Electricity Distribution

nationalgrid

Company Directive

STANDARD TECHNIQUE: SD2A/1

132kV Connections – Guidance Document

Summary
This document provides guidance for the design of 132kV substations.

Author: **Seth Treasure**

Implementation Date: **November 2024**

Approved by

Carl Ketley-Lowe
Head of Engineering Policy

Date: **12th November 2024**

Target Staff Group	**NGED and ICP engineers responsible for 132kV substation design**
Impact of Change	**Amber – The document consolidates the standard designs available**
Planned Assurance checks	**Policy Engineer to review ICP and NGED design submissions for confirmation of compliance**

IMPLEMENTATION PLAN

Introduction

This document provides guidance of the design of 132kV substations.

Main Changes

Clarification provided on subject areas as detailed below, following initial roll out sessions provided to internal stakeholders.

Impact of Changes

Information was previously provided as guidance and this has been formalised into a formal policy, however, this document shall be read in conjunction with other NGED documentation and not in isolation, as this document aims to provide consolidation of information but does not supersede other NGED standards.

Target Staff Group	**NGED and ICP engineers responsible for 132kV substation design**
Impact of Change	**Amber – The document consolidates the standard designs available**

Implementation Actions

The document has previously been disseminated within NGED, with changes being implemented to improve clarity.

An external stakeholder event is being provided in November 2024.

Implementation Timescale

This document shall be implemented on issue for new or substantially modified connections (including any connection that has missed a pre-construction milestone).

Where planning permission has been granted for a site and when the design approval process has commenced, the site may be designed to previously detailed requirements, however, the design principles of this document shall be followed where appropriate / available.

REVISION HISTORY

Document Revision & Review Table		
Date	**Comments**	**Author**
01/11/24	• Clause 4.10.2 – Provision of lower rated burden CTs made available • Section 7 – Protection arrangements, greater clarification of design, installation and ownership requirements, with inclusion of drawing • Clause 8.1.8 – All sites to have the ability to install mobile generation • Section 11 - 15 – section regarding CCPs and G99 wall box re-structured with additional guidance to provide greater clarity, with inclusion of drawing • Clause 14.5 – Confirmation of 500mm above flood height requirement • Clause 21.1.13, inclusion of simplified drawing for boundary ownership arrangements of key items	Seth Treasure
15/05/24	• This is the first Standard Technique regarding 132kV connection design, however, the below denotes changes made from the previously available connection guide. • Clause 2.4 details requirement to mitigate operational complexity of installations • Requirement for manual application of circuit main earth between 103 and 124/114, rationalisation of motorised switchgear (isolators) • Clause 7.4 added regarding operation and ownership of protection systems • Clause 8.1.5 mobile generator requirements –firmer set of requirements noted • Clause 8.3.1 – new substation layouts • Clause 8.4.1 – new thermal conductivity requirements of walls – in line with proposed ENA guidance. • Sections 11 & 12 detail CCP and interface panel arrangements for connections incorporating IDNOs • Clause 13.1.5 – separate NGED and customer control rooms • Clause 13.5.2 – flood risk and site locations • Clause 13.14 – provision of sanitary facilities • Section 17 – substation security – all 132KV sites shall be deemed to require a category 1 security status • Section 19 – Detailed arrangements for IDNO / Customer connection arrangements • Clause 20 – electric vehicle charging facilities	Seth Treasure

Contents

1.0 Introduction

1.1 This document has been prepared to assist Independent Connection Providers (ICPs) and National Grid Electricity Distribution (NGED) engineers with the design and specification of 132kV substation assets for adoption by NGED. It may also be of broader interest to our Customers, their consultants and contractors. The aim of this document is to enable ICPs to streamline the design submission process but the document also has applicability to 132kV connection projects for which such a process is not required in full.

Within the document, reference is made to Independent Distribution Network Operators (IDNOs), these organisations may also be referenced as Other Authorised Distributers (OAD) as defined by the Distribution Code.

1.2 The document applies to embedded generator and demand connection projects where the Point of Connection (POC) is at 132kV and an outdoor switchgear solution is envisaged. The document provide guidance on all aspects of design i.e. Substations, Cables and Overhead Lines. Where additional guidance is required, initial contact should be made through the Primary Network Design Team.

1.3 It is not intended that this document be used as a detailed reference for power system analysis, network modelling or power quality aspects of a particular connection. The requirements in this respect will generally be defined within the connection offer prepared and issued by our Primary Network Design Team.

1.4 This document makes some reference to the degree of contestability that may be expected for certain connection works, however, project-specific connection offer documentation should always be consulted for more detailed understanding.

1.5 Network Operators have a duty of care to ensure that substation environments provide suitable conditions to safely accommodate our electrical apparatus such that it does not present an unacceptable hazard to Customers, NGED employees, contractors and the public. Relevant legislation in this arena includes but is not limited to:

The Electricity Safety Quality and Continuity Regulations
The Electricity at Work Regulations
The Workplace (Health, Safety and Welfare) Regulations
The Management of Health and Safety at Work Regulations
The Construction Design and Management Regulations

Before energising a connection to the NGED network, we must satisfy ourselves that it is so constructed, installed and protected (both electrically and mechanically), to prevent danger, interference with, or interruption of supply, so far as is reasonably practicable. We must also ensure that the substation environment is constructed so as to prevent, as far as is reasonably practicable, danger and unauthorised access.

In recognition of the above, we acknowledge the importance to all project stakeholders of NGED clearly identifying criteria for acceptance / adoption at the earliest opportunity. We believe that this will enable substation designers to incorporate the requisites of NGED approval into their submissions.

1.6 This document summarises many of the requirements included in other NGED policy documents relating to 132kV connections and is designed to supplement rather than replace these documents.

The policy documents referenced within this document and within other project specific correspondence should always be consulted for detailed guidance.

NGED policy documents are available online via our technical website www.nationalgrid.co.uk/tech-info. This service is provided free of charge to users and policy updates are notified to registered users.

2.0 Design Submission and Approval Process

2.1 Where formal assessment and approval of an ICP design is required for a connection project, the ICPs design submission shall comprise sufficient project-specific information for NGED to assess the suitability of the proposals for adoption (and connection to our network).

Further guidance can be sought from the following documents;

- Standard Technique: NC2F Relating to Design Approval
- Standard Technique: SD1F Regarding Competition in Connections Code of Practice

2.2 The ICP shall provide full and comprehensive designs for all of the plant and equipment proposed for adoption by NGED. Additionally, the ICP shall submit full and comprehensive design information to enable NGED to confirm that the substation compound and civil features (including calculations) are designed to provide a suitable environment for our equipment.

2.3 It is essential that NGED are afforded sufficient information to enable our engineers to assess the validity of the design of the adoptable assets and of any infrastructure directly related to these assets including associated access and working requirements (for operation, maintenance and replacement). To afford the most comprehensive and efficient design submission response to the Customer and/or IDNO, via their ICP, NGED require a comprehensive design submission including all aspects of the adoptable assets.

2.4 To align with the fundamental principles of the Construction, Design and Management Regulations (CDM), the design of the connection and extension asset works (for all parties) shall mitigate risk for works undertaken during the installation phase and any future inspection, maintenance or replacement works.

Any new proposed works shall not increase the site operational complexity i.e. a non-complex site, shall not be made to be complex in accordance with Standard Technique: OS5F and shall not introduce a confined space risk in accordance with Standard Technique: HS14A.

2.5 Notwithstanding the above, NGED recognise that there are occasions where connection timeframes may require the customer or ICP to submit designs for long-lead plant items and civil features in advance of having completed detailed protection designs and / or earthing study and design work. In such circumstances to help accelerate progression of the works, a design submission can be split into a maximum of four partial submissions as outlined below;

Part 1 – High Level Electrical Design and plant approval

Part 2 – Cable and overhead Line technical design

Part 3 – Site Civil Works and Infrastructure

Part 4 – Full detailed design

If a customer opts for a partial design approval approach, all relevant components of the Part are required to be submitted together. This will ensure that an objective assessment can be undertaken and ease coordination. Therefore, NGED are unable to accept individual drawings or design detail. The ICP will be responsible for ensuring subsequent design Part submissions remain compatible and interface correctly with future submissions. Incomplete full or partial designs may be rejected if they do not provide sufficient detail to enable the validity of the relevant design aspect, as a whole, to be assessed.

2.6 The design submission shall be in a commonly used electronic format, via email or a link to a shared online drive (e.g. dropbox™) to the designated NGED Primary Network Design contact. Due to mailbox constraints, NGED require that email submissions are restricted to a maximum size of 10MB per transmittal.

132kV Connection – Indicative Design Submission Components

	Information Type	Probable Component Parts
Part 1	Section A - **Electrical Design**	• Overall single-line diagram / network design of IDNO / customers installation • Operational interface requirements / procedures • Main connections and protection diagram
	Section B – **EHV Switchgear Design**	• Switchgear and other primary equipment manufacturers submission indicating type, variant, ratings etc. • Supporting manufacturers literature/ technical datasheets including manufacturers references / nomenclature • General arrangement drawings including cabling and holding down details. • Main connections & protection diagram, showing tripping to and from the customer's equipment • Mechanical / electrical interlocking diagram • Schematic diagrams (AC and DC) showing protection, instrumentation and metering arrangements and terminal block presentation • List of protection relays with full model numbers
Part 2	Section C - **132kV Overhead Line (OHL) Design**	• OHL construction details • OHL disconnector manufacturer, type, ratings and supporting specification/information • OHL route plans
	Section D - **132kV Underground Cable Design**	• Cable, joint and terminations manufacturer, type, ratings and supporting specification/information • Cable route plans
Part 3	Section E – **Substation Civil Design**	• Substation location plan, showing access roads from the public highway • Substation compound layout • Control room civil drawings, showing structure and substructure materials and construction, access doors, cable and multicore cable trench details • Substation compound civil drawings showing foundation designs, ground-works, roads, drainage, fencing, multicore cable troughs/ ducts etc. • Control room electrical equipment layout drawing/s (also showing LVAC fit-out) • Site flood, noise pollution and EMF risk assessment • Site security layout (alarm panels, sensors, cameras and lights) • Physical security (electric fence, doors, gates etc.)
	Section F - **Earthing Design**	• Site earthing study and interpretive report • Confirmation of hot / cold status of the site and proposed mitigation measures for the former • Description of proposed earthing materials / jointing techniques etc. • Earthing layout drawing
	Section G – **DC Battery System Design**	The following information is required for both the 110V (switchgear & protection) and 48V (SCADA) systems: • Battery capacity and charger current rating assessment • Battery / charger manufacturer, type, ratings and supporting specification/information. • Battery / charger / DC distribution board general arrangement drawings / schematic drawings • Auxiliary cabling – multicore & multipair cable block diagram and schedule
	Section H – **Substation Communications Infrastructure Design**	• Substation microwave communication tower design (where applicable) • Substation microwave communication tower foundation designs • Substation fibre communication route plans • Substation fibre comms route chamber designs

2.7 NGEDs internal Guaranteed Standards of Performance (GSOP) for design submissions, will start on receipt of sufficient data required to confirm compliance with the relevant Part of works.

