Independent Networks Association

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2	13 April 2023	Document renamed to 'INA Low Voltage Design Standard' to be consistent with the website references. Section 3: Additions to the references table. Section 5: 'Electrical Design' amended to provide further guidance on cables connected to LV Apparatus. Section 5.4 title amended. Section 5.5: 'Harmonics' amened to provide further guidance on harmonic requirements. Section 5.10.2: 'Calculation of Demand' amended to include Unconstrained Electric Heating. Section 5.14: 'Secondary Supplies' amended to provide further guidance on secondary supplies and labelling requirements. Section 5.18.2.2: 'For Services Metered in each Flat' amended to provide further guidance on cable routes and cable separation.	INA	INA	INA Board	INA Board
3	17 October 2023	Section 5.10.2: 'ADMD Table updated'	INA	INA	INA Board	INA Board

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CONTENTS

1. Purpose

The purpose of this document is to provide a standard for the design and planning of new Low Voltage (LV) networks and covers the LV design criteria for electricity networks to be adopted by Independent Distribution Network Operators (IDNOs), either direct build or via adoption partners.

The WinDEBUT LV modelling tool is widely used by all Network Operators (NO) for LV planning & design. Other modelling tools may be used.

The LV network electrical design shall comply with the specific requirements of the relevant NO.

This document shall be read in conjunction with the relevant adopting network operator's requirements.

For any changes to the requirements set out within this document, application should be made to the Design Authority which is the Independent Networks Association Electrical Technical Sub Committee (INA ETSC).

2. Scope

This document covers the design parameters for Low Voltage networks. In particular, the document sets forward common requirements for design of networks considering the impacts of Low Carbon Technologies (LCT).

For the purpose of this document Low Voltage refers to voltages of 1kV or less.

This LV design policy does not include allowances to take account of any network losses as this is not in line with licence obligations to construct efficient and cost-effective networks.

3. References

Reference	Title
ENA EREC P2	Security of Supply
ENA EREC P5	Design methods for LV underground networks for new housing developments
ENA ER P23	Guidance on Earth Fault Loop Impedance at Customers' Intake Supply Terminals
ENA EREC P25	The short-circuit characteristics of single-phase and three-phase low voltage distribution networks
ENA EREC P28	Planning limits for voltage fluctuation caused by industrial, commercial and domestic equipment in the UK
ENA ER P29	Planning Limits for Voltage Unbalance in the United Kingdom
ENA 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
ENA EREC G12	Requirements for the application of Protective Multiple Earthing to LV networks
ENA EREC G81	Framework G81 Standards
NO G81	Network Operative G81 Standards
ENA EREC G88	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)
ENA EREC G98	Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019
ENA EREC G99	Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019
ENA EREC G100	Technical Requirements for Customer Export Limiting Schemes
ENA EREC G103	Generic industry risk assessment and asset management approach for Low Voltage termination equipment
IET Code of Practice	Electric Vehicle Charging Equipment Installation
ESQCR	Electricity, Safety, Quality & Continuity Regulations 2002
BS 7671	IET Wiring Regulations

4. Acronyms

Acronym	Description
ADMD	After diversity maximum demand
ACB	Air Circuit Breaker
ASHP	Air Source Heat Pump
EV	Electric Vehicle
EVCP	Electric Vehicle Charge Point
GSHP	Ground Source Heat Pump
ICP	Independent Connection Provider
LCT	Low Carbon Technology
LV	Low Voltage – not exceeding 1,000 volts AC
MPAN	Meter Point Administration Number
NO	Network Operator A term commonly used to define a licensed Distribution Network Operator (DNO) or a licensed Independent Distribution Network Operator (IDNO)
PME	Protective Multiple Earthing sometimes referred to as TN-C-S
PV	Photovoltaic
SNE	Separate Neutral & Earth, sometimes referred to as TN-S
TT	There is no earth connection to the supply network provided. The earth connection is the responsibility of the property owner and is normally provided by a single earth rod to ground

5. Electrical Design

All cables connected to LV Apparatus at the origin of the circuit, such as transformer take-off chambers, cabinets and boards, shall be a minimum of 300mm^2 Aluminium cable unless otherwise agreed with the NO.

Where unused LV ways are present, these shall have a 300mm^2 spare Aluminium cable connected, extending to minimum of 3 meters outside the boundary of the substation and terminated in a stop-end joint with PME earth electrode. The earth electrode shall be omitted where the stop-end joint would be situated within the 'Hot' zone of a substation with segregated HV/LV earthing.

Where it is intended that a spare LV cable will be extended imminently, through further phases of a development, a shorting end cap may be installed in lieu of a pot end, subject to agreement with the associated NO. Where a shorting end cap is used, this shall be indicated by the display of a prominent temporary label, in accordance with NO procedures.

Spare LV cables shall be left de-energised.

5.1. Maximum Voltage Regulation from LV Busbars of HV/LV Substation

Point of Measure	Voltage
To remote end of service	Urban area +10%/-6% on 230V

Individual NOs will have their own policy on the maximum voltage drop and voltage rise that can be accepted on the LV network.

Although LV networks on housing estates remain relatively undisturbed for many years, future trends are difficult to accurately predict but it is recommended that networks should be designed to be within the above limits, after allowing for future load growth for a period of 20 years.

LV networks are normally designed on the principle of single radial tapered circuits.

5.2. Maximum Service Volt Drop

Maximum Service volt drop between LV main and service cut-out 2%.

Maximum Voltage rise at Point of Common Coupling (POCC) where embedded generation is to be installed shall be no greater than 2%. Refer section 5.9 for further guidance on Embedded Generation.

