinity.
- The removal of existing supplies to buildings and street furniture.
- Ensuring that one premise only has one electrical supply.

10.2 Security of Supply

The minimum design requirement will satisfy Engineering Recommendation P2 (as amended), comply with SPEN's policy as detailed in this document and will ensure the technical and performance characteristics of the existing network infrastructure are not compromised below SPEN' acceptable minimum standards. However, it should be noted that P2 applies to Demand Groups and not individual end customers so specific solutions may be offered to meet an individual customer's requirements.

The connection of a new or additional load must not adversely affect the performance of the existing network or the security of supply provided to existing customers to levels below SPEN minimum acceptable standards.

ICPs must ensure that customers are made aware of (and understand) all possible connection arrangements which can vary the level of supply security for specific connections.

Security of supply issues include the ability to restore the network following a fault, the continuity of supply as construction proceeds and continuity of supply during maintenance of the local network. This may be particularly relevant to larger developments, where the alternative means of supply may not be available until completion of the final phase of the development, some years ahead. Networks shall be designed to limit the number of customers affected by any fault and to facilitate the shortest restoration and repair times. Likewise, networks shall be designed to minimise system losses.

11. PRE START

11.1 Self-determinations of POCs

Only ICPs with appropriate National Electricity Registration Scheme (NERS) accreditation can consider self-assessment of POCs. Details of the scheme are available from Lloyds Register Energy at:

https://www.lrqa.com/en-gb/utilities/ners/

Prior to determining POCs in SPEN's distribution networks ICP staff should have attended the initial workshop session with SPEN, or subsequently undertaken a review of the "presentation pack" to ensure a full understanding of this document and are able to access and interpret the information available to them. The presentation pack is available on our website:

https://www.spenergynetworks.co.uk/pages/workshop_presentations.aspx

The following network information is available to ICPs.

- Access to Utility Map Viewer (UMV). Including PowerOn, GIS and GND is provided by following this link:

  https://www.spenergynetworks.co.uk/pages/utility_map_viewer.aspx

- UMV – This access provides geographical locations, sizes of underground cables, overhead lines and transformers, plant and ancillary apparatus details and schematic diagrams.

- The following paragraph applies to all SPEN's records

Information about apparatus given on the drawings produced by UMV is indicative only as the original depths and lines of cables and pipes may have been changed by persons unknown. Normally electricity cables are laid in trenches between 450mm and 1m deep, but cellars or structures such as bridges may prevent cables and pipes being laid at these standard depths. Also, the depth may be above or below the standard due to re-grading of the surface or other work after the cables are laid. Where known non-standard depths are indicated. Any interference with, or damage to, SPEN's apparatus may result in serious accident. Health and Safety Executive booklet HSG47 provides information on the avoidance of danger from underground services.

Authorities and contractors will be held liable both for the full cost of repairs to SPEN's apparatus and all claims made against SPEN Third parties as a result of interference or damage.

- GIS – This access provides geographical locations, sizes of underground cables, overhead lines and transformers, plant and ancillary apparatus details.

- GND – Geo schematic circuit diagrams for LV with open points indicated where available.

- PowerOn schematic operational circuit diagrams for HV.

- Primary Supply Point loading and capacities are available through SPEN's Long-term Development Statement.

  https://www.spenergynetworks.co.uk/pages/long_term_development_statement.aspx

- High Voltage Network loadings are available through SPEN's IT tools for both SPD and SPM. Until such time the information is available to ICPs through RAdAR or our website requests for this will need to be included when advising SPEN of the ICPs interest in a project. Details in Section 12.2.

- Ground Mounted Secondary Substation maximum demands are available on the HV/LV Transformer Loading database which is published on our website:

  https://www.spenergynetworks.co.uk/pages/transformer_loadings.aspx

  If you require further clarification this can be requested as detailed in Section 12.2.

11.2 Self-Assessed Design Approvals

Only ICPs with appropriate National Electricity Registration Scheme (NERS) accreditation can consider self-accreditation for Design. Details of the scheme are available from Lloyds Register Energy at:

https://www.lrqa.com/en-gb/utilities/ners/

Prior to assessing contestable designs in SPEN's distribution networks ICP staff should have attended the initial workshop session with SPEN, or subsequently undertaken a review of the "presentation pack" to ensure a full understanding of this document and are able to access and interpret the information available to them. The presentation pack is available on our website:

https://www.spenergynetworks.co.uk/pages/workshop_presentations.aspx

11.3 Probationary Periods

After the workshop for either POC or contestable design approval the ICP will enter into a probationary period for each category and licence area. This may be extended across both licence areas for the relevant category, subject to individual application, and may be limited to a certain network topology.

During this period SPEN will continue to progress in parallel and charge fees for POC assessment and Design Approval. If after five projects there are no issues identified SPEN will stop progressing either the POC or DA and will as a result not charge the ICP the relevant fees for future POCs or Design Approvals as appropriate.

ICP's can elect to enter another probationary period during which time SPEN can assist the ICP. SPEN will charge for POCs / Design Approvals during any probationary periods. The probation period and charges can be applied to individual projects or project types. Please see Appendix 1A.

11.4 Auditing

After the probationary period SPEN may sample audit self-determined POCs and self-assessed Design Approvals.

- Any and all issues identified will be raised with ICPs in the first instance who will be advised there are issues to address, all audit results will be shared with Lloyds.

- If safety or network security issues are identified or highlighted then work may be suspended on the project. In addition SPEN will consider progressing all pending and future POCs or DAs applying the standard fees pending the ICPs investigations and conclusion of appropriate remedial actions.

- SPEN reserve the right to return ICPs to the probationary level if common failures persist or issues are not addressed adequately.

12. SELF-DETERMINATION OF POINTS OF CONNECTION

12.1 Establishing the Customer's Requirements

Prior to assessing the existing network the ICP will need to establish some basic requirements for the proposed development / changes:

- Location of the site;
- Area of the development;
- What is the extent of the change of use of land;
- Proposed new layout of the site;
- Required new load;
- Will this load have potential special requirements: starting currents, harmonics etc.
- Will there be generation;
- Are there any proposed or known future phases;
- Are existing assets on the site which may require diversions as a result of:
  - change in land use;
  - the extent of the new structures / development / roads infringing SPEN's existing assets or access to existing assets; or
  - facilitating the works associated with the new development to be carried out safely.
- If the assets are supplying existing customers the ICP must identify whether:
  - these customers will be disconnected, following the appropriate industry protocols; or
  - how supplies to these customers will be maintained.

Once the accredited ICP has met with the customer, established the requirements as above and applied the appropriate diversity factors, the network can now be assessed.

12.2 Notice to Register a Point of Connection

Having identified the customer's requirements as detailed in 12.1 above the accredited ICP should make an initial assessment of the distribution network. The ENA Competition in Connections Code of Practice Section 4.5.4 states:

'Where the Accredited ICP elects to determine the Point of Connection it shall submit a notice (a Point of Connection notice) to register it with the DNO.

Before self-assessing a POC the ICP shall provide SPEN with the following information to enable SPEN to register the ICPs interest.

- The proposed Point of Connection (12 figure grid reference number) based on ICP initial high level assessment. (For example closest suitable cable to site).
- Associated high voltage circuit number for their proposed connection or secondary substation name.
- Highlight the presence of any embedded generation connections.
- The load and number of connections requested together with any disruptive load details.
- A polygon of the site.

- The ICP should highlight that if in the ICP's opinion there could be reinforcement or enabling work.

SPEN will use the above information to assess the POC request and advise the ICP of other factors (if known) which could materially affect the point of connection assessment process. These factors could include but are not limited to the following:

- Proposed or recent connections on the circuit which may affect the assessment;
- Proposed recent or connected generation connections that may be adversely affected by the ICP POC and / or circuit diversions assessment; or
- Plans to move or disconnect any of the existing assets in the vicinity.
- In SP Manweb confirm the operating voltage.

This information will be shared using SPEN's IT interface system for ICPs RAdAR. Section 14 has some more details however must be read in conjunction with our RAdAR processes which can be found at: https://www.spenergynetworks.co.uk/pages/documents.aspx

12.3 Establishing the Point of Connection

When assessing existing networks for a point of connection, for new or additional loads, there are some key principles that need to be adhered to.

- The DNOs are required to design, develop, maintain and operate an efficient, coordinated and economical system for the distribution of electricity.
- The addition of new load and / or connections to an existing network cannot adversely affect the quality of supply to existing customers.
- In addition to minimum obligations for example ENA P2 requirements for group demand DNO's have a number of other targets and obligations resulting from the Distribution License and Ofgem incentives and targets, therefore our network design requirements reflect these targets.

The point of connection for new or additional loads will normally be either an existing low voltage Main(s), the outgoing fuse way(s) of an existing secondary substation, an existing high voltage Main(s) (requiring a secondary substation), or an extension of existing high voltage switchboard (requiring a secondary substation).

12.4 Existing Low Voltage Point of Connections

Some Low Voltage points of connection can be determined using a Standard Design Matrix which can found on the SP Energy Networks website at

https://www.spenergynetworks.co.uk/pages/standard_design_matrix.aspx

The matrix contains details of connection scenarios where a full network modelling analysis may not be necessary. All other connection scenarios require full analysis.

12.4.1 Cable Type and Identification

For all new point of connections, the ICP will be required to record how the low voltage cable will be identified prior to jointing.

Options include:

- only cable in the vicinity;
- only waveform cable in the vicinity;
- track to expose an existing LV service joint; or
- requirement for operational support to identify the existing HV cable.

The designer will need to confirm the cable type using all the information sources on UMV and contact SPEN for further guidance. New connections cannot be taken from the following types of low voltage cables:

- Cable of imperial size less than 0.1 square inch;
- Cable of metric size <95mm^2;
- Concentric cables look for cables marked as 2 core with imperial sizes, TCLC (SPM TRCC), (triple concentric lead covered), marked as ex dc (direct current) cables;
- Three core LV cables – 2 phase and neutral;
- Cables indicated as operating (Bunched) – check the various layers available on UMV for PILC LV cables marked as 3;
- Belgium cables and Consac; and
- Interconnectors with no existing connected customers.

Please note with some cables we are unable to joint live.

12.4.2 Earthing Type

The Electricity Safety Quality and Continuity Regulations, regulation 24 (4) & (5) that:

- 'Unless he can reasonably conclude that it is inappropriate for reasons of safety a distributor shall, when providing a new connection at low voltage, make available his supply neutral conductor or, if appropriate, the protective conductor of his network for connection to the protective conductor of the consumer's installation.
- In this regulation the expression 'new connection' means the first electric line, or the replacement of an existing electric line, to one or more consumer's installations.'

The configuration and design of LV networks has changed over the years as have the requirements for the earthing on the network and in customers' installations. New LV networks shall be designed using Protective Multiple Earthing (PME), whereas extensions and additions to existing LV networks must take account of the existing network conditions and the customer connections.

The overriding consideration when planning or carrying out alterations must be the safety of customers and compliance with the requirements of the Electricity Safety Quality and Continuity Regulations (ESQCR). Replacement of service connections, cables or equipment on a 'like for like' basis without achieving compliance with the requirements of the ESQCR is not acceptable.

It is incumbent on the designer to assess the existing LV network to identify what earthing arrangements are available and for what purpose the new connections are to be used. If proposing a new connection from a low voltage overhead network it is recommended that a site survey be completed to determine the nature of existing earthing arrangements.

Please refer to the current document EART-01-002 Low Voltage Earthing Policy and Application Guide.

12.4.3 Volume of Customers

To assist in customer restoration during LV cable faults, a maximum of 75 Customers shall be connected to a radial LV feeder as per ESDD-02-012. LV feeders with a Customer count in excess of this shall be provided with a suitable alternative network source or backfeed. However, in some circumstances and where reasonably practicable SPEN can insist on a suitable backfeed for LV feeders with less than 75 Customers.

If the proposed new connections(s) take the volume of metered customer to 75 or above then an alternative network source shall be made available.

Note: The GIS system only shows known underground services it does not indicate where there are internal rising mains and services. A site survey will be required to confirm the building types and presence of internal mains.

12.4.4 Pole Mounted Transformer (PTE) Size

The following section details how the spare capacity for a ground-mounted substation may be assessed using the maximum demand readings. There are no maximum demand readings for pole mounted transformers (PTEs).

PTEs have been installed in a number of sizes, 5 kVA, 15kVA, 25 kVA single phase 50 kVA and 100 kVA single/ split phase, 50 kVA, 100 kVA and 200 kVA three phase.

