Electricity Distribution

nationalgrid

Company Directive

POLICY DOCUMENT: SD2/9

Relating to 132kV Network Design

Policy Summary

This document describes the requirements for the design of the 132kV network.

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Implementation Date: **October 2023**

Approved by

Carl Ketley-Lowe
Engineering Policy Manager

Date: **20th October 2023**

Target Staff Group	**Staff involved with the analysis, design, construction, maintenance and replacement of National Grid Electricity Distribution's network**
Impact of Change	**Green – Rebranded and update of hyperlinks only**
Planned Assurance checks	**None**

IMPLEMENTATION PLAN

Introduction

POL: SD2 specifies the requirements for 132kV network design.

Main Changes

- Rebranding and updating of links only

Impact of Changes

Target Staff Group	Staff involved with the analysis, design, construction, maintenance and replacement of National Grid Electricity Distribution's network
Impact of Change	Green - Rebranded and update of hyperlinks only

Implementation Actions

None – no significant change.

Implementation Timescale

Document is implemented on issue.

REVISION HISTORY

Document Revision and Review Table		
Date	Comments	Name
October 2023	• Re-branded and update of hyperlinks only	Seth Treasure
October 2020	• Note 6 and 7 in Table 1 amended	Andy Hood
May 2020	• Document has been re-formatted to comply with POL:GE1. • Definitions have been added. • References to the Electricity Safety Quality and Continuity Regulations and to the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) have been added. • **Generation Security**, **Network Integrity**, **System Integrity** requirements have been added. • Network complexity requirements have been clarified. • **Load Management Scheme** requirements have been modified. • **Step Voltage Change** requirements have been modified. • A section on network Losses has been added.	Andy Hood
December 2019	Page 5, Section 2.1.2 - ST:AM5C removed and replaced with POL:AM5.	Andy Hood
September 2018	A reference to EREC G99 has been added to Section 2.3 and Appendix B.	Andy Hood
September 2017	Section 2.1.1 relating to the requirements for networks that include active load management has been added.	Andy Hood
September 2014	The following page amendments have been made: Links to the Distribution Code, Grid Code and to Engineering Recommendations updated. Engineering Recommendation version / issue numbers removed and replaced with the term “as amended”. 132kV network complexity shall be in accordance with EREC P18.	Andy Hood

Contents

1.0 INTRODUCTION

1.1 This document describes the standard requirements for the design of the 132kV network including for **Demand Security**, **Generation Security**, **Network Integrity**, **System Integrity**, supply quality, safety, network losses, asset utilisation and capital investment requirements. Where any difficulty is encountered with the application of this policy, the author should be notified, who will consider if a variation to this policy is appropriate.

2.0 DEFINITIONS

2.1 **Demand Security**: The ability to meet customer demand under **Intact Network** and outage conditions.

2.2 **Generation Security**: The ability to accept customer export under **Intact Network** and outage conditions.

2.3 **Intact Network**: A network operating with open points in their normal position and without any outages that are material to the condition being considered or studied. The **Intact Network** arrangement shall be agreed between Primary System Design, Network Strategy, Operations Support, Control and Network Services and indicated on network diagrams and control systems.

2.4 **Load:** The apparent power (e.g. kVA or MVA) associated demand and/or generation.

2.5 **Load Management Schemes**: Plant, equipment and software systems that together manage network loading and voltages by either controlling demand and/or generation connected to the network, operating switchgear to change the topology of the network and/or controlling the settings of tap-change controllers, reactive compensation equipment and flexible power links.

Examples of **Load Management Schemes** include but are not limited to:

- Operational Intertripping
- Active Network Management (ANM)
- Soft-intertripping
- Timed connections
- Overload protection
- Auto-changeover
- Voltage constraint systems
- Remote control of switchgear or other plant and equipment

The following are outside of the scope of this definition:

- Customer-owned export limitation schemes
- Conventional independent tap-change control schemes
- Network protection for fault clearance
- Loss-of-mains protection, including loss-of-mains intertripping

2.6 **Network Integrity**: The ability of a network to operate within thermal, voltage and other technical limits, excluding frequency-related limits, under both **Intact Network** and outage conditions.

2.7 **Operational Secured Next Fault:** A fault outage after which **Demand Security, Generation Security, Network Integrity** and **System Integrity** requirements must be satisfied when operating the network.