Looped services for domestic customers shall not be installed on new LV networks.

5.3. Maximum Voltage Unbalance

To ensure compliance with ENA ER P29, the maximum voltage unbalance, at any point, shall not exceed 1%.

5.4. Maximum Earth Loop Impedance

To the end of the domestic services shall not exceed 250 milli-ohms. Where this is unachievable the maximum Earth Loop Impedance permissible at the service cut out position is 300 milli-ohms, with individual service calculations undertaken as needed. This shall only be considered where the upstream LV POC offered exceeds 200 milli-ohms and other steps to reduce the Earth Loop Impedance, such as shorter routes and increased cable sizes, have already been exhausted.

For other services, refer to the requirements of ENA ER P23.

5.5. Harmonics

New equipment connecting to a network must demonstrate compliance with ENA Engineering Recommendation 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 G5 outlines a three-stage process for assessing the connection of harmonic sources to UK distribution networks. Customers shall follow the three-stage approach outlined in EREC G5 to demonstrate to the NO that this approach has been followed and that the connection of new harmonic sources is compliant.

It is the responsibility of the customer to demonstrate compliance. If the customer cannot demonstrate compliance with EREC G5, they should discuss this with the NO at the earliest opportunity.

For further guidance, please refer to Engineering Recommendation G97 — "Process for the connection of non-linear and resonant plant and equipment in accordance with EREC G5".

5.6. Phase to Earth Fault Clearance Time

Designers shall ensure that a phase to earth fault at the end of the main will be cleared by the chosen LV fuse.

Fuse sizes shall be calculated after consideration of cable sizes and transformer ratings for short circuits.

Where a NO network is directly connected to another NO's network, the designer should consider the whole network to ensure that the protection on the upstream network will operate within the required timescale. Where this is not achievable for a direct connection, consideration should be given to sub-fusing the network.

For internal fuses as contained within Heavy Duty Cut-Outs (HDCO) and/or Multi-Service Distribution Boards (MSDB), a maximum 5 second clearance time for short circuits shall be allowed. Consideration should be made to ensure that the selected fuse discriminates with the upstream fuse/protection.

5.7. Prospective Short Circuit Current (PSCC) at LV Busbars of HV/LV Substation

Further guidance on PSCC can be found within ENA Engineering Recommendation P25.

Design maximum PSCC is 25kA for 1 second.

All equipment shall be capable of withstanding 36kA for 1 second, and 21.6kA for 3 seconds.

5.8. Prospective Short Circuit Current (PSCC) at the Cut-Out

Prior to design work being carried out, the exact design values of PSCC, at the point of connection onto the upstream NOs network, shall be established.

The maximum design value of the PSCC for single phase 230V supplies should be taken as 19.6kA at the connection of the service to the LV distribution main. In practice a service length of 2m or more will reduce this value to 16kA. As a result, the latest issue of ER P25 and BS7671 requires, as a minimum standard, that all equipment must be capable of withstanding 16kA for single-phase connections up to 100A.

The Maximum design value of PSCC for three phase 400V supplies, in situations where the service is connected directly to the LV busbar at the substation, should be taken as 25.9kA. Where the service is connected to the LV distribution main the maximum PSCC will be lower than 25.9kA, dependent upon the length and size of the LV main and service.

5.9. Contribution to PSCC from LV Generation and Motors

Generators, Motors and Low Carbon Technology (LCT) connected to an electrical network have the potential to contribute to the short circuit current during a fault and must be considered as part of the LV design.

The type, rating and method of connection to the LV distribution network will determine how much contribution they will have to the overall PSCC at the connection point and at the Substation LV busbar.

The following are examples of Generators and Motors that may be part of the design or connected to the existing LV distribution network;

- A generator which is directly coupled to the LV network.
- A generator which is coupled via power electronics to the LV network.
- An induction motor which is directly connected (coupled) to the NO LV network.

Calculations to determine the additional fault contribution under short circuit conditions from motors and generators should be conducted in accordance with BS60909-0, using either an approved network modelling tool or calculation spreadsheet in accordance with ER G74. Details of the substation transformer, cables resistance and reactance values, and relevant motor and generator details will be required to conduct the assessment.

When the short-circuit location is near-to-generator, then the machine (motor or generator) will contribute to the current and hence, to the magnitude of the quantities I''_k, i_p and I_b. Due to the magnitude of the initial alternating current (A.C.) component of PSCC decaying with time for near-to-generator faults, the contribution from the motor or generator will also vary over time. The NO may require this to be considered.

5.9.1. LV Directly Coupled Generation

Generators coupled directly to the Network are generally broken into 2 categories;

- Synchronous generators.
- Asynchronous / Induction generators.

5.9.1.1. Synchronous Generators

Synchronous Generators rotate at a speed which is synchronised with the grid network frequency (50Hz) and are separately excited, i.e., by means of a permanent magnet generator providing the supply to the excitation field controlling the output from the generator.

Under short circuit conditions at the terminals of a synchronous generator, the fault current will start out very high and decay to a steady state value. They generally deliver a current around 6 times the rated output of the generator before decaying.

The below table taken from ER P25 (2018) can be used as a guide for initial assessments of the fault contribution from a single synchronous generator to the PSCC at the substation LV busbar for early design or tendering purposes.

