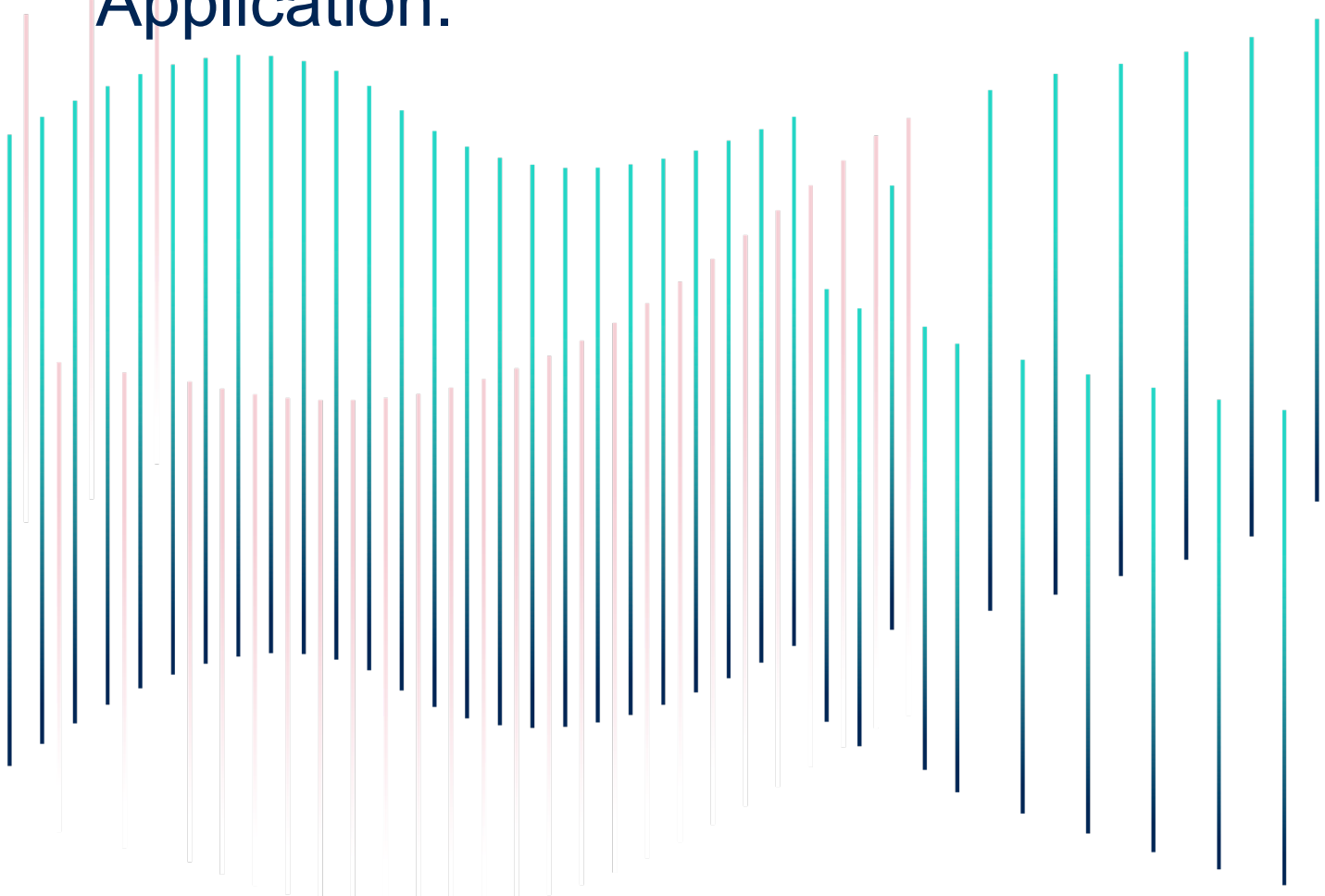




## Appendix to ENA Engineering Recommendation G81 Part 1 & 4

### New Electricity Connection or Modification of an Existing Connection Application.





## 1. Document Control

### Version:

| Ref | Author      | Date     | Reason          |
|-----|-------------|----------|-----------------|
| 1.0 | Yuan Zhuang | May 2025 | Initial release |