The following fault conditions starting from the prevailing running arrangement:

- Each circuit fault
- Each busbar fault

Outages at all voltage levels relevant to the network in question shall be considered, including outages on the transmission system and other third party networks, where applicable.

2.8 **Secured Outage**: An outage or combination of outages after which **Demand Security, Generation Security, Network Integrity** and **System Integrity** requirements must be satisfied in design studies.

The following types and combinations of outages are considered when 132kV networks are designed:

- Each circuit fault outage*
- Each busbar fault outage
- Each circuit arranged outage*
- Each circuit arranged outage followed by each circuit fault outage*
- Each circuit arranged outage followed by each busbar fault outage
- Each busbar arranged outage*
- Each busbar arranged outage followed by each circuit fault outage*
- Each busbar arranged outage followed by each busbar fault outage

Outages at all voltage levels relevant to the network in question shall be considered, so far as is possible, including outages on the transmission network and other third-party networks where applicable.

Network Integrity and **System Integrity** requirements apply to all **Secured Outages**.

Demand Security and **Generation Security** requirements are set by EREC P2, bilateral agreements with customers, consideration of CIs and CMLs and consideration of vulnerable customer obligations, in accordance with Section 3.1. They may only apply for a subset of **Secured Outages**. The outage types and combinations with **Demand Security** requirements in EREC P2 are marked with asterisks (*) above.

2.9 **Step Voltage Change:** The change from the initial voltage level to the resulting voltage level after all generating unit automatic voltage regulator (AVR) and static VAr compensator (SVC) actions and transient decay (typically 5s after the fault clearance or network switching) have taken place, but before any other automatic or manual tap-changing and switching actions have commenced.

The percentage **Step Voltage Change** is the value of **Step Voltage Change** in volts expressed as percentage change of the nominal system voltage.

2.10 **System Integrity**: The ability of the GB system to operate within acceptable frequency-related technical limits under both **Intact Network** and outage conditions.

System Integrity is primarily managed by National Grid, but it can be affected by the operation of NGED's network and customers. This includes but is not limited to:

- Low Frequency Demand Disconnection
- Generator Interface Protection
- Changes in net **Load** caused by protection operation, manual intervention or the operation of **Load Management Schemes**.

2.11 **Unsecured Outage:** An outage condition that is beyond the scope of a **Secured Outage**.

Unsecured Outages are not normally considered when designing the network. Examples include:

- Multiple concurrent arranged outages
- Circuit breaker failure fault outages
- Multiple concurrent fault outages
- The concurrent fault outage of multiple circuits sharing the same structure, such as double circuit tower lines

3.0 POLICY

The design of the 132kV network shall satisfy the requirements of the Electricity Safety, Quality and Continuity Regulations, Distribution Code of Licensed Distribution Network Operators of Great Britain and the relevant requirements of the Grid Code and the National Electricity Transmission System Security and Quality of Supply Standard.

3.1 Security

132kV networks shall be designed to satisfy the **Demand Security** requirements and **Generation Security** requirements specified in:

- EREC P2 for **Demand Security**
- bilateral connection agreements with customers and other network operators for both **Demand Security** and **Generation Security**

Due consideration shall also be given to Customer Interruptions (CIs), Customer Minutes Lost (CMLs) and to vulnerable customer obligations.

3.2 Network Integrity

132kV networks shall be designed to enable **Network Integrity** to be maintained under **Intact Network** and **Secured Outage** conditions and for **Operational Secured Next Faults**. **Network Integrity** may be maintained by the inherent capability of the plant and equipment, operation of protection, operation of **Load Management Schemes** or by manual intervention.

It is recognised that Primary System Design (PSD) engineers do not currently have access to design tools that are capable of automatically assessing every **Secured Outage** under all relevant network loading conditions. In the absence of such design tools Primary System Design engineers may study a limited number of scenarios that, to the best of their knowledge, represent the most onerous cases.

132kV networks shall be designed to allow Control Engineers and Outage Planning Engineers to maintain **Network Integrity** for **Operational Secured Next Faults**, even where these go beyond the requirements of **Secured Outages**. Typically this can be achieved by splitting the network into multiple radial networks. Where that is impractical, Operational Intertripping meeting the requirements of POL:SD11 Category A should be considered.