Three phase synchronous Generator rated power (kVA)	Contribution to PSCC at LV busbar (kA)
100	0.45
200	0.9
300	1.8
400	2.7

The values given in the table above are on the following assumptions;

1. The synchronous generators are assumed to deliver 6 times rated current to the initial symmetrical short-circuit current,
2. The generator is connected directly to the LV busbar on a cable of negligible impedance,
3. The contribution values are applicable for a 3-phase fault,
4. The contribution values have been determined with only one generator running,
5. The PSCC at the LV busbars will be subject to attenuation on the LV distribution main and / or service.

If the contribution from the generator takes the PSCC at the LV Busbar above 25.9kA, then additional assessment and mitigation measures will need to be considered, or uprated equipment used to enable the connection of the generator.

5.9.1.2. Asynchronous / Induction Generators

Asynchronous Generators rotate at a speed faster than synchronous speed and draw a supply from the grid network for the excitation field, and therefore should be treated in the same way as an induction motor.

Under short circuit conditions at the terminals of the generator the initial fault current is very high, but completely decays with a short time constant, and as such does not contribute to the symmetrical short circuit breaking current.

Where the design assessment concludes a fault current of 25.9kA at the LV busbar, the minimum size of induction motor that needs to be considered during short circuit calculations is an equivalent 200kVA unit or aggregate value exceeding 200kVA, on the assumption that the machine delivers 5 times its rated current to the initial symmetrical short circuit current.

The designer should aggregate any inductive machine as part of this assessment. This includes any induction motors as part of the collective 200kVA. Where a number of small induction motors or generators are connected to the LV network, the capacity can be summated and modelled as a large single induction motor for the contribution to PSCC.

For example, a single 4kW Air Source or Ground Source heat pump on an individual basis may have a negligible effect on the PSCC, however where a large number are connected in close proximity or to the same feeder, their summated value may have a considerable contribution to the PSCC at the busbar. If 50 where connected to the same substation on a new development, they would have an estimated contribution of around 1.1kA, similar to that of a 200kVA induction machine.

5.9.2. LV Generation Coupled via Power Electronics

The most common form of power electronics used to create or convert voltage and current waveforms for generation purposes is an inverter or converter.

Due to the lack of a rotating mass like a synchronous or induction generator, inverters and converters do not develop inertia and therefore the fault current decays much faster.

The current engineering best practice is to assess the short circuit contribution of power electronic connected generation at 1.2 times its rated current. For single connections that comply with G98 the fault contribution is assumed to be negligible. However, where there is a high density of inverter or converter based generation connected to the LV network, or the current limitation of the power electronics is greater than 1.2 times the rated current, it should not be assumed as insignificant.

5.9.3. LV Motors

LV Motors are asynchronous machines, otherwise known as induction motors.

Please refer to section 5.9.1.2 above in relation to Asynchronous / Induction Generators.

5.10. Network Load Criteria

5.10.1. LV Network Design

Generally, LV networks are designed using the WinDEBUT program or an alternative as approved by the NO. These programs are design tools which use predefined daily demand profiles for different types of customers to propose cable and fuse sizing requirements for LV networks.

5.10.2. Calculation of Demand

The traditional ADMD method establishes an expression to derive the maximum demand for a group of customers based on an average kW value per customer. The number of customers on a given circuit may impact the sizing of the LV network.

Data for calculation of demand is determined by the program and is dependent upon the number of connections and the estimate of annual unit consumption.

The following table is for initial capacity estimation only. Final network load shall be determined through calculation.

The standard ADMD kW per property may be estimated utilising the following values based on number of bedrooms:

Note. The designer shall establish that the property use is sufficiently typical before using estimated ADMDs.

Number of Bedrooms	Non-Electric Heated (Gas, District Heating)	Electric Direct Heated (Off-peak)	Electric Direct Heated (unconstrained)	Electric Heated by Heat Pump (*)
		Flatted Properties		Non-flatted Properties
1-2	1.2	2.2	2	2.2
3	1.5	2.7	2.5	2.9
4	1.8	2.9	3	3.7
5+	2.2	3.6	3.5	4

(*) Refer to Section 5.10.2.1 for requirements for Heat Pumps, once the capacity is known.

5.10.2.1. Air or Ground Source Heat Pumps (ASHP, GSHP)

Given that heat pump power may be expressed differently between manufacturers the Designer must establish the actual electrical demand of the heat pump.

For Air or Ground Source Heat Pumps, 50% of the electrical input load shall be added to the standard Gas Heated ADMD for each plot (based on the correct size property demand) to ensure sufficient load allowance.

Some heat pumps are fitted with a boost / cold pick-up element forming part of the system which should be considered when estimating the maximum demand value. The worst-case loading for Heat Pumps is likely to be 'cold start' pick up following a fault restoration in winter, where diversity could be minimal.

5.10.2.2. Unconstrained Electric Heating

An allowance of 50% of the installed electric heating load shall be allowed in addition to the Gas Heating ADMD once the installed electric heating load is known.

5.10.2.3. Electric Vehicle Charging Points (EVCP)

In all cases the domestic service capacity shall be designed to be sufficient to provide for maximum foreseeable EV charging and local (domestic) demand. In most cases a 100A single phase service will be sufficient for up to 7.2kW (32A) EVCP demand at a domestic dwelling, but larger EVCPs or multiple EVCPs may require a 3-phase arrangement, particularly if significant electrical heating load is expected. If there is a local constraint, e.g., measurement at the meter position to limit EVCP demand or to limit total demand on the service, the service must be sized for the maximum foreseeable demand on the installation.

- EVCP demand of 7.2kW or less at each domestic property requires no additional allowance provided the standard ADMD figures are used for the network.
- Public / communal / workplace EVCP demand to be sized at 0.8 x maximum installed capacity.
- For car chargers exceeding 7.2kW per plot, they will be reviewed on a case-by-case basis.