The existing PTE will have been sized to accommodate the load it is supplying; a larger capacity PTE will not have been installed where a smaller one would have accommodated the load. On that basis if the new proposed load is greater than or equal half the PTE capacity the capacity of the transformer shall be increased. Care should be taken to identify whether there are existing generator connections present.

To assess the existing load please follow the guidelines in Section 12.4.6 below for building network models to assess capacity of LV networks, voltage drops, earth loop impedance and fault levels.

Take care and identify whether a PTE is a single, split or a three phase transformer. It is not uncommon to have 2 wire high voltage spurs feeding single or split phase transformers. When assessing networks for new / additional load where there are overhead line sections it is recommended that each section is checked and cross-referenced to an alternative source of information to confirm the size of conductor and number of wires. Further work is often required to ensure that the overhead line protection equipment is suitable for any increased capacities or load.

12.4.5 Ground Mounted Substation Capacity and Loading

Prior to connecting new or increased demands to a network, confirm that the existing transformer can accommodate the new demand. Subtract the existing maximum demand from the transformer nameplate rating; if the result is greater than the maximum new load, then the development can be accommodated.

The max demand readings provided by SPEN should be used cautiously. It is important to assess the readings and confirm whether or not they are consistent. If it is suspected that the readings are inconsistent, or conditions have changed, further checks and measurements will be required. Where there is any doubt, contact SPEN to arrange access to the substation so that the ICP can make their own assessment.

If the ICP has appropriate operational authorisations they can install measuring and recording devices to determine the actual feeder and Substation loads. Note, when assessing the results consider whether the demand could be seasonally affected.

If there are no maximum demands indications available each low voltage feeder can be assessed as detailed in Section 12.4.6 (below) and the aggregate used for load for the substation.

If adding more than 200 kW, or greater than half the transformer rating, the ICP shall assess the impact on the high voltage network.

12.4.6 Modelling a Low Voltage Network

Most new connections, and additional load to the LV network, will require a detailed model of the existing network to be constructed. The proposed new load is then added to the model. The outputs of the model will confirm whether the addition of the proposed new network maintains the quality of supply to all new and existing connected customers.

ICPs shall assess existing networks to build the models using appropriate tools. (Note: SPEN uses the ENA's Windebut (or similar) low voltage modelling package for this type of assessment.)

Appendix 2 of this document demonstrates how models shall be built. Appendix 3 demonstrates how to assess the maximum demand of existing commercial or industrial connections. If the usage and / or floor area of the existing commercial / industrial connection is not known, then 80% of service capacity should be used as the ADMD for the network modelling. Access to our UMV and GND system will provide low voltage circuit details an initial assessment of customer volumes. A site survey may be required to establish premises where internal mains could be present. The loading associated with each connection will also need to be assessed.

ESDD-02-012 'Framework for Design & Planning of LV Housing developments, including U/G networks and associated HV/LV substations' provides guidance on how to estimate ADMDs.

The settings and cable types used by SPEN are shown in Appendix 4.

Table 1, below, shows a mapping between the estimated ADMD and the units and load curves used in ENA's Windebut low voltage modelling package. Calculation of demand is determined by Windebut and is dependent upon the number of connections and the designer's estimate of annual unit consumption. The table indicates the classifications of properties and typical unit consumptions used by SPEN.

Having estimated the ADMDs the table shows a mapping to the customer types in Windebut plus the estimated annual consumption in units which are to be used in the modelling exercise for domestic premises. The table assumes gas central heating unless otherwise stated. It should be noted that more developments are utilising electric heating systems and care should be taken when determining heating loads of existing properties.

Care should be taken when identifying the load profiles to be used for commercial connections. If the precise use of the premises cannot be verified, then a point load for commercial premises shall be utilised. For example, some churches have successful case/restaurants operating during the week, so the load does not peak on Sundays.

It should be noted when modelling existing networks very few connections have a balanced load. Similarly when assessing existing networks it must be assumed all connected premises are in full use. For example a premise which is empty today could be fully operational when the proposed development is complete.

Table 1: ADMD to equivalent Windebut estimate curve and annual units.

	ADMDs (kW)		WINDEBUT curve / units		
Type	**Day**	**Night**	**Curve**	**Day**	**Night**
1/2 Bed Gas C/h	1.2	0.3	URLC	3500	0
3 Bed Gas C/h	1.5	0.3	URLC	4400	0
4 Bed Gas C/h	1.8	0.5	URMC	5800	0
5+ Bed Gas C/h	2.4	0.5	URHC	7500	0
1/2 Bed Other C/h	1.5	2	ESEVEN	3500	2000
3 Bed Other C/h	1.9	2.5	ESEVEN	4400	2500
4 Bed Other C/h	2.1	3	ESEVEN	5800	3000
5+ Bed Other C/h	3.1	3.5	ESEVEN	7500	3500
E7 1 Heater / W/h	2.2	5.13	ESEVEN	5500	5000
E7 2 Heater / W/h	2.5	7.56	ESEVEN	5700	7500
E7 3 Heater / W/h	2.8	9.99	ESEVEN	6000	10000
E7 4 Heater / W/h	3.4	12.42	ESEVEN	7500	12000
15kW Boiler	4.5	16.2	ESEVEN	10300	16000
19kW Boiler	5.7	19.8	ESEVEN	12000	18800

When designing a new low voltage network with generation connections, the voltage rise due to the generation must not result in the statutory LV voltage limit of 253V being exceeded at any points on the existing / new low voltage network. Consideration should also be given to the setting voltage on the 11kV network and the voltage rise across the existing HV/LV transformer.

The Electricity Supply Regulations require that the voltage at a customer's supply terminals shall be maintained within the range 216V to 253V. This is equivalent to: 230V +10%, -6%.

Low voltage networks with connections to networks operated by Independent Distribution Network Operators (IDNOs) have a declared voltage drop at their point of connection. The ICP shall contact the IDNO to establish their network parameters in order to ensure that the IDNO's connected customers are not adversely affected by any new connections or additional load to the DNOs network.

12.4.7 Presentation of 'Self-Determined' POC in RAdAR

A record of the assessments completed shall be uploaded to RAdAR. The records shall indicate the information and any assumptions used at each stage of the assessment and the outcome.

The information will be presented in a series of drawings showing the details assessed. With more complex proposals, the drawings should be accompanied by a technical report. The drawings should clearly indicate the following:

- **Cable Type and Identification**

A 1:500 or 1:1250 drawings identifying the POC. This should indicate how the cable will be identified. Drawings should be annotated with Danger HV cables in the vicinity if applicable.

- **Earthing Type**

The proposed earth type of the connection(s). A narrative should be included indicating how the earth type was identified.

- **Volume of Customer and Distance from Substation**

A 1:500 or a 1:1250, drawing as appropriate, which shows the volume of connected customers and the open points on the LV network. Annotated to indicate the proposed point of connection and distance to the substation and if modelling has been completed.

- **Substation Capacity and Loading**

The substation capacity and the maximum demand readings should be included.

- **PTE Size**

If from a PTE the transformer capacity should be detailed.

- **Modelling a Low Voltage Network**

The results from the modelling should be shown on 1:500 or 1:1250 drawings detailing the voltage drop / rise, fault current and earth loop impedance with and without the new load at the POC, at the end of the longest existing feeder and also at the end of any new network to be adopted. The node points for the model build and results of the model should be clearly annotated.

Network modelling is complex often with a number of assumptions and ADMDs included. In these cases a technical report should be prepared to record the detail.

It should be noted that these drawings will be used to assess the POC and will also be issued if SPEN staff are delivering non-contestable works. If there are HV cables in the vicinity of the project all drawing should be annotated 'Danger HV Cables'

Some examples have been included for guidance in Appendix 5.

12.5 Outgoing Fuse way of Existing Substation

Having assessed the network there will be occasions when the proposed new load cannot be accommodated from the existing low voltage network. In such cases it may be possible to provide the supply from an outgoing fuse way in a substation, if one is available. The ICP should contact SPEN, who will arrange access to the required substation.

If there are no spare ways available, or substation alterations are necessary, non-contestable enabling works or reinforcement works will be required. Please apply to SPEN for a Point of Connection Offer.

In all circumstances when assessing new or increased loads of 200kW or greater, the upstream High Voltage networks shall also be assessed.

12.6 Determining a High Voltage Point of Connection

Finding a suitable high voltage Point of Connection is an iterative process, normally starting with the closest HV asset. Assess the suitability of the asset, as detailed below, and continue with alternative Points of Connection until a suitable asset is confirmed.

The checks are categorised as follows:

- capacity of the assets;
- restoration of supplies in the event of an outage in line with ENA P2;
- quality of supply; and
- operational requirements.

The steps to assess the high voltage network are as follows.

Capacity
- Can the Primary Substation / Group accommodate the new load?
- Can the primary circuit accommodate the load?
- Does the new load cause fault level issues?

Security of Supply ENA EREC P2
- Can the new load (and associated group demand) be accommodated in an N-1 situation?
- Can the new load be accommodated without affecting ENA P2 – radial feeds?

Quality of Supply
- Does the new load cause quality of supply issues for example: voltage change, flicker; or harmonics?

Operational Considerations
- Could the new connection compromise existing circuit protection or automation?
- Can the equipment at the point of connection accommodate the connection of new assets?
- Could new connection assets over-complicate the Network?

In order to assess the HV network, a network model should be constructed, see Section 12.6.5.

12.6.1 Capacity

Primary substation capacities and maximum demands are published in SPEN's Long-term Development Statement. If the addition of the new proposed load takes the load of the substation to within 10% of the rated capacity please contact SPEN.

Circuit Cables have to be identified from UMV, and their capacities derived from SPEN's document ESDD-02-007 Equipment Ratings.

Cable circuits need to be de-rated if:

- Running for over 30m in ducts;
- Laid in cable tray or surface mounted; or
- Run in groups.

See ESDD-02-007 for further information on de-rating factors.

If the prospective POC cable conductor size is less than 0.1 square inch or 95mm^2 Aluminium please refer to SPEN for clarification.

Overhead line circuit types (3 phase or 2 phase lines) or conductor sizes are to be confirmed using at least two sources of information. For example network records and IT mapping tools, if the sources do not match it is highly recommended that a site visit and detailed survey is progressed before design work commences.

Please note overhead line circuit ratings, for the purposes of any connection, are based on the summer ratings detailed in SPEN's document ESDD-02-007 Equipment Ratings. This sets out the rating principles and methodologies applicable to standard system components.

Switchgear load current rating are specified in SPEN's document ESDD-02-007 Equipment Ratings. Please note the High Voltage schematic (PowerOn diagram) indicates circuit capacities. However, these are emergency ratings and are not to be used for design purposes.

Once the ICP has submitted a Notice to Register a Point of Connection, see Section 12.2, SPEN will provide details of the High Voltage circuit loading, for the requested circuits, where they are available.

The circuit loading readings are provided using CTs mounted on a single (yellow) phase at primary Substation circuit breaker panels. The values recorded are the maximum current in any half hour period flowing in either direction. Care should be taken in situations where generation is connected as the maximum demand could be that with the generation in operation however the network has to accommodate all connections whether the generation is operational or not.

The circuit loading details are the first step to the assessment. The designer needs to assess where there are connections not utilising their full capacity. For example a development not yet completed or fully occupied or a large customer maintaining an agreed capacity for future requirements.

If High Voltage circuit loading details are not available, the designer must add the transformer ratings and customer capacities and use 80% of the aggregate as the demand on the circuit. In addition the designer can also request access to the Primary Substations where the ammeter readings can be taken from the appropriate circuit breakers.

12.6.2 Security of Supply ENA EREC P2

ENA P2 states group demand over 1MW has to have an alternative switched network source. High voltage circuits are typically configured to run in rings either with an open point or no open points and utilising unit protection schemes. The alternative source(s) have to be assessed to ensure the circuit load including the new proposed load can be accommodated in the event of an outage on the circuit. The capacity of the alternative source(s) must be assessed as above.

High Voltage spurs can be used for up to 1MW of group demand. If the proposed new connection increases the load above 1MW an alternative high voltage source must be made available.

12.6.3 Quality of Supply

Voltage levels on the high voltage network are managed using automatic tap change equipment in Primary substations; there is off-line tap change equipment in most Secondary substations.

The introduction of large loads in circuits with high impedance (e.g. extensive circuits in rural areas), or any generation, can have an adverse effect on the voltage control and requires detailed modelling. In these situations an application for a Point of Connections offer should be made to SPEN using RAdAR.

