Electricity Distribution

nationalgrid

# Company Directive

## POLICY DOCUMENT: SD2/10

## Relating to 132 Network Design

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

**Author:** **Andy Hood**

**Implementation Date:** **December 2024**

**Approved by**

**Carl Ketley-Lowe**
**Head of Engineering Policy**

**Date:** **20th December 2024**

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|---|---|
| **Target Staff Group** | **Staff involved with the analysis and design of National grid Electricity Distribution's (NGED's) 132kV network, telecommunication systems and information technology systems** |
| **Impact of Change** | **Amber – This document relaxes the requirements for System Frequency Integrity. It also explicitly specifies the Network Integrity requirements for Operational Technology (OT) outages and faults** |
| **Planned Assurance checks** | **One year after the issue of this document Engineering Policy shall audit a number of 132kV network modifications to check that they comply with the requirements of this policy.** |

## IMPLEMENTATION PLAN

### Introduction

This document specifies the requirements for 132kV network design.

### Main Changes

A number of definitions have been added and some exiting definitions have been renamed or modified to provide additional clarity.

System Frequency Integrity requirements are now based on the magnitude of the Normal Infeed Loss Risk, as defined in the National Electricity Transmission System (NETS) Security and Quality of Supply Standard (SQSS).

The document has also been modified to explicitly require Network Capability to be satisfied under Secured Operational Technology (OT) Outage and Operational Technology (OT) Secured Next Fault conditions.

### Impact of Changes

| | |
|---|---|
| **Target Staff Group** | **Staff involved with the analysis and design of National grid Electricity Distribution's (NGED's) 132kV network, telecommunication systems and information technology systems.** |
| **Impact of Change** | **Amber – This document relaxes the requirements for System Frequency Integrity. It also explicitly specifies the Network Integrity requirements for Operational Technology (OT) outages and faults.** |

### Implementation Actions

Managers shall ensure that staff involved in the analysis and design of 132kV Networks and associated telecommunication systems and information technology systems are aware of, and follow, the requirements of this document.

PowerPoint Presentation

### Implementation Timetable

This document is implemented on issue for new and substantially modified 132kV networks and associated telecommunication systems and information technology systems.

**REVISION HISTORY**

| DOCUMENT REVISION & REVIEW TABLE | | | |
|---|---|---|---|
| **Issue** | **Date** | **Comments** | **Author** |
| 10 | December 2024 | • Section 1.0 Introduction has been renamed as Scope<br>• Section 2.0 - The following definitions have been added, renamed or amended:<br>  ○ Advanced Distribution Management System (ADMS)<br>  ○ Customer Limitation Scheme<br>  ○ Customer Security<br>  ○ Failover<br>  ○ Information Technology (IT) Secured Next Fault<br>  ○ Network Capability<br>  ○ Operational Technology (OT) Secured Next Fault<br>  ○ Secured Information Technology (IT) Outage<br>  ○ Secured Next Fault<br>  ○ Secured Operational Technology (OT) Outage<br>  ○ Secured Telecommunication Outage<br>  ○ System Frequency Integrity<br>  ○ Telecommunication Secured Next Fault<br>• Section 3.2 - The requirements for Network Capability have been modified to explicitly cater for Operational Technology Secured Next Faults and Secured Operational Technology Outages.<br>• Section 3.3 - The requirements for System Frequency Integrity have been modified and are now based on the magnitude of the Normal Infeed Loss Risk of 1320MW, as defined in the NETS SQSS.<br>• Section 3.10 Short circuit and load flow analysis tool shall be approved by the Head of Modelling and Analysis | Andy Hood |
| 9 | Oct 2023 | • Document rebranded and links updated | Seth Treasure |
| 8 | May 2020 | • Document has been re-formatted to comply with POL:GE1.<br>• Definitions have been added.<br>• 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.<br>• Generation Security, Network Integrity, System Integrity requirements have been added.<br>• Network complexity requirements have been clarified.<br>• Load Management Scheme requirements have been modified.<br>• Step Voltage Change requirements have been modified.<br>• A section on network Losses has been added. | Andy Hood |
| 7 | Sep 2018 | • A reference to EREC G99 has been added | Andy Hood |
| 6 | Sep 2017 | • Section 2.1.1 relating to the requirements for networks that include active load management has been added. | Andy Hood |
| 5 | May 2012 | • Step voltage change limit increased to 10% | Andy Hood |