### Sign off:

| Role | Name          | Comments | Date |
|------|---------------|----------|------|
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### 3. Introduction

This document forms Aurora Utilities (AUL) Appendix to the Energy Networks Association (ENA) Engineering Recommendation G81 Part 1&4 - Design and planning for new housing development installations and commercial/industrial installations.

This document should be read in conjunction with ENA EREC G81 Parts 1 through 6 and provides specific information to be used in the design and planning of AUL IDNO network.

This document should be read in conjunction with the other AUL Design Policy and Standards and Health, Safety, Environment and Quality Policy and Standards.

The design philosophy of the network proposed by the ICP designer will be discussed and agreed with AUL in accordance with the design principles and documents and referred in the G81 documentation of the host DNO.

The details of the proposed design should be submitted to AUL for review and approval 10 working dates prior to ordering any materials and construction start.

Any technical queries regarding design should be address to AUL via Technical Queries for clarification for determination. AUL welcome suggestions to improve these design standards.

This document does not apply to generation connections onto AUL; generation connections should be designed in line with AUL document: **AUL\_DD\_Generation Connections**.

### 4. Glossary and abbreviations

|              |                                                                                                                                                                                                                                       |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>ACB</b>   | Air Circuit Breaker                                                                                                                                                                                                                   |
| <b>ADMD</b>  | After Diversity Maximum Demand                                                                                                                                                                                                        |
| <b>CDM</b>   | The Construction (Design and Management) Regulations 2015                                                                                                                                                                             |
| <b>CNE</b>   | Combined Neutral Earth                                                                                                                                                                                                                |
| <b>DNO</b>   | Distribution Network Operator                                                                                                                                                                                                         |
| <b>ESQCR</b> | Electricity Safety, Quality and Continuity Regulations 2002                                                                                                                                                                           |
| <b>EVCP</b>  | Electric Vehicle Charging Point                                                                                                                                                                                                       |
| <b>GRP</b>   | Glass Reinforced Plastic                                                                                                                                                                                                              |
| <b>HV</b>    | High Voltage. Any voltage exceeding LV (as defined by The Electricity Safety Quality and Continuity Regulations 2002). In the context of this document, HV refers to 20kV, 11kV, 6.6kV, 3kV and 2kV                                   |
| <b>IDNO</b>  | Independent Distribution Network Operator                                                                                                                                                                                             |
| <b>LV</b>    | Low Voltage. 'A voltage exceeding 50V (rms) measured between phases (or phase to earth) but not exceeding 1000V phase to phase or 600V phase to earth' (as defined by The Electricity Safety Quality and Continuity Regulations 2002) |



|                             |                                                                                                                                                                                                                 |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Mains</b>                | A low voltage underground cable or overhead line which connects a substation to either a pot-end earth, an overhead LV earth or to another substation                                                           |
| <b>MSDB</b>                 | Multi-Service Distribution Board                                                                                                                                                                                |
| <b>Ofgem</b>                | Office of Gas and Electricity Markets                                                                                                                                                                           |
| <b>PME</b>                  | Protective Multiple Earthing. A form of TN-C-S earthing.                                                                                                                                                        |
| <b>PNB</b>                  | Protective Neutral Bonding. PNB is similar to PME except the neutral conductor is only earthed at one point which is usually located closer to the customer than the transformer and often connected at cut-out |
| <b>POC</b>                  | Point of Connection                                                                                                                                                                                             |
| <b>Secondary Substation</b> | A substation with an operating voltage of 20kV, 11kV, 6.6kV, 3kV or 2kV and may include transformation to 400V. Also termed 'Distribution Substation'                                                           |
| <b>Service</b>              | A low voltage underground cable or overhead line, which connects a customer to a main or directly to a substation                                                                                               |
| <b>SNE</b>                  | Separate Neutral Earth                                                                                                                                                                                          |
| <b>Supply Terminals</b>     | Outgoing terminals of the cut-out, LV way or ACB which forms the ownership boundary with the customer                                                                                                           |
| <b>TT</b>                   | Terre Terre. A system in which earth function is provided by a local earth electrode provided by the customer                                                                                                   |
| <b>WinDEBUT</b>             | EA Technology LV network modelling software                                                                                                                                                                     |