Large motors and generators add to the fault level of a network. SPEN's Long-term Development Statement includes details of the calculated fault level, expressed in bandings for SP Manweb, and rating for each Primary Substation. Most high voltage switchgear on SPEN's network is rated to13,100Amps, 250MVA at 11kV and 150MVA at 6.6kV, however care must be taken in overhead networks as air breaks and other similar pole mounted equipment have lower fault level ratings. SPEN's document ESDD-02-007 'Equipment Ratings' provides the fault level ratings for equipment. SPEN's document ESDD-02-006 'Calculation of System fault Levels' provides guidance on assessing network fault levels.

Excessive distortion of the system voltage waveform, caused by certain types of load, may result in difficulties to users of the distribution system or damage to connected apparatus. The ICP shall ensure that the prospective POC ensures that customers' equipment will be able to meet the requirements detailed in the following documents: Engineering Recommendation P28 Planning Limits for Voltage Fluctuations caused by Industrial, Commercial and Industrial Equipment in the United Kingdom.

- Engineering Recommendation P29 Planning Limits for Voltage Unbalance in the United Kingdom
- Engineering Recommendation G5/4-1 Planning Levels for Harmonic Voltage Distortion the Connection of Non-Linear Equipment to Transmission Systems & Distribution Networks in the United Kingdom

Note: rural networks with a number of single-phase High Voltage spurs need careful consideration with respect to voltage unbalance (ER P29).

12.6.4 Operational Considerations

When determining potential POCs the following operational considerations shall be taken into account.

12.6.4.1 Circuit Protection and Automation

Overhead Lines are protected using auto re-closures and sectionalisers. In the event of a transient fault, the network the supply could be lost and re-energised up to four times in less than one minute.

Automatic load transfer schemes are designed to ensure that customers' supplies are quickly restored after a fault event. New connections may necessitate the re-design of automation points.

In SPD unit protected networks can be used for dedicated secure supplies to a customer. Typically, these circuits are not used for additional customer connections.

Both SPD and SPM have unit interconnected networks, which run with two or more sources utilising unit protection. Unit protected networks are identified in PowerOn by the type of switchgear and annotations. If, for the network being considered, the protection type is unclear, seek clarification from SPEN. Full network models shall be used to determine the POC in these instances.

If connecting to a High Voltage radial the ICP shall consider the magnetising inrush current of connected transformers. This may require changes to circuit protection and operational equipment to prevent inadvertent operations.

Ferroresonance (or non-linear resonance) occurs when a circuit containing a nonlinear inductance is fed from a source that has series capacitance, and the circuit is subjected to a disturbance such as single phase switching. It can cause over voltages and over current in an electrical power system and can impose an unnecessary risk to equipment and operational personnel. Guidance on protection systems for overhead live circuits is contained in ESDD-02-011 'Application of Overhead Line Switchgear and Protection Systems'.

12.6.4.2 Equipment at the point of connection

The Construction (Design and Management) Regulations 2015 places a duty on the designer to consider not only the construction of the assets but also the future operation, maintenance, replacement or demolition and how the risk of these activities can be minimised. In assessing a potential POC, designers shall comply with SPEN's specifications and consider future works utilising SPEN's standard working practices and methods. Bespoke configurations lead to a number of issues including:

- Extended repair under fault conditions;
- Extended outages;
- No standard working methods to operate, maintain or replace;
- No material to maintain or replace;
- No trained staff to operate the bespoke solution.

ICPs shall ensure SPEN's standard plant, equipment and network configurations can be utilised at the POC.

For example, overhead line poles can only accommodate a limited amount of equipment whilst enabling operatives to climb and work safely. Cable jointing should not be positioned where excavations could affect the foundations of adjacent structures or tree roots.

12.6.4.3 Complicating the Network

When determining a POC the designer should ensure that the network does not become more complex to operate and maintain. For example:

- Increasing the number of points of isolation;
- Increased fault restoration time.

External factors can or may have an influence on the choice of point of connection, for example the close proximity of other utilities.

12.6.5 High Voltage Network Modelling

A High Voltage network model will often be required to determine whether a proposed connection can be accommodated. Network models will always be required:

- For Interconnected unit protected networks for example the SPM 'X' type network or 'Y' type interconnected transformers, mesh networks. (There are interconnected unit protected networks in areas of SPD also);
- To determine if embedded generation can be connected; and
- Where disruptive loads for example high starting currents, are to be connected.

When creating system models it must be clear what type of connection is to be assessed as the parameters required for the model will be different. For example a new load connection must consider the maximum demand and zero embedded generation contribution on the network whereas a new generation connection the minimum load conditions and maximum generation loadings must be considered.

When modelling networks, the operation of the network has also to be considered. This allows the extent of the network model to be determined. For example the SPM 'X' type network operates with 3 to 5 single (7.5MVA to 10MVA) primary transformers in a Group. It is designed that in the event of a system fault and one of the transformers cannot supply the group the remainder can pick up the load. The Group will run with all breakers and switches closed, fully interconnected or mesh type network, meaning a model has to be established to determine the load flows associated with all the transformers and connected networks in the group. The most onerous fault condition then has to be modelled to ensure any prospective new load can be accommodated in accordance with ENA ER P2. Therefore the whole group needs to be modelled.

To build HV network models, the following details are required:

- Available on the SPEN Internet:

    - Generation heat maps and associated spreadsheets showing saturated circuits and constrained areas
    - Long-term Development Statement – Primary Substation Capacity / loadings and fault levels
    - Equipment ratings and electrical characteristics
    - Secondary substation loadings
- Available through UMV – GIS / GND / PowerOn
    - Cable and overhead line types, sizes, length and open points – GIS / GND / PowerOn
    - Secondary Substation transformer rating – GIS / GND
    - Volume and type of connected customers – GIS and online mapping tools
    - Network configuration – PowerOn
- Available through Other Factors on Notice of Interest
    - High voltage circuit loadings indicating minimum and maximum loadings
    - Primary substation high voltage busbar readings and settings
    - The Primary transformer automatic voltage regulator type see note below
    - Transformer tap changer reverse power restrictions
    - Maximum permitted voltage rise on the existing high voltage network
    - Accepted but not yet connected load and generation on relevant network

Automatic voltage regulators operate within a specified bandwidth which results in the busbar voltage exceeding the setting voltage target by the bandwidth prior to operation of the scheme to change (lower / raise) the voltage. This can result in higher / lower voltages to customers. The effect of this bandwidth shall be considered when modelling especially for HV customers. The bandwidth for schemes used in SPEN are:

Scheme Type	Bandwidth
micro tap	+/- 1.25%
super tap	+/- 1.25%
parallel auto	+/- 1.25%
master follower	+/- 2.5%

The model should enable the ICP to assess the network in detail for example considering but not limited to the following factors:

- Fault Levels, and the effects of generator fault current contribution (ER G74).
- Security of Supply to existing customers (ER P2).
- Voltage Fluctuations and unbalance (ER P28, P29).
- Voltage Rise (ESQCR).
- Harmonics (ER G5).
- Substation Rise of Earth Potential (ER S34).
- Protection Requirements – for example trapped load.
- Transformer's tap changer, reverse power restrictions.
- For interconnected/meshed substation groups, under normal or N-1 running conditions no transformer should exceed 500kVA of reverse running, even if the transformers are fully rated for reverse running.
- Thermal power flow limits of power system assets.

The above should assist both the POC to be determined and contribute to the connection design.

12.6.6 Presentation of the Self-Determined POC

The complexity of the project and the associated assessments will determine the volume and type of information presented, which includes:

- Technical Report indicating the extent of the studies and the size and type of load to be connected. Reference should be made to modelling, fault level calculations etc. as required.

- 1:500 GIS drawing showing the Point of Connection and showing the existing cable type and size or overhead line pole or proposed position of a new pole to be connected to and any stays required.
- 1:1250 or 1:2500 drawing indicating the circuit route and the alternative circuit route indicating de rated sections.
- For Overhead lines a 1:1250 or 1:2500 showing the relevant section of the existing network.
- Network Modelling Results. The parameters used to build the model must be clearly shown. This could involve a technical report to show the various parameters and explaining any assumptions made: for example how the minimum load was distributed for generation modelling. The outputs and results must be also be shown. These will vary depending on the type of connection the model is built for. For example:
    - A new load connection in the SPM 'X' type network the model must demonstrate ENA EREC P2 compliance for worst case fault scenario; or
    - For a generation connection the maximum voltage rise on the existing network and at the point of supply for the proposed new connection.
- PowerOn Diagram showing the point of connection. Annotated to the Diagram:
    - Primary Substation / Group capacity and loading;
    - Existing circuit capacity and loading;
    - Alternative circuit capacity and loadings;
    - Protection and automation arrangements on both circuits;
    - If a radial feed include transformer capacity and load details.

12.7 Existing Assets

When determining POCs and the effect of new developments on existing assets it is incumbent on the ICP designer to fully consider the requirements of the Construction (Design and Management) Regulations 2015. It is part of the Designer's / Principal Designer's duties to ensure that all risks during the construction and future operations, maintenance, replacement or demolition of the assets are eliminated by design or are reduced to a minimum.

This must include consideration of equipment and working methods readily available and used by SPEN to complete these works. For example the use of mini excavators requiring level hard standing access to excavate and expose cables for future works. The guidelines below are some examples of such requirements.

The designer must consider the nature and type of work and the access by staff to carry out future work. In addition what danger could these assets present to others in the future and changes in the use of the surrounding land as a result of the development. If as a result of the development any of the following requirements are unable to be met then the existing assets required to be re-sited.

If the following principles cannot be applied then provision must be made for the equipment to be re-sited. If in doubt, please contact SPEN.

12.7.1 Cables

- A suitable track (typically 2m wide) along the cable route, free from trees and bushes, ensuring SPEN can access the cables;. Cable routes should avoid existing trees or proposed landscaped areas.
- If adjacent to a wall or other high structure future excavations to access cables should not undermine or interfere with the stability of the adjacent structure.
- At a new development, cables should not be run under highways, unless for a highway crossing. Such crossings shall always be ducted, and spare ducts shall be provided in accordance with ESDD-02-012.
- A flat, 5m hard standing area, free from trees, bushes or other potential hazards / blockages. This area shall be directly adjacent to the 2m strip and enable safe access and egress for mini excavators and/or HGVs.
- A minimum of 5m wide access from a fully adopted highway to site must be available 24hours per day.

- Underground cables should be moved before any work on site that could compromise the existing cover commences, or if heavy plant could cross the route potentially damaging the cable.
- Any work adjacent to underground cables should be in line with HSG 47.

12.7.2 Overhead Lines

- No structure, building, garden or perimeter to be within falling distance plus 5m of a high voltage wooden pole overhead line.
- Access to pole mounted operational equipment, for example fuses, smart links, airbrake switches, re-closers, Soule switches etc., should be no further than 2 spans from a highway or 5m hard standing.
- A minimum of 5m wide access from a fully adopted highway to site must be available 24hours per day.
- Pole mounted transformers must have an accessible vehicular route (typically 5m wide) to an adopted highway, available 24hours per day.
- If any part of the development, or work to establish the development, infringes on overhead lines, the requirements of HSE Guidance Note GS 6 shall adhered to.
- Overhead lines should be moved before any work that might compromise the existing ground clearances.

12.7.3 Substations

- Substations should be at street level with 24 hour unobstructed access from a flat hard standing area directly adjacent to the substation. Vehicular access should be suitable for HGV to carry replacement equipment to the site and safely unload directly adjacent to the substation.
- A minimum of 5m wide access from a fully adopted highway to site must be available.
- A re-sited secondary substation should ideally be free standing, with a clear 1m area around the building and 2m in front of the door.
- Under no circumstances will substation doors be permitted to open directly into the carriageway. A re-sited substation should be set back so the doors do not open into a footpath utilised by pedestrians.
- If an existing substation is embedded in, or directly adjacent, to an existing building which is to be demolished the substation will need to be re-sited before the demolition starts.

12.7.4 Change of Use of Land

- All overload lines passing through a development area shall be diverted away from new structures or undergrounded as per section 12.7.1. For further information on proximity of overhead lines to structures please refer to HSE GS6 guidance.If the development has created land that could be used as recreational areas, ensure there are no SPEN assets in the vicinity.
- The location of pole-mounted equipment should consider the potential future use of the land at this location. An example would be pole-mounted equipment currently proposed at the edge of a development but becoming surrounded / enclosed by further phases, developments or change of use to public open space.

13. ICP 'SELF-ASSESSMENT' OF DESIGN

When an ICP submits a design for approval, SPEN will:

- Assess the design to ensure that it meets SPEN's requirements, including confirming that no circuit is de-rated or existing customers' security of supply is compromised;
- Create and issue for signature the Construction and Adoption Agreement;
- Create and issue for signature the Connection Agreement; and
- Create and issue for signature the Site Responsibility Agreement.