The Electricity (Standards of Performance) Regulation 2015 Guaranteed Standards of Performance will start of receipt of the full and complete design submission.

2.8 An ICP may submit the design submission information in full on acceptance of the Offer subject to all of the above being available and where the information provided is not subject to change.

2.9 On completion of a project, the ICP or Customer shall submit NGED the final as constructed drawing plans as noted above. These drawings should detail as laid / installed construction plans and detail any changes that were implemented during the construction phase and where a revised design submission was not required.

3.0 Switchgear Technical and Protection Requirements

3.1 NGED competitively tender the supply of switchgear and associated equipment on a term basis. In this way, stakeholders can benefit from economies of scale, both commercially and in terms of being able to minimise design input by establishing generic arrangements. NGED presently have 132kV outdoor switchgear framework arrangements in place for the purchase of:

- Siemens type 3AP1-DT1S
- Alstom Grid DT1-145-F1-FK3

It may be advantageous for an ICP / Customer to benefit from the use of the designs / specifications based upon the above switchgear, although alternatives may be offered to NGED by the Customer for consideration, assuming that they meet our design criteria.

3.2 NGED's technical requirements for 132kV outdoor circuit breakers / disconnectors, are detailed below,

- *Engineering Specification: EE Spec 170 regarding Dead Tank CB's*
- *Engineering Specification: EE Spec 171 regarding Live Tank CB's*
- *Engineering Specification: EE Spec 173 regarding Disconnectors*
- *Engineering Specification: EE Spec 174 regarding Instrument Transformers*

3.3 *Engineering Specification: EE Spec 87* describes NGED requirements for protection and control cubicles for outdoor 72kV and 36kV equipment. With the exception of the table overleaf, the data therein is applicable to 132kV protection and control cubicles.

3.4 NGED's technical requirements for ancillary equipment for use in conjunction with switchgear and protection/control panels are described in *Engineering Specification: EE Spec 136.*

3.5 Section 5 of this document shows typical arrangements for single circuit teed and single circuit looped connections. The table overleaf provide a broad overview of the technical and protection requirements for such arrangements:

Description	**145M1 Metering CB (single circuit tee-off arrangement)**
Standard Drawings * Single Line Diagram Schematic Diagram	*To be provided*
Pollution Level	Level iv (31mm/kV)
Rated Voltage kV	145kV
Rated Insulation Level (lightning impulse withstand voltage) kV	650kV
Rated Normal Current A	2500A
Rated Short Time Withstand Current kA	31.5kA
Rated DC time constant mS	120mS
Tripping & Closing Supplies	110V DC
CTs and VTs	
CTs for customer use The customer is to provide instantaneous protection across the NGED metering CB and the customer's transformer. NGED will accommodate a set of the customer's CTs in the metering CB for this purpose. Class PX The customer shall provide the full CT specification	One set of 3
CTs for Overcurrent and Earth Fault protection 1000/500/1 30VA 5P20 (2500A continuous rating)	Two sets of 3
CTs for Transducer and GCP 1000/500/1 15VA Class 0.5S (2500A continuous rating)	One set of 3
CTs for Metering Ratio to be agreed#, typically 15VA Class 0.2S (120% continuous thermal rating) # Dual ratio CTs shall be employed. The rated primary current on the lower ratio winding shall be proportionate to the authorised supply capacity, and the rated primary current on the higher ratio winding shall be twice this value.	For circuit capacities up to 100MVA, one set of 3 For circuit capacities over 100MVA, two sets of 3
Voltage Transformer 132000/√3 : 110/√3 : 110/√3 Star/Star/Star For circuit capacities up to 100MVA Class 0.5/3P For circuit capacities over 100MVA Class 0.2/3P	3 off single phase
Control/Relay Cubicle	
Circuit breaker control switch and handle	1
Local/Supervisory switch and handle	1
Telecontrol CB open interposing relay	1
Telecontrol CB Close interposing relay	1
Current/Voltage/MW/MVAR Transducer	1

Main Protection Relay/s	3HSOC 3DOCIT DEIT 3OCIT EIT VTS
Backup Protection Relay/s	3OCIT EIT
Trip/Intertrip Relay	TDS
IDNO / Customer Trip Flag Relay	TI
SF6 Gas Low	A (SF6 Low) All stages
Spring Charge Fail	A (SCF)
Trip Circuit Supervision	TCS
Test Block	TTB (3off)
CB Indication/Spring Charged Lamps	3 off
Terminal Blocks	As Required
Fuses & Links	As Required

3.6 All protection and ancillary relays shall be of a type/ designation approved by NGED. The standard schematic diagrams detail the protection relay types applicable to the scheme. Full details of all NGED approved relays, including their respective CORTEC identifier are detailed within *Engineering Specification: EE Spec 98*.

3.7 The standard schematic diagrams show a generic switchgear arrangement and are not specific to a particular connection. Detailed protection scheme design (such that may include NGED/Customer intertripping, alarms and more complex protection requirements) will be advised on a project-specific basis and it will be the responsibility of the Customer to deliver certain outputs. Typically, the Customer should assume that the following facilities will be required (in addition to NGED circuit protection):

- Close-inhibit of the NGED metering breaker (to prevent it being closed unless the Customer's generator interface breaker is open)
- Intertrip send (and receive) facilities between the NGED metering breaker and the Customer's generator interface protection

3.8 An emergency trip button (break glass type) shall be provided that will enable the Customer to trip the NGED circuit breaker. The emergency trip will be located in the Customer's accommodation in a location that the Customer feels is optimal for an emergency situation. In assessing prospective locations, the Customer would logically wish to identify areas to which potential site occupants have prompt access in an emergency.

3.9 NGED specify that the Customer's points of automatic disconnection will be located no more than 100 metres from the NGED metering breaker in order that multicore cable intertripping, emergency break glass tripping facilities and overvoltage constraint functions remain functional under all conditions. NGED reserve the right to request multi-core cable volt-drop calculations from the Customer to confirm effective operation of these facilities at the upper limit of separation distance.

4.0 Metering and CT Requirements

4.1 A metered connection is only required for direct connections to an end customer. Connections incorporating an IDNO network are not required to have boundary metering, however, for planning and design purposes shall include a means of measuring Real and Reactive Power.

4.2 The single line diagrams shown within Section 5 are the same for both Customer and IDNO connections, however, the outputs from the VTs and CTs are as detailed below;

Customer connection,

- The instrument transformers are used for protection and billing purposes (the outputs are connected to protection relays and suppliers meter)

IDNO connection,

- The instrument transformers are used for protection and monitoring purposes (the outputs are connected to protection relays and a transducer used for monitoring)

4.3 The Balancing & Settlement Code's metering codes of practice define the minimum requirements for metering equipment. Code of Practice Two (COP2) applies to circuits with a rated capacity between 10MVA and 100MVA and Code of Practice One (COP1) applies to circuits with a rated capacity in excess of 100MVA. Instrument transformer selection and configuration shall be as defined within the relevant COP guidance for the circuit capacity of the proposed connection.

4.4 Transducers used for monitoring purposes shall be provided in accordance with the requirements of EE Specification: 136 – Ancillary Electrical Equipment for use in Conjunction with Switchgear and Protection/Control Panels.

4.5 Metering facilities where required shall be provided in accordance with the requirements of ST: TP14C – Distribution Business Provided Metering Facilities.

4.6 Instrument transformers shall be error tested in accordance with the requirements of ST: TP14C – Distribution Business Provided Metering Facilities, EE Spec: 170 - 145kV Outdoor Dead Tank Circuit Breakers and EE Spec: 174 - 145kV Outdoor Structure Mounted Instrument Transformers.

4.7 Test certificates are to be provided in accordance with the requirements of ST: TP14J – Management of Metering CT & VT Test Certificates.

4.8 Installation of the Remote Meter Cabinet plus the associated multicore cable, and commissioning of the metering CTs and VTs is a non-contestable activity in accordance with the requirements of ST: TP14D – Commissioning of Distribution Business Provided Metering Facilities.

4.9 Voltage Transformer

4.9.1 The Voltage Transformer shall be provided in accordance with the requirements of EE Spec: 174 – 145kV Outdoor Structure Mounted Instrument Transformers.

4.9.2 For circuit capacities up to 100MVA, all windings shall satisfy the requirements for both Class 0.5 and Class 3P.

4.9.3 For circuit capacities over 100MVA, all windings shall satisfy the requirements for both Class 0.2 and Class 3P.

4.9.4 Metering VTs typically have a 100VA rating and for compliance with the accuracy thresholds require a total burden on the secondary winding between 25% and 100%, however, to ensure this requirement is satisfied a lower rated VT may be provided.

4.9.5 The VTs shall be solely for NGED use and shall not be used directly to provide a voltage reference for IDNO / Customer synchronisation or interface protection

4.10 **Metering Current Transformers**

4.10.1 Dual ratio metering CTs are to be provided for 132kV connections and are to be selected in accordance with EE Spec: 174 – 145kV Outdoor Structure Mounted Instrument Transformers and ST: TP14C – Distribution Business Provided Metering Facilities. Preferred ratios are given below for information:

200/100/1

300/150/1

400/200/1

600/300/1

800/400/1

2000/1200/1

4.10.2 Metering CTs should preferably have a 15VA rating and satisfy the requirements of Class 0.2S. For circuit capacities up to 100MVA, one dedicated set of CTs is required. For circuit capacities above 100MVA, two dedicated sets of CTs are required.

The total burden on metering CTs shall be between 25% and 100% of the rated burden, to ensure this requirement is satisfied a lower rated CT may be provided e.g. 7.5VA.

The metering CTs shall be solely for NGED use and shall not be used to provide reference values for curtailment schemes.

5.0 Operational Requirements for NGED Switchgear

5.1 The connection arrangement will be determined by NGED's Primary Network Design team and will be designed dependent on site-specific network considerations. The following options describe NGED's preferred switchgear arrangements for simple teed and looped connections.

