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ENGINEERING DESIGN STANDARD

EDS 08-1112

SUBSTATION LVAC SUPPLIES

Network(s): EPN, LPN, SPN

Summary: The standard details the requirements and options for the provision of LVAC supplies to customer 132kV, 33kV and 11kV metered connections for demand and generation and UK Power Networks grid, primary and secondary substations.

Author: Stephen Tucker **Date:** 20/12/2023

Approver: Paul Williams **Date:** 09/01/2024

Circulation

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Revision Record

Version	5.0	**Review Date**	30/11/2028
Date	20/12/2023	**Author**	Stephen Tucker

Reason for update: Tariff metering included in new design standard EDS 08-1114.

What has changed:

- Section 5.2 IDNO/DNO supply arrangement clarified.
- Section 8 outdoor substation options previously in Section 7.5 included in Sections 8.3 & 8.5.
- Section 8.7 reference to approved LVAC switchboards included.
- Section 8.10 tariff metering application corrected to only include grid and primary substations and switching stations.
- Section 8.10 reference to EDS 08-1114 added.
- Section 9 reference to EDS 08-1114 added.
- Appendix tariff metering requirements removed as now to EDS 08-1114.
- Appendix auto-changeover logic removed as now included in approved LVAC switchboards.

Version	4.0	**Review Date**	14/07/2027
Date	14/07/2022	**Author**	Stephen Tucker

Reason for update: Business feedback.

What has changed:

- Sections 4, 6.1, 6.2, 0, 6.4, 7.3, 7.4, 7.5, 7.6 & 8.9 HOT site replaced with high EPR site or separate HV/LV earths.
- Section 5 caveat added to allow the provision of an LVAC supply from an IDNO network to a UK Power Networks substation.
- Section 6.4 customer 11kV LVAC requirements amended to allow customer derived LVAC where approved by Network Planning.
- Section 8.1 secondary substation options amended.
- Section 8.6 location of external generator socket corrected.
- Section 8.6 customer LVAC supply to be recorded in the SRS.
- Section 8.10 tariff meeting requirements from EBB 08-0064 incorporated.
- Section 8.10 customer metering note added.
- Appendix A load calculation updated and future growth requirement clarified.
- Document reviewed.

Version	3.0	**Review Date**	12/10/2025
Date	22/09/2020	**Author**	Stephen Tucker

Reason for update: Business feedback.

What has changed:

- Section 5 IDNO substations and supplies added.
- Section 6.3.1 City of London 33kV sites added.
- Section 7 HOT site section removed and requirements included in each substation section.
- Section 7.1 critical infrastructure added.
- Section 7.4 primary substation requirement changed to dual supplies.
- Section 7.6 132kV switching station options clarified.
- Section 8.1 all secondary substation arrangements moved to single section.
- Section 8.2 new section for LV cabinet/board supplies added. Cut-out requirement for these supplies removed.
- Section 8.8 provision of generator connection for customer provided LVAC added.
- Section 8.10 metering requirements added.
- Document reviewed.

Version	2.0	**Review Date**	07/11/2022
Date	27/10/2017	**Author**	Stephen Tucker
Reason for update: Review and revision to include all customer and network substations. **What has changed:** • Section 2 expanded to cover both customer demand and generation connections. • Section 6.2, 6.3 & 6.4 pole-mounted transformer supply options included. • Section 6.3 & 6.4 use of customer provided LVAC supply clarified. • Section 7 network grid, primary and secondary substations added. • Document renumbered from EDS 08-0055 and title amended.			
Version	1.0	**Review Date**	29/10/2016
Date	15/10/2015	**Author**	Kevin Burt
New document providing guidance for the provision of LVAC supplies to distribution generation sites			

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1 Introduction

The standard details the requirements and options for the provision of low voltage AC (LVAC) supplies to:

- Customer 132kV, 33kV and 11kV metered connections for demand and generation.
- UK Power Networks grid, primary and secondary substations and switching stations.

The provision of a secure LVAC supply is essential for the health of UK Power Networks operational batteries that supply the substation protection and control systems. These are intrinsic to ensuring fast restoration of customer supplies and ongoing development of a ‘smart grid’. The objective of this standard is to ensure these systems are as reliable as practicable.

LV supplies are required for:

- Battery charger for tripping, protection and SCADA batteries.
- Substation lighting, power, heating and dehumidification.
- Outdoor lighting.
- Security system.
- Power transformer cooling.
- On-load tap changer motor.

This standard provides a harmonised hierarchical approach to the options available when assessing the most appropriate source of LV supply for new and existing customer and network substations.

2 Scope

This standard applies to the provision of LVAC supplies to all new substations including customer interface substations at 132kV, 33kV and 11kV.

At existing grid and primary substations where the assets continue to remain in a sound and healthy condition the existing LV supply arrangements may be retained; however where substations are being refurbished or upgraded the requirements of this standard shall be applied.

3 Glossary and Abbreviations

Term	Definition
ACB	Air Circuit Breaker
BTS	Bilateral Technical Statement
CiC	Competitions in Connections
Customer Switchroom	A substation that typically only contains 33kV or 11kV switchgear required to provide a connection to a generation or demand customer
EPR	Earth Potential Rise. EPR is the potential (voltage) rise that occurs on any metalwork due to the current that flows through the ground when an earth fault occurs on the network
Grid Substation	A substation with an operating voltage of 132kV or 66kV and may include transformation to 33kV, 22/20kV, 11kV or 6.6kV
High EPR	A high EPR site is typically where the EPR exceeds twice the touch voltage limit (e.g. 466V for a fault clearance time of 1s where the touch voltage limit is 233V
ICP	Independent Connection Provider
IDNO	Independent Distribution Network Operator
LVAC	Low Voltage AC
ONAN, ONAF, OFAN, OFAF	Types of transformer cooling where O = oil, A = air, N = natural and F = forced
Pad-mounted Substation	A self-contained substation installed on a concrete pad usually without an additional enclosure. Also referred to as micro (50-100kVA) or compact (200-300kVA) substations
POC	Point of Connection
Primary Substation	A substation with an operating voltage of 33kV and may include transformation to 11kV, 6.6kV or LV
SCADA	Supervisory Control and Data Acquisition
Secondary Substation	A substation with an operating voltage of 20kV, 11kV or 6.6kV and may include transformation to 400V. Also termed ‘Distribution Substation’
SRS	Site Responsibility Schedule
SWA	Steel Wire Armour
TBS	Temporary Builders Supply
UK Power Networks	UK Power Networks (Operations) Ltd consists of three electricity distribution networks: • Eastern Power Networks plc (EPN). • London Power Network plc (LPN). • South Eastern Power Networks plc (SPN).