## 5. Design approval

The network design proposed by the ICP should be discussed and agreed with AUL at the beginning of the design process. The design must be approved by AUL prior to the commencement of works on site. The network will only be adopted by AUL if they have been built to the agreed design and hand-over documentation has been issued to AUL by the ICP.

AUL will provide the ICP access to a SharePoint website that can be used to submit design documentation. Each design submission should be accompanied with a design transmittal; this should be a summary of:

- Name of documents/files submitted
- Version of documents/files submitted
- Summary of the contents of each document or file

Please allow 10 working days for design approvals and design variations.

In certain circumstances, ICP may self-approve their own designs, subject to agreement with AUL. This option is generally available to ICPs with a proven track record of delivering similar projects for AUL and where the same design concepts and materials are consistently applied.

Self-approval may be applied to both Low Voltage (LV) and High Voltage (HV) demand projects.

ICP is responsible for documenting the self-approval process using AUL's designated checklist. Full design documentation must still be formally submitted to AUL prior to the construction stage.



## 6. Design deliverables

An engineering report or equivalent should be submitted for design approval including the following points as minimum:

- Project details, including site address, DNO and AUL reference.
- Point of Connection (POC), including connection voltage and type of connection.
- Import and/or export capacity.
- Any details of disturbing loads.
- Material list including full specification of all equipment to be adopted by AUL.
- Metering type and location.
- Earthing report, including target impedance, step and touch potentials and any other considerations affecting the earthing installation and equipment in the vicinity. There should be clear indication where the site is “Hot” or “Cold”.
- Network analysis, including thermal, voltage and protection calculations.
- Power quality calculations demonstrating compliance with P28, P29 and G5, where appropriate.
- Design Risk Assessments (DRA).
- Health and Safety: HAZID & HAZOP.
- Environmental Impact and Compliance.
- Operation and Maintenance (O&M) Requirements.

Scaled General Arrangement drawing and Schematics including the following:

- Onsite/offsite site boundary and location plan.
- Most up to date site background.
- Cable cross sections for DNO/IDNO adoption.
- Substation locations and cable demarcation onto DNO and customer network.
- Network layout showing, cable routes, joint positions, cable sizes, link box positions, network termination point, meter positions, and/or any phase connections.
- Unmetered connections.
- Temporary building supplies.
- Any other equipment to be adopted by AUL.
- Single Line Diagram showing all network ownership boundaries and ACB/MCCB protection settings.
- Earthing details.
- Substation details including LV supply for substation lighting and small power.

All drawings should include a title block with the following essential information:

- Project name and description
- Drawing number and revision



- Date of issue and revision history
- Name and signature of the designer and/or approving authority
- Scale of the drawing
- The draughtsman's name or initials
- Site location or reference

AUL will accept partial submissions of the above requirements no later than 3 weeks before mobilisation and works commencing on site.

## 7. Applicable legislation and guidance

All designs and installations should be in accordance with the legislation and regulations applicable at the time.