Earthing;

- Domestic EVCPs shall be installed and certified as compliant with the latest IET Requirements for Electrical Installations (Currently BS7671:2018 Amendment 3). Current recommendation is that these may operate as a TT earthing system (i.e. with own electrode and RCD), but PME may be permissible if the equipment is able to detect a broken neutral scenario (rise of voltage on the system customer's earth terminal) and disconnect the phase, neutral and protective conductors from the source of supply. It is the responsibility of the customer to make sure that the PEN device functions correctly.
- Dedicated LV services to street furniture or public chargers / kiosks / feeder pillars must not offer an earth terminal if this could give rise to danger; in general, the requirements of ENA EREC G12 apply. Typically, a PME earth (TN-C-S) can be offered in most circumstances, but the customer shall not make use of this or extend it to charging equipment where an alternative form of earthing is required. Different earthing systems (e.g., PME/TN-C-S and TT) shall be separated by at least 2.5m above and below ground.

5.10.2.4. PV installations

PV installations must comply fully with EREC G98 and G99 as applicable.

When accounting for PV installations two scenarios should be considered to determine the design demand and voltage regulation, namely;

Winter maximum demand - The power output of a domestic PV installation over the winter should be assumed to be minimal and therefore ignored.

Summer maximum demand – High PV generation should be assumed to coincide with low daytime demand therefore voltage rise should be determined. Voltage rise will depend on the penetration of PV on the proposed network.

If the connection to the upstream network is at LV, PV should be considered to ensure voltage rise remains within the limits. 200W of base load shall be assumed. Allowances should be agreed with the NO.

5.10.2.5. Three Phase domestic supplies

Where three phase domestic connections are utilised, the designer shall consider the breakdown of load required and how the supplies are to be utilised when assessing. Network load used may require a bespoke diversity factor to be agreed with the Electricity Network Manager. Consideration shall be given to ensuring balance on the network. If the property after diversity demand is greater than 23kW, a three-phase supply shall be provided.

5.10.3. Voltage Regulation

- Maximum Voltage at the distribution system Exit Point shall not exceed 253V.
- Minimum Voltage at the distribution system Exit Point shall not be less than 216.2V.
- Maximum voltage dip allowable for motor starting is 1% for frequent and 3% for infrequent starting at the Point of Common Coupling (POCC) as per EREC P28.
- Maximum Voltage Rise at any point on the LV distribution network or POCC shall not exceed 2%.

- Normal system voltage of the LV network should be considered as 230V single phase and 400V three phase when conducting the network assessment.
- A value of 250V should be utilised for PSCC and faults assessments, in accordance with the setting in WinDEBUT.

5.10.4. Embedded Generation

Compliance must be in line with Engineering Recommendations EREC G98 & G99 where the connection is to be made and generation equipment commissioned. Where export limitation devices are required or suggested as part of the application, this shall be in accordance with EREC G100.

Where a network design contains any form of embedded generation, the customer should make an application to the NO's website contact information using the relevant form from the standards detailed above, which are available of the ENA website.

Connections for generation rated at 16A (3.6kW) per phase or less should be made using the G98 form and from a design and assessment point of view, the requirements for these standards must be met. Connections for generation greater than 16A per phase should be made using the G99 application form and the requirements within the relevant standard must be met for the application to be approved.

Any metered connection where the capacity of the generation being installed is greater than 30kVA, may require an additional Export MPAN (Meter Point Administration Number) to be raised, subject to supplier request. MPAN Requests will require the following information to raise an MPAN for the approved connection;

- Network Number, and Plot number where generation is being connected, or corresponding Import MPAN for the supply.
- Export capacity that has been agreed between the NO and the customer.
- The export/generation to be marked on the design drawing.
- If the generation is intermittent or non-intermittent.

The designer should liaise closely with the customer and, where required, the upstream network operator to ensure the network is able to support the connection. The embedded generation department will assist with the network design and ensure the requirements and guidance on the following at adhered to; the maximum voltage rise on the network, the contribution to the PSCC, as detailed in section 3.11, and power quality of the network. Guidance can be found within the relevant G99 standard, G5 (for Harmonic contribution), P28 (step voltage change), P29 (network unbalance), ETR 126 (Guidance on active management solutions for voltage control), ETR 113 (guidance for the protection of embedded generating plant up to 5MW) and ETR 130 (guide for assessing the capacity of networks containing distributed generation).

Where the customer is proposing the use of stand-by generators as part of the development the customer must confirm these meet the requirements of BS7671 where the generator is not intended to be connected in parallel with the distribution network, or the relevant G99 standard, with particular attention to the section detailed infrequent short term parallel, where the customer has required the generator be connected in parallel.

5.10.5. Maximum Number of Connections per Isolation point

Networks shall be designed so that the maximum number of connections on each cable section does not exceed 80. Any deviation shall be agreed with the NO. Link boxes or feeder pillars may be used as necessary to reduce the number of connections per feeder.

5.10.6. Points of Isolation

Link boxes or feeder pillars may be required by the adopting NO.

5.11. LV Interconnection

LV networks should be designed on the principle of underground radial single distribution mains. No LV Interconnections are required as a matter of course however they may be considered by the NO on a case-by-case basis.

5.12. Maximum Number of Services per Joint

Where appropriate a maximum of four single phase service cables; or one three phase and one single phase service cables will be installed in one service joint.

Overall phase balance shall be considered as part of the design function.

Compliance with ER P29, with the phasing clearly marked on the design.

5.13. LV Supply Arrangements 100A to 1600A

This section covers the various standard supply arrangements from single phase 100A connections up to 1600A ACB supplies.