4 Selection Requirements

As a minimum the substation LVAC supply shall:

- Adhere to the methodology in Section 6 for metered customer demand and generation connections and Section 7 for network substations. Refer to Section 5 for IDNO substations and LVAC supplies.
- Provide the capacity to supply the site's LV load requirements.
- Consist of a single 100A single-phase or three-phase service unless otherwise stated.
- Include a backup generator connection where specified.
- Be monitored via UK Power Networks SCADA system.
- Have an appropriate earthing system (refer to Section 8.4).

Note: LVAC supplies **shall not** be provided directly from the LV distribution network to 132kV substations, 33kV substations or other substations with a high EPR, due to the danger of transferring high voltages to the LV system and onwards to other UK Power Networks customers. Refer to EDS 08-2108 for further information.

5 IDNO Substation and IDNO LVAC Supplies

5.1 LVAC Supply to IDNO Substation

The LVAC supply for all IDNO owned and maintained grid, primary and secondary substations[1] shall be provided by the IDNO and should be provided from the IDNO network.

However, where is it not practical for an IDNO to obtain an LVAC supply from their own network or there are limitations (e.g. load side of ACB in a secondary substation) in the available IDNO supply, they may request an LV connection from an adjacent UK Power Networks distribution network. This supply arrangement should terminate in a dual cut-out arrangement inside the substation (similar to EDS 08-2110.21). This solution is unmetered and shall be included in the BTS.

The IDNO is responsible for the integrity and security of the LVAC supply.

The supply options detailed in this document should be considered as good practice for the provision of LVAC supplies to all substations.

5.2 IDNO Supply to UK Power Networks Substation

The LVAC supply for all UK Power Networks owned and maintained substations should only be provided from the UK Power Networks distribution network in accordance with the relevant section in this document and should not be provided from an IDNO network.

However, if all other solutions have been exhausted, the LVAC supply may be taken from an IDNO network, subject to, the IDNO being able to comply fully with the relevant requirements in Section 8 of this document and subject to the prior approval of the regional CiC Lead Design Engineer and the Network Planning Manager. This supply arrangement should terminate in a dual cut-out arrangement inside the substation (similar to EDS 08-2110.21).

[1] The definition of ownership is with regard to who is the head lessee/freeholder and thus is not dependent upon the majority asset holding within the substation.

6 Customer Substations

6.1 Overview

It is the responsibility of the customer to provide the LVAC supplies, including any backup/standby arrangement, to UK Power Networks substations for 132kV, 33kV and 11kV connections for demand and generation. An overview of the options is outlined in Table 6-1 and described further in the sections that follow.

During the period between the installation of the UK Power Networks equipment and the commissioning of the permanent LVAC supply, the customer is also responsible for providing a temporary supply to ensure the environment for equipment is maintained, the batteries remain charged and commissioning activities can proceed. This may be provided via a temporary builder's supply (TBS) or site generator.

ICPs who install equipment for adoption shall ensure that suitable precautions to prevent damage are in place prior to adoption.

Table 6-1 – Customer Substation LVAC Supply Options

Option	**Metered Connection**				
	132kV	**33kV Ringed**	**33kV Teed**	**11kV Combined HV/LV Earth**	**11kV Separate HV/LV Earth**
Main and Backup Supply from Auxiliary Transformers	6.2				
Main Supply from Auxiliary Transformer and Backup Supply from Secondary Substation	6.2				
Secondary Substation		6.3	6.3	6.4	6.4
Pole-mounted Transformer	5.2	6.3	6.3	6.4	6.4
LV Distribution Network				6.4	
Customer LVAC			6.3	6.4	6.4

6.2 132kV Customer Generation and Demand Substations

In addition to the main LVAC supply, the customer shall also provide a reliable backup supply with auto-changeover facilities to operate if the main supply fails. This shall be fed to the UK Power Networks switchroom or control room, preferably from dedicated auxiliary transformer(s) connected to the main transformer(s). Other possible solutions may be considered provided that the arrangement has sufficient resilience to ensure that control and protection systems (including battery supplies) are not put at risk.

Refer to EDS 08-2108 for supplies to sites with a high EPR from the distribution network.

Therefore, customer generation and demand substations at 132kV shall be provided with a main and backup LVAC supply using one of the following options:

1. Where there is more than one incoming transformer circuit the main and backup supply shall be derived from auxiliary or earthing/auxiliary transformers associated with at least two main transformers that can be supplied from different 132kV sources.

2. Where there is a single incoming circuit (usually for generation):

    a) The main LVAC supply shall be derived from an auxiliary or earthing/auxiliary transformer (associated with the customer's main transformer).

    b) The dedicated backup LVAC supply shall be derived from either:

    - A dedicated secondary substation or pole-mounted transformer and supplied from the local 11kV underground cable or overhead line network or
    - Where reasonably practicable the backup LVAC supply can be taken from the UK Power Networks LVAC panel at a local UK Power Networks grid substation. This shall be derived from a separately fused LV way.

The LVAC supply shall be provided in accordance with Section 8.7.