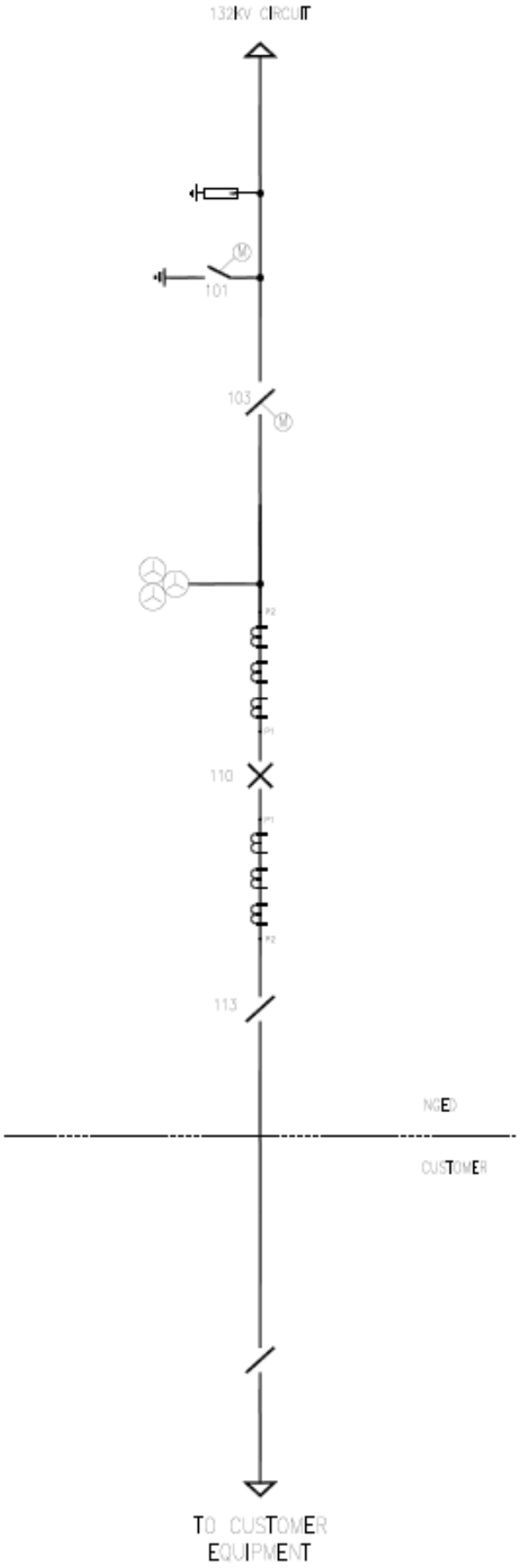
Actual arrangements may differ depending on the design and manufacturer of the switchgear being considered and NGED's protection requirements. The operational requirements listed below must be satisfied in all circumstances:

5.2 **Single Circuit Teed Connection**

- The CB interlock key 110 shall only be released with the CB in the open position.
- Disconnectors 103 and 113 shall only operate with electrical interlock key 110 inserted. Key 110 shall be trapped during operation, but released with the Disconnector in the open or closed position.
- Disconnector 103 shall release a key 103 when in the open position.
  Line Earth Switch 101 shall only operate with key 103 inserted. Key 103 shall be trapped during operation and when the switch is closed to earth. It shall only be released with the earth switch opened from earth.
- Motorised switches 101 and 103 shall be capable of remote operation (onsite) and 103 shall be capable of SCADA control.
- The CB 110 is fitted with CTs and is provided for both customer and IDNO connections.

  The typical interlocking arrangement diagram can be found via this <link>

See overleaf for typical single line diagram and nomenclature


132kV CIRCUIT
101
103
110
113
NGED
CUSTOMER
TO CUSTOMER
EQUIPMENT

5.3 Single Circuit Teed/Looped Connection

- The CB interlock key 110 shall only be released with the CB in the open position.

- Disconnectors 113, 114, 103 & 203 shall only operate with electrical interlock key 110 inserted. Key 110 shall be trapped during operation, but released with the
Disconnector in the open or closed position.

- Disconnectors 103 & 203 will not be fully interlocked with this network arrangement. A warning label shall be attached at the operating position of these disconnectors.

- Disconnector 103 shall release a key 103 when in the open position.

- Line Earth Switch 101 shall only operate with key 103 inserted. Key 103 shall be trapped during operation and when the switch is closed to earth. It shall only be released with the earth switch opened from earth.

- Disconnector 203 shall release a key 203 when in the open position.

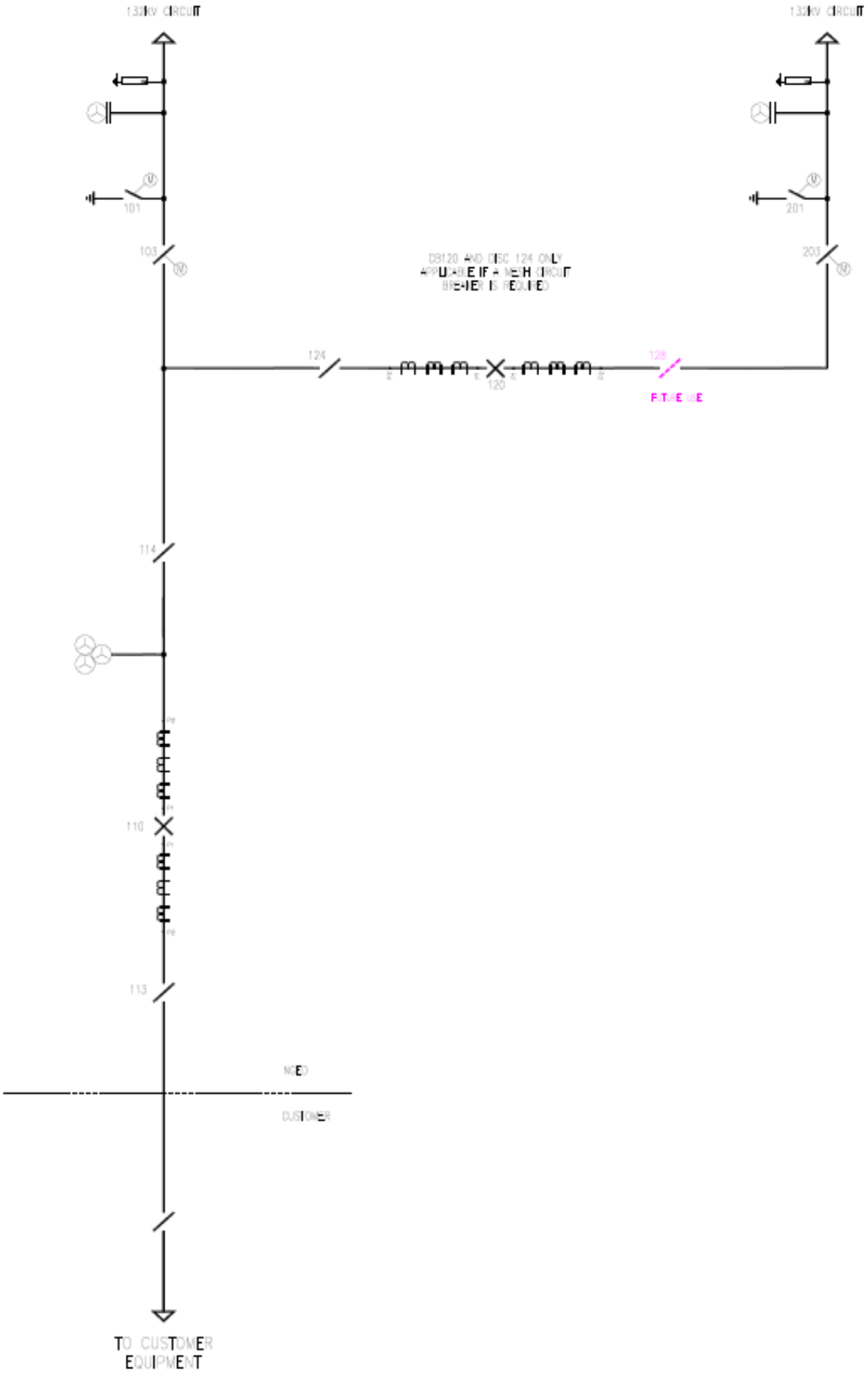
- Line Earth Switch 201 shall only operate with key 203 inserted. Key 203 shall be trapped during operation and when the switch is closed to earth. It shall only be released with the earth switch opened from earth.

- Motorised switches 101, 201, 103 and 203 shall be capable of remote operation (onsite) and 103 and 203 shall be capable of SCADA control.

- The CB 110 is fitted with CTs and is provided for both customer and IDNO connections.

  The typical interlocking arrangement diagram can be found via this <link>

See overleaf for single line diagram


132kV CIRCUIT
132kV CIRCUIT
101
201
103
203
CB120 AND DISC 124 ONLY
APPLICABLE IF 4 MESH CIRCUIT
BREAKER IS REQUIRED
124
120
128
FUTURE USE
114
110
113
METER
CUSTOMER
TO CUSTOMER
EQUIPMENT

6.0 Customer Switchgear and Earth Facility

6.1 This shall be the responsibility of the ICP / Customer to determine. The Customer shall have a facility to apply a fully-rated earth towards the NGED equipment (earth switch or portable earth). Unless the connection from NGED equipment terminates directly onto a Customer's transformer, where it is acceptable for the earth facility to be provided on the LV side of the transformer.

7.0 Protection Arrangements

7.1 NGED are required to retain full ownership and control of assets required to maintain operational control of the wider NGED distribution system.

This will typically require NGED to own and operate an automatic disconnection and Point of Isolation device / equipment at the Point of Supply.

7.2 Where an IDNO or Customer solely utilise a circuit/s and where there is a protection scheme that interfaces between upstream circuit breakers owned and operated by NGED and with downstream circuit breakers owned and operated by an IDNO or Customer.

NGED will specify in collaboration with the IDNO or Customer, the protection arrangement and equipment associated with feeder protection schemes (unit, distance and intertripping) which includes primary and secondary protection relays and the interface medium. The chosen arrangement will take into consideration the requirements of all parties, the available / required communications media and interface with existing infrastructure. The primary protection relay shall be owned and operated by NGED and the secondary relay owned and operated by the IDNO or Customer.

The IDNO or Customer shall own and operate the downstream communication medium from a communication interface panel located at the source substation (metering cubicle).

The installation, inspection, partial commissioning and maintenance activities beyond the interface point are deemed to be contestable, however, any changes to the system will require appropriate interaction with NGED.

7.3 Where an NGED circuit connects to more than one IDNO or customer, or connects to other NGED substations, the assets including the protection assets/systems shall be specified, owned, operated, maintained and controlled by NGED.

An example diagram is available <here>

7.4 To aid Customers and IDNOs in their design of the required wiring diagrams for protection and control, NGED have made the following standard / typical Main Connection and Protection drawings (MC&P) available, these diagrams should be used as a template / base drawing in the determination of the required scheme.

The finalised MC&P drawing will typically incorporate any required site specific amendments / alterations and this will be acceptable, however, moderate deviation shall be from the provided standard arrangement.

<Link to drawing database>

7.5 Customer generation shall satisfy the requirements of the Grid Code, Distribution Code and associated ENA Engineering Recommendations, for example, EREC G99 or EREC G59, as applicable. This includes the requirements interface protection. The detail of this protection shall be agreed with NGED or with the IDNO, as applicable. The IDNO is responsible for providing relevant protection information to NGED.

8.0 Substation LVAC Supplies and Building Service

8.1 Derivation of LVAC Supply

8.1.1 The LVAC supply shall be three phase and have an Agreed Supply Capacity of 50kVA – Three Phase, the supply shall be fused at 80A.

8.1.2 The degree of resilience of the LVAC supply to the substation will be determined based upon the criticality of any protection systems at the site to the security or stability of the broader NGED network. Before proposing an LVAC solution, it is recommended that the ICP has project-specific dialogue with NGED over the criticality of protection systems at the site.