The principal legislation, regulation and documentation are:

- The Electricity Act 1989 as amended by the Utilities Act 2000
- The Electricity Safety, Quality and Continuity Regulations 2002
- Construction (Design and Management) Regulations 2015
- Electricity at Work Regulations 1989

Ofgem approved documents:

- Standard Conditions of the Electricity Distribution Licence
- The Distribution Code (DCode) and therefore the ENA Engineering Recommendations, including:
  - EREC P2: Security of Supply
  - EREC P28: Planning limits for voltage fluctuations caused by industrial, commercial and domestic equipment in the United Kingdom
  - EREC P29: Planning limits for voltage unbalance in the United Kingdom for 132kV and below
  - EREC G5: Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom
  - EREC G12: Requirements for the application of protective multiple earthing to low voltage networks
  - EREC G87: Guidelines for the provision of low voltage connections to multiple occupancy buildings

The requirements of all documents described in this appendix should be met including the ENA G81 suite of documents, including the legislation and industry standards referred and the Independent Networks Association (INA) design standards.

The network design and cable laying practices should comply with the New Roads and Street Works Act (NRSWA) and the National Joint Utilities Group Guidelines (NJUG) on the positioning and colour coding of utilities.



## 8. Network design principles.

**Quality** - Maintaining and enhancing the quality of both the built and natural environments is important to all of us. These design principles aim to meet these aspirations by promoting the highest possible standards in the design of developments.

**Safety** - Ensuring AUL assets are designed, constructed, operated and maintained to standards that promote good safety performance through the life of the asset and when decommissioned.

**Flexibility** - AUL can offer a degree of flexibility to accommodate the end user needs when specific network requirements are needed. Any specific requirements deviating from the standards or specifications shall be discussed and approved by with AUL at the design stage.

**Adaptability** - The design should provide a level of flexibility to allow for future expansion of the network such that this causes minimal disruption to the operation of the plant and facilities.

**Environmental** - The UK aims to decarbonize all electricity generation by 2035. The goal of the design should be minimizing the carbon intensity by integrating low-carbon technologies, to help achieving a fossil-free future within a generation.

**Economic** - The design should aim minimising unnecessary costs during construction but at the same time developing a cost-efficient design to minimise the cost during the operation of the network.

## 9. Design and planning network design

### 9.1 HV network design

The high voltage network shall utilise the standard design of overhead line or type of underground cable and conductor sizes employed by the host DNO. The interface between host DNO and AUL network should, where possible, follow EREC G88 requirements; when G88 does not clearly apply, the designer should discuss possible HV designs with AUL. The designer should ensure that the interface point allows for adequate security of supply for EREC P2 requirements.

### 9.2 Distribution Transformers

Standard Transformer sizes that are accepted include 500kVA; 800kVA; 1000kVA. All transformers will be Eco Loss (Tier 2). Transformers above 1000kVA can be used to supply single commercial/industrial connections subject to the client accepting that the arrangement will not comply with EREC P2.

Padmount transformers use will be restricted to temporary connections, pumping stations and street lighting installations.

Transformers filled with MIDEI 7131 should be used in situations where transformers are contained within buildings which require higher level of safety.

Anti-vibration pads shall be provided for all transformers.



### 9.3 Cables and ducting requirements

AUL will adopt CNE and where appropriate SNE low voltage cables; standard size mains cables are 95mm<sup>2</sup>/185mm<sup>2</sup>/300mm<sup>2</sup>; service cables to be 35mm<sup>2</sup> hybrid or split concentric can be used for internal laterals/risers and 25mm<sup>2</sup> for unmetered connections.

Ducts shall be to ENATS 12-24 Black Rigiduct marked as 'Electric Cable Duct'. LV and HV Warning tape shall be to ENATS 12-23.

Manufacturer cable ratings should be used for design loading. Ducted cabling is acceptable, but the cable thermal derating should be included in the design. The ICP should outline derating assumptions to AUL at the design stage. Typical cable ratings can be provided on request.

Cables should be identifiable either by colour or marking in accordance with BS 7671 and MOCOPA requirements.

All road crossings shall be ducted with at least one spare duct per crossing, per voltage level. Where ducts are installed within concrete then they will be steel pipe, to be medium quality, screwed, complying with BS1387:1985, with a spare per cable.