The sections below provide guidance for each of the above.

13.1 ICP Assess the Design to confirm it meets SPEN's requirements

In self-assessing the contestable design the ICP is confirming the proposal meets, as a minimum, the following:

- SPEN's specifications;
- the customers' requirements;
- good industry practice;
- CDM regulations (fully considered and implemented);
- surface types of cable and line routes minimise future access costs;
- Legal / land consents are feasible for asset locations and future access and operations

In approving the design, the ICP warrants that all requirements have been met and that the design is fit for purpose.

Any future issues requiring remedial works will be fully funded by the ICP.

Our design requirements and approved equipment details are published on our website.

https://www.spenergynetworks.co.uk/pages/documents.aspx

ICPs shall contact SPEN to seek clarification whenever they are uncertain about SPEN's requirements. They shall not make assumptions.

If information required by the ICP, to enable them to confirm that the proposed design meets SPEN's requirements, is not available, the ICP shall submit the design using the RAdAR processes for SPEN to approve.

13.2 ICP Construction and Adoption Agreement (C&AA)

Guidance on the completion of the Construction and Adoption Agreements is contained in our website through the link below.

https://www.spenergynetworks.co.uk/pages/construction_adoption_agreements.aspx

13.3 Connection Agreements

The Connection agreement templates are available on the SPEN's website.

https://www.spenergynetworks.co.uk/pages/connection_agreements.aspx

The ICP needs to add the site details and the details of who will be responsible for the connection. The published templates detail the information required.

There are ten Connection Agreement templates for each of SPD and SPM.

- four generation connections,
  - LV Generation (G99),
  - 11kV and above No Generation,
  - 11kV and above Generation No Export,
  - 11kV and above Generation Export
- three specific for IDNOs,
  - HV Close Coupled (11kV),
  - LV Link Box (230V/400V),
  - LV No Link Box (230V/400V)
- two for IDNOs or connected customers
  - LV Standard (230V/400V),
  - HV Standard (11kV)
- one for EHV Connections.
  - EHV (33kV)

The information required is detailed on the Template Agreements and summarised below. Guidance on how to complete the forms is provided during the initial workshop sessions.

- **SP reference number** – from RADAR (the number starting with N or S).
- **The Connected Customer Company House registered address and Company number**.
- **Site Name**.
- **Type of Connection**: Firm; automatic firm; alternative switched or single circuit Connection.
- **Details of Connection:** Brief Details of User's Distribution Networks, Location of Connection, Connection Reference Number(s), Exit Point, Location of Exit Point Metering Equipment, Voltage(s) of Delivery, Anticipated Volt Drop at the Point of Supply (POS), Voltage(s) of Metering, Commencement Date, Type of Connection, Maximum Fault Level (at the Point of Isolation), Earth Loop Impedance, Upstream Protective Device (and rating/setting), Method of Earthing Connection Charge.
- **User's Maximum Capacity** for both export and import and the ramp up arrangements for three years.
- **Drawings** one indicating the geographic point of supply and the other geographic boundary of the customers (IDNOs) network.
- A **diagram** showing the Connection Equipment and Control Boundary Appendix 6 contains typical examples.
- **Ownership and Responsibility of Buildings, Plant and Equipment Consents (Servitudes and Wayleaves)**.
- **Details of Distributed Generation Connected to User's Distribution System**.
- **Exclusion and Limitations of Liability for Distributed Generation Unavailability Payment**.
- **Contact Details** including: Control Room, Control Emergencies, Control/Planning Correspondence, operational Planning, No Supply, network operations and Maintenance, Operations and Maintenance, Distribution Use of System Billing.
- **Transformer test certificate(s)**.

A sample connection agreement completed for a close coupled substation at an IDNO boundary is available on the website:

http://www.spenergynetworks.co.uk/userfiles/file/Sample_connection_agreement_com-20-015.pdf

13.4 Site Responsibility Agreements

The site responsibility agreement is between the customer and SPEN and incorporates the following:

- The equipment at the interface of each network.
  For each item of equipment / plant at the interface details
  - Responsibility for each item of plant or equipment
  - The ownership for each item of plant or equipment
  - Whose safety rules are applicable
  - Who operates: opens, close, isolate or earth
  - Who maintains: Primary or protection equipment
  - Who is responsible for fault investigation: Primary or protection equipment, who recloses / re energise equipment
  - Who is responsible for testing : trip and alarm or primary equipment
- Responsibility maintain the building maintenance, safety and security
- Details of contacts for both parties
- Any access or operational requirements

This document is signed by SPEN and the Customer prior to energisation and a copy posted in the substation.

The template for the Site Responsibility Agreement (CON-09-005), and a sample completed Site Responsibility Agreement (CON-09-006) can both be found here:

https://www.spenergynetworks.co.uk/pages/documents.aspx

14. INFORMATION EXCHANGES

The Competition in Connections Code of Practice (Version 1.5, October 2019) sub-section 4.11.1 states the following:

The ICP and DNO shall each use their reasonable endeavours to exchange information required to determine the Point of Connection. The information from the ICP will be provided at the following stages:

- *Point of Connection Notice – when the ICP commences investigating a Point of Connection;*
- *Point of Connection Issue – when the ICP issues a quotation to a Customer; and*
- *Point of Connection Acceptance – when the Customer accepts the quotation issued by the ICP.*

14.1 ICP commences investigating a Point of Connection

To facilitate the flow of information SPEN and ICPs will utilise the IT web based collaboration system RAdAR. Appendix 7 shows a flow chart of the following processes, detailed guidance is contained in CON-04-009 Register of Adopted Asset Requests (RAdAR) Process for Self-Determined and Dual Offer Connection Projects.

The ICP will create a self-determination point of connection enquiry, which will include the details specified in Section 12.2 Notice to Register a Point of Connection as detailed in CON-04-009. The ICP will then request the other factors.

14.2 ICP issues a quotation to the Developer

The ICP will advise SPEN they have issued the offer in accordance with the details contained in CON-04-009 and by emailing the CIC Admin accounts.

Scotland: CiCAdminNorth@scottishpower.com

England and Wales CiCAdminSouth@scottishpower.com

The ICP should include the RAdAR reference and the designer who issued the 'Other factors' information.

14.3 Developer accepts the quotation issued by the ICP

The process now depends on whether the ICP is self-assessing the Design Approval or not.

14.3.1 If the ICP is not self-assessing the Design Approval

The ICP will upload to RAdAR the POC information specified in Section 12.4.7 (above) for LV POCs or Section 12.6.6 (above) for HV POCs.

The ICP will update RAdAR in accordance with CON-04-009 and e-mail CIC Admin to advise the documents have been uploaded, The RAdAR reference number and the name of the designer who issued the 'other factors' information shall be stated in the e-mail.

The e-mail and uploaded documents should clearly state what parts of the connection process the ICP shall progress themselves:

- Self-POC;
- Self-Design Approve; and
- Self-Connect.

On receipt of the email SPEN will assess the 'self-determined' point of connection, design prepare and issue an offer for acceptance and payment.

On receipt of the offer the ICP will also follow the established RAdAR processes until the project is completed.

14.3.2 ICP progress Self-Design Approval

The ICP will upload to RAdAR the POC information specified in Section 12.4.7 (above) LV POCs or Section 12.6.6 (above) for HV POCs.

Once they are available, the ICP shall upload the contestable design details, as specified in the RAdAR processes, and the following draft documents:

- Construction and Adoption Agreement;
- Connection Agreements (as required); and
- Site Responsibility Schedules
- Letter of authority from the developer confirming the appointment of the ICP. The letter should follow the below conditions
  - Signed by the developers authorised signatory on their letter headed paper
  - Dated within 3 months of of the acceptance
  - Should be specific to the project in question (i.e. not generic)

Contestable Design information must be submitted within four months of acknowledgement of POC in RAdAR.

If the ICP is not ready to share the Contestable Design information this can be progressed at a later stage.

The ICP shall update RAdAR in accordance with CON-04-009 and e-mail CIC Admin to advise that the documents have been uploaded. The e-mail and uploaded documents should clearly state whether the ICP proposes to complete their own closing joints to make the final connection.

On receipt of the RAdAR application and e-mail notification, SPEN will review the 'self-determined' point of connection and design, prepare and issue the offer for any associated SPEN costs for the provision of the connection.

The ICP shall then follow the established SPEN and RAdAR acceptance process to confirm acceptance and payment of the offer.

On receipt of the payment and providing the ICP has progressed the acceptance in RAdAR, as per the processes, SPEN will move the project to Design Approval.

The ICP can then upload the contestable design documents, if they have not already done so.
The ICP will create a design request in RAdAR. SPEN will accept the design request enabling the RAdAR process to progress in accordance with the established processes.

More detailed guidance is contained in our document CON-04-009 Register of Adopted Asset Requests (RAdAR) Process for Self-Determined and Dual Offer Connection Projects available on the internet.

https://www.spenergynetworks.co.uk/pages/documents.aspx

Applicants are required to accept their quotation within three months of the SPEN offer and upload their signed acceptance and proof of payment, through the RAdAR system. Upon the ICP accepting the SPEN offer they will have deemed to have entered into an agreement with SPEN.

Under the Design module within RAdAR, ICP's will have one month from the SPEN offer expiry date to submit their Design Approval documentation or Self-Approved Design documentation.
If this is not received within the required timescale, the Applicant (payee) will be issued a refund, minus any applicable fees and any other costs that SPEN have incurred. The quotation will then become expired and the Applicant will be required to submit a new Application if they wish to proceed further with the development.

Detailed in Paragraph 4 and 5 of the Construction and Adoption Agreements are defined timescales to complete the connection and the earliest date of energisation for those works.

APPENDIX 1A – SELF DETERMINATION AND ASSESSMENT QUALIFYING CRITERIA

Information on self-determination of points of connection and self-assessment of design approvals can be found at

https://www.spenergynetworks.co.uk/pages/self_determination_of_point_of_connection.aspx

https://www.spenergynetworks.co.uk/pages/self_design_approval.aspx

APPENDIX 1B – STANDARD DESIGN MATRIX

Details on the SP Energy Networks Standard Design Matrix can be found at

https://www.spenergynetworks.co.uk/pages/standard_design_matrix.aspx

APPENDIX 2 – GUIDE TO LOW VOLTAGE MODELLING

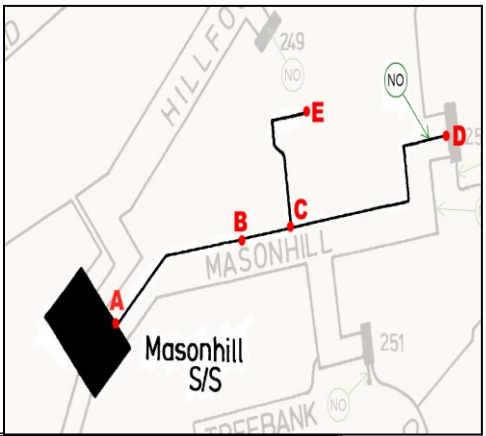
A2.1 Volt Drop Calculations

There are a variety of methods for calculating system voltage drops for a development. This ranges from hand calculations, spreadsheet analysis, voltage drop charts or specific computer analysis packages.

Whatever method is adopted for the actual calculation, the basic preparation and data gathering process and structure remains consistent. Fundamentally, the data structure identifies:

1. circuit lengths,
2. circuit size (and hence impedance),
3. distributed load (load spread evenly along the length of the section) and,
4. point load (loads which act on a single point on a distributor)

The following example provides an illustration of these fundamentals and data structure. The figure illustrates a section of an LV aluminium cable system supplying 52 customers, the ADMD per customer in this case being 3kW. Section A-B supplies 12 of these from a section of 185mm^2 aluminium distributor 110m in length. This is followed by section B-C which supplies no houses.



At point C the cable branches into a 180m section (C-D) of 95mm^2 aluminium distributor supplying 22 houses and an 80m section (C-E) of 95mm^2 aluminium distributor supplying 18 houses.

This can be summarised in a structured manner as follows:

Section	Distributed Houses	Terminal Houses	ADMD (kW)	Length (m)	Cable Size (mm^2)
A-B	12	40	3	110	185
B-C	0	40	3	45	185
C-D	22	0	3	180	95
C-E	18	0	3	80	95

The objective is to identify the overall voltage drops at points D and E.