8.1.3 Critical protection systems are those that must remain in operational service when the metering circuit breaker is in the open state and the Customer's installation is de-energised. For example, a looped connection arrangement where relays at the site are used to protect the NGED 132kV feeders and busbars.

8.1.4 LVAC supplies required to retain power to critical protection systems shall be sourced from either the NGED or IDNO LV distribution systems.

These systems shall be metered and the bill shall be funded by the predominant user of the site.

For example, a site that is primarily providing supplies to the wider NGED network, the LVAC metered supply usage will be funded by NGED but a site that provides a connection to a single customer or IDNO, the customer or IDNO will fund the LVAC usage.

The initial cost of the installation of the LVAC supply is deemed to be part of the minimum scheme to provide the connection works and as such, the installation costs will be funded by the party that is funding the substation build.

8.1.5 Non-critical protection systems are those that do not need to remain in operational service when the metering circuit breaker is in the open state and the Customer's installation is de-energised. For example, a looped or teed connection arrangement where relays at the site are solely used to protect the customer's installation.

8.1.6 Where it is confirmed that no critical protection systems will be present at the metering substation, the LVAC supplies may be derived from the Customer's LV network as long as:

- The LVAC voltage is maintained between 400/230V RMS +10%, -6% and has a frequency of 50Hz +/-1%.
- The LVAC supply is not disconnected when any of the following (where applicable) operates:
    - The Customer's generator protection, or
    - The Customer's G59/G99 interface protection, or
    - The Customer's export or import limitation scheme, or
    - The NGED Customer Constraint Scheme Stage 1 or 2

- The LVAC supply is firm. Should the main LVAC supply fail for any reason, the Customer must restore the LVAC supply within 12 hours via an alternative LV connection or by a permanently installed, adequately maintained and periodically tested standby generator, which has a sufficient supply of fuel to maintain the LVAC supplies for as long as is required.

- In the event that the LVAC supply is not restored within the 12 hour time period and in the event of 'deep discharge' event damaging NGED battery systems. The IDNO / Customer shall be liable for costs to replace any damaged assets.

8.1.7 NGED require a backup supply capable of 50kVA Three phase, however, the developer shall review the critical site demand to determine the overall back up requirement (battery chargers, dehumidification, metering CB anti-condensation heater, Connection Control Panel (CCP) and any other loads deemed to be critical to the safe operation and security of the site).

8.1.8 All sites shall be capable of being connected by a mobile generator, the site owner shall provide suitably rated female Litton™ type connectors in a location easily accessible by a generator and towing vehicle. The connection interface shall not reduce site security and therefore it is anticipated that the connections are made within a secured cubicle on an externally facing wall within the boundary of the site.

The siting of the mobile generator shall not impede access or egress into the site or buildings.

The termination cubicle must remain secure when the generator leads are in place.

8.1.9 To avoid potential underground cable damage, the site owner shall make an Earth reference point available for the mobile generator chassis at the location of the Litton™ connectors.

8.2 LVAC and Building Services Generally

8.2.1 The fixed electrical installation is an integral part of the substation building and shall be owned, operated and maintained by the majority asset owner of the building, to whom ESQCR responsibilities lie. NGED will typically own and operate the 132kV switchroom and shall therefore own, operate and maintain the electrical infrastructure within the building, however, the responsibility of the electrical feed to supply the building and all other external LVAC infrastructure will be retained by the site owner.

8.2.2 NGED may provide customers with signalling for availability of network capacity, these signals are typically provided through systems called 'Connection Control Panels' (CCP).

These panels are normally located within the NGED owned and operated switchroom where a NGED owned and operated 'interface' panel will be provided. The customer or IDNO will own and operate the secondary wiring from the output of the interface panel.

Consideration shall be given to the expected number of end connections and the required number of CCPs required to manage the connections i.e. at the time of writing, one CCP is required per end user.

8.3 L.V. Electrical Installation Generally

8.3.1 A standard layout of the heating, lighting and small power requirements at metering substations is provided on our standard GCS0019-5 and GCS0020-5 drawings. Design/ sizing of the components that comprise the installation is to be carried out by the ICP.

8.3.2 The consumer unit (CCU) for NGED's control room heating/ lighting/ small power requirements is to be:

- located in the NGED control room.
- of a metal-clad type, suitable for terminating SWA multicore cables with appropriate glanding
- provided with a 100 amp rated 2 pole main switch.
- provided with sufficient MCB ways to service the building heating, lighting and small power requirements
- provided with further sufficient dedicated single phase MCB outgoing ways for

a) 110 Volt Battery Charger Supply
b) 48 Volt Battery Charger Supply
c) Protection & Intertripping Panel Compartment Lighting Supplies
d) Switchgear Compartment Heater Supplies
e) 32A rated Mode 3 electrical vehicle charge point provided with a curtailment device to ensure usage is restricted to within capacity during periods of high demand
f) 63A rated circuit breaker with a 10mm² CU circuit to a rotary isolator for connection to consumer unit for Security requirements.

a) & b) to be provided with a rotary isolator in a logical position adjacent to the apparatus being served.

c) & d) to be provided with 20A MCBs.

e) to be provided with a 32A Type B RCBO (not to be installed downstream of any other RCD).

f) to be provided with a type C breaker.

a) & b) to be provided with MCBs with a type D characteristic to withstand battery charger inrush currents. MCB current rating shall comply with battery charger manufacturer's requirements. Indicative current ratings are as follows:

Battery Voltage	Charger Current Rating	MCB Rating
110 V	20 A	32 A
	25 A	40 A
	40 A or 50 A	80 A
48 V	20 A	16 A
	25 A	20 A
	40 A or 50 A	32 A

- provided with separate dedicated 5 amp MCB type D ways to feed unswitched spurs for
    - Connection Control Panel (CCP)
    - Active Network Management (ANM) Panel (where required as part of the connection offer)
- Provided with a facility for future expansion as necessary

8.3.3 Traywork / trunking is to be supplied and installed by the Customer / ICP vertically from the consumer unit to a suitable cable trench or overhead trunking solution. Cable tray must only be used where suitable additional impact protection is offered by the cable system itself, such as SWA or SY Flex. All trunking/tray shall be formed of galvanised steel.

Circuits shall be segregated it the following categories and shall be affording separate trunking;

- 110V & 48V DC
- 230V AC
- Communication medium
- Security

For 132kV sites, NGED prefer cable trenches over that of cable trays, as we believe that the solution provides the best methodology for connecting the all of the switchgear and associated equipment.

8.3.4 A PIR activated external light shall be provided above the entrance doors to afford safe approach to the building during the hours of darkness.

8.3.5 Emergency lighting shall be provided in accordance with BS 5266 (Emergency lighting. Code of practice for the emergency escape lighting of premises) at the most recent edition, including any subsequent amendments.

8.3.6 All wiring not enclosed in overhead trunking, cable trenches or attached to tray, shall be run in galvanised conduit.

8.3.7 All LVAC accessories such as switches and general purpose sockets shall be of metal clad construction

8.3.8 All general purpose 13A socket outlets are to be provided with RCD earth fault protection of 30mA. This may be afforded by the use of an RCBO module within the CCU protecting the circuit or by the use of RCD incorporated 13A sockets.

8.3.9 The electrical installation shall conform, where applicable, fully with the requirements set out in BS 7671 ‘Requirements for Electrical Installations’ (The IET wiring regulations) as amended at the time of commissioning. The installer should be registered as approved by a regulatory organisation such as the NICEIC ECA or Elecsa. Copies of all relevant installation certificates (including test schedules and emergency lighting certification) should be provided to NGED upon completion of the LVAC installation.

No gas/water/telecoms or any other utilities fixtures (other than those for sole NGED use) are to be located within the substation enclosure.

8.4 Heating / Ventilation

8.4.1 The control room constructed with a heating and ventilation system set to provide optimum environmental conditions for the batteries and electronic equipment. The design shall:

- Show appropriate insulation levels - thermal conductivity of the walls and roof/ceiling between 0.18 and 0.35W/m^2K .
- Avoid rapid variations in temperature within the switchroom.
- Minimise air exchange to the outside.
- Utilise natural / passive ventilation

8.4.2 Building designs with a low thermal mass may be susceptible to large temperature swings and therefore to the generation of condensation. To minimise the risk of condensation it is generally important to ensure that ventilation is kept to the minimum required to control temperature/dissipate excessive heat. Careful selection of the building external finishes may also be required to minimise solar gain.

8.4.3 Rooms that house sensitive electronic circuitry (e.g. protection and control panels), shall have a relative humidity maintained below 60% to minimise malfunctioning / failure due to condensation. A system of de-humidifiers and heaters may be required, however, depending on manufactures requirements and local conditions, more sophisticated climate control systems may be required (e.g. air conditioning).

8.4.4 The volume of gas emitted by valve regulated lead-acid cells or monoblocs should be considered to be small under normal charging conditions, however, it increases significantly in the event of overcharging. Sufficient natural ventilation shall be provided to prevent the formation of an explosive hydrogen concentration under fault conditions, specifically, in the event of an overvoltage condition of 2.40V per cell. Ventilation requirements shall be calculated in accordance with BS EN 50272-2.

8.5 Phone line / Broadband

8.5.1 Following acceptance of a scheme or undertaken as part of a feasibility study, NGED Telecoms will review the overall site communication requirements to assess if a third party phone line / broadband link is required or whether the proposed NGED fibre optic or microwave communication medium are sufficient for the transferal of CCTV and voice data back to the NGED management systems.

8.5.2 The chosen communication medium shall provide a high level of communication integrity as well as being robust and cyber secure.

8.5.3 It is envisaged that the communication medium will not consist of copper wire, however, for sites with historic communication arrangements, consideration shall be given to phone line isolation where the site earthing system has been deemed to be ‘Hot / High’. This classification shall be identified during the design assessment phase and noted within the design submission regarding the substation earthing system.

9.0 Substation DC Supplies

9.1 The provision of 110 Volt and 48 Volt batteries, chargers and distribution facilities for NGED switchgear, protection and Supervisory Control and Data Acquisition (SCADA) facilities is a contestable element of connection works.

9.2 For economies of scale, NGED specifies the systems from a relatively small number of standard configurations. For connections where the battery system is being delivered contestably, the sizing of this system will be the responsibility of the ICP.

9.3 This document assumes that the substation is to be constructed for the sole purpose of supplying a single Customer via a single 'metering' circuit breaker. The connection may be teed or looped, and in the case of the latter, may consist of up to three circuit breakers i.e. two 'feeder' and one 'metering' circuit breakers.

9.4 EE SPEC 25 details NGEDs requirements for the supply of 110 Volt battery, charger and distribution systems for metering substations. A battery sizing calculator is available within this specification document.

9.5 EE SPEC 104 details our requirements for 48V Volt battery, charger and distribution systems. A battery sizing calculator is available within this specification document.