6.3 33kV Customer Generation and Demand Substations

6.3.1 City of London[2]

Customer 33kV substations in the City of London shall be provided with a dual LVAC supply using the options below:

1. A main supply via single-phase service from the UK Power Networks local LV distribution network[3] in accordance with Section 8.4.

2. A main supply from the customer in accordance with Section 8.6 where there is no local LV network and with agreement from the Network Planning Manager.

3. A backup supply from the customer in accordance with Section 8.6.

The LVAC supply shall be provided in accordance with Section 8.7.

6.3.2 Other Locations

Customer generation and demand substations at 33kV shall be provided with a single LVAC supply using one of the options below.

Refer to EDS 08-2108 for supplies to sites with a high EPR from the distribution network.

1. A dedicated secondary substation or pole-mounted transformer supplied from the local 11kV underground cable or overhead line network in accordance with Section 8.1, which includes typical configurations.

2. Where the connection is teed, the preferred option is as above, however the customer may opt, with agreement from UK Power Networks, to provide a secure and reliable LVAC supply in accordance with Section 8.6. However, to ensure the safe and reliable operation of the network is maintained and to avoid a complete loss of battery supply to network protection this is subject to the following conditions:

    - The 110V and 50V battery charger voltages shall be monitored by UK Power Networks SCADA system.
    - If either battery charger voltage falls below the specified limit, UK Power Networks will open the customer metering circuit breaker and disconnect the batteries to preserve their charge.

The LVAC supply shall be provided in accordance with Section 8.7.

[2] The 33kV substations in the City of London have permission from City of London planners for reduced generation due to the dual 33kV supplies from two separate grid supply points. Security of supply is critical to the safe operation of life safety systems for these skyscrapers and the justification for dual LVAC supplies.
[3] The 33kV substations in the City of London are designed such that the earth potential rise (EPR) cannot exceed 430V and a supply from the LV distribution network is acceptable.

6.4 11kV Customer Generation and Demand Substations

Customer generation and demand substations at 11kV shall be provided with a single LVAC supply using one of the following options:

1. A single-phase service from the UK Power Networks local LV distribution network in accordance with Section 8.4.

   Note: This option is not suitable for sites with separate HV/LV earth unless an isolation transformer is utilised.

2. A secondary substation or pole-mounted transformer supplied from the local 11kV underground cable or overhead line distribution network in accordance with Section 8.1, which includes typical configurations for ringed and teed underground cable connections.

The above options ensure the operational security of the distribution network, however where they are not viable due to technical or practical reasons or where the site has separate HV/LV earths, alternative options, including the use of a customer derived supply or network reinforcement, shall be discussed with Network Planning. All customer provided LVAC supply solutions shall be approved by the Network Planning Manager and shall be provided in accordance with Section 8.6.

The LVAC supply shall be provided in accordance with Section 8.7.

7 Network Substations

7.1 Overview

The provision of LVAC supplies to UK Power Networks substations has developed differently across the three licence areas. An overview of existing legacy arrangements is given in Appendix B.

The following sections provide a harmonised solution across all licence areas whilst maintaining the status quo at existing substations where the assets continue to remain in a healthy condition. However, if changes are required the options detailed in this document shall be applied.

The LVAC supply arrangements detailed in the following sections apply to UK Power Networks owned or adopted substations. For LVAC supplies to IDNO substations refer to Section 5.

Additional LVAC supplies or alternative supplies from different sources may be required for underground substations, substations with tunnels and supplies to rail infrastructure e.g. Cross-rail, HS2 etc. and should be justified on a case-by-case basis as part of design process.

7.2 National Grid Sites

LV supplies to National Grid sites shall be provided in accordance with EDS 08-2108.

7.3 Grid Substations

For the purposes of this standard, a grid substation is classified as a substation where the highest voltage is 132kV or 66kV. Refer to EDS 08-2108 for supplies to sites with a high EPR from the distribution network.

Grid substations shall be provided with a dual (main and backup) LVAC supply as detailed in Sections 7.3.1 to 7.3.3. Both the main and backup supply shall be capable of supporting the full load. Appendix A includes a typical load calculation example.

The LVAC supply shall be provided in accordance with Section 8.7.

7.3.1 Multiple Transformer Substations

At a grid substation with multiple transformers the main and backup LVAC supply shall be derived from different auxiliary or earthing/auxiliary transformers such that the loss of a single circuit or upstream substation will not affect the LVAC supply. The auxiliary transformers shall be connected to either:

- Independent circuits (Figure 7-1).
- Independent banked transformers (Figure 7-2).
- One winding of a three-winding transformer (Figure 7-3).

At substations that require n-2 resilience, a main and two backup LVAC supplies shall be provided utilising three different auxiliary or earthing/auxiliary transformers.

Note 1: At substations with more than two grid transformers, generally only two transformers should be used for LVAC supplies.

Note 2: At substations with water-cooled transformers, every transformer shall be equipped with an auxiliary transformer due to the zero rating during the loss of cooling and the likelihood of forced tripping in these circumstances.

Note 3: At substations with multiple voltage transformers refer to Section 7.3.2.