Greater than 1600A supplies require a bespoke arrangement and should be discussed with the NO at the earliest opportunity.

As per G88, supplies into a single building (within defined boundaries) shall not be derived from multiple NOs (DNO or IDNO), including any secondary supplies or LV supply points e.g. electric vehicle charging. The HV supply for the building may be supplied by another network operator but the responsibilities and duties in respect of supply of electricity to the building are managed by one DNO/IDNO.

5.14. Secondary Supplies

For secondary supplies, these shall only be considered on the following basis:

No opinion is offered by the NO as to whether the supply will meet the requirements BS9999, BS8519 or any other regulations relating to supplies for life safety and firefighting. It is the customers responsibility to ensure secondary supplies have been designed to their requirements and relevant British Standards. Both supplies may fail simultaneously under external fault event conditions. Both supplies may be required to be disconnected temporarily for maintenance reasons. The availability of the second supply should not be assumed or relied upon. Each supply must be kept separate electrically (including separation of neutral) within the building. Switch over devices shall be of 4-pole type. 3-pole devices shall not be used.

Where a secondary supply is provided to a single customer within the same building, then only one Main Earth Terminal shall be provided with the customers primary supply; i.e. no earth terminal shall be provided with secondary supplies. Such secondary supplies shall not be utilised simultaneously with the primary supply.

Each intake position is required to clearly identify using permanent labelling that there is a second intake position and its location. Both supplies shall be sourced from the same network operator.

5.15. Service Entry Requirements

Guidance can be found in EREC G103 'Generic industry risk assessment and asset management approach for low voltage service termination equipment'.

Service termination equipment should be designed in accordance with BS7657. Internal service positions must comply with the requirements set out under BS7670, BS7671, BS9999, BS9991, MOCOPA guidance, Building and Fire regulations and the Electricity Safety, Quality and Continuity Regulations (ESQCR).

Under regulation 3 and 5 of ESQCR, all NOs have a duty to ensure, so far as reasonably practicable, that their equipment is;

- Sufficient for the purposes and the circumstances in which it is used,
- So constructed, installed and protected (both electrically and mechanically), used and maintained as to prevent danger, interference with or interruption of supply.

5.15.1. Single phase connections (domestic)

On new housing developments the preferred method of service entry in England and Wales to a customer's electrical installation is via a duct (with draw-wire) and a hockey stick to an outdoor meter cabinet, complying with: Streetworks UK Volume 2: Street Works UK Guidelines On The Positioning Of Underground Utilities Apparatus For New Development Sites; ENATS 12-24 standard.

Internal positions may be provided however it is not permitted to have the service position within kitchens, bathrooms, washrooms or inside dustbin, coal or refuse areas.

Where the meter position is within a garage, although not deemed internal to the property, it is permissible subject to:

1. The service shall be protected by a suitable cable guard, provided by the Developer, for the full length from the floor to the service termination position.
2. The service position shall be installed between 1.2m and 1.8m height to improve visibility and reduce the risk of impact damage to the meter position.
3. The service shall be positioned at least 1.2m into the garage to reduce weathering damage.
4. Where a risk of drilling into the service cable exists from inside the premises, the Developer shall pre-install a steel sheet, of at least 1mm thickness, to the wall behind the service cable, service termination and meter. This shall be connected to the main earth terminal by the electrical contractor.

Looped services shall not be used.

All house services will be a minimum 35mm^2 AL cable with a 100amp cut-out installed at the customer's termination.

The provision of brick or block behind the outdoor meter cabinet or internal meter position may not always be possible, i.e., in timber framed buildings. In such circumstances the wall behind the service/metering equipment and the service cable shall be fitted with a steel sheet (min. 1mm thick) bonded to the cut-out earth terminal. This is to protect persons drilling through the wall and receiving an electric shock.

In certain circumstances an internal termination position may be agreed. This will be due to circumstances dictated by the style or positioning within the property. Where the customer cannot provide a suitable external location for a meter box, any internal meter positions shall comply with the following;

- Be enclosed in a purpose-built, 30 minute fire rated, cupboard that is exclusively for the cut-out and meter arrangement.
- Where the cupboard is not exclusively for the cut-out and meter, i.e. under the stairs, the whole cupboard shall be appropriately fire rated (30 minutes), and the electrical equipment shall be provided with additional mechanical protection, for example between water & electricity equipment (if this increases the ambient air temperature in the vicinity of the equipment, this may have a derating affect).
- The maximum height to the top of the meter board shall be 1800mm from ground finished floor level. The minimum height of the base of the meter board shall be 450mm from ground finished floor level. The meter board shall be a minimum of 450mm by 600mm.
- The service termination shall be mounted on a standard 18mm fire resistant meter board.
- The service cable shall be installed in continuous black polypipe ducting of 38mm OD (outside diameter) minimum 32mm ID (internal diameter), conforming to ENA TS 12/24 which terminates at the level at which it enters the building. It shall be routed inside the building by the shortest and most direct route possible to allow installation and/or future removal of service cable as may be required. The internal end of the duct shall be sealed to prevent the ingress of gas, water, and rodents immediately after the service cable has been installed.
- There shall be 750mm clear access to the front of the enclosure surrounding the service termination and metering equipment.
- The minimum size meter board space shall be reserved entirely for the use of metering, service termination, isolator, and earth terminal equipment. No other equipment shall be installed in this space or on the meter board.

N.B. - A standard GRP external meter box does not meet the fire regulations for internal use.