9.6 When a site enters into a 'Curtailable or Flexible' connection arrangement, NGED are required to incorporate a CCP that includes intertripping facilities to enable the curtailment of load under curtain network configuration or loading conditions. Therefore, when required, dedicated digital communications multiplexer standing DC loads may approach levels that exceed the capacity of certain SCADA battery systems (due to the additional SCADA RTU). Multiplexer systems may result in an additional standing load of 5 amps and therefore this load should be added to other burdens in the ICPs SCADA battery system design. In circumstances where the ICP doesn't wish to carry out site-specific SCADA battery design in advance of system specification, NGED would be confident that a 40A 340Ah system would suffice for foreseeable connection arrangements.

9.7 Dedicated DC distribution board facilities are to be provided with both the 110V and 48V battery systems. These are to be wall-mounted in a location in close proximity to the respective battery/ charger.

9.8 Where there is a more complex connection arrangement, for example, more than one customer or IDNO connection, more than one metering circuit breaker, or more than three 132kV circuit breakers in total, the ICP must have project-specific dialogue with NGED over the 110V system at the site. An alternative approach is likely to be required in order to meet NGED criteria. This may involve the provision of a 110 volt battery system with an auto-disconnect (and reconnect) facility for the loss (and return) of substation LV supplies*. In these instances the 110V system shall be in accordance with EE SPEC 23.

*Such systems are often referred to as 'Black Start' enabled.

9.9 Where DC supplies cross boundary positions, appropriate isolation facilities shall be provided at accessible locations to each party (e.g. entry / exit positions

10.0 SCADA RTU and Interface Cabling

10.1 NGED require full Supervisory Control and Data Acquisition at 132kV connection interfaces and the following information and functionality shall be provided as a minimum;

- Status / position of switches
- Operation of automated switches
- Real and Reactive power flows (per outgoing circuit breaker)
- Voltage (per outgoing circuit breaker)
- Current flow (per outgoing circuit breaker)

The remote terminal unit (RTU) will provide real time data to the NGED management systems installed within a metering substation needs to be configured such that requisite status, analogue and control facilities are available at all times via the NGED SCADA system.

10.2 Due to security requirements, work involving the RTU is deemed to be non-contestable, therefore, the RTU shall be supplied, installed and commissioned by NGED (at a charge).

No direct data link between the Customer / IDNO installation and the NGED RTU will be permitted, irrespective of the proposed communications protocol.

10.3 NGED shall install a marshalling cabinet adjacent the NGED RTU for the ICP to terminate the customer / IDNO multipair cables.

NGED shall install the appropriate cables between the marshalling cabinet and the NGED RTU.

10.4 The supply and installation of multipair cables between the IDNO / Customer / NGED equipment and the NGED marshalling cabinet adjacent the NGED RTU can be treated as contestable.

All secondary wiring shall be carried out in accordance with the standard NGED DC wiring schematics.

11.0 Operational Monitoring of Generation

11.1 For all generation installations metered at 132kV, any installed Power Generating Module (PGM) would be deemed to be a Type D PGM, where full Operational Monitoring and control is required.

11.2 EREC G99 requires NGED to provide an ADMS (Advanced Distribution Management System) RTU (Remote Terminal Unit) which provides telecontrol facilities for NGED switchgear and protection systems and limited analogue values (e.g. current, voltage and power). NGED provides these facilities as standard at 132kV connections.

11.3 EREC G99 also requires the Generator to provide dynamic system monitoring, fault recording and where specified by the Distribution Network Operator (DNO) power quality monitoring facilities. NGED always requires power quality monitoring to be provided by the Generator at 132kV connections. This requires the Generator to monitor/measure the current and voltage at the point of supply, i.e. at 132kV; further information on the provision of the associated instrument transformers is included in Section 14.0.

11.4 Where G99 Operational Monitoring is required, NGED provide a 'G99 Wall Box' which provides the communication interface between the Generator's dynamic system monitoring, fault recording and power quality monitoring systems and NGED. The Generator connects their monitoring equipment to NGED's wall box to allow the required G99 data to be exchanged. The procurement and installation of the G99 wall box is deemed to be a non-contestable item due to the technical challenges and cyber security implications of interfacing with the wider NGED communication and Operational Technology (OT) systems.

11.5 The G99 wall box which measures 400mm high, 400mm wide and 265mm deep is located within NGED's switchroom, One wall box is required per metering circuit breaker. The device includes a sim card for communications and an aerial can be included for enhanced reception.

11.6 The customer shall present the analogue data in one of the forms below,

For a 'Cold / Low' ERP site, CAT6 ethernet cable with RJ45 termination plug, with a maximum length of 100m.

For a 'Hot / High' EPR site, a fibre optic (non-conductive) communication medium is required with fibre media converters at each end.

For both arrangements, the cables shall be laid within an electrical duct (to provide resilience and insulation) with each end sealed to prevent water ingress and transferal of gases.

11.7 NGED does not normally install a wall box at IDNO connections since, for these arrangements, the IDNO is responsible for ensuring their customer, i.e. the Generator, provides G99 Operational Monitoring.

12.0 Load Management Schemes (LMSs)

12.1 NGED requires load management facilities to be provided where the customer has an agreed export capacity exceeding 500kVA or where these are required to manage a constraint on NGED's network, NGET's (National Grid Electricity Transmission's) network or to provide an emergency response on instruction by NGESO (National Grid Electricity System Operator). Where these facilities are required NGED will install a Connection Control Panel (CCP). CCPs may also be used to provide the telecontrol and analogue data mentioned in 11.2. In practice this means that the vast majority of new and substantially modified 132kV generation connections will require a CCP. Any specific load management requirements will be clearly defined within the connection associated with each project.

12.2 The procurement and installation of the CCP is deemed to be a non-contestable item due to the technical challenges and cyber security implications of interfacing with the wider NGED communication and Operational Technology (OT) systems.

12.3 The CCP is either installed within NGED's switchroom or for IDNO connections, may alternatively be installed within a separate room within the IDNO substation. Sufficient space shall be allocated for the CCP and for all other associated apparatus required to curtail the end users demand or generation (e.g. battery charger). In order that the ICP may make sufficient provision within the switchroom at design stage, the Connection Control Panel (CCP) should be assumed to be a wall-mounted panel weighing 75kg with external dimensions of 977mm high, 800mm wide and 305mm deep. The CCP has bottom-entry cable glands and a full-sized front door hinged on the left (when viewed from the front). It needs to be located in close proximity to its associated interface panel and mounted on a suitably strong wall.

12.4 The CCP is required to be provided with a confirmation signal in acknowledgement of a request and confirmation to curtail capacity, this is typically provided by closing a set of normally open contacts. This signal may be provided via an IDNO.

12.5 In the case of IDNO connections, where the IDNO requires the CCP to be located within their substation, the IDNO shall provide a separate room that meets the following requirements:

- The room shall be owned by the IDNO and be located within the IDNO substation boundary; this will enable an interface arrangement between NGED and the IDNO in line with the DCUSA requirements.
- The room shall be for NGEDs equipment alone and shall be continuously accessible (24 hours a day, 7 days a week) by NGED.
- The room will have a minimum size of 2500mm(w) x 2500mm(d) x 2200(h).
- The door to the NGED controlled room will have an NGED locking arrangement with a door compliant with the LPS1175 SR2 security rating. The security door will have a panic exit provision and capable of receiving a Euro profile locking cylinder which will be supplied and fitted by NGED. All door hinges shall be vandal resistant / heavy duty with concealed fixings.
- The IDNO shall gain legal permission for the siting of telecommunication equipment when required i.e. radio mast.
- A duct with appropriate legal rights is installed between the mast and the interface room.
- To provide a stable environment, the room will have suitable thermal conductivity properties (between 0.18 and 0.35W/m2K).
- To provide a stable environment, the room will be required to incorporate heating and ventilation.
- The room will be fitted with a central light and a socket

Notes,

- The connection agreement may be utilised to secure legal access rights for the equipment.
- The interface panel may be installed remotely – clause 12.4.

12.6 Further guidance can be sought from the following sources;

- POL:SD11 - Requirements for Load Management Schemes
- POL:TP18 - Application of Connection Control Panels
- EE SPEC: 143 - Functional Specification for Connection Control Panels

13.0 Interface Panel for CCP

13.1 To standardise and simplify the installation, commissioning and maintenance of multicore cabling between NGED and IDNO / Customer equipment, NGED provide and install an interface box, typically in close proximity to the associated Connection Control Panel (CCP).

13.2 The interface panel affords clearly identified spring screw terminals (with flip links) for the termination of requisite multicore cabling from the IDNO / Customer's apparatus. It also affords a facility for interfacing digital inputs with analogue outputs, effectively ensuring the interface facility is suitable for all foreseeable connection variants that have an export capacity of 500kW or above.

13.3 The interface panel is an extension asset of the CCP and therefore is also deemed to be non contestable.

13.4 The interface panel may be installed within the IDNO substation subject to the following;

- A physical conductor can be laid between the CCP and interface panel.
- The entire route length (CCP to measurement node does not exceed 250m).
- Suitable access arrangements are provided with appropriate legal rights detailing inspection, maintenance and replacement requirements.
- The interface panel is installed within the IDNO substation.
- The ownership and operation of the components aligns with the guide attached below.
- Provision of a 12V/20W power supply.

Arrangement for remotely installed interface panel <link>.

13.5 The switchroom should be sized such that it can accommodate the CCP interface box in addition to all other apparatus required for the connection. In order that the ICP may make sufficient provision within the switchroom at design stage, the Connection Control Panel (CCP) interface box should be assumed to be a wall-mounted panel with external dimensions of 380mm high x 600mm wide x 210mm deep.

13.6 The interface box has bottom-entry cable glands and a full-sized front door hinged on the right (when viewed from the front).

13.7 We have produced standard drawings to assist ICP understanding of the termination arrangements to our standard interface panel.

These are available via the following links;

- 132kV CCP interface to a customer connection
- 132kV CCP interface to an IDNO connection

A simplified layout drawing is available <here>.

14.0 Customer Limitation Schemes (CLSs)

14.1 The Customer may need to install a Customer Limitation Scheme to ensure they do not exceed the Agreed Import Capacity or Agreed Export capacity specified in the Connection Agreement. Where this is the case the customer's installation shall satisfy the functional requirements of EREC G100.

14.2 CLSs require the customer to monitor/measure the current and voltage at the point of supply, i.e. at 132kV; further information on the provision of the associated instrument transformers is included below.

15:0 Instrument Transformers for Customer Operational Monitoring or Customer Limitation Schemes

15.1 Where the customer is required to provide G99 Operational Monitoring or a Customer Limiting Scheme they will need to monitor the current and voltage at the point of supply, i.e. at 132kV. The customer is responsible for specifying and providing the associated instrument transformers (CTs and VTs). The same is true where the customer requires current and voltage measurements for other purposes, e.g. for their ADMS or energy management systems.

This requirement may introduce an additional space requirement within the customers switchgear compound i.e. requirement for customer to own additional structures to house CTs, VTs or wound CVTs.

15.2 In the case of EREC G99 Operational Monitoring, the customer's CTs and VTs shall satisfy the requirements of section C.6 of EREC G99. For EREC G100 Load Management Schemes the LMS shall meet the maximum permissible tolerance specified in G100.