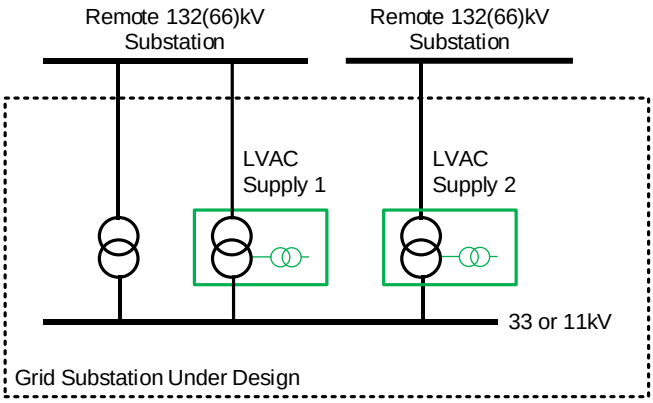

Figure 7-1 – Grid Substation LVAC Supply from Independent Transformers

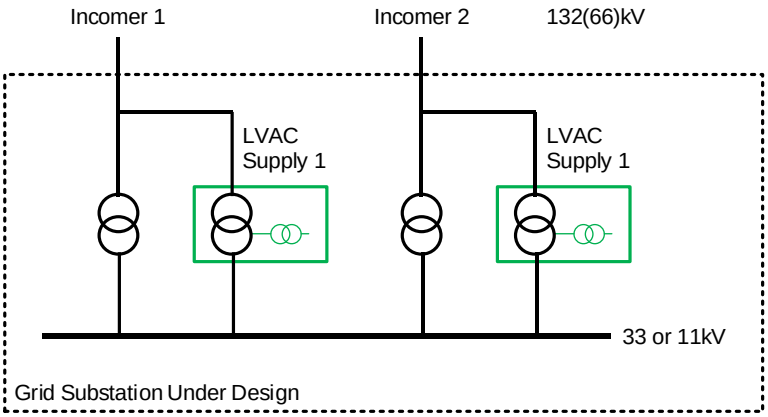

Figure 7-2 – Grid Substation LVAC Supply from Banked Transformers

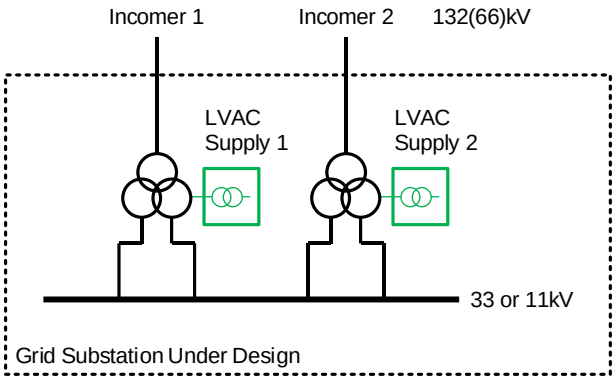

Figure 7-3 – Grid Substation LVAC Supply from a Three-winding Transformer

7.3.2 Grid Substations with Multiple Voltages

At a substation with multiple voltages (e.g. 132/33kV and 33/11kV) the HV winding of the transformer with the highest voltage (e.g. 132kV) shall be equipped with the auxiliary transformer (Figure 7-4). If there are existing auxiliary transformers at lower voltages, these may be used for LVAC supplies provided they are of a sufficient size to meet the required demand (Figure 7-5). However, where there is interconnection at an intermediate voltage e.g. 33kV either option may be used to ensure the LVAC supply has the highest possible level of resilience.

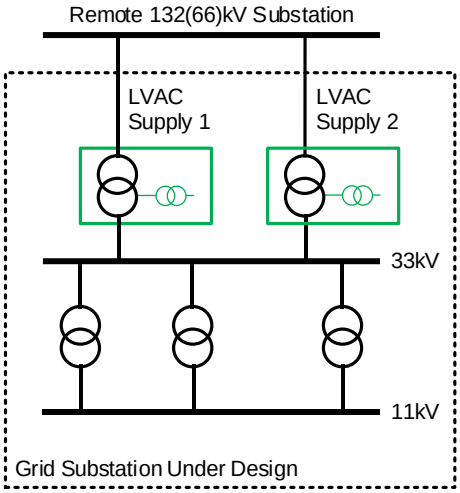

Figure 7-4 – Grid Substation with Multiple Voltage Levels – LVAC Supply New Option

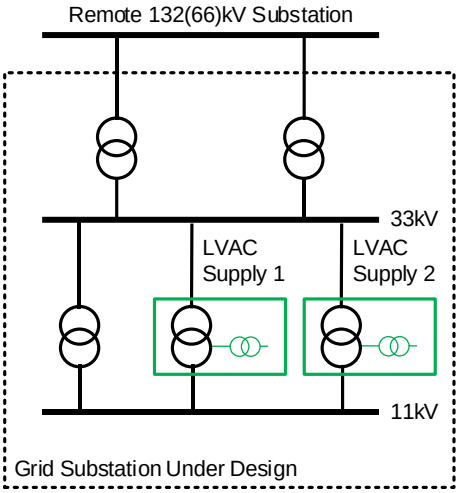

Figure 7-5 – Grid Substation with Multiple Voltage Levels – LVAC Supply Existing Option

7.3.3 Single Transformer Substations

At a grid substation with a single transformer:

- The main LVAC supply shall be derived from an auxiliary or earthing/auxiliary transformer.
- The backup LVAC supply shall be derived from a secondary substation supplied from the local 11kV underground cable or overhead line. Where possible the backup shall remain energised for the loss of the transformer.

7.4 Primary Substations

For the purposes of this standard, a primary substation is classified as a substation where the highest voltage is 33kV. Refer to EDS 08-2108 for supplies to sites with a high EPR from the distribution network.

Primary substations shall be provided with a dual LVAC supply using one or more of the following options:

1. A dedicated secondary substation provided in accordance with Section 8.1, located within the boundary of the primary substation. The secondary substation should be ring connected to the first leg of one of the outgoing UK Power Networks circuits.

2. In rural locations, a pole-mounted transformer in accordance with EDS 08-3000 may be used.

3. Additionally, the back-up supply may be provided via a three-phase service from the UK Power Networks local LV distribution network in accordance with Section 8.4.

The LVAC supply shall be provided in accordance with Section 8.7.

7.5 Secondary Substations

For the purposes of this standard, a secondary substation is classified as a substation where the highest voltage is below 33kV i.e. 20kV, 11kV or 6.6kV.