Locations <u>unsuitable</u> for internal meter positions;

- Adjacent to any localised heating source, such as an immersion tank, heating boiler, radiator, district heating equipment etc, that will increase the ambient air temperature and de-rate the service equipment,

- Immediately adjacent to other utility apparatus, a minimum of 250mm separation is required,
- Above internal or external doorways,
- Inside a bin, coal or refuse store,
- Inside a toilet, kitchen, bathroom, or utility/wet room,
- Not under the stairs of any building unless this space is 30-minute fire rated and the space should not be used as storage,
- In any location not compliant with the current edition of BS7671.

One single branch joint from any direct service is permissible to service a single street lighting column only.

5.15.2. CT Metered Supplies

Any supply with a capacity greater than 69kVA, or where specified by the supplier, and metered at the service termination, shall utilise a CT metering unit in accordance with the NOs G81 approved material specification list.

All CT Metered supplies should have a Connection agreement where appropriate as required by the NO for CT metered customers which lists all of the site-specific details and the terms of the connection as agreed with the customer. This should be completed and issued to the customer with the design, for the customer to sign and return.

The CT ratio and intended capacity for the customers supply shall be clearly indicated as part of the design. It shall not be permitted to allow the settlement metering CT's to be installed within customer owned equipment unless otherwise agreed with the NO.

5.15.3. 200A to 400A CT Metered Supplies

The main and service cabling should be selected appropriately to account for the customers capacity, the capacity of any other connections to the distribution main and an appreciation for the service termination equipment. Not all service termination equipment will have the facility to accept the full range of cable sizes.

5.15.4. 400 & 500A CT Metered Supplies

Supplies of this capacity shall be designed from a dedicated way at the substation, with consideration for cable conditions and maximum ratings. A ducted length of more than 20m of 3 or 4 core 300mm AL Cable will not be able to sustain the requested capacity for these connections.

The designer shall ensure discrimination is maintained between the selected fuse in the 630A fused way at the substation and the selected fuse at the customers service termination unless otherwise agreed with the NO.

5.15.5. Bulk LV Metered ACB up to 1600A

The preferred connection method for this arrangement is to provide the customer with a PME supply at the outgoing bolted termination of the ACB, with settlement meter connected to the ACB and installed in a GRP enclosure provided by the customer adjacent to the substation or a dedicated metering room, where the substation is integral to the building. The metering cable length shall not be greater than 20m unless otherwise agreed with the NO.

Privately owned cables cannot be installed in adoptable highway.

The following should be detailed in the design and provided to the customer;

1. ACB will not accept multi-core cables.
2. Customers LV Cables to comply with BS7671 and the following requirements;
   - 2.1 Earth Loop impedance at (unearthed) substation end of cables sufficiently low to achieve max 5 second disconnection of the ACB.
   - 2.2 ACB is used to provide both overload and short circuit protection the LV cables must be sized to carry overload capacity in accordance with the ACB settings – not just transformer full load current (FLC) or Maximum Import/Export Capacity (MIC/MEC)
3. Where the customer's main incoming circuit breaker or fuses provide overload protection, smaller cables may be used (refer to BS7671 for details). In this case, the customer's designer must ensure that the cables are adequately rated for the short circuit protection afforded by the substation ACB settings applied. The earthing of the cable armouring can only be facilitated at the customers main intake switchboard/position.
4. At the customers intake position the cable should be suitably glanded onto a metallic gland plate, including a banjo and individual trailing earths to each cables armouring.
5. The customer should design their network to be a balanced load, and embedded generation or disturbing loads should be declared to the onsite designer, which may require additional consideration to ensure compliance with EREC P28, P29 and G5.

Where the customer has requested the utilisation of a neutral conductor more than half the size of the phase conductor, the designer will need to liaise closely with the customers chosen electrical contractor to understand why and if this is to account for any of the items detailed under point 5 above.

5.15.6. Supply to a Building Network Operator (BNO)

A Building Network Operator (BNO) could be the installation company on behalf of the developer or appointed by the developer/building owner after construction has been completed. This is generally only applicable to multiple occupancy buildings.

In accordance with the Distribution Code (DCode) there is no legal requirement for boundary metering between the NOs network and the network managed by the BNO. However, depending on the size of the BNO network and if the owner is licenced exempt (not able to raise and issue MPANs), the supply to a BNO network may be one of the following;

- Bulk metered at the supply point to the building. The NO would raise a single MPAN for this connection. Where the connection is;

  - Less than 1,000kVA, and at LV, the designer shall follow the guidance under the relevant sub section of the LV supply arrangements detailed above, for the requested capacity.
  - Greater than 1,000kVA, the designer should provide a point of connection at HV, via a metered Ring Main Unit, or metered connection from a multi-panel HV switchboard.

  Note – in this scenario any connections on the BNO network would not receive individual MPANs and would therefore not be tradable.

- Metered individually at each customer's premise.
  - The NO would issue multiple MPANs to the customer. The customer shall provide all the relevant information to raise the MPANs.
  - The boundary point between NO and the BNO network shall be clearly marked and indicated on the drawing, at a fused/isolation point or via an ACB where appropriate.
  - The asset that indicates the boundary point shall be adopted by and under the control of NO, with the outgoing bolted termination to the customers cable forming the boundary point.
  - The boundary point cannot be contained within an asset, where joint access would be required for operational, safety and security requirements, and the obligations placed on the NO under regulation 3 and 5 of ESQCR.