15.3 NGED are unable to provide the customer access to their instrument transformers due to the safety risks, risk of protection mal-operation, accuracy concerns and, in the case of CTs and VTs used for settlement metering, the requirements of the relevant Metering Code of Practice (see section 4)

16.0 Substation Communications Infrastructure

16.1 Requirement for Digital Communications

16.1.1 NGED requires 132kV connections to include digital communications facilities to be provided for the purpose of supervisory control and data acquisition, dynamic system monitoring, fault recording, power quality monitoring and load management, as applicable. ST: SD1G specifies the high level requirements for parallel generation sites.

16.1.2 132kV connections require a digital communication medium to our Control Centre via the NGED telecommunications network.

16.1.3 The communication system shall be designed to provide sufficient communication paths for the following aspects;

- Operational instructions
- Operational data (load)
- Operational Monitoring (power quality)
- Operational security (video and voice)

16.2 **Selection of Communications Medium**

16.2.1 The selection of optimal communications medium will generally require a viability study. Upon receipt of instruction from the IDNO / Customer to instigate this study, NGED will commission a requisite desk-study work and fieldwork via NGED Telecoms.

NGED envisage that either a Fibre Optic or microwave communication interface will be required.

16.2.2 The study shall typically only be undertaken on receipt of a signed acceptance of an Offer, alternatively a study can be requested and undertaken by NGED Telecoms separately to that of the electrical connection Offer quote.

A customer would be expected to fund the survey works prior to the works being undertaken.

16.3 **Communications at Connection Offer Stage**

16.3.1 To ensure that no delay is added to the provision of an electrical connection Offer cost and to appropriately manage workflows, NGED will initially assume that a microwave radio communications solution will be required unless alternative medium are deemed to be readily available.

16.3.2 Therefore, at the Offer stage, the ICP Customer shall assume that space and planning permissions will be required for a 15m tall communications tower and space within the substation building for a communication multiplexer.

16.4 **Communications on Receipt of Accepted Offer**

16.4.1 On receipt of an accepted offer, NGED shall commission NGED Telecoms to undertake a site specific assessment to determine the most cost effective solution to provide a robust communication infrastructure suited to the cyber security and integrity requirements of the installation.

16.5 **Contestability of Communications Infrastructure**

16.5.1 The communication infrastructure shall be adopted by NGED on commissioning of the overall site as the equipment is required to retain operational control of the NGED distribution system, therefore the design and commissioning of the communication equipment is deemed to be non-contestable.

16.5.2 The installation of following items are deemed to be contestable, however, the items shall be designed and constructed to NGED requirements;

- Communications tower supply and installation*
- Communications tower foundation construction*

- Communications tower cable duct installation*
- Communications tower earthing*
- Fibre cable duct supply, installation and backfilling*
- Fibre cable joint bay/ chamber civil works*
- 48 Volt (or where applicable 24 Volt) battery charger system supply, installation and commissioning (as defined in section 8 of this document)

* NGED recognise that the provision of broader site digital communications infrastructure may be a project requisite with which the IDNO / Customer (or their ICP) have limited familiarity. NGED Telecoms have extensive experience in the establishment of communications towers, microwave and fibre communications links and have established relationships with delivery contractors in this respect. Therefore, these services can be requested to be undertaken by NGED.

16.5.3 The design, installation and commissioning of the following items are deemed to be non-contestable and therefore shall be undertaken by NGED Telecoms;

- Site specific survey
- Determination of required solution
- Design of infrastructure
- Procurement of telecommunication equipment (excluding the above)
- Commissioning of telecommunication infrastructure

16.6 Design/ Specification for Communications Towers

16.6.1 The preferred tower provided by NGED Telecoms is a triangular lattice type structure, other options may be considered on a site by site basis.

16.6.2 Tower structures are designed to support the relevant telecommunications equipment at the required height. The design process includes a site-specific derivation of applied static and dynamic loads (including, those relating to snow/ ice and wind loading effects) and an assessment of the tower's capability to safely withstand these loads. This process would conventionally require the input of a suitably qualified/ experienced structural engineer, conversant with relevant design codes/ methodologies.

16.7 Design/ Specification for Communications Tower Foundations

16.7.1 Tower structure foundations are designed to safely transmit to ground all static and dynamic loads imparted from the communications tower. For a site-specific design to be concluded, particular founding conditions are evaluated. This evaluation will require geotechnical fieldwork, analysis and reporting.

16.7.2 Tower foundations are configured to accommodate sufficient multilayer D90 Ducts in accordance with NGED ST: TC3A. These ducts exit the top of the base vertically in close proximity to the tower leg position/s and enter the foundations horizontally at a minimum depth of 600mm. A 90 degree slow bend duct is provided for the duct transition between horizontal and vertical. As a minimum this bend shall be formed using two 45 degree duct connectors. The duct run terminates at the NGED switchroom multicore cable trench in close proximity to the multiplexer.

16.8 **Design/ Specification for Fibre Cable Duct Installation**

16.8.1 Such activities are carried out in accordance with NGED ST: TC3A - Relating to the Installation of Underground Telecoms Ducts

16.9 **Design/ Specification for Fibre Cable Chambers**

16.9.1 Such activities are carried out in accordance with NGED ST: TC3B - Relating to the Installation of Telecoms Chambers

17.0 NGED Compound and Control Room Specification

17.1 **General**

17.1.1 The arrangements for accommodating NGED's switchgear and the IDNO / customer's switchgear shall be determined on a project-specific basis.

17.1.2 NGED require unrestricted 24 hour access to and egress to the substation. Wherever possible the substation shall be layout in such a way that it avoids the need for NGED personnel to pass through any joint perimeter fence/security controls.

17.1.3 NGED would encourage clear demarcation between areas of the substation compound under NGED Safety Rules and the areas under the IDNO / Customer Safety Rules.

However if this is unavoidable, site access shall be provided with a dual locking facility. Incorporating a NGED substation security locking arrangement in accordance with POL: SP5 and a padlock in accordance with ST: SP5D.

17.1.4 It is anticipated that for an outdoor metered 132kV connection, the IDNO / Customers 132kV substation will generally be immediately adjacent to the NGED substation compound. This would permit primary connection of the substation via busbars over sailing the boundary fence between respective operational areas.

17.1.5 NGED required separate buildings to be provided for the NGED 132kV control room and the IDNO / Customer switchroom, shared use buildings are not permitted.

There shall be clear separation and demarcation between accommodation to ensure identification of ownership boundaries and responsibilities.

NGED will own, inspect, maintain and repair the NGED 132kV control room, all other buildings shall be owned, inspected, maintained and repaired by the customer or IDNO. The demarcation of responsibility shall be included within a responsibility schedule.

17.1.6 NGED specify that the Customer's points of automatic disconnection will be located no more than 100 metres from the NGED metering breaker in order that multicore cable intertripping, emergency break glass tripping facilities and overvoltage constraint functions remain functional under all conditions. NGED reserve the right to request multi-core cable volt-drop calculations from the Customer to confirm effective operation of these facilities at the upper limit of separation distance.

17.1.7 When evaluating the possible location of a substation, thought shall be given to potential customer concerns relating to Noise pollution and the production of Electric and Magnetic Fields (EMFs). Therefore, when the substation is to be positioned close to domestic installations, a noise and EMF survey and report are expected to be undertaken with the findings provided to the IDNO / Customer, NGED and any other impacted party.

Further guidance can be sought from the following sources;

- POL:TP24 – Power Frequency Electric and Magnetic Fields
- ST: TP24A – Procedure for Handling Queries Concerning Electric and Magnetic Fields
- ST: SP2R – Relating to Noise Complaints

17.2 Standard NGED Control Room & Substation Layout Designs

17.2.1 To assist ICPs with substation design tasks, NGED have produced standard designs. These designs relate to commonly used configurations of plant and equipment and construction methods. The designs are made available by NGED, in electronic form, free-of-charge and Customers and ICPs are welcome to use these as a basis for their site-specific designs.

The designs include underground and overhead connected variants where appropriate, the use of these designs will facilitate a swift approval process.

The designs currently available are detailed below:

NGED Standard 132kV Substation Designs – Control Building		
Drawing No	**Title**	**Status**
GCS0019-5	132kV Connection – Single Circuit Tee Off	
GCS0020-5	132kV Connection – Looped Connection	
NGED Standard 132kV Substation Designs – Looped Connections		
GCS0020-1	132kV Connection – OHL Connection (Plan View)	
GCS0020-2	132kV Connection – OHL Connection (Elevations)	
GCS0020-3	132kV Connection – Cable Connection (Plan View)	
GCS0020-4	132kV Connection – Cable Connection (Elevations)	
GCS0020-6	132kV Connection – Single Line Diagram	
GCS0020-7	132KV Connection – Looped Interlocking Arrangement	
NGED Standard 132kV Substation Designs – Tee' d Connections		
GCS0019-1	132kV Connection – OHL Connection (Plan View)	
GCS0019-2	132kV Connection – OHL Connection (Elevations)	
GCS0019-3	132kV Connection – Cable Connection (Plan View)	
GCS0019-4	132kV Connection – Cable Connection (Elevations)	
GCS0019-6	132kV Connection – Single Line Diagram	
GCS0019-7	132KV Connection – Tee'd Interlocking Arrangement	
NGED Standard 132kV Substation Designs – LVAC Single Line Diagram		
GCS0020-8	132kV Connection – Looped Connection	
GCS0019-8	132kV Connection –Tee' d Connection	

17.3 Land and Property Rights

17.3.1 At locations where NGED will have a separate substation area (typically a fenced off compound for 132kV substations) NGED will require the Freehold or long term Leasehold of the site (including control room/switchroom buildings), along with suitable access rights for vehicles and equipment to the site from the adjoining land.

17.3.2 NGED will require suitable land and access rights for any adoptable on-site cables or overhead lines. This will be in line with NGED policy and normally will be via a deed of easement.

All planning consents for substation buildings are to be obtained by the IDNO / Customer.

Further information on landowner Legal Permissions and Consents, along with guidance on this for Independent Connection Providers (ICPs) and sample lease and easement documents, can be found under the Competition in Connections section of our website (www.nationalgrid.co.uk/connections)

17.4 Vehicular Access

17.4.1 Access roads (including unloading areas / crane landings) on substation sites should be designed to allow for the safe delivery / maintenance / replacement of plant and equipment safely and as close as practicable to the final location e.g. switchroom or transformer bunds.

Access road design, their load capacity, height and width shall be adequate for movements of anticipated plant delivery and shall be agreed upon between the manufacturer and the Customer.

Where delivery of plant and equipment relies on areas outside the boundary of the substation, a level access road, and wide enough to accommodate the movement of the largest piece of plant shall be part of the design with access rights guaranteed for NGED

The calculation of the road strength shall be provided to NGED to ensure that the road is suitable for any foreseeable NGED maintenance and replacement activities, this will typically require evidence to be provided for ground investigation / assessment works.

17.4.2 As a guide, the below dimensions are considered to be typical minimum values, however, guidance shall be sought from the manufacturer of the plant to be delivered to site.