7.5.1 GRP or Brick-built Enclosed Secondary Substations

GRP or brick-built enclosed secondary substations shall be provided with an LVAC supply using one of the options below. If the secondary substation has separate HV/LV earths, the LVAC supply shall be provided via an isolation transformer (refer to EDS 06-0014 and EDS 06-0023 for further details).

1. A 32A auxiliary supply directly from the UK Power Networks LV cabinet/board in accordance with Section 8.2.

2. A single-phase service from the UK Power Networks local LV distribution network in accordance with Section 8.4.

3. A pad-mounted substation in accordance with Section 8.1.

Note: If a supply from an IDNO network is being considered, refer to Section 5.2.

7.5.2 Outdoor (Non-enclosed) Secondary Substations

Outdoor secondary substations without an enclosure (e.g. close-boarded or metal fence) shall only be provided with an LVAC supply where required to power an RTU using one of the following options:

1. A single-phase supply directly from the UK Power Networks LV cabinet/board/pillar (within the substation) in accordance with Section 8.3.

2. A single-phase service from the UK Power Networks local LV distribution network in accordance with Section 8.5.

7.6 Switching Stations

For the purposes of this standard, a switching station is a substation where there is no local transformation on site. Refer to EDS 08-2108 for supplies to sites with a high EPR.

7.6.1 132kV Switching Stations

132kV switching stations shall be provided with a dual (main and backup) LVAC supply from the local network using one of the following options, listed in order of security, subject to availability and practicality:

1. Two dedicated secondary substations, in accordance with Section 8.1, supplied from two different circuits (single point of failure is the loss of the primary substation).

2. Two dedicated secondary substations, in accordance with Section 8.1, supplied from the same circuit and can be independently energised (single point of failure is the loss of entire 11kV feeder).

3. Two dedicated secondary substations, in accordance with Section 8.1, supplied from the same circuit but cannot be independently energised (single point of failure is network fault affecting both substations).

4. One dedicated secondary substation, in accordance with Section 8.1, with generator backup, may be considered for generator/storage connections provided the switching station includes a 72-hour battery system.

The highest possible level of security shall be sought at every opportunity and cost shall not be an overriding factor.

The LVAC supply shall be provided in accordance with Section 8.7.

7.6.2 33kV Switching Stations

33kV switching stations shall be provided with a single LVAC supply using one of the following:

1. A dedicated secondary substation, in accordance with Section 8.1, ideally with an alternative HV supply, located within the boundary of the switching substation.

2. In rural locations, a pole-mounted transformer in accordance with EDS 08-3000 may be used.

The LVAC supply shall be provided in accordance with Section 8.7.

7.6.3 Other Switching Stations

Other switching stations shall be provided with a single LVAC supply using any of the options from Section 7.5. Alternatively, where no local LV supply is readily available, a pad-mounted substation shall be installed in accordance with Section 8.1.

8 General Requirements

8.1 Secondary Substation

Where specified, a secondary substation (including pad-mounted substations) shall be selected and provided in accordance EDS 07-3101 and EDS 07-3102. The secondary substation shall be connected in accordance with EDS 08-3000.

The use of a pad-mounted substation is acceptable in urban areas where they are connected via a switch or circuit breaker (refer to EDS 08-3000 for the latest guidance on pad-mounted substations).

Typical arrangements for grid and primary substations and customer 132kV and 33kV connections are shown in Figure 8-1 and Figure 8-2.

Typical arrangements for customer HV metering and HV switching stations are shown in Figure 8-3 and Figure 8-4. The actual equipment arrangement is dependent on the substation enclosure. Refer to EAS 03-0000 for available switchgear options, including extensible, to deliver these solutions.

Note: The standard approved GRP enclosure does not have sufficient operational clearance to install HV switchgear and a pad-mounted substation together.