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|---|---|---|---|
| 4 | Oct 2010 | • References to the Distribution Code and Grid Code added<br>• G59/2 reference added and G59/1, G75/1 and ETR113 references removed | Andy Hood |
| 3 | May 2009 | • System reliability schemes shall be assessed in accordance with ST:AM5C<br>• Step voltage changes shall be assessed following operation of auto-close schemes where these operate within 5s<br>• Schemes shall be financially assessed in accordance with POL:AM5 and POL:FI06/04/01 | Andy Hood |
| 2 | Mar 2003 | • G75 reference updated to G75/1 | N J Turvey |
| 1 | April 2001 | • Document rebranded | N J Turvey |
| 0 | July 1996 | • Document issued | N J Turvey |
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**CONTENTS**

## 1.0 SCOPE

This document specifies the standard requirements for the design of the 132kV network including those associated with Customer Security, Network Capability, System Frequency Integrity, network complexity, load management, network improvement, supply quality, safety, losses, asset utilisation and capital investment. Where any difficulty is encountered with the application of this policy, the author shall be notified, who will consider if a variation is appropriate.

## 2.0 DEFINITIONS

| Name/Phase | Definition |
|---|---|
| Advanced Distribution Management System (ADMS) | A NGED system that provides Supervisory Control and Data Acquisition (SCADA), Distribution Management System (DMS) and Outage Management System (OMS) functionality. |
| Customer Limitation Scheme (CLS) | A system that is owned by a customer and that controls the net flow of electricity into or from the distribution network at the Connection Point to prevent the customer exceeding their agreed export capacity and/or agreed import capacity. |
| Customer Security | The requirement for Demand Security and Generation Security. |
| Demand Security | The ability to meet customer demand under Intact Network and outage conditions. |
| Failover | The ability to switch automatically and seamlessly to a reliable backup system when a component or system fails. |
| Generation Security | The ability to accept customer export under Intact Network and outage conditions. |
| Information Technology (IT) Secured Next Fault | An IT fault outage after which Customer Security, Network Capability and System Frequency Integrity requirements must be satisfied when operating the network.<br>The following fault conditions starting from the prevailing running arrangement are considered:<br>• each front-end processor (FEP)<br>• each firewall system<br>• each ADMS server<br>• each ANM system server<br>• each network switch<br>• each ethernet circuit<br>• each GPS time synchronising clock<br>• each independent source of electrical power<br>Outages in all relevant parts of the IT system shall be considered, including outages on third party systems and equipment, where applicable. |
| 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.<br>The Intact Network arrangement shall be agreed between Primary Network Design, the Distribution System Operator Modelling and Analysis Team, NGED's Control Centre and the relevant Operations Team and shall be recorded on network diagrams and within ADMS. |
| Load | The apparent power (e.g., kVA or MVA) associated with demand, generation and/or electrical energy storage. |

| Name/Phase | Definition |
|---|---|
| Load Management Scheme (LMS) | 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:<br>• Operational Intertripping<br>• Active Network Management (ANM)<br>• Soft-intertripping<br>• Overload protection<br>• Auto-changeover<br>• Voltage constraint<br>• Manual Curtailment<br>The following are not considered to be Load Management Schemes:<br>• Customer Limitation Schemes.<br>• Conventional independent tap-change control schemes<br>• Network protection for fault clearance<br>• Loss-of-mains protection, including loss-of-mains intertripping<br>• Timed connections |
| Network Capability | Thermal, voltage and other technical limits, excluding frequency-related limits, within which the network must operate to prevent damage to plant and equipment and to prevent, so far as is reasonably practicable, danger. |
| Operational Technology (OT) Secured Next Fault | An Information Technology Secured Next Fault or Telecommunication Secured Next Fault. |
| Secured Information Technology (IT) Outage | An IT outage or combination of outages after which Customer Security, Network Capability and System Frequency Integrity requirements must be satisfied in design studies.<br>An arranged outage and also an arranged outage followed by a fault outage, of any combination of the following components, is considered:<br>• FEP<br>• Each firewall system<br>• Each ADMS server<br>• Each ANM server<br>• Each network switch<br>• Each ethernet circuit<br>• Each GPS time synchronising clock<br>• Each independent source of electrical power<br>Outages in all parts of the IT system shall be considered, so far as is possible, including outages in third-party networks, where applicable. |
| Secured Next Fault | An electrical fault outage after which Customer Security, System Frequency Integrity and Network Capability requirements must be satisfied when operating the network. The following fault conditions starting from the prevailing running arrangement are applicable:<br>• Each Circuit fault<br>• Each busbar fault |