Cables laid within the foundation of a building must be installed in steel ducts to protect the cable for future maintenance and repair.

Any required joints should be located beneath the footpath and not in the carriageway.

Mains cables cannot pass under buildings or cross third-party owned land, they must be laid in ground to be adopted by the local authority wherever possible. Where cables cannot run in adopted highway they should follow an accessible route (i.e. private footpath), and an Easement will be required highlighted in the land rights section below.

Mains and service cables should avoid parking bays where possible, where this cannot be achieved, they shall be ducted and installed with a spare.

### 9.4 Design of unmetered supplies

Loads shall be calculated in accordance with BSCP 520, where this provides information on the class of load. The network design shall otherwise follow LV network design practice described in this document.

Unmetered supplies can be provided in the following circumstances and in line with 'The Electricity Unmetered Supplies Regulation':

- The load is of a predictable nature (i.e. hours of operation)
- The load is below 500 watts

Examples include street lighting, bollards, street signs etc. but reference should be made to the Elexon list to determine whether an item of street furniture can be given an unmetered supply.

Normally these types of supply would be adopted by the local authority, however they can also be provided to privately owned installations if the location is accessible 24 hours a day and agreement is made regarding consumption with the management company.

Unmetered supplies cannot be provided in the following circumstances



- Car Park Lighting
- Electric gates
- Lighting within gated developments
- Footway bollards

Any other loads that can be broadly categorised as landlords supplies with indeterminate or variable loads.

Service cables will be a minimum of 25mm<sup>2</sup>, cut-out within columns to be a minimum of 25Amps

Service cables from the nearest main will not exceed 20m with the loop impedance not to exceed 250 milliohms to the end of the service, otherwise the nearest main must be extended.

A schedule of unmetered connections as detailed in Appendix 2 will be required to obtain design approval. This will include the following: -

- Connection number/column number matching design General Arrangement drawing
- Street Furniture Type
- Switching regime

## 9.5 Security of supply

Networks should be designed to limit the number of customers affected by a fault or outage, and to facilitate the shortest restoration and repair times. The network design will as a minimum satisfy the requirements of ENA Engineering Recommendation P2. AUL always aims to surpass the security of supply requirements in EREC P2, especially where loads are deemed to be high risk. Where a connection supplies a single customer, that customer may request that their supply falls below the requirements of EREC P2. A new connection must not adversely affect the security of supply performance of the upstream network.

Generally, LV back feeds between distribution substations should not be used. AUL prefers the use of generators to provide back-up supply during fault and outage; facility to connect the generator should be provided on the LV side of the substation. LV back feeds between adjacent substations should only be used in conjunction with LV automation to ensure LV supply to critical loads; the customer should discuss this with AUL if it is the preferred option.

## 9.6 SCADA

For HV network or high profiles projects, an allowance for SCADA control may be requested, these will be flag as early as possible by AUL

Any costs associated will be covered by AUL to a limit.

## 9.7 Substations

All substations must have unimpeded 24-hour pedestrian and vehicle access from the highway. AUL accepts the sharing of substations with customer equipment, as long as:

- AUL equipment cannot be inadvertently accessed by customer employed personnel that are not competent to operate that equipment.



- AUL equipment is clearly marked as belonging to AUL and marked as only to be operated by AUL contractors.

GRP substations should not be located any closer than 7m from any property, this can be reduced to 3m if the substation is constructed in Brick.

Substations should be positioned as centrally to the development load as is possible, with consideration for future load growth taken into account. Where a ring main is used, the open point should be placed to divide the load equally across the ring.

## 9.8 Substation enclosures

The minimum lifetime of enclosures is 30 years. Substation floor height should sit flush with or above the surrounding land. Water runoff should not gather around the substation. To avoid this, substation foundations should not be put in place until kerb lines are in place and surrounding landscaping topography is confirmed.

## 9.9 Auxiliary power and lighting supply

Where the enclosure includes plant that is owned by the host DNO then power and lighting within the substation should be to the host DNO specification.