5.16. Earthing

All new networks will normally be to Protective Multiple Earth (PME) standards as laid out in ER G12, except for individual installations where PME would be unsafe (e.g. filling stations, swimming pools, temporary supplies and multiple occupied steel frame buildings). Permanent service cable connections will provide customers with a combined neutral and earth terminal or a separate earth terminal (SNE) if PME is not practical. For Temporary Supplies, no earthing facility shall be provided and therefore the arrangement shall be TT.

The customer's main earthing lead minimum cross-sectional area will be 16mm^2 copper.

5.17. LV Cables

LV cables shall comply with the requirements of ENA TS 09-09, and all cable used entirely within buildings shall be Low Smoke Zero Halogen (LS0H) and CE marked. For intake cabling, a maximum of 4 meters exposed non-LS0H cable may be installed within intake rooms and in line with a risk assessment. Cables from different manufacturers will have slightly different characteristics, however, they should all be within the tolerances of the above standard and therefore the current ratings in the below table should be utilised at design stage.

5.17.1. Current rating table for 3 and 4 core LV Waveform Cables

Nominal Conductor area	Direct Laid	Ducted	In Air	Maximum Fuse Size*

95mm²	245A (169kVA)	205A (142kVA)	255A (176kVA)	200A
185mm²	355A (245kVA)	300A (207kVA)	385A (266kVA)	315A
300mm²	465A (322kVA)	395A (273kVA)	525A (363kVA)	400/500A

Thermal ratings are based on the Prysmian data sheets. These ratings are for continuous (sustained) load, calculated in line with IEC 60287 (the international standard for calculating current ratings).

* Fuse sizes shall be considered in accordance with ENA TS 12-08.

Any cable route that is ducted for more than 20m continuously or a total of 30m along a 100m section should be designed utilising the values for ducted cable.

Multiple cables laid in close proximity, that are loaded at the same time, can create an environment and characteristics that affect the current carrying capacity of those cables in close proximity.

5.18. Specification for Supplies to Multi-Occupied Buildings

To be read in conjunction with ENA Engineering Recommendation G87.

5.18.1. Intake position

The supply intake position (which may not be the metering position), should be a suitably sized, secure, ground floor room accessible from a communal area preferably adjacent to the entrance, but not in the sole primary fire escape, and as near as possible to the point of entry of the supply cables. Where there are no alternative means of escape, a site-specific risk assessment (SSRA) may be required on the intake location.

Basement intake positions are not acceptable due to the risk of flooding without prior approval from the NO, as special consideration must be given to the likelihood of flooding and special measures such as pumping, or flood walls must be considered at the design stage and agreed with the developer.

The preferred arrangement is for the electricity supply cable(s) to enter the building at a single point, the intake plant room. The supply cable(s) must be terminated in suitably sized fused cut-out or distribution board.

Where there are multiple intake positions into a block then it is important that all intake positions are clearly marked and referenced to aid isolation under emergency situations.

5.18.2. Supply Arrangements

Where multiple flats are supplied, an approved multiway service distribution board (MSDB) will be used to provide the required number of connections. Allowance should be made for the landlord's supplies when specifying the number of ways in the multiway unit. Single phase 35mm² hybrid service cable terminated in a 100amp SNE cut out should be installed for each flat.

All cables used in multi occupied buildings beyond the intake termination will be of LS0H (low smoke zero halogen) and SNE specification.

Distribution Network Equipment does not fall within the scope of BS7671.

5.18.2.1. Communal cupboard

Where all supplies are metered at the supply intake position or at communal metering positions on higher floor levels fed from rising mains, the Red Head/Red Link cut out should be fixed next to the meter for each individual flat. An SNE earth terminal will be provided at each individual meter position.

Each meter position should be clearly labelled with the address/flat no. Customer installation equipment shall not be affixed to meter boards.

The individual service cables between the communal metering position and each flat will be installed by the developer and must be tagged during installation by the contractor to avoid errors when making the final meter connections.

The service fuse in the multiway unit shall be 100-amp rating and the service cable between the multiway head and each red head cut out shall be 35mm^2 hybrid split concentric LS0H type.

The Developer is responsible for installing suitable trunking or cable tray to the NO specifications between the multiway unit and the meters and for the installation of fire breaks, sealing or other special requirements in the rising main and lateral cable runs. Where multiple meters are installed at a communal position it is essential to ensure that sufficient wall space is allowed.

Group meter positions shall:

- Be for electrical equipment only.
- Be of adequate size for the installation of cut outs, metering equipment and isolation equipment.
- Be formed in brick or blockwork only. Note: plasterboard partitions are not permitted.
- Have full width opening doors and 750mm space in front for access to equipment.
- Be fire resistant to comply with fire regulations.
- Not contain other utility service equipment (e.g., Water or gas).
- Not be used as a storage room.
- Not be under stairs where headroom is less than two metres.
- Top level of any meter shall not be more than 1,800mm above floor level in accordance with MOCOPA requirements.
- Not be below ground level i.e., basements.

- Have ducted cable entry with easy bend to vertical position adjacent to wall. The ducts must be sealed after the installation of the supply cables to prevent the ingress of gas, etc.
- Have output routes for lateral services with supports provided at least every metre.
- Not be situated in the primary means of escape.

There may be situations where the above restrictions are not reasonably practicable, and any variation shall be agreed in writing with the NO.

5.18.2.2. For services metered in each flat

All rising mains or services cables in multi occupied developments shall be SNE (separate neutral and earth); via 4 core SNE cable for the rising mains and 35mm^2 hybrid split concentric cable for the services. All HDCOs (Heavy Duty Cut-outs), MSDBs and service Red Heads/Red Links downstream of the main intake position/isolation, shall have the neutral earth link removed.