3.3 System Integrity

132kV networks shall be designed to enable **System Integrity** to be maintained under **Intact Network** conditions and **Operational Secured Next Fault** conditions for **Secured Next Faults** and for credible step changes in **Load**. In this context, the change of **Load** across all license areas and all voltage levels shall not exceed 300MW unless explicitly agreed with National Grid

It is recognised that Primary System Design (PSD) engineers do not currently have access to design tools that are capable of automatically assessing every **Operational Secured Next Fault** under all relevant network loading conditions. In the absence of such design tools Primary System Design engineers may study a limited number of scenarios that, to the best of their knowledge, represent the most onerous cases.

3.4 Network Complexity

132kV networks shall be designed to comply with the requirements of EREC P18, Complexity of 132kV Circuits.

This assessment shall be carried out for **Intact Network** conditions only**.** For the purpose of these studies it is assumed that 132kV transformers will be disconnected by local protection or by intertripping where the 132kV circuit feeding the transformer is disconnected due to a fault.

3.5 Load Management Systems

Where the **Load** is actively managed the network and the associated **Load Management Scheme** shall satisfy the requirements of POL:SD11.

3.6 Network Improvements

Improvements to **Demand Security**, **Generation Security**, **Network Integrity**, **System Security** and network complexity will be considered in accordance with POL:AM5.

3.7 Supply Quality

132kV networks shall be designed to:

- have a voltage regulation that will ensure normal operating voltages are achieved on the 132kV Network and lower voltage networks for **Intact Network** conditions, **Secured Outage** conditions and for other arrangements that are required to meet **Demand Security** and **Generator Security** after automatic voltage regulation operation.
- ensure that customer connections comply with the voltage unbalance limits contained in EREC P29
- ensure that customer connections comply with the voltage fluctuation requirements of EREC P28. Clause 6.2 of EREC P28 allows Distribution Network Operators some discretion with regard to **Step Voltage Change** limits caused by customer equipment and installations. National Grid Electricity Distribution's **Step Voltage Change** limits applicable to customer connections are defined in Table 1.
- ensure that customer connections comply with the limits for harmonics in the UK contained in EREC G5
- have a **Step Voltage Change** no higher than the limits specified in Table 2 for Distribution Network Operator, Independent Distribution Network Operator and Transmission Network Operator events and operations.

Condition[3]	Step Voltage Change Limit[1,2]
Import / Export Variation	-3% fall and +3% rise subject to compliance with P28 flicker limits[4]
Load Management Scheme curtailment	-3% fall and +3% rise subject to compliance with P28 flicker limits
Generator interface (e.g. G59 or G99) protection trip	-6% fall and +6% rise
Fast frequency response (e.g. maximum import to maximum export and vice versa)	-3% fall and +3% rise
Frequent[5] operational switching by the customer	-3% fall and +3% rise subject to compliance with P28 flicker limits
Infrequent[6] operational switching by the customer	-3% fall and +3% rise
Very Infrequent[7] operational switching by the customer	-6% fall and +6% rise
Note 1: *Limits apply at the point of common coupling*	
Note 2: *Limits are expressed as percentage of nominal system voltage. For example, for 132kV networks a 3%* ***Step Voltage Change*** *equates to a voltage change of 3.96kV phase-phase.*	
Note 3: *Consider the most onerous operating arrangements specified in P28 and the most onerous demand / generation conditions (e.g. max. demand and min. generation / min. demand and max. generation).*	
Note 4: *For the purpose of this assessment wind turbine and photovoltaic* ***Generating Units*** *are assumed to have a minimum output of 20% of their maximum capacity. Other types of* ***Generating Units*** *are assumed to have a zero minimum output.*	
Note 5*: Frequent operational switching events are those that are expected to occur more than 4 times in any month, consist of more than 4 operations in any day or include operations that are separated by less than 10 minutes.*	
Note 6: *Infrequent operational switching events occur more frequently than once every three months up to a maximum of 4 times in a calendar month. Each event may consist of up to 4 operations in one day, each operation separated by at least 10 minutes.*	
Note 7: *Very infrequent operational switching events occur no more frequently than once every 3 months. Each event may consist of up to 4 operations in one day, each separated by at least 10 minutes.*	

Table 1 Step Voltage Change Limits associated with Customer Equipment and Connections