A2.2 Simple Volt Drop Calculations

The voltage drop experienced over a known length of circuit is a function of load and circuit impedance, expressed as a percentage. For ease of calculation when not utilising computer-modelling packages, it is assumed that the loads are balanced over the three phases and that the demand is a point load at the circuit section end. Where demand is distributed along the circuit section, an equivalence end-point-load can be deduced or assumed.

The percentage voltage drop (%V_d) is given by:

Where:
P_L end-point-load (load on each phase, assuming perfect balance
V_L line voltage (i.e. phase-N voltage)
L circuit section length
Z circuit impedance (per standard unit of measure)

$$\%V_d = \frac{\left(P_L / V_L\right) \times L \times Z \times 100}{V_L}$$

Care should be taken to ensure that the units of measurement utilised are appropriate and consistent, e.g. the length of the circuit and the impedance values should be expressed to the same base unit of measure – impedance values are typically expressed on a per-km basis but LV cable lengths are likely to be expressed in metres.

An example calculation for a 10kW three-phase balanced load at the end of a 70m 0.1in^2 copper LV distributor (with electrical parameters of R=0.276 and X=0.0733 Ω/km) is as follows:

$$\%V_d = \frac{\left(10{,}000 / 230\right) \times 70 \times \sqrt{(0.000276)^2 + (0.0000733)^2} \times 100}{230} = 0.125959\%$$

A2.2.1 Spreadsheet Analysis

A spreadsheet model can be utilised which will enable rapid and interactive analysis of volt drop calculations using the above simple calculation methodology. Spreadsheet tools also reasonably simply enable assessment of unbalanced loads, distributed loads and the cumulative effect of node and branch loads on a network.

It is **essential** that any spreadsheet models are validated and have robust governance procedures to ensure that any studies and output are of a consistent quality and accuracy.

A2.2.2 Use of Voltage Drop Charts

For small schemes it may save time to use voltage drop charts rather than build a computer model to determine cable selection and voltage drop. For any length of distributor if the length in metres is known together with the number of distributed and terminal houses, the- voltage drop for any standard size of cable can be found. In preparing these charts, account was taken of the effects of unbalance and diversity between customers. The charts, therefore, give the unbalanced load voltage drop, i.e. the voltage drop in the most heavily loaded phase.

Starting on the "distributed houses" axis, proceed by successive (vertical and horizontal) intersections clockwise until the voltage drop for the chosen distributor size is obtained.

Voltage drop assessment for service cables utilising the chart method is simple and provides an acceptably accurate result. The intersection of a straight line between the appropriate chart values for ADMD and service length through the voltage drop axis provides a normalised percentage volt drop value for a nominal cable size and an assumed unity power factor. The nominal cable size for the single-phase chart is 25mm^2 (35mm) aluminium and 95mm^2 (185mm) aluminium for the three-phase chart. Voltage drops for other cable sizes are a function of their impedance relative to the nominal cable size.

It is important to note that the voltage drop charts assume an LV system operational voltage of 240/415 volts and therefore, when using a variety of tools, the overall voltage drop requires to be rationalised to a common base.

Scaled versions of the MV Distributor voltage drop charts follow as Figure 1 and Figure 2

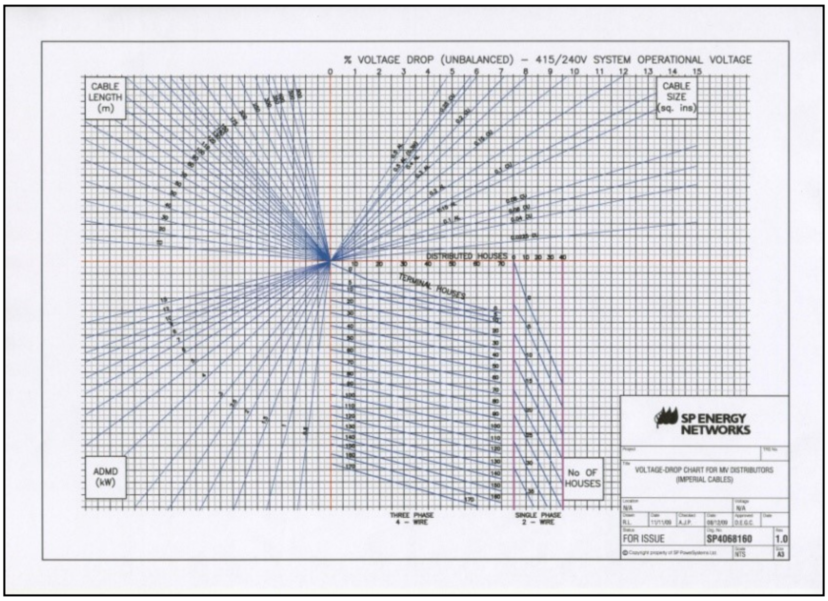


Figure 1: Imperial Cable MV Distributor volt drop chart

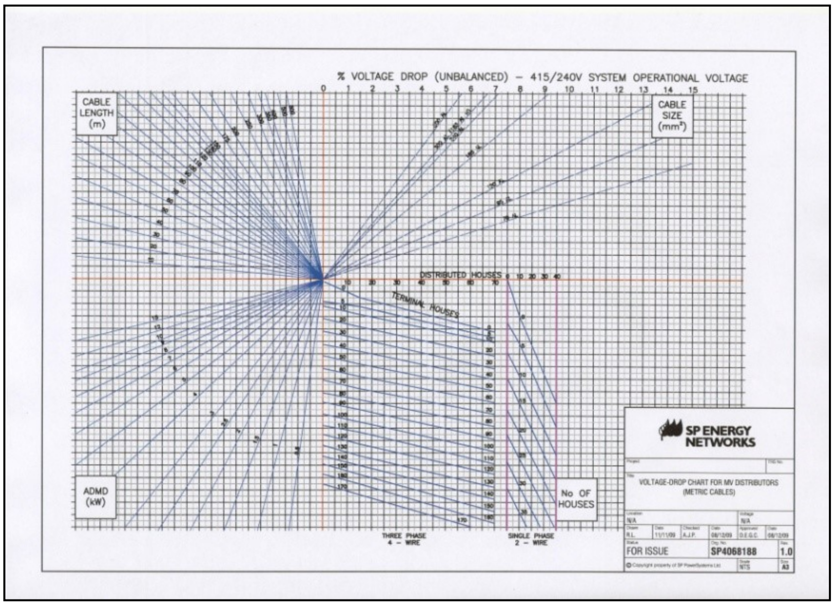


Figure 2: Metric Cable MV Distributor volt drop chart

A2.2.3 Use of Computer Model

Analytical packages vary in input and output. Input and execution of the analysis should be in accordance with the application guidance.

The voltage drop in three phase services and higher customer loads are best processed in this manner.

A2.2.4 Output Summary

Whichever methodology is applied, the following table demonstrates a typical output which extends the input data to show the method steps and final derived voltage drops.

Section	Distributed Houses	Terminal Houses	ADMD (kW)	Length (m)	Cable Size (mm^2)	Voltage Drop (%)
A-B	12	40	3	110	185	2.45
B-C	0	40	3	45	185	0.95
C-D	22	0	3	180	95	2.60
Node D						**6.00**
C-E	18	0	3	80	95	1.30
Node E						**4.70**

A2.3 Assessment of Voltage Rise & Network Impact from Micro-Generation

The connection of multiple exporting developments to an LV network can result in the voltages experienced at remote nodes on the system being higher than the source substation. Further generator acquisitions exacerbate the issue until, potentially, the voltage on the network exceeds statutory limits.

Micro-wind and micro-CHP will, in general, have a diversity across the users on the system and as a result are more likely to be constrained by the thermal rating of the system as opposed to any voltage rise issues. Photo-Voltaic (PV) generation on the other hand is likely to have a very low diversity (i.e. a cluster of domestic dwellings will have similar ambient light conditions and similar export potential) and therefore a number of units will be generating simultaneously with identical operating cycles. This reduced diversity may give rise to high voltage issues either on distributors or on the LV busbars of the source secondary substation.

Until more detailed data, evidence and conclusions are available from connected systems, as an initial rule of thumb:

- The aggregate PV capacity connected to a secondary transformer should not exceed 70% of the transformer capacity.
- When considering PV installations on an LV feeder, no diversity of operation should be considered and the maximum generation output of the units should be considered against a background of minimum demand. Analytical or mathematical modelling may be required to assess system and feeder voltage profiles.
- Services hosting micro-generation must be balanced across the phases. Failure to achieve a viable balance could result in significant neutral core loads, transformer winding overloads, equipment overheating and higher system losses. For installations being fitted to existing serviced premises, this may require physical work to identify and re-apportion phase connections.
- Further generation capacity may be acquired by lowering the transformer set voltage, provided that the voltages for the “no generation/max demand scenario” remain within statutory limits.

Conventional micro-wind and micro-CHP are likely to be reasonably benign in terms of harmonic distortion. PV however, by the nature of the technology and control systems, is anticipated to present some power quality issues. The draft IEC for the assessment of emission requirements for dispersed generating systems in LV networks suggests that switching frequencies in the range 2 kHz to 9 kHz have been observed. As these switching frequencies are not an integer multiple of 50Hz, they are unlikely to be measurable by harmonic analysers. Therefore, the fact that harmonic distortion may not be detected by harmonic analysers does not necessarily provide a problem-free installation from the supply network perspective. The switching frequencies can also still result in overheating in transformers and power supplies as well as failures of electronic control equipment and audible noise issues.

Figure 3 provides an indication of the waveform distortion possible from the connection of a high power PV inverter installation.

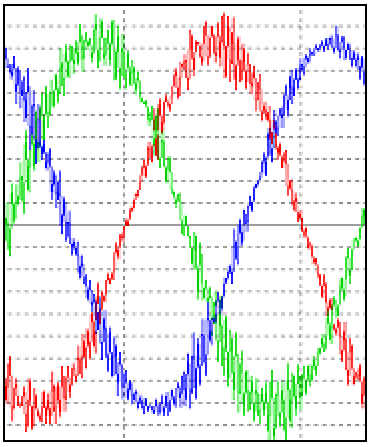


Figure 3: Detected waveform due to a high power PV inverter

APPENDIX 3 – DEMANDS FOR NON-DOMESTIC LOADS

Assessment of MDs for Industrial, Commercial, Retail & Office Units

Premises Type	Additional Premises Load	Size of Premises (Floor area m^2)	Generic Load Density Assessment (watts/square metre)
Individual Premises on an Industrial Estate	Standard lighting & heating, no heavy machinery	≤ $1,000m^2$	70
		> $1,000m^2$	40
Distribution Warehouse	Standard lighting & heating, no heavy machinery	≤ $1,000m^2$	70 See Note
		> $1,000m^2$	40 See Note
Office or Individual Premises on a Business Park	Standard lighting, office equipment. No air conditioning	≤ $1,000m^2$	140 See Note
		> $1,000m^2$	65 See Note
	Standard lighting, office equipment. Air conditioned	≤ $1,000m^2$	250 See Note
		> $1,000m^2$	110 See Note
Individual Premises on a Retail Park	Standard lighting, display lighting, office equipment. No air conditioning	≤ $1,000m^2$	200 See Note
		> $1,000m^2$	90 See Note
	Standard lighting, display lighting, office equipment. Air conditioned	≤ $1,000m^2$	500 See Note
		> $1,000m^2$	225 See Note
Individual Shops in a Precinct	Standard lighting, display lighting, office equipment. No air conditioning	≤ $1,000m^2$	175
		> $1,000m^2$	65
	Standard lighting, display lighting, office equipment. Air conditioned	≤ $1,000m^2$	300 See Note
		> $1,000m^2$	135 See Note
Restaurant	Standard lighting, equipment, climate control	≤ $1,000m^2$	90 See Note
		> $1,000m^2$	40 See Note
Hotel	Standard lighting, equipment, climate control	≤ $1,000m^2$	105 See Note
		> $1,000m^2$	50 See Note

Note: As an explanatory note for the data provided in the above table, it should be noted that, where indicated, the Generic Load Density Assessment data provided in the above table is to be considered indicative. This is due to the lack of in-area historical data and industry guidance and these will be updated over time as industry data emerges or following site-specific load assessment.