Each service cable will be protected by a 100amp fuse in the supply cut-out or multiway service unit at the intake position or riser offtake position. Individual service cables will be terminated at the meter position in a Red Head/Red Link cut out (solid link for isolation purposes only) and an SNE earth terminal will be provided and labelled accordingly. Where a service is derated, or a service calculation indicates that the timescale of a 100A fuse operation would be excessive, an 80A fuse can be installed.

Care should be taken to ensure that cables are adequately supported and separated on cable trays and in floor or ceiling ducts.

The preferred option is for cable routes to be continuously ducted from the Multi Service Distribution Board (MSDB) to individual cut-out positions, exiting through the ceiling immediately and vertically above the cut-out position in each flat. Service ducts should be fixed to cable tray at suitable intervals of not less than 1000mm.

Where cables are fixed directly to cable tray, they shall be accessible throughout the full route and shall only be installed in flat formation e.g. cables shall not be stacked on top of each other. A minimum of one cable diameter separation shall be maintained between adjacent cables to prevent de-rating and facilitate future access, inspection, and replacement. Cables shall only be installed to the top surface of cable trays and shall not be underslung unless explicitly agreed with the associated NO.

5.19. Unmetered Supplies (UMS)

The NO will provide unmetered supplies in the following circumstances, in line with 'The Electricity Unmetered Supplies Regulation' and BSCP520; except where the cumulative load of multiple individual items taken from the supplying connection (NO exit point) exceeds 2000W, or where the usage is not Predictable in load and operation, or the equipment connected or to be connected to the relevant Exit Point does NOT have a national Charge Code issued by Elexon unless otherwise expressly authorised by the NOs Unmetered Supplies Operator (UMSO).

The type of installation which can be unmetered includes streetlighting under solar cell control, street signs, bollards, surveillance cameras and traffic monitoring systems, etc.

Reference should be made to the Elexon list to determine whether an item of street furniture can be given an unmetered supply.

Normally this type of supply will be provided to an installation which will be adopted and maintained by the Local Street lighting Authority but in some cases, it will be acceptable to provide unmetered supplies to privately owned installations provided certain conditions are met.

These supplies shall be supplied via single phase 35mm^2 LV CNE cables unless otherwise agreed with the NO and a 25A Cut Out.

There are three main options in providing electricity supplies to street lighting installations which are outlined below.

5.19.1.1. Option 1: Route of Main Connections

Where an LV main is present, the lighting columns shall be individually serviced using standard 35mm^2 CNE service cable unless otherwise agreed with the NO.

The length of the individual service cable should not normally exceed 29m and up to this service length the standard design parameters of the NO low voltage networks will ensure that the loop impedance to the end of the service will not exceed 250 milli-ohms. The WinDEBUT study of the proposed network shall include the furthest points of the mains cable network and if there will not be domestic service connections nearby a token load shall be added at the furthest point to ensure that the loop impedance at that point will be within normal limits. This will ensure that the main fuse controlling the circuit will clear within 100 seconds.

Roadside signs, bollards and miscellaneous street furniture shall normally be supplied from the nearest lighting column using a suitable cut-out with a sub fuse rated at 6amps and standard 35mm^2 CNE service cable. If the nearest column is more than 30m from the required supply point to the street furniture a mini pillar shall be installed. This will have a normal street lighting service installed with a fuse rating of 6amps.

If longer service lengths will be necessary to supply individual remote columns the loop impedance of the most remote run shall be calculated to ensure that the substation or supply pillar fuse will clear correctly. The controlling fuse should clear a fault on the main or service within 100 seconds.

To determine the loop impedance at the end of the street lighting service first find the loop impedance in milliohms at the proposed joint position from WinDEBUT. Then add the loop impedance of the proposed service cable: if using standard 35mm^2 service cable (Length (m) x 1.751) milliohms.

5.19.1.2. Option 2: Looping of Additional Columns

Up to 3 additional lighting columns could be looped from the final route of main connected column without sub-fusing provided the loop impedance of the furthest column will be within the limits for mains fuse clearance.

This will be installed in the control column using an NO approved cut out which has the option of a second fused out feed. The sub fuse size will be normally a 6amp fuse.

5.19.1.3. Option 3: Extension of Main

When the street lighting installation extends beyond the limits of housing, it will be necessary to extend the NOs cable network to provide secure street lighting supplies. The cabling must be included on the WinDEBUT study to determine the maximum loop impedance at the furthest point of the extended network. Street lighting load shall be balanced across all three phases with adjacent columns connected to different phases.

If the loop impedance at the furthest column exceeds the specified limits, it will be necessary to sub fuse the section of the extended network. This can be achieved by installing a mini-pillar at a convenient point on the route and installing a 3phase cut out to supply the remote section of the circuit. The sub fuse size will depend on the street lighting load and the loop impedance.

5.19.2. Earthing Requirements

Extended cable networks for street lighting shall be designed in the same way as a normal network with neutral earthing electrodes installed at the furthest point on the network. Individual columns where a PME service will be provided will not need an electrode if the main will have one installed beyond the service position; as per the normal arrangement for domestic services. Every column will be earthed. If columns will be looped as in option 3, an electrode will be installed at the furthest column, and it will be connected to the supply neutral using 16mm² copper earthing conductor.

5.19.3. Supplies to Traffic Lights, Roundabouts or Traffic Islands

Where supplies are required for traffic signs, bollards, traffic lights, street lighting columns sited on roundabouts or similar situations, the NO would normally provide a service into a supply pillar provided by the developer from which private cable will supply the installation. Normally such installations will be metered. The supply pillar must not be located on the roundabout.