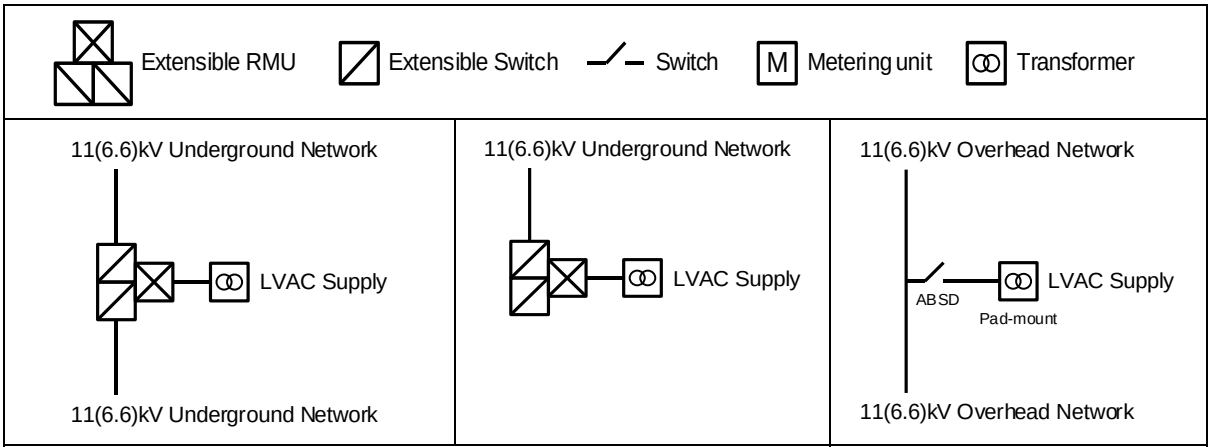

Figure 8-1 – LVAC Supply from a Ringed or Teed HV Underground Cable

Figure 8-2 – LVAC Supply from an HV Overhead Line

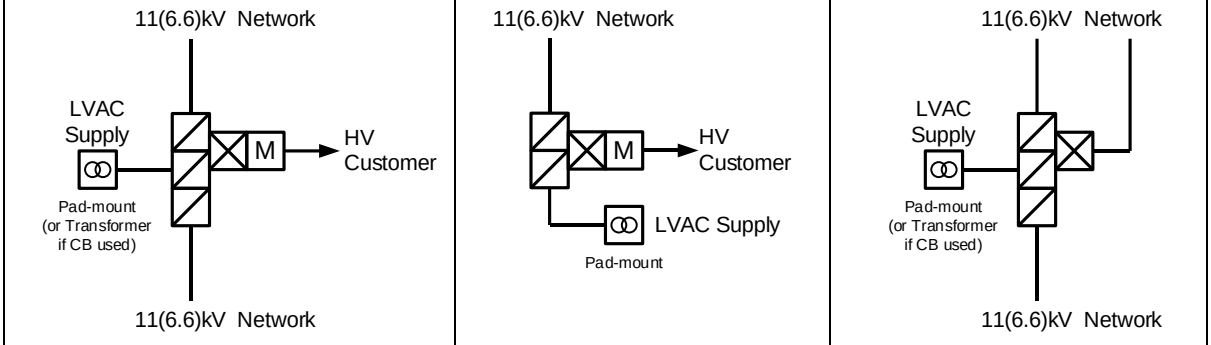

Figure 8-3 – LVAC Supply for a 11kV Ringed or Teed Customer Connection without Local LV

Figure 8-4 – LVAC Supply for a Switching Station without Local LV

8.2 LV Cabinet/LV Board 32A Auxiliary Supply to Enclosed Substation

Where specified in this document, supplies from the LV cabinet/pillar/board 32A auxiliary terminals shall be provided as follows:

- The supply shall use a minimum 4mm^2 SWA cable (refer to EAS 07-1000).
- The cable shall either be terminated in the substation distribution board or in a single-phase 100A cut-out (refer to EAS 13-0000) fused at 30A and connected to the distribution board using 25mm^2 tails.
- The SWA shall only be bonded to the cabinet/pillar/board earth and shall be insulated at the distribution board.
- An earth terminal shall **not** be provided from the incoming auxiliary supply cable. The distribution board shall be connected to the substation earth to form a TT earthing system. All earthing and bonding shall be installed in accordance with EDS 06-0014 and ECS 06-0023.
- An external generator connection and changeover switch (Section 8.8) shall be provided (if it is not part of the LV cabinet/LV board) to facilitate connection of a backup generator.

8.3 LV Cabinet/LV Board Supply to Outdoor Substation

Where specified in this document, supplies from an outdoor LV cabinet/pillar shall be provided as follows:

- The supply shall be derived either directly from the spare auxiliary terminals (fused at 5A or less) or via an un-switched fused connection unit (refer to EAS 07-1000) fused at 3A and mounted securely in the cabinet/pillar.
- The supply shall be connected to the RTU equipment using a minimum 2.5mm^2 SWA cable (refer to EAS 07-1000). To avoid a parallel earth path the armouring shall only be earthed[4] at the LV pillar end with a suitable gland, the RTU end should be secured in a plastic gland. Any unused cores should be made safe and left as spare.
- The supply shall be labelled 'CAUTION – Automation Supply' using a suitable label.
- The un-switched fused connection unit shall be connected to the RTU equipment using a minimum 2.5mm^2 SWA cable (refer to EAS 07-1000). Any unused cores shall be made safe and left as spare.
- An earth terminal shall not be provided from the incoming auxiliary supply cable. The substation earth shall be used to form a TT earthing system. All earthing and bonding shall be installed in accordance with EDS 06-0014 and ECS 06-0023.

Note: The provision of an LV supply from an existing pillar requires careful consideration and any proposed method of working shall be covered by a site-specific risk assessment.

[4] Legacy installations may have been earthed at the RTU end only but for consistency the armouring on all SWA supply cables is now only earthed at the pillar (source) end.

8.4 LV Distribution Network Supply to Enclosed Substation

Where specified in this document, supplies from the LV distribution network or a secondary substation shall be provided as follows:

- The service shall be via a 35mm^2 single-phase or three-phase aluminium cable (refer to EAS 02-0000) and be no greater than 43 metres in length.
- The cable shall be installed in a 32mm internal diameter duct (refer to EAS 02-0000) and terminated in a 100A single-phase, or three-phase cut-out (refer to EAS 13-0000) fused at 100A.
- The cut-out shall be positioned in the substation (refer to EDS 08-2110) within 3 metres of the distribution board and be connected to it using 25mm^2 tails.
- An earth terminal shall **not** be provided from the incoming service. The distribution board shall be connected to the substation earth to form a TT earthing system. All earthing and bonding shall be installed in accordance with the relevant earthing standards EDS 06-0013/ECS 06-0022 or EDS 06-0014/ECS 06-0023.
- An external generator connection and changeover switch (Section 8.8) shall be provided (if it is not part of the LV cabinet/LV board) to facilitate connection of a backup generator.

8.5 LV Distribution Network Supply to Outdoor Substation

Where specified in this document, supplies from an outdoor LV cabinet/pillar shall be provided as follows:

- The service shall be via a 35mm^2 single-phase aluminium cable (refer to EAS 02-0000) and be no greater than 43 metres in length.
- The cable shall be installed in a 32mm internal diameter duct (refer to EAS 02-0000) and terminated in a 25A cut-out (refer to EAS 13-0000) fused at 16A.
- The cut-out shall be mounted in a LV mini pillar (refer to EAS 13-0000) with an un-switched fused connection unit (refer to EAS 07-1000).
- A standard 'Danger' notice shall be attached to the pillar.
- The fused connection unit shall be connected to the RTU equipment using a minimum 2.5mm^2 SWA cable (refer to EAS 07-1000). To avoid a parallel earth path the armouring shall only be earthed[5] at the mini pillar end with a suitable gland, the RTU end should be secured in a plastic gland. Any unused cores should be made safe and left as spare.
- The supply shall be labelled 'CAUTION – Automation Supply' using a suitable label.