APPENDIX 4 – LOW VOLTAGE ASSET CHARACTERISTICS FOR MODELLING

			Operating Resistance		Fault Resistance		Fault Reactance	
CABLE TYPE	CABLE SIZE	RATING (AMPS)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)
CONSAC	70	185	0.443	0.386	0.551	0.48	0.0705	0.0315
CONSAC	95	220	0.32	0.31	0.398	0.386	0.069	0.028
CONSAC	120	250	0.253	0.242	0.315	0.301	0.0685	0.0265
CONSAC	185	320	0.164	0.164	0.205	0.205	0.0685	0.0235
CONSAC	240	370	0.125	0.125	0.157	0.157	0.068	0.026
CONSAC	300	420	0.1	0.1	0.126	0.126	0.0675	0.0245
CU	0.0225	100	1.26	1.257	1.553	1.553	0.086	0.086
CU	0.04	140	0.703	0.703	0.875	0.875	0.078	0.078
CU	0.05	160	0.583	0.544	0.68	0.68	0.076	0.078
CU	0.06	175	0.464	0.464	0.58	0.58	0.075	0.075
CU	0.1	240	0.276	0.276	0.339	0.339	0.073	0.073
CU	0.15	290	0.188	0.188	0.241	0.241	0.07	0.07
CU	0.2	345	0.142	0.142	0.186	0.186	0.069	0.069
CU	0.25	395	0.113	0.113	0.153	0.153	0.067	0.067
CU	0.3	445	0.092	0.142	0.131	0.186	0.067	0.067
CU	0.5	570	0.055	0.142	0.073	0.186	0.064	0.064
AL	0.06	135	0.767	0.767	0.952	0.952	0.075	0.075
AL	0.1	185	0.456	0.456	0.596	0.569	0.073	0.073
AL	0.15	225	0.312	0.312	0.394	0.394	0.07	0.07
AL	0.2	270	0.234	0.234	0.295	0.295	0.069	0.069
AL	0.25	310	0.187	0.187	0.241	0.241	0.068	0.068
AL	0.3	350	0.152	0.152	0.197	0.197	0.068	0.068
AL	0.5	450	0.092	0.152	0.12	0.197	0.067	0.067
AL	70	185	0.443	0.443	0.55	0.55	0.071	0.071
AL	95	225	0.32	0.32	0.398	0.398	0.07	0.07
AL	120	255	0.253	0.253	0.315	0.315	0.068	0.068
AL	185	330	0.164	0.164	0.205	0.205	0.068	0.068
AL	300	430	0.1	0.164	0.126	0.205	0.067	0.067
OCU	0.025	151	1.088	1.088	1.336	1.336	0.347	0.347
OCU	0.05	206	0.544	0.544	0.668	0.668	0.325	0.325
OCU	0.1	313	0.272	0.272	0.335	0.335	0.289	0.289
OCU	0.15	404	0.183	0.183	0.224	0.224	0.278	0.278
OCU	16	152	1.083	1.083	1.331	1.331	0.347	0.347
OCU	32	207	0.541	0.541	0.665	0.665	0.325	0.325
OCU	70	324	0.259	0.259	0.318	0.318	0.289	0.289
OCU	100	414	0.176	0.176	0.216	0.216	0.278	0.278
OAL	0.05	193	0.541	0.541	0.675	0.675	0.297	0.297
OAL	0.1	300	0.269	0.269	0.335	0.335	0.276	0.276
OAL	0.15	386	0.182	0.182	0.227	0.227	0.26	0.26
OAL	50	193	0.542	0.542	0.675	0.675	0.297	0.297
OAL	100	300	0.27	0.27	0.336	0.336	0.276	0.276
OAL	150	385	0.183	0.183	0.228	0.228	0.26	0.26
ABC	35	125	0.868	0.868	1.08	1.08	0.084	0.084
ABC	50	160	0.641	0.641	0.8	0.8	0.084	0.084

			Operating Resistance		Fault Resistance		Fault Reactance	
CABLE TYPE	CABLE SIZE	RATING (AMPS)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)
ABC	70	205	0.443	0.443	0.55	0.55	0.08	0.084
ABC	95	255	0.32	0.32	0.4	0.44	0.077	0.077
WAVE	70	205	0.443	0.386	0.551	0.48	0.0705	0.0315
WAVE	95	235	0.32	0.32	0.398	0.398	0.0735	0.0735
WAVE	120	300	0.32	0.31	0.398	0.386	0.069	0.028
WAVE	185	335	0.164	0.164	0.205	0.205	0.074	0.074
WAVE	300	435	0.1	0.164	0.126	0.126	0.0725	0.0725
WAVEF	95	270	0.32	0.16	0.398	0.1984	0.069	0.028
WAVEF	185	400	0.164	0.082	0.205	0.1017	0.0685	0.0236
WAVEF	240	486	0.125	0.071	0.126	0.088	0.0675	0.0245
WAVLS	95	235	0.32	0.32	0.398	0.398	0.0735	0.0735
WAVLS	185	335	0.164	0.164	0.205	0.205	0.074	0.074
WAVLS	300	435	0.1	0.164	0.126	0.126	0.0725	0.0725
WAVLSF	95	270	0.32	0.16	0.398	0.1984	0.069	0.028
WAVLSF	185	400	0.164	0.082	0.205	0.1017	0.0685	0.0236
WAVLSF	240	486	0.125	0.071	0.126	0.088	0.0675	0.0245
ACS	25	115	1.2	1.3	1.42	1.42	1.45	1.45
ACS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ACT	25	97	1.2	1.3	1.42	1.42	1.45	1.45
ACT	35	115	0.868	0.91	1.02	1.02	1.05	1.05
ASCS	25	115	1.2	1.3	1.42	1.42	1.45	1.45
ASCS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ASCT	25	97	1.2	1.3	1.42	1.42	1.45	1.45
ASCT	35	115	0.868	0.91	1.02	1.02	1.05	1.05
ACLSS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ACLST	35	115	0.868	0.91	1.02	1.02	1.05	1.05
ASCLSS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ASCLST	35	115	0.868	0.91	1.02	1.02	1.05	1.05
POC	300	539	0.1	0.1	0.126	0.126	0.0675	0.0245

			MINIMUM FAULT LEVELS (AMPS) for each fuse size						
Cable Type	Cable Size	Max Fuse Rating	100	200	250	300	315	400	500
CONSAC	70	500	200	250	500	700	750	1000	1450
CONSAC	95	500	200	250	500	700	750	1000	1450
CONSAC	120	500	200	250	500	700	750	1000	1450
CONSAC	185	500	200	250	500	700	750	1000	1450
CONSAC	240	500	200	250	500	700	750	1000	1450
CONSAC	300	500	200	250	500	700	750	1000	1450
CU	0.0225	100	200	250	500	900	1000	2500	4600
CU	0.04	200	200	250	500	700	750	1000	1450
CU	0.05	200	200	250	500	700	750	1000	1450
CU	0.06	200	200	250	500	700	750	1000	1450
CU	0.1	300	200	250	500	700	750	1000	1450
CU	0.15	300	200	250	500	700	750	1000	1450
CU	0.2	400	200	250	500	700	750	1000	1450
CU	0.25	400	200	250	500	700	750	1000	1450
CU	0.3	400	200	250	500	700	750	1000	1450
CU	0.5	400	200	250	500	700	750	1000	1450
AL	0.06	200	200	250	500	700	750	1000	1450
AL	0.1	200	200	250	500	700	750	1000	1450
AL	0.15	300	200	250	500	700	750	1000	1450
AL	0.2	300	200	250	500	700	750	1000	1450
AL	0.25	400	200	250	500	700	750	1000	1450
AL	0.3	400	600	700	950	1100	1200	1600	2100
AL	0.5	400	200	250	500	700	750	1000	1450
AL	70	200	200	250	500	700	750	1000	1450
AL	95	300	200	250	500	700	750	1000	1450
AL	120	300	200	250	500	700	750	1000	1450
AL	185	400	200	250	500	700	750	1000	1450
AL	300	400	200	250	500	700	750	1000	1450
OCU	0.025	100	200	250	500	900	1000	2500	4600
OCU	0.05	200	600	700	950	1100	1200	1600	2100
OCU	0.1	300	600	700	950	1100	1200	1600	2100
OCU	0.15	400	600	700	950	1100	1200	1600	2100
OCU	16	100	200	250	500	900	1000	2500	4600
OCU	32	200	200	250	500	700	750	1000	1450
OCU	70	300	200	250	500	700	750	1000	1450
OCU	100	400	200	250	500	700	750	1000	1450
OAL	0.05	200	200	250	500	700	750	1000	1450
OAL	0.1	300	200	250	500	700	750	1000	1450
OAL	0.15	400	200	250	500	700	750	1000	1450
OAL	50	200	200	250	500	700	750	1000	1450
OAL	100	300	200	250	500	700	750	1000	1450
OAL	150	400	200	250	500	700	750	1000	1450
ABC	35	200	200	250	500	900	1000	2500	4600
ABC	50	200	200	250	500	700	750	1000	1450
ABC	70	200	200	250	500	700	750	1000	1450
ABC	95	300	200	250	500	700	750	1000	1450
WAVE	70	315	600	700	950	1100	1200	2000	3500
WAVE	95	315	600	700	950	1100	1200	2000	3500

			MINIMUM FAULT LEVELS (AMPS) for each fuse size						
Cable Type	Cable Size	Max Fuse Rating	100	200	250	300	315	400	500
WAVE	120	315	600	700	950	1100	1200	2000	3500
WAVE	185	400	600	700	950	1100	1200	2000	3500
WAVE	300	400	600	700	950	1100	1200	2000	3500
WAVEF	95	315	600	700	950	1100	1200	1600	2300
WAVEF	185	400	600	700	950	1100	1200	1600	2100
WAVEF	240	400	600	700	950	1100	1200	1600	2100
WAVLS	95	315	600	700	950	1100	1200	1600	2100
WAVLS	185	400	600	700	950	1100	1200	1600	2100
WAVLS	300	400	600	700	950	1100	1200	1600	2100
WAVLSF	95	315	600	700	950	1100	1200	1600	2100
WAVLSF	185	400	600	700	950	1100	1200	1600	2100
WAVLSF	240	400	600	700	950	1100	1200	1600	2100
ACS	25	100	600	700	950	1100	1200	1600	2100
ACS	35	100	600	700	950	1100	1200	1600	2100
ACT	25	100	600	700	950	1100	1200	1600	2100
ACT	35	100	600	700	950	1100	1200	1600	2100
ASCS	25	100	600	700	950	1100	1200	1600	2100
ASCS	35	100	600	700	950	1100	1200	1600	2100
ASCT	25	100	600	700	950	1100	1200	1600	2100
ASCT	35	100	600	700	950	1100	1200	1600	2100
ACLSS	35	100	600	700	950	1100	1200	1600	2100
ACLST	35	100	600	700	950	1100	1200	1600	2100
ASCLSS	35	100	600	700	950	1100	1200	1600	2100
ASCLST	35	100	600	700	950	1100	1200	1600	2100
POC	300	300	600	700	950	1100	1200	2000	3500

Transformer Electrical Characteristics			
RATING	RESISTANCE	REACTANCE	MAX FUSE RATING
(KVA)	(OHMS)	(OHMS)	(AMPS)
1000	0.00219	0.00863	500
800	0.00291	0.0107	500
750	0.00371	0.01176	500
500	0.00509	0.0171	500
315	0.00901	0.0268	500
300	0.00948	0.0281	300
200	0.0158	0.0406	300
100	0.0225	0.0589	200
50	0.0321	0.089	200
25	0.0321	0.089	200
200	0.00429	0.00073	300
100	0.0147	0.00146	200
50	0.0364	0.00292	100
100	0.01547	0.00084	300
50	0.011	0.00169	200
25	0.02137	0.00337	100