| Name/Phase | Definition |
|---|---|
| | Outages at all voltage levels in question shall be considered, including outages on the transmission system and other third-party networks, where applicable. |
| Secured Outage | An electricity network outage or combination of outages after which Customer Security, Network Capability and System Frequency Integrity requirements must be satisfied in design studies.<br>The following types and combinations of outages are considered:<br>• each circuit fault outage*<br>• each busbar fault outage<br>• each circuit arranged outage*<br>• each circuit arranged outage followed by each circuit fault outage*<br>• each circuit arranged outage followed by each busbar fault outage<br>• each busbar arranged outage*<br>• each busbar arranged outage followed by each circuit fault outage*<br>• each busbar arranged outage followed by each busbar fault outage<br>Outages at all voltage levels shall be considered, so far as is possible, including outages on the transmission network and other third-party networks, where applicable.<br>*Outage types and combinations with Demand Security requirements in EREC P2 are marked with asterisks (*) above.* |
| Secured Operational Technology (OT) Outage | A Secured IT Outage, Secured Telecommunication Outage or combination of these outages after which Customer Security, Network Capability and System Frequency Integrity requirements must be satisfied in design studies.<br>An arranged outage and also an arranged outage followed by a fault outage, of any combination of the components identified in the definitions for Secured IT Outage and Secured Telecommunication Outage, is considered. |
| Secured Telecommunication Outage | An operational telecommunication network outage or combination of outages after which Customer Security, System Frequency Integrity and Network Capability requirements must be satisfied in design studies.<br>An arranged outage and also an arranged outage followed by a fault outage of any combination of the following components, is considered:<br>• each communication circuit<br>• each fibre<br>• each communication mast / tower<br>• each fixed radio link (Super High Frequency)<br>• each multi-drop/combiner facility<br>• each multiplexer<br>• each network switch<br>• each firewall<br>• each independent source of electrical power<br>• each time synchronising clock<br>Outages in all parts of the operational telecommunication network shall be considered, so far as is possible, including outages in third-party networks, where applicable. |

| Name/Phase | Definition |
|---|---|
| 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.<br>*Derived from EREC P28* |
| System Frequency Integrity | The ability of the GB system to operate within acceptable frequency-related technical limits under both Intact Network and outage conditions.<br>System Frequency Integrity is primarily managed by the National Energy System Operator (NESO), but it can be affected by the operation of NGED's network and customers. This includes but is not limited to:<br>• Low Frequency Demand Disconnection<br>• Interface Protection associated with Power Generating Modules<br>• Changes in net Load caused by protection operation, manual intervention or the operation of Load Management Schemes. |
| Telecommunication Secured Next Fault | An operational telecommunication network fault outage after which Customer Security, System Frequency integrity and Network Capability must be satisfied when operating the Network.<br>The following fault conditions starting from the prevailing running arrangement are considered:<br>• each communication circuit<br>• each fibre<br>• each communication mast / tower<br>• each fixed radio link (Super High Frequency)<br>• each multi-drop/combiner facility<br>• each multiplexer<br>• each network switch<br>• each firewall<br>• each independent source of electrical power<br>• each time synchronising clock<br>Outages in all relevant parts of the operational telecommunication network shall be considered, including outages on third party systems and equipment, where applicable. |
| Unsecured Outage | An outage condition that is beyond the scope of a Secured Outage.<br>Unsecured Outages are not normally considered when designing the network. Examples include:<br>• Multiple concurrent arranged outages<br>• Circuit breaker failure fault outages<br>• Multiple concurrent fault outages<br>• The concurrent fault outage of multiple circuits sharing the same structure, such as double circuit tower lines |

## 3.0 REQUIREMENTS

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 (NETS) Security and Quality of Supply Standard (SQSS).