[5] Legacy installations may have been earthed at the RTU end only but for consistency the armouring on all SWA supply cables is now only earthed at the pillar (source) end.

8.6 Customer LVAC Supply

Where specified in this document and agreed with Network Planning, a customer LVAC supply shall be provided from the customer substation as follows:

- A 32A auxiliary supply shall be derived from the customer's essential services board using a minimum 10mm^2 SWA cable (refer to EAS 07-1000) and terminated in the substation distribution board (refer to EDS 07-1119).
- A backup supply shall be provided via a standby or emergency generator provided by the customer and available within 8 hours of the loss of the supply.
- An external generator connection (Section 8.8) and changeover switch in the UK Power Networks substation shall be provided to facilitate the connection of a backup generator.
- The LVAC supply shall not be affected by any loss of generation infeed through tripping of generator circuit breaker(s).
- The LVAC supply shall be monitored via the UK Power Networks SCADA system via the local RTU. An alarm may also be provided to the customer's SCADA where required.
- An earth terminal shall **not** be provided from the incoming service. The distribution board shall be connected to the substation earth to form a TT earthing system. All earthing and bonding shall be installed in accordance with the relevant earthing standards EDS 06-0013/ECS 06-0022 or EDS 06-0014/ECS 06-0023.
- The LVAC supply details including the agreed backup generator provision shall be recorded on the SRS.

8.7 Position and Termination

Each LVAC supply shall be provided via a cut-out and metering where appliable (Section 8.10) to an indoor LVAC switchboard or distribution board (secondary stations and small customer switchrooms). At sites with distributed buildings, the use of multiple LVAC switchboards should be considered where beneficial.

Note: New outdoor LVAC switchboards shall not be used.

The cut-out and metering (where applicable) shall be positioned in accordance with the relevant LV service drawing from EDS 08-2110 and installed in accordance with the LV jointing manual.

An auto-changeover scheme shall be provided where multiple LVAC supply options are utilised.

The LVAC supply arrangement shall include a three-phase generator connection, to allow a backup generator to be connected, with a manual changeover switch to prevent paralleling with normal LVAC supplies (Section 8.8).

For further information on the approved LVAC switchboards including the auto-changeover and generator selection functionality refer to EAS 07-1011 (internal) or EAS 07-1000 (external).

8.8 Generator Connection

Where a substation requires a connection for mobile generator, the generator connection shall be sized to match the main LVAC supply and a minimum of 63A.

The generator connection shall include:

- A minimum IP65 rated single-phase or three-phase, neutral and earth socket.
- A suitable 2-pole or 4-pole changeover switch inside the substation with an IP rating in accordance with EDS 07-1119 for the substation/switchroom type.

The generator socket shall be located externally to the substation, at ground level and easily accessible for the connection of the generator. Where the generator connection is for a GRP substation with a generator flap, the socket can be located inside the substation.

Note: If a separate enclosure is required to house generator connection, it shall be an approved GRP kiosk from EAS 07-0000 and installed in accordance with EDS 08-2110.

8.9 Earthing

The combination of the earthing systems associated with LVAC supplies and HV substations requires careful consideration to ensure dangerous voltages are not transferred between the systems. However, where conditions are suitable, the earthing systems should be bonded in accordance with the relevant earthing standards EDS 06-0013/ECS 06-0022 or EDS 06-0014/ECS 06-0023.

Furthermore, LVAC auxiliary supplies derived from the 11(6.6)kV secondary distribution network shall satisfy the earthing requirements detailed in EDS 06-0014 for the supplies to higher voltage sites.

LVAC supplies **shall not** be provided **directly** from the LV distribution network to 132kV substations, 33kV substations or other substations with a high EPR, due to the danger of possible transferred voltages to the LV system and onwards to other UK Power Networks' customers. Refer to EDS 08-2108 for suitable options.

8.10 Tariff Metering

All LVAC supplies to grid and primary substations and switching stations, including those for customer demand/generation, shall include appropriate tariff metering.

The meter shall be fitted by the UK Power Networks electricity supplier. Further details on the complete process can be found in EDS 08-1114.

Existing unmetered LVAC supplies at grid and primary substations shall be converted to a metered supply at the earliest opportunity during the next substation rewire, upgrade or refurbishment.

Note: If a customer provides an LVAC supply and it is metered at the customer end, additional metering is not required at the UK Power Networks end.

LVAC supplies to secondary substations are considered unmetered supplies.

8.11 Substation Electrical Services

Refer to EDS 07-1119 and the relevant substation civil design drawings for further information on internal substation electrical services including power, lighting, heating and dehumidification.

9 References

EAS 02-0000	Approved Equipment List - Cables and Joints
EAS 03-0000	Approved Equipment List - Switchgear
EAS 07-1000	Approved Equipment List - Substation Electrical Services
EAS 07-1011	LVAC Switchboard (internal document only)
EAS 13-0000	Approved Equipment List - LV Plant and Metering
EDS 02-0415	LV Jointing Manual
EDS 06-0013	Grid and Primary Substation Earthing Design
EDS 06-0014	Secondary Substation Earthing Design
ECS 06-0022	Grid and Primary Substation Construction
ECS 06-0023	Secondary Distribution Network Earthing Construction
EDS 07-1119	Substation Electrical Services
EDS 07-3101	Pre-design Requirements for Secondary Substations
EDS 07-3102	Secondary Substation Civil Design Standards
EDS 08-1114	Substation LVAC Supplies Metering
EDS 08-2108	Supplies to High EPR Sites and National Grid Sites
EDS 08-2110	LV Electrical Service Drawings
EDS 08-3000	HV Network Design

Appendix A – LVAC Load Calculation

The calculation of the total LVAC demand is achieved by adding all individual loads, however in most cases diversity can be applied as all load is unlikely to be used simultaneously.