- A surfaced access road between the public highway and substation compound of minimum width of 4.5m wide and designed to accept a minimum axle weight of 11 tonnes**
- A minimum headroom of 4.5m along the entire length of access road*
- A minimum internal radius on corners of 6.0m
- A minimum external radius on corners of 13.5m
- A maximum gradient of 1:15
- A maximum negotiable concave ‘valley’ of 48m
- A maximum negotiable convex ‘crown’ to avoid ‘grounding out’ of 76m
- A turning bay/ splay where vehicular access is only possible from one direction**
- A surfaced unloading area of minimum dimensions 3.0m x 3.0m on plan directly outside the entrance doors of NGED’s Control/Switch Room

*It should be noted that transport height restrictions will need to be identified on a project-by-project basis taking into consideration the need to maintain sufficient clearance to all structures over-sailing the haulage route (including the need to maintain sufficient clearance to all LV/HV/EHV overhead line crossings)

**The above are to be delivered through the provision (as a minimum) of a road base of engineered granular material with a suitable separation medium/ membrane from underlying sub-grade. This road-base should be suitably configured for safe access and egress, throughout all seasonal conditions, by two-wheel drive vehicles having a ground clearance of 140mm and track width of 1500mm. Failure to provide and maintain a functional vehicular access route to our substation may impair our ability to witness, commission and maintain the adoptable assets. This may have a potential attendant effect on the network connection.

17.5 Flood Resilience / Water Ingress

17.5.1 Substations will not normally be sited within a flood risk area.

Where the positioning of a substation within a flood risk area is unavoidable, the flood risk associated to the land shall not normally exceed a 1 in 1000 year fluvial or 1 in 1000 year pluvial flood risk. See POL: SP9 for guidance.

17.5.2 Flood risk assessment shall be carried out to assess the risks of all forms of flooding (i.e. Pluvial, fluvial, sea, reservoir burst etc.), considerations to future climate change predictions shall be taken.

Where flood mitigation is required, the simplest and most cost effective form of mitigation is the raising of the floor height or the elevation of equipment within buildings.

NGED shall not adopt a new substation building where intrusive and costly (initial and long term) flood defences are required.

17.5.3 In all areas, the finished floor level shall be a minimum of 500mm above the flood risk level. Where there is no flood risk, the floor level shall be 500mm above the ground level, this will enable security in a flash flood type event.

Care shall be taken to ensure that the presence of cable ducts / cable entries within the substation buildings / features do not breach any flood defences / protective measures.

17.5.4 The creation of the substation shall not negatively impact on the flood risk to other buildings / dwellings.ess

17.5.5 External ground / access road levels shall be designed such that there is no detrimental build-up of surface water in the proximity of the enclosure.

17.5.6 The substructure of the enclosure shall be tanked / sealed / treated to prevent water ingress and minimise condensation. All substructure duct entries shall be sealed* around cables using NGED approved products. A suitable sump shall be formed within the substructure trench area to assist with the removal of surface / ground water during construction. A maintenance-free submersible pump with float-switch actuation shall be permanently installed within the sump, with discharge to a suitable point of disposal.

*NGED Approved cable duct sealing products shall be used, these are presently ‘Roxtec’ ‘CSD Rise’ or ‘Hauftecnik’.

17.5.7 The enclosure shall be designed to adequately collect and convey surface / storm water to a suitable point of disposal.

17.6 Ground Stability

17.6.1 The site developer shall ensure that searches are conducted to ensure that the purchased land is stable and free from below ground mines or mine shafts.

17.6.2 The land shall be free from subsidence and provide a stable environment for the lifespan of the connection (minimum 50 years' service).

17.7 Ground works

17.7.1 The following form of works are provided as typical works that are expected to be undertaken in the preparation of the site, however, site specific ground preparation works will be determined on a site by site basis.

- Clear site excavate and dispose of all topsoil / vegetable matter.
- Excavate / fill as necessary to reduced level subject to geotechnical data but min. 150mm below finished site level and compact sub-grade to receive compound sub-base and surfacing
- Install compound storm / ground / surface water drainage system as necessary to effectively drain the site and prevent the unacceptable build-up of ground water or the ponding of surface water. Collect / convey discharge from drainage network to a suitable point of disposal.
- Install Terram T1000 (or similar approved) geotextile as sub-base / sub-grade separation membrane in full compliance with the manufacturer's technical recommendations.
- Lay and compact (min. 75mm thick) bed of approved, well graded hardcore / granular sub-base material.
- Lay minimum 75mm thick bed (nb. earthing design may require a greater thickness) of 20mm single size graded clean granite/ limestone chippings / aggregate, spread and levelled around concrete bases and the like.
- Form insitu concrete plant bases as per the accepted design submission. These shall be designed in accordance with the codes of practice relevant to the proposed structural materials and shall adequately carry and transmit to the to the natural foundation all dead, imposed and wind loads

17.7.2 Site Topography - the NGED substation compound surface shall be configured so that there is maximum gradient of 1 in 60 fall across the area but where a greater incline would be advantageous, NGED may consider a different value on a site by site basis.

Site levelling / earthworks / cut-and-fill / earth retainment operations may need to be carried out to achieve this.

Terracing of the compound area owned and operated by NGED shall not be permitted.

17.8 Substation Compound Cable Access Requirements

To assist initial installation and later modification / extension / development, we require, as a default, multicore cable runs across the site to be formed using preformed, or insitu cable troughing. This troughing shall be provided with suitably rated covers for the anticipated loading conditions.

NGED require as a minimum, multicore trough runs to intersect any circuit breaker and VT positions.

17.9 Oil Containment

17.9.1 Oil-filled plant poses a risk of ground and water contamination if allowed to leak into the surrounding ground. Oil from leaking or failed plant can find its way into ground water aquifers and adjacent watercourses.

17.9.2 The risk is increased when substations are in close proximity to bodies of water, bore holes, Sites of Special Scientific interest (SSSI) or Areas of Outstanding Natural Beauty (AONB).

Therefore, all 132kV sites shall incorporate a bund around oil filled plant.

Where NGED are the responsible party for the transformer/s, the following arrangements shall be followed. ICPs may choose to align with the following or alternatively seek guidance from engineering requirements.

17.9.3 Where bunds are exposed to rainwater, these shall be designed to accommodate 120% of the total oil contained within the transformer and a rainwater management system is required to maintain volume capacity.

17.9.4 To prevent a major cooling-fluid spillage during a disruptive failure of the transformer followed by fire, the bund shall be designed with a 90 minutes fire resistance as a minimum; increased fire resistance may be prescribed by the Network Operator.

17.9.5 Oil bunds / containment are not intend to contain leaks from fluid-filled cables outside of the transformer bund but secondary containment should be considered for fluid-filled cable top up tanks.

17.10 NGED Control Room Sizing and Layout.

17.10.1 Designers shall allow sufficient space to accommodate protection and control and other secondary equipment and to afford sufficient operator access and emergency egress. The control room footprints indicated on the standard NGED drawings will provide an optimal configuration for the control room.

The control room layout shall ensure the safe installation, inspection, maintenance and replacement of assets whilst maintaining the site electrical integrity.

Space shall also be afforded for security interface panels and sensors, see security section below.

17.10.2 Door swings should be taken into account when considering minimum internal control room dimensions

17.10.3 Aisles within the switchroom small have a minimum dimension of 800mm and shall not be reduced in dimension by any permanently installed equipment including operating mechanisms.

17.10.4 Exists shall be arranged so that the length of the escape route within the room does not exceed 20m.

17.10.5 Permanently installed ladders or similar shall be installed for access into any cable trenches.

17.10.6 To align with the Construction, Design and Management Regulations (CDM regulations), the building shall be designed to limit risk of danger during construction, inspection, maintenance or replacement activities.

17.10.7 Discrete smooth-walled cable ducting or cable trenches (maximum depth of 500mm) shall be provided for LVAC supply cabling, communication cabling, compound lighting, CCTV or fence electrification systems, where these exist.

17.10.8 Cable ducting / trenches shall be easily accessible with removable covers / cover plates installed along the entire route length. The cover plates shall be designed to provide sufficient strength for the loading to which is expected within the area of the trench.

17.11 NGED Control Building Construction Materials & Fire Resilience

17.11.1 The design life of the enclosure shall, unless otherwise agreed, be a minimum of 50 years and every effort shall be made to specify materials with minimised structure / fabric maintenance requirements.

NGED prefer a masonry-constructed building with pitched slate / tiled roof or a steel portal frame building to provide a robust, low-maintenance, vandal-resistant, stable and cost-effective environment for switchgear and ancillary equipment. This view is based on experience of our extensive operational property portfolio.

17.11.2 However, NGED recognise that the particular characteristics of a connection may be such that the Customer, or their ICP, wish to use a construction technique that minimises the site construction phase or are required to make the site 'in keeping with local building styles and use of materials'.

17.11.3 NGED are therefore receptive to any construction technique / material selection proposed by the Customer / ICP, providing that these satisfy the criteria set out in this document (**the use of single skin steel containers and GRP housing is prohibited**).

17.11.4 The control room enclosure shall be designed in accordance with the codes of practice relevant to the proposed structural materials and shall adequately carry and transmit to the to the natural foundation all dead, imposed and wind loads

17.11.5 The building shall be constructed to ensure that it can withstand an overpressure event due to the disruptive failure of equipment to which the building is intended to 'house' e.g. blast ventilation is required.

17.11.6 The enclosure shall be designed to protect the structure and its contents from damage or risks to health and safety due to the effects of weather, water / moisture penetration and ground contaminants.

17.11.7 The chosen materials shall comply with ENA EREC S39 regarding fire precautions in substation design and therefore the control room enclosure shall be designed to provide a minimum fire resistance of 1 hour.

17.11.8 All dedicated fire escape routes within the enclosure shall be a minimum of 750mm wide.

17.11.9 All escape doors are to be provided with internal panic crash bar/ pad release devices.

17.11.10 Internal surfaces that may otherwise cause dust to propagate (masonry/ concrete etc.) shall be effectively sealed by the application of appropriate paints/ sealants etc.

See Section 17 regarding Site Security requirements

17.12 NGED Control Room Thermal Performance / Insulation

17.12.1 The enclosure shall be designed to deliver a thermal conductivity of the walls and ceiling between 0.18 and 0.35W/m^2K .Any risk of condensation build-up at cold-bridging points shall be mitigated. This is of particular importance on the underside of switchgear and control gear.

17.13 NGED Compound Design

17.13.1 Installations and equipment shall be capable of withstanding electrical, mechanical, climatic and environmental influences anticipated on site i.e. a substation installed within a coastal region shall be designed for a greater resilience to salt corrosion and pollution.

17.13.2 The electrical compound shall be sized and equipment positioned to facilitate the safe installation, inspection, maintenance and replacement of assets whilst maintaining the electrical security and integrity of the site.

17.13.3 All electrical plant shall be designed to facilitate the required safety and working & access clearance requirements as detailed within ENA TS 41-38 & the ESQC Regulations.

Note – the dimensions provided within TS 41-38 are 'minimum requirements', to ensure the electrical integrity of a site, these separation requirements may need to be increased to enable the safe use of machinery and access equipment.