Electrical Characteristics of Various Cable Types for LV network Modelling								
			Operating Resistance		Fault Resistance		Fault Reactance	
CABLE TYPE	CABLE SIZE	RATING (AMPS)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)
CONSAC	70	185	0.443	0.386	0.551	0.48	0.0705	0.0315
CONSAC	95	220	0.32	0.31	0.398	0.386	0.069	0.028
CONSAC	120	250	0.253	0.242	0.315	0.301	0.0685	0.0265
CONSAC	185	320	0.164	0.164	0.205	0.205	0.0685	0.0235
CONSAC	240	370	0.125	0.125	0.157	0.157	0.068	0.026
CONSAC	300	420	0.1	0.1	0.126	0.126	0.0675	0.0245
CU	0.0225	100	1.26	1.257	1.553	1.553	0.086	0.086
CU	0.04	140	0.703	0.703	0.875	0.875	0.078	0.078
CU	0.05	160	0.583	0.544	0.68	0.68	0.076	0.078
CU	0.06	175	0.464	0.464	0.58	0.58	0.075	0.075
CU	0.1	240	0.276	0.276	0.339	0.339	0.073	0.073
CU	0.15	290	0.188	0.188	0.241	0.241	0.07	0.07
CU	0.2	345	0.142	0.142	0.186	0.186	0.069	0.069
CU	0.25	395	0.113	0.113	0.153	0.153	0.067	0.067
CU	0.3	445	0.092	0.142	0.131	0.186	0.067	0.067
CU	0.5	570	0.055	0.142	0.073	0.186	0.064	0.064
AL	0.06	135	0.767	0.767	0.952	0.952	0.075	0.075
AL	0.1	185	0.456	0.456	0.596	0.569	0.073	0.073
AL	0.15	225	0.312	0.312	0.394	0.394	0.07	0.07
AL	0.2	270	0.234	0.234	0.295	0.295	0.069	0.069
AL	0.25	310	0.187	0.187	0.241	0.241	0.068	0.068
AL	0.3	350	0.152	0.152	0.197	0.197	0.068	0.068
AL	0.5	450	0.092	0.152	0.12	0.197	0.067	0.067
AL	70	185	0.443	0.443	0.55	0.55	0.071	0.071
AL	95	225	0.32	0.32	0.398	0.398	0.07	0.07
AL	120	255	0.253	0.253	0.315	0.315	0.068	0.068
AL	185	330	0.164	0.164	0.205	0.205	0.068	0.068
AL	300	430	0.1	0.164	0.126	0.205	0.067	0.067
OCU	0.025	151	1.088	1.088	1.336	1.336	0.347	0.347
OCU	0.05	206	0.544	0.544	0.668	0.668	0.325	0.325
OCU	0.1	313	0.272	0.272	0.335	0.335	0.289	0.289
OCU	0.15	404	0.183	0.183	0.224	0.224	0.278	0.278
OCU	16	152	1.083	1.083	1.331	1.331	0.347	0.347
OCU	32	207	0.541	0.541	0.665	0.665	0.325	0.325
OCU	70	324	0.259	0.259	0.318	0.318	0.289	0.289
OCU	100	414	0.176	0.176	0.216	0.216	0.278	0.278
OAL	0.05	193	0.541	0.541	0.675	0.675	0.297	0.297
OAL	0.1	300	0.269	0.269	0.335	0.335	0.276	0.276
OAL	0.15	386	0.182	0.182	0.227	0.227	0.26	0.26
OAL	50	193	0.542	0.542	0.675	0.675	0.297	0.297
OAL	100	300	0.27	0.27	0.336	0.336	0.276	0.276
OAL	150	385	0.183	0.183	0.228	0.228	0.26	0.26
ABC	35	125	0.868	0.868	1.08	1.08	0.084	0.084
ABC	50	160	0.641	0.641	0.8	0.8	0.084	0.084
ABC	70	205	0.443	0.443	0.55	0.55	0.08	0.084
ABC	95	255	0.32	0.32	0.4	0.44	0.077	0.077

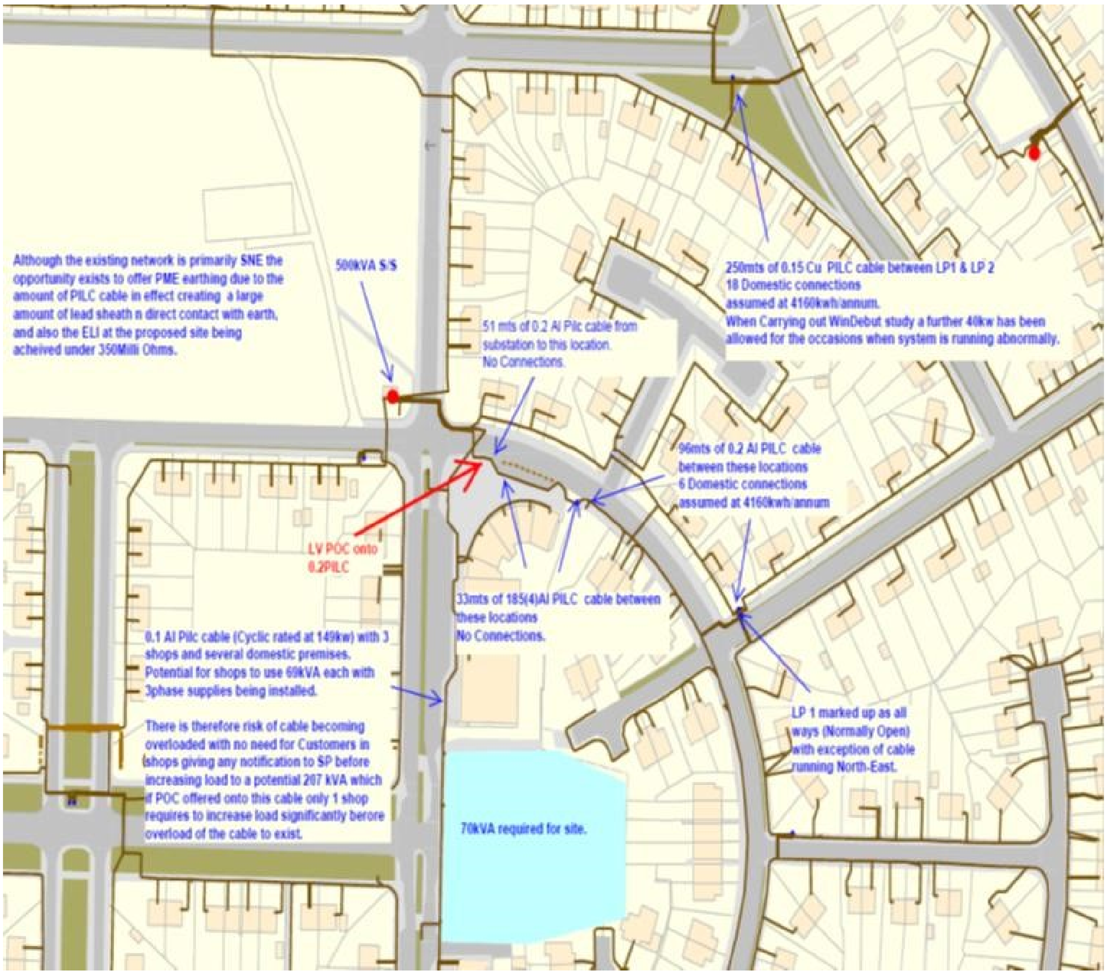
Electrical Characteristics of Various Cable Types for LV network Modelling								
			Operating Resistance		Fault Resistance		Fault Reactance	
CABLE TYPE	CABLE SIZE	RATING (AMPS)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)	Phase (MILLIOHMS/M)	Neutral (MILLIOHMS/M)
WAVE	70	205	0.443	0.386	0.551	0.48	0.0705	0.0315
WAVE	95	235	0.32	0.32	0.398	0.398	0.0735	0.0735
WAVE	120	300	0.32	0.31	0.398	0.386	0.069	0.028
WAVE	185	335	0.164	0.164	0.205	0.205	0.074	0.074
WAVE	300	435	0.1	0.164	0.126	0.126	0.0725	0.0725
WAVEF	95	270	0.32	0.16	0.398	0.1984	0.069	0.028
WAVEF	185	400	0.164	0.082	0.205	0.1017	0.0685	0.0236
WAVEF	240	486	0.125	0.071	0.126	0.088	0.0675	0.0245
WAVLS	95	235	0.32	0.32	0.398	0.398	0.0735	0.0735
WAVLS	185	335	0.164	0.164	0.205	0.205	0.074	0.074
WAVLS	300	435	0.1	0.164	0.126	0.126	0.0725	0.0725
WAVLSF	95	270	0.32	0.16	0.398	0.1984	0.069	0.028
WAVLSF	185	400	0.164	0.082	0.205	0.1017	0.0685	0.0236
WAVLSF	240	486	0.125	0.071	0.126	0.088	0.0675	0.0245
ACS	25	115	1.2	1.3	1.42	1.42	1.45	1.45
ACS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ACT	25	97	1.2	1.3	1.42	1.42	1.45	1.45
ACT	35	115	0.868	0.91	1.02	1.02	1.05	1.05
ASCS	25	115	1.2	1.3	1.42	1.42	1.45	1.45
ASCS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ASCT	25	97	1.2	1.3	1.42	1.42	1.45	1.45
ASCT	35	115	0.868	0.91	1.02	1.02	1.05	1.05
ACLSS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ACLST	35	115	0.868	0.91	1.02	1.02	1.05	1.05
ASCLSS	35	140	0.868	0.91	1.02	1.02	1.05	1.05
ASCLST	35	115	0.868	0.91	1.02	1.02	1.05	1.05
POC	300	539	0.1	0.1	0.126	0.126	0.0675	0.0245

Key:

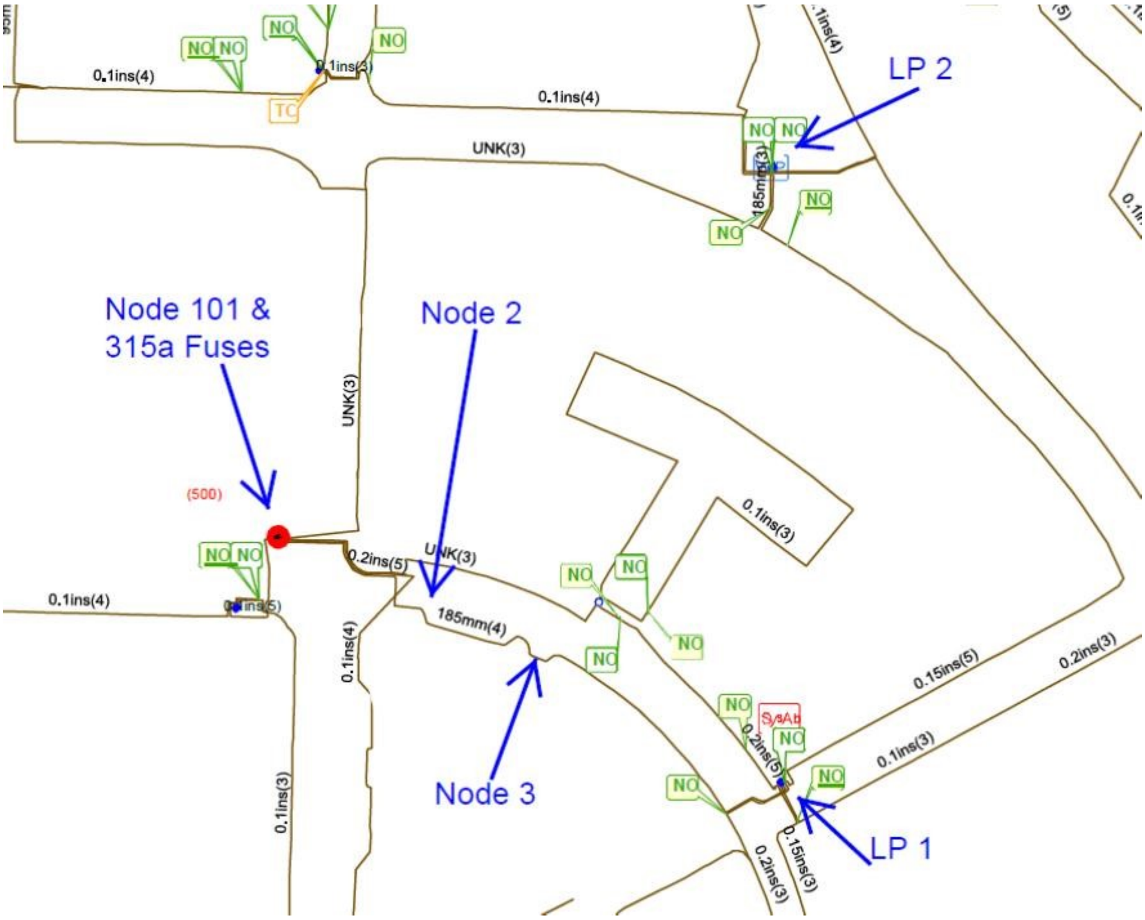
Cable Type	Description
CONSAC	impregnated paper-insulated cables with aluminium sheath/neutral conductor and three shaped aluminium phase conductors
CU	Copper
AL	Aluminium
OCU	Overhead Copper
OAL	Overhead Aluminium
ABC	Aerial bunched conductor
WAVE	3 Core Waveform
WAVEF	4 Core Waveform
WAVELS	LSOH 3 Core Waveform
WAVELSF	LSOH 4 Core Waveform
ACS	Single phase Aluminium service (CNE)
ACT	Three phase Aluminium service (CNE)
ASCS	Aluminium split concentric single phase service (SNE)
ASCT	Aluminium split concentric three phase service (SNE)
ACLSS	LSOH single phase Aluminium service (CNE)
ACLST	LSOH three phase Aluminium service (CNE)
ASCLSS	LSOH Aluminium split concentric single phase service (SNE)
ASCLST	LSOH Aluminium split concentric three phase service (SNE)
POC	Not used