Condition	Step Voltage Change Limit[8,9]
Trip metering circuit breaker	-6% fall and +6% rise
Secured Outage[10]	-6%[11] fall and +6%
Specific secured events[12]	-12% fall and +6% rise
Load Management Scheme communication system or IT system disconnection or failure	-10% fall and +6% rise
Fast Frequency Response event	-6% fall and +6% rise
Frequent[13] operational switching	-3% fall and +3% rise
Infrequent[14] operational switching	-6% fall and +6% rise
Note 8: *Limits apply at customer Connection Points and at the lower voltage busbar of Bulk Supply Points.*	
Note 9: *Limits are expressed as percentage of nominal system voltage. For example, for 132kV* ***Connection Points*** *a 3%* ***Step Voltage Change*** *equates to a voltage change of 3.96kV phase-phase.*	
Note 10: *See the definition for* ***Secured Outage.***	
Note 11: *If the -6% limit is exceeded then values up to -10% may be considered as long as this is supported by an appropriate cost benefit analysis that is approved by the Primary System Design Manager.*	
Note 12: *Events specified within section b) and c) of Table 6.5 of the National Electricity Transmission System Security and Quality of Supply Standard (SQCC)*	
Note 13: *Operational switching events that are expected to occur several times per day, including automatic operation of tap-changers etc.*	
Note 14*: Operational switching events that are expected to occur less than once per day on average associated with plant/equipment commissioning and maintenance etc.*	

Table 2 Step Voltage Change Limits for Network Operations, Outages and Events

3.8 Safety

132kV networks shall:

- be protected in accordance with POL:TP2
- comply with EREC G59 or EREC G99, as applicable
- to take account of the fault level calculation methodology detailed in EREC G74
- operate within equipment design ratings including any appropriate cyclic or short term rating as defined in the appropriate Engineering Instructions and Directives.

3.9 Losses

National Grid Electricity Distribution is obliged to operate an efficient and economic system through the Distribution Licence. Standard Licence Condition 49 requires NGED ensure distribution losses are as low as reasonably practicable, to maintain a Losses Strategy and to design, build and operate the network in a manner that is reasonably expected to ensure losses are as low as reasonably practicable.

132kV Networks shall be designed in accordance with ST:SD1H, The Treatment of Losses in an Inclusive Network Design Process

3.10 Asset Utilisation and Capital Investment

132kV networks will be designed:

- using short circuit and load flow analysis tools approved by the Network Strategy Manager.
- using equipment of standard capacities.
- to improve asset utilisation whilst meeting the **Demand Security**, **Generation Security**, **Network Integrity**, **System Integrity**, supply quality, safety and network loss requirements specified in this document.
- for the lowest lifetime cost in accordance with POL:AM5
- to ensure correct operation in parallel with other Network Operator systems.

4.0 BACKGROUND INFORMATION

The requirements of this policy have evolved over a period of time and represent tried and tested principles.

Engineering Directive POL:SD1 contains further information on the fundamental aims of system design.

APPENDIX A

SUPERSEDED DOCUMENTATION

This document supersedes POL: SD2/8 dated September 2018 which has now been withdrawn

APPENDIX B

RECORD OF COMMENT DURING CONSULTATION

POL: SD2/9 - Comments

APPENDIX C

ANCILLARY DOCUMENTATION

The Electricity Safety, Quality and Continuity Regulations

The Distribution Code of Licensed Distribution Network Operators of Great Britain

The Grid Code

National Electricity Transmission System Security and Quality of Supply Standard

EREC P2, Security of Supply

EREC P18, Complexity of 132kV Circuits

EREC P29, Planning limits for voltage unbalance in the United Kingdom

EREC P28, Voltage fluctuations and the connection of disturbing equipment to transmission systems and distribution networks in the United Kingdom

EREC G5, Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom

EREC G59, Recommendations for the connection of private generating plant to the distribution systems of Licensed Distribution Network Operators

EREC G99, Recommendations for the connection of generating equipment in parallel with public distribution networks on or after 27th April 2019

EREC G74, Procedure to meet the requirements of IEC 60909 for the calculation of short-circuit currents in three-phase AC power systems

POL: AM5, Technical Appraisal, Approval and Post Investment Appraisal for Network Relating Capital projects

APPENDIX D

KEY WORDS

132kV, network, system, design, security, unbalance, fluctuation, harmonics, utilisation.