If there is a significant financial benefit from optimising the size of the supply (e.g. for auxiliary transformer sizing), then diversity factors may be applied to some of the loads. A ratio of 80% has been determined as a suitable threshold for the use of diversity factors for sizing.

The following should be used to size the LVAC supply:

1. Determine whether diversity can be applied to any of the load.

2. Determine an appropriate diversity factor for each load.

3. Calculate total diversified and non-diversified demand including a provision of 20% for future load growth.

4. Calculate the ratio of diversified total demand to non-diversified total demand.

5. If the ratio is greater or equal to 0.8, the LVAC supply shall be sized for the non-diversified total demand. If the ratio is less than 0.8, the LVAC supply shall be sized for the diversified total demand.

A typical example is shown in Table A-1 where the ratio of diversified to non-diversified demand is 77%; therefore the LVAC supply is sized for the diversified total demand of 69.93kVA.

Note: The items included in Table A-1 are not applicable to all substations but should be considered when the LVAC is sized and the values adjusted to suit the particular substation where applicable.

Table A-1 – LVAC Load Calculation Example

Item	Quantity	Connected Load (kw)	Power Factor	Load (kW)	Load (kVA)	Diversity Factor	Diversified Load (kW)	Diversified Load (kVA)
Lighting	15	0.065	0.95	0.98	1.03	80%	0.78	0.82
Power Sockets	10	0.5	0.95	5.00	5.26	50%	2.50	2.63
Dehumification	2	3	0.95	6.00	6.32	80%	4.80	5.05
Heating	6	2	0.95	12.00	12.63	70%	8.40	8.84
Ventilation	2	1.5	0.85	3.00	3.53	80%	2.40	2.82
Air Conditioning	1	4	0.95	4.00	4.21	70%	2.80	2.95
Dampers	1	1	0.95	1.00	1.05	80%	0.80	0.84
Fire Suppression	2	1	1	2.00	2.00	80%	1.60	1.60
Fire Alarm	1	1	1	1.00	1.00	80%	0.80	0.80
Pumps	2	3	1	6.00	6.00	80%	4.80	4.80
110V Transformer	1	3	0.95	3.00	3.16	80%	2.40	2.53
Battery Switchgear	1	7.2	1	7.20	7.20	80%	5.76	5.76
Battery SCADA	1	3.6	1	3.60	3.60	80%	2.88	2.88
EV Charger	1	22	1	22.00	22.00	80%	17.60	17.60
Future Load	1	10	0.85	10.00	11.76	85%	8.50	10.00
Totals				86.78	90.75		66.82	69.93
Diversified/Non-Diversified Ratio							0.77	0.77

Appendix B – Legacy Arrangements

B.1 LPN

At existing 132/11kV 60MVA transformer sites each transformer has its own auxiliary transformer (normally 100kVA) and transformer LV board feeding its specific transformer requirements. All transformer LV boards are linked together with auto-changeover between systems and interlocked to prevent paralleling.

The essential services switchboard and building services switchboard have a connection to one of the LV boards (so has an auto-changeover secure supply). There is no distinction between essential and non-essential services in this arrangement.

For older 132/33kV, 66/33kV sites: The arrangement follows the earlier CEGB practice. Typically, each transformer has its own auxiliary transformer and transformer LV board feeding its specific transformer requirements. This is normally an outdoor board. All Transformer LV boards are linked together and interlocked to prevent paralleling. A single LV switchboard (indoor) with backup (maybe auto-changeover or manual) on site feeds essential services and building services. This is fed from one of the Transformer LV boards. The other side for auto-changeover may be from another transformer LV board or from the local LV network'. There is no distinction between essential and non-essential services in this arrangement.

For new 132kV switchgear including 132/11kV 60MVA transformer sites, each transformer has its own auxiliary transformer and transformer LV board feeding its specific transformer requirements. All transformer LV boards are linked together and interlocked to prevent paralleling. A single LV switchboard with auto-changeover on site feeds essential services and building services. This is fed from a secondary substation on site (or larger auxiliary transformer, i.e. 200KVA). The other LV infeed for auto-changeover may be from another secondary substation/large auxiliary transformer/network LV - typically each a secondary on a different section of 11kV switchboard. There is no distinction between essential and non-essential services.

For older 33/11kV, 66/11kV installations (all transformer ONAN type): A single LV switchboard with manual changeover on site feeds essential services and building services. Both sides of changeover fed from LV network (typically each fed from a secondary substation on different section of 11kV switchboard). There is no distinction between essential and non-essential services in this arrangement.

For older 33/11kV, 66/11kV installations (transformer OFAN,OFAF, ONAF - including previous ONAN sites where enhanced cooling been added): A single LV switchboard with auto-changeover on site feeds essential services and building services. Both sides of the auto-changeover scheme are fed from the LV network (typically each fed from a secondary substation on different section of 11kV switchboard). There is no distinction between essential and non-essential services in this arrangement.

B.2 EPN

For earlier designs of grid site (132/33kV), as with early LPN designs, LV supplies are taken from the earthing/ auxiliary transformers on the LV side of the transformer. Each is taken to a dedicated LV board (normally outdoors).

An indoor LV switchboard is normally fed from either one of the outdoor LV boards and a network supply, or both outdoor LV boards.

This approach seems to have been maintained.

For primary sites, early designs had a single LV supply from the network. Later urban substation designs became more complex with either two pad-mounted substations with an auto-changeover scheme or a single pad-mounted substation and a network supply. A generator socket is also provided on the single LV board.

For rural primary substations, early designs relied upon a single supply from a local pole transformer. Later designs added in a supply from a second pole transformer on the opposite 11kV busbar section to the first supply.

B.3 SPN

Grid sites are in the main the same as the original CEGB design; that is LV supplies are taken from the earthing/auxiliary transformers and fed into the local LV boards which in turn feed the indoor LV board.

For primary sites, a single LV supply is taken from the network or a local secondary substation within the primary substation boundary.

The latest design of sites has maintained this approach.