Where the enclosure includes AUL plant only:

Distribution substations containing only an HV RMU and HV/LV transformer: an additional light should be provided, powered from the LV pillar socket.

Larger substations should have adequate lighting and heating provided by a separate electric heater.

## 9.10 Ventilation

The enclosure should have adequate ventilation such that the internal air temperature of the enclosure does not exceed 40°C when equipment is operating at its normal rating. Natural ventilation should be used. If forced ventilation is required, then this should be discussed with AUL on a case by case basis.

Substation enclosure should prevent egress of objects and water to IP23 as a minimum, in accordance with IEC 60529.

The enclosure should have sufficient space to allow a person to move around the equipment for maintenance purposes. There must be sufficient access such that a person cannot be trapped within the substation during e.g. equipment failures during maintenance.

## 9.11 Explosion relief

All prefabricated distribution substation housings shall be subjected to a type test in which the effects of an internal arc within a sealed chamber mounted inside the enclosure are demonstrated. The arc energy shall be 250 MVA (13.1kA) for 1 second. Full details of the proposed testing method shall be submitted for approval. Test methods include those outlined in Building Research Establishment technical report TCR 20/97 or in IEC 62271-202.

The pass criteria for the test shall include:

- Doors to remain closed and latched.
- Minimum projection of flame through door and joint gaps.
- No breakage of wall or roof material or any building joints.
- If pressure relief is achieved by a lifting and tethered roof, then the roof shall return to its original position



- Deflection of any ejected flame away from persons directly adjacent to the housing.
- Tests to be recorded on high-speed video recorder for consideration.

Generally, enclosures that have been approved for use on DNO networks will have passed the above criteria and be adoptable by AUL. The above criteria mainly applies where a new enclosure design is being proposed by the ICP/developer.

### 9.12 Internal substations

Internal substations are not preferred. Where internal substations are required:

- The substation must be accessible by AUL contractors at all times for operational purposes.
- AUL will assess the suitability of proposed substation designs for maintenance and repair activities.
- Adequate ventilation is required, as outlined above, where required AUL can ask for ventilation calculations.
- Where natural ventilation cannot be provided, passive ventilation will be required as a minimum
- Internal substations must comply with fire and building regulations; a minimum 4-hour fire rating is required, on walls and ceiling
- Substations must be able to withstand blasts associated with catastrophic failure of plant; plant failure must have no detrimental effect on the building.
- Integral substations should not be located directly against living areas of homes, other residential properties, schools, libraries or other public areas of similar occupancy as a precaution against high EMF's (in accordance with ENA ER G92), this will also mitigate issues such as access, noise, vibration etc.
- A minimum operational and maintenance clearance will be required around the equipment of 750mm.

The developer/ICP must demonstrate that the above criteria are met.

### 9.13 Earthing

Substation earthing designs must follow ENATS 41-24, relevant British Standards (BS7430, BS EN 50522), and ESQCR Regulations.

The earthing design should generally follow the host DNO's standards. If not, a custom design must be submitted for approval. The design should include earth potential rise and site status modelling as per EREC S36, using a fault duration of 1 second for EPR calculations. Substation earthing studies should be submitted for approval for AUL records.

For substations near special locations like Leisure Centres, Sports Complexes, or Medical Facilities, extra measures may be needed to control Touch & Step Potentials, requiring a custom design.

A PME earth will usually be used in new developments, following EREC G12, with an earth terminal provided for customer use unless unsafe.

Each LV main must have an earth rod at the stop-end joint. Branch or spur mains with 4 or more services, or over 40 meters long, will also need earth rods. No earth rod is needed if the main connects to another substation via a link box.



Steel-framed buildings or those with shared metallic services should not have multiple PME earth terminals. Services to these buildings should use SNE cable.