APPENDIX 5 – EXAMPLES OF LV ASSESSMENT DETAILS

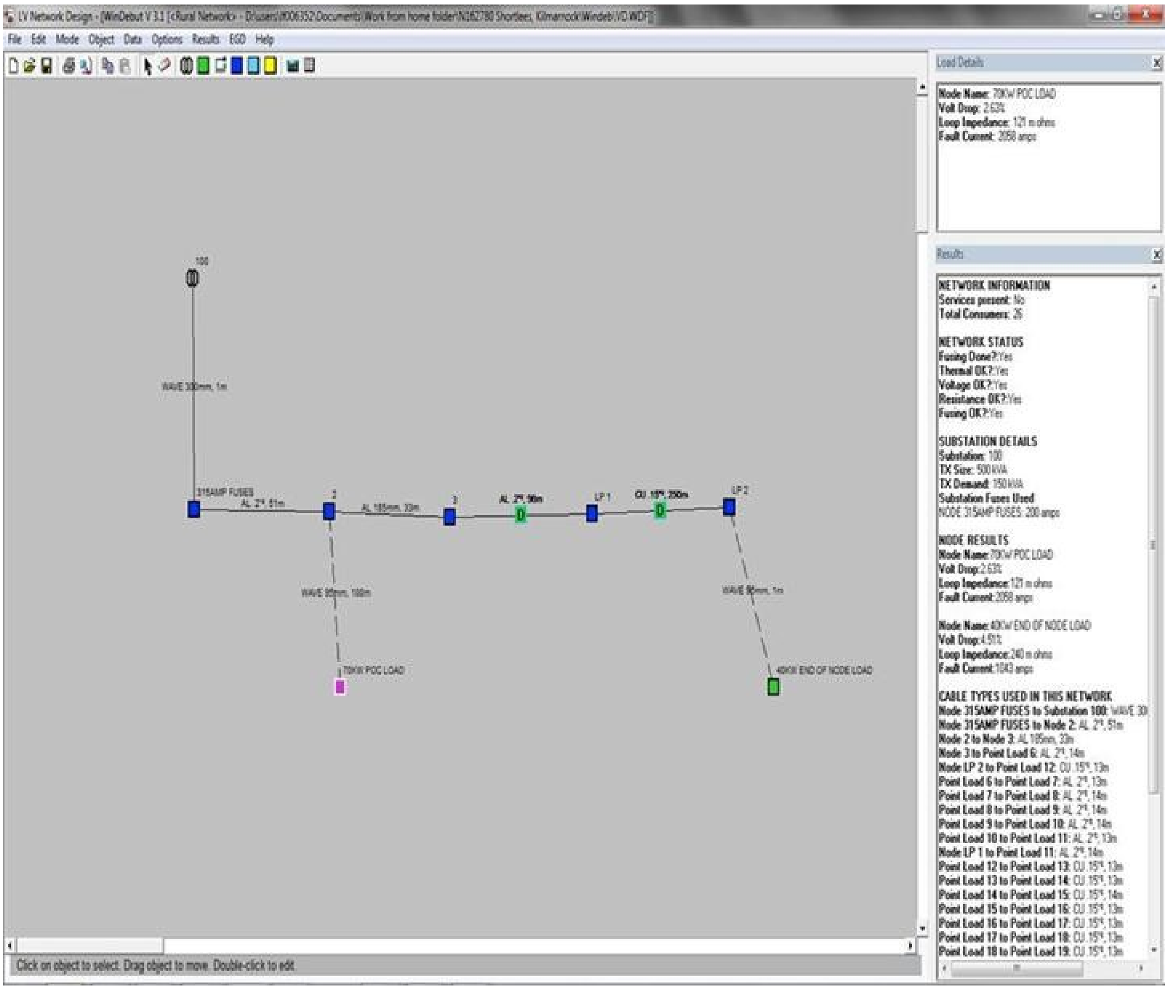
A UMV Drawing showing the POC and relevant sections of the Network



A GND Drawing showing the Node points for the low voltage Model



An ENA Low Voltage Modelling Windebut Results



APPENDIX 6 – STANDARD INTERFACE ARRANGEMENT DRAWINGS

A6.1 LV Interface Arrangements for an IDNO Network

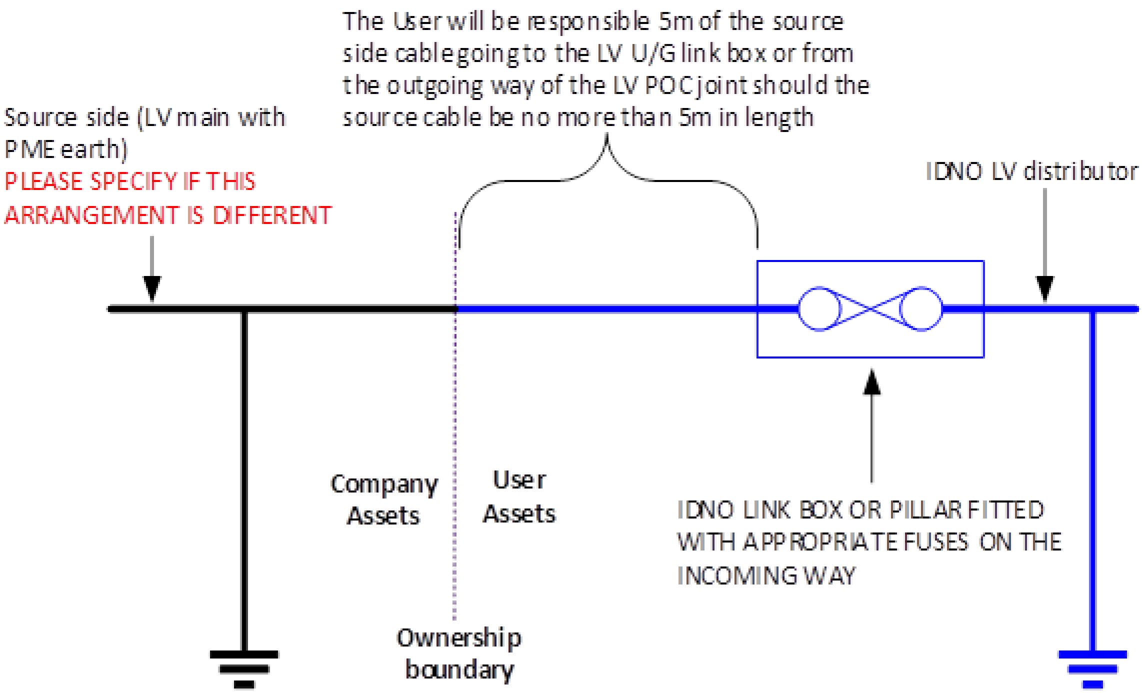


Figure 4: Interface arrangements for a Link Box / Feeder Pillar connecting IDNO network

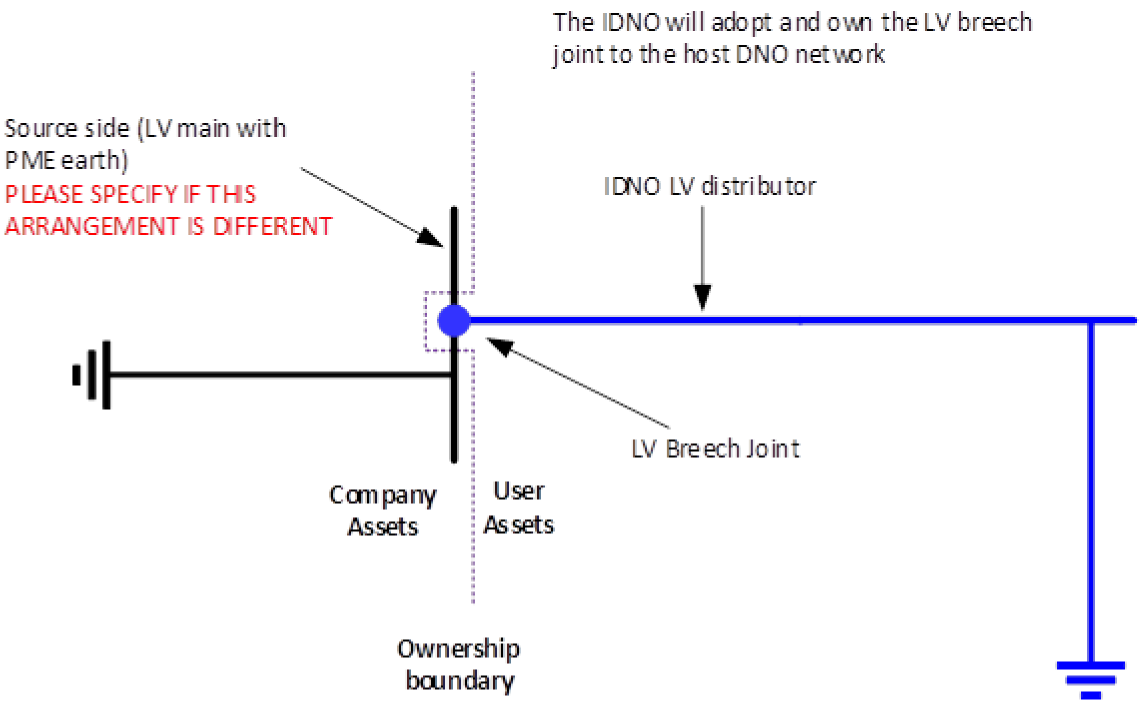


Figure 5: Interface arrangements for LV breech joint connecting IDNO network

A6.2 HV Interface Arrangements for an IDNO Network

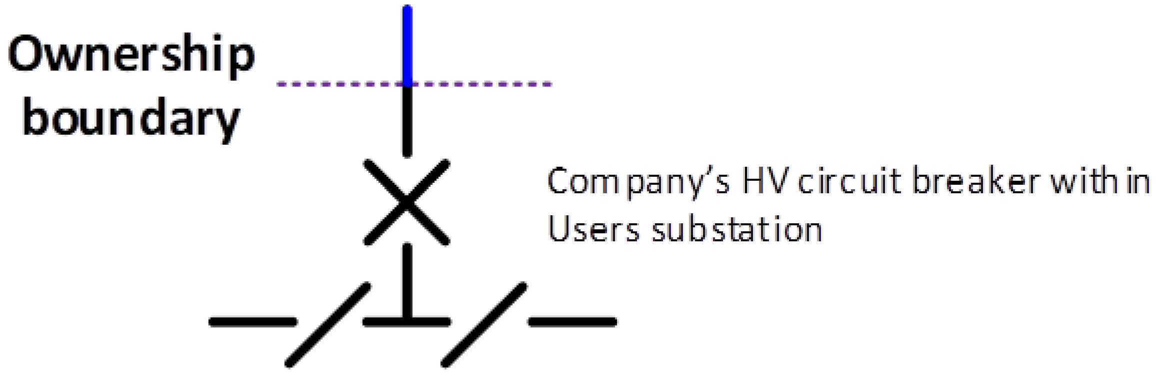


Figure 6: Interface arrangements for single substation interface

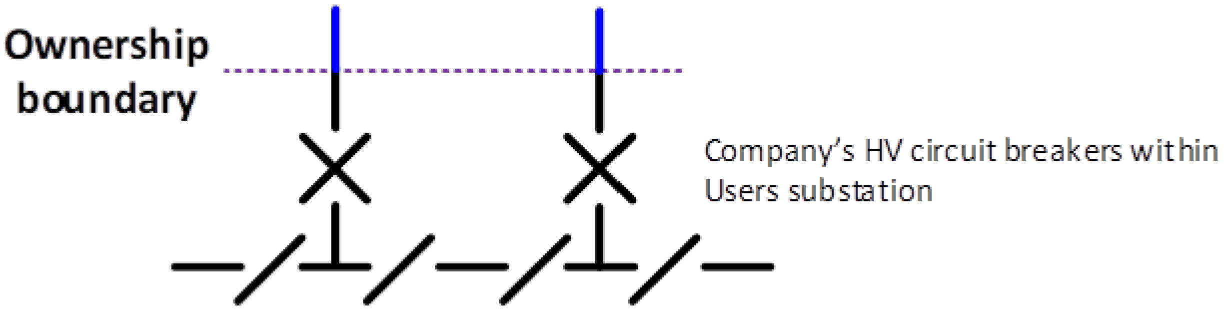


Figure 7: Interface arrangements for double substation interface

APPENDIX 7 – INFORMATION EXCHANGES FLOWCHART