### 3.1 Customer 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 Capability

132kV networks shall be designed to operate within their Network Capability under Intact Network, Secured Outage and Secured OT Outage conditions.

NGED networks shall also be designed so they may be operated within their Network Capability for Secured Next Faults and OT Secured Next Faults. For example, under Secured Outage conditions an interconnected/parallel network could be re-configured as a radial network so that for further Secured Next Faults, protection systems will not only clear the fault but also disconnect the associated Load, preventing remaining healthy circuits from being overloaded.

Network capability may be satisfied by the inherent capability of the plant and equipment, operation of protection, operation of Load Management Schemes and by flexibility services and/or manual intervention.

Outages of IT components (e.g., FEPs, firewalls, servers, network switches, ethernet switches, GPS time synchronising clocks etc.) are typically mitigated by providing 3 independent instances of each component and by only taking an arranged outage on one item at a time. Where this is the case, each component shall be designed to carry the full load and to Failover successfully.

It is recognised that Primary Network Design 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 Network Design engineers may study a limited number of scenarios that, to the best of their knowledge, represent the most onerous cases.

### 3.3 System Frequency Integrity

132kV networks shall be designed to enable System Frequency Integrity to be maintained under Intact Network and Secured Outage, Secured OT Outage, Secured Next Fault and OT Secured Next Fault conditions.

To achieve this requirement the change of Load across all NGED license areas under these circumstances shall not exceed the magnitude of the Normal Infeed Loss Risk defined in the National Electricity Transmission System (NETS) Security and Quality of Supply Standard (SQSS). At the time of issue of this document the SQSS defines the Normal Infeed Loss Risk as 1320MW. In addition, for Secured OT Outages and OT Secured Next Faults the magnitude of the net change in Load across all NGED license areas shall not exceed 300MW per minute unless otherwise agreed with the National Energy System Operator (NESO).

It is recognised that Primary Network Design engineers do not currently have access to design tools that are capable of automatically assessing every Secured Next Fault and Operational OT Next Fault under all relevant network loading conditions. In the absence of such design tools Primary Network 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 Distribution Circuits Operated at or above 22kV.

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

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

## 3.6 Network Improvement

Network improvement proposals shall be technically appraised and approved 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 control 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 Network 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
- 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**

NGED is obliged to operate an efficient and economic system under its Distribution Licence. Standard Licence Condition 49 requires NGED to ensure distribution losses are as low as reasonably practicable, 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 Head of Modelling and Analysis.
- using equipment of standard capacities.
- to improve asset utilisation whilst satisfying Customer Security, Network Capability, System Integrity, supply quality, safety and network loss requirements specified in this document.
- for the lowest lifetime cost in accordance with POL: AM5

## 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 network design.

## APPENDIX A: SUPERSEDED DOCUMENTATION

This document supersedes POL: SD2/9 dated October 2023 which has been withdrawn

## APPENDIX B: RECORD OF COMMENT DURING CONSULTATION

POL: SD2/10 – 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 (NETS) Security and Quality of Supply Standard (SQSS)
EREC P2, Security of Supply
EREC P18, Complexity of Distribution Circuits Operated at or above 22kV.
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
PAD: SD, System Design Policy
POL: AM5, Technical Appraisal, Technical Approval and Post-investment Technical Appraisal for Network Related Capital Projects
POL: SD3, 66kV and 33kV Network System Design
POL: SD4, 11kV and 6.6kV Network System Design
POL: SD5, LV Network Design
POL: SD11, Load Management Schemes
ST: SD1H, The Treatment of Losses in an Inclusive Network Design Process

## APPENDIX D: KEYWORDS

ANM, Category A, Category B, Category C, Category D, Category Z, design, intertrip, soft intertrip, Load Management Scheme, network, system, planning, network analysis