### 9.14 Voltage Regulation

The Maximum Voltage at the distribution system Exit Point shall NOT exceed 10% of the nominal voltage of 230V (i.e. 253V) and the minimum voltage at the distribution system Exit Point shall NOT be less than -6% of nominal voltage of 230V (i.e. 216V).

The maximum voltage regulation at the end of any main shall not exceed 5% and in any service, cable shall not exceed 2%.

Disturbing loads must comply with ER P28, the maximum voltage dip allowed for frequent starting is 1% and for infrequent starting is 3% at the point of common coupling.

Details of all disturbing loads to be provided on the Windebut file and supported with a data sheet.

The maximum voltage unbalance should comply with ER P29 and shall not exceed 10%.

### 9.15 Earth Loop Impedance

The maximum earth loop impedance value to the most distant service termination (or main, if no service is present) must be low enough to provide sufficient phase-to-neutral fault current to trigger the operation of the LV circuit fuse within 80 seconds. The design requirements are as follows:

- To the end of the domestic services, the impedance must be 250 milli-ohms.
- Where this is unachievable, the maximum Earth Loop Resistance permissible at the service cut-out position is 300 milli-ohms, with individual service calculations performed as necessary. This shall only be considered if the upstream LV Point of Connection (POC) exceeds 200 milli-ohms and after all efforts to reduce the Earth Loop Resistance, such as shorter routes and larger cable sizes, have been fully explored.

### 9.16 Boundary between DNO and IDNO

The DNO-IDNO boundary should follow the principles outlined in EREC G88; where the design is different from the common approaches in G88 this must be agreed with AUL and the Host DNO.

### 9.17 Services and Service Entry

Metering equipment should be placed in a position such that it is accessible to the customer and to MOCOPA operator. Service termination and metering equipment shall be between 0.5 metres and 1.8 metres above finished floor level, subject to unavoidable constraints. The preferred location of the service termination is in an external meter cabinet with an external hockey stick.

For HV and LV CT metered supplies, the interface test/isolating facilities shall be installed in an accessible position near to the location of Metering Equipment. The CT and VT secondary circuits shall be connected to earth on the AUL side of the interface.

With whole current supplies, a means of isolating voltage supplies (e.g. cut-out) shall be installed in an area that is accessible to the meter operator.

The test/isolating facility provided must allow the following operations to be carried out via a safe electrical connection and without the need to disturb any wiring:



- short circuit individual current transformers
- directly connect an ammeter
- connect test equipment to inject current into the secondary circuit towards the meter
- connect a testing device on each phase of the voltage circuit

Internal cabling and metering arrangements must comply with all associated legislation within ESQCR, BS7671, building regulations, fire regulations and MOCOPA requirements.

Risers and laterals should be installed in accordance with EREC G87. Riser mains must be fully accessible. Low smoke zero halogen cabling must be used in multi floor risers. AUL assets should be protected from third party tampering or vandalism. The termination positions for all electrical equipment must be segregated from other utilities by min 300mm. Metalwork in risers, laterals or termination enclosures should be bonded to earth.

Each service must be connected to its own fuse-way, either using a cut-out or distribution board. The point of isolation will form the boundary between the IDNO asset and the downstream assets.

Any BNO/landlord network downstream of the IDNO network should be designed to BS7671; schematics of the design should be provided to AUL. AUL will determine the rating of cut out fuses. ENATS 50-19 standard ferrule marking should be used.

### 9.18 BNO Networks

A Building Network Operator can be used supply a multi-occupancy building. This connection will be a bulk supply to the customer network, from that point forward a BNO will be responsible for the internal electricity network and any faults.

During a fault a BNO will be the first point of contact and if required, the fault will be escalated to AUL once all the relevant checks have been carried out to confirm the fault is not internal.

Bulk Supply, Single MPAN, individually metered privately. Intake cabling, single supply provided. Any cabling and individual metering beyond this supply not adopted by AUL.

The Design shall include a schedule of responsibility for each site defining the BNO and AUL obligations regarding these Networks.