17.13.4 All equipment and supporting structures, including associated foundations, shall be designed to withstand the anticipated mechanical stresses associated with the substation locality - as per ENA TS 41-38

17.13.5 Where appropriate,

- All Structural steel and Aluminium elements shall be fabricated to a minimum of Execution Class EXC1 in accordance with BSEN 1090 and suitably marked to this effect
- All bolts, nuts, etc. shall comply with BS4190 grade 8.8 unless otherwise stated.
- All bolts shall be spun galvanised finish in accordance with BS 7371.

17.13.6 Where the IDNO / Customer 132kV substation is conjoined to the NGED 132kV substation, the compound fence between the two substations shall comply with the security requirements specified in Section 20 and the earthing requirements specified in Section 18.

17.14 Provision of Sanitary Facilities

17.14.1 Over the lifetime of an outdoor metering substation it would be anticipated that frequent visits would need to be made to site by NGED staff. Similarly it is anticipated that the IDNO / Customer's personnel will frequent the site during the lifetime of their connected assets. Therefore due to the collective frequency (and likely duration) and diversification of workforce of site access by NGED and Customer staff, the provision of permanent site WC and handwashing facilities shall be provided. For this reason, a WC is indicated on NGED standard drawings.

17.14.2 It is anticipated that NGED and the customer / IDNO will have separate WC facilities to ensure easy access by each party and to separate maintenance activities.

17.14.3 NGED will typically require a mains water and mains sewage connection, however, may consider an alternative solution where the installation of 'mains' connections is cost prohibitive i.e. where the excavation works extended greater than 500m from site works (e.g. 500m greater than the overall site and access road works).

17.14.4 Where a mains water connection is prohibitive, NGED may consider alternative solutions for toilet flushing facilities i.e. water harvesting systems (these systems shall be sited upstream of any bunded transformer).

The storage tank shall have a minimum storage capacity of 7000 litres and be located below ground to minimise algae growth.

Rain water harvesting systems shall be compliant with BSEN 16941 for non potable water.

17.14.5 Where a foul drain connection is prohibitive, NGED will require the installation of a cesspool with a minimum capacity of 7000 litres.

The tank shall incorporate an alarm to signify a requirement to empty the tank when required.

Water treatment plants are unable to be utilised due to the low / infrequent throughout and inability to successfully function.

The tank shall be fully sealed and incorporate appropriate ventilation, which outputs at an appropriate height.

17.14.6 The ownership and maintenance responsibilities of the water supply and foul water systems shall typically remain with the majority asset owner of the site (this will typically be the IDNO or customer).

However, if a sole use water harvesting system and cesspool are installed for NGED's use, NGED shall own and operate the systems.

NGED will always retain the maintenance activities for foul water drainage within NGED's compound.

17.14.7 Where utilised, the cesspool and/or Water harvesting system shall be located for ease of installation, inspection, maintenance, emptying and replacement.

17.14.8 Alternative hand washing facilities shall be provided when a mains water connection is unable to be provided e.g. chemical hand washing.

18.0 Earthing Requirements

18.1 The earthing design shall be in accordance with *Engineering Specification EE SPEC 89*, as amended. An integrated earthing design - where the IDNO / Customer earthing system is connected to the NGED substation earthing system – is normally the optimum as this gives the lowest earth impedance and hence the lowest earth potential rise, lowest touch and step voltage and lowest equipment stress voltage and allows electrode surface area requirements to be met more readily.

18.2 The NGED substation is relatively small and so will normally require:

- An earth electrode loop around the substation building, 1m out, connected in duplicate to the substation earth bar.
- Multiple connections of the concrete base reinforcing bar to the earthing system.
- An earth electrode laid for all / part of the incoming / outgoing cable route to help reduce the earth impedance of the NGED substation.
- Interconnection in duplicate to the IDNO / Customer earthing system.
- Customer main earthing system to be relied upon for safety[1].

18.3 A consequence of the optimal integrated design is that:

- The specification of the Customer main earthing system needs to meet minimum requirements so that it can be relied upon by NGED.
- A duty of care arises from NGED to the Customer to verify that design of the Customer earthing ensures safe touch, step and transfer voltages. Note this occurs if the earth potential rise exceeds 120V for a 3s protection clearance. Consequently we ask to see safety verified for the Customer earthing system and associated metal fence.

18.4 The earthing system shall be connected to all above ground objects that present a conductive surface to mitigate step / touch potentials (within the switch room and within the compound).

18.5 **Clarifications**

18.5.1 **Ratings**

The following clarification on the application of EE SPEC 89 is provided with regard to earthing conductor and earth electrode ratings:

I_{swgr} = Switchgear three-second rated withstand current (I_k) (e.g. 31.5kA/40kA).

132kV networks are solidly and multiply earthed and earth-fault current is usually greater in magnitude than phase-fault current.

The short-time current rating of earthing conductor depends on the material constants, permissible temperature rise and the fault clearance time. Material constants depend on whether the earthing conductor is made of copper, aluminium or copper-clad steel. The maximum permissible temperature rise depends on whether the earthing conductor is bare, PVC insulated or XLPE insulated, and the type of joints used i.e. welded/brazed or bolted/crimped. The short-time current rating of earthing conductor shall be based on a three-second fault clearance time.

Each section of the substation interconnected mesh electrode shall have a short time current rating:

- Not less than 100% I_{swgr} where it connects single-phase switchgear together
- Not less than 60% I_{swgr} in all other circumstances

[1] NB The touch voltage at the NGED substation will vary with the soil model but may be as high as 25% of the earth potential rise; consequently the earth potential rise may have to be designed to be no more than the touch voltage limit divided by 0.25. For example with a 3s clearance time this gives 120V/0.25 = 480V; hence the need for an integrated design with a low earth impedance.

Spur earthing conductor connections off the substation interconnected mesh electrode to individual items of plant and equipment:

- Which may carry fault current shall have a short-time current rating not less than 100% I_{swgr}
- Which are not reasonably likely to carry fault current shall have a cross sectional area not less than 50mm^2 copper equivalent

Where the substation is supplied from a 132kV overhead line incorporating an earth-wire and the terminal tower is located within the compound or in close proximity, the terminal tower shall be bonded to the substation interconnected mesh electrode via two diversely routed, insulated, stranded conductors with a cross sectional area not less than 240mm^2 copper equivalent. These bonding conductors shall preferably conform with the requirements of BS 7912 Annex A and shall be laid in electrical ducts where they are within 2m of the 132kV compound fence.

Where the terminal tower is remote from the substation and there is a 132kV cable connection between the two, the expectation is that the terminal tower will be bonded to the substation interconnected mesh electrode via the 132kV cable sheaths (where solid bonding and cross bonding is employed) or via a 240mm^2 copper equivalent bonding lead / earth continuity conductor laid with the cable (where single point bonding is employed).

The NGED interconnected mesh electrode shall be bonded to the IDNO / Customer interconnected mesh electrode via two diversely routed conductors each having a short-time current rating not less than 100% I_{swgr}. These bonding conductors shall be laid in electrical ducts where they are within 2m of the NGED 132kV compound fence.

18.5.2 Earth Potential Rise

The EE SPEC 89 does not specify a maximum earth potential rise but gives functional requirements in section 6.1.1. For clarity, consideration of stress voltage in relation to fence insulators, as may be required for specific fence panels to prevent transfer voltages, and any future electric fence security system leads to the requirement to limit earth potential rise to no more than 3kV, in general.

18.5.3 Joints

Note that bolted joints are not permitted underground by EE SPEC 89.

Note that lightning protection joints to BS EN 50164-1 are not suitable for the earthing system as they are not rated for power frequency earth fault current, only lightning impulse current.

18.5.4 Joints to Reinforcing Bar

Exothermically welded joints are approved for joining from copper earthing conductor to steel reinforcing bar.

18.5.5 Stranded Earth Electrode

Care is required in ordering/specifying electrode. Cases have arisen where electrode having small strand diameter which was considered insufficient for mechanical and corrosion reasons was used and had to be overlaid. The minimum accepted for NGED stranded copper earth electrode is 3mm. For IDNO / Customer electrode BS 7430 now defines a minimum size of 1.7mm. See Appendix A.

Note that stranded copper earth electrode shall be hard-drawn copper to BS 7884. Soft-drawn is not suitable due to mechanical considerations and its ability to ‘bird-cage’ on installation.

18.5.6 Materials

Copper is approved for tape and stranded earth electrode as per EE SPEC 89. Galvanised steel is not approved for earth electrode in EE SPEC 89. Should the IDNO / Customer wish to consider galvanised steel for the Customer main earth electrode then detailed corrosion assessment may be required, particularly if the safety of the NGED substation relies on it. In general, the corrosion performance of copper is much better making it suitable for most situations.

18.5.7 Checklist

In checking proposed earthing designs, NGED will use the checklist in Appendix A, as amended, as a guide to identify if the design is correct or needs revision. The list is not exhaustive. If those preparing earthing designs check against the design against the checklist before submission this may help reduce iterations/speed up approval.

18.6 Conjoining Compound Fence

Where the IDNO / Customer 132kV substation is conjoined to the NGED 132kV substation, particular care is required with the earthing arrangements on the dividing compound fence between the two substations when the main perimeter compound fence is independently earthed.

The dividing compound fence shall be earthed by direct connection to the substation main earth electrode. In order to control hand-hand touch potentials, the dividing compound fence shall be effectively electrically separated from the main perimeter compound fence by mounting the fence panels which abut the main perimeter fence on approved insulated bushings in accordance with NGED Drawing SF72. The insulated bushings shall conform with the requirements of EE Specification 132.

19.0 Metering Equipment Accommodation

19.1 Metering equipment shall be accommodated in a separate weather-proof room or cubicle that is accessible by NGED, the meter operator, data collector (aka meter reader) and the Customer. This room or cubicle shall be located close to the NGED switchroom to keep the connections to the metering CTs and VTs as short as practicable. Access to the metering equipment shall not be via NGED's operational area.

19.2 The settlement metering equipment shall consist of a Remote Meter Cabinet, a multicore cable interconnecting the remote meter cabinet and the metering CTs and VTs, and other meter operator equipment.

19.3 NGED will own operate and maintain the remote meter cabinet and the associated multicore cable. The remote meter cabinet contains the multicore cable terminal blocks, the safe access test terminal blocks and the isolation fuses & links and its dimensions are typically 600mm (h) x 500mm (w) x 250mm (d). A separate remote meter cabinet and multicore cable is required for each circuit to be metered.

19.4 The Supplier and appointed Meter Operator is responsible for providing the main and check meters (which are normally mounted on the remote meter cabinet) and any additional control equipment, communication equipment, outstations, terminal blocks, fuses, links etc. The ICP should consult the appointed Meter Operator for the accommodation requirements of its equipment.

19.5 The bottom of the remote meter cabinet must not be less than 0.5m above the finished floor level. The top of the remote meter cabinet must not be greater than 1.8m above the finished floor level. The wall on which the remote meter cabinet is mounted shall be suitable for fixing / supporting the weight of this equipment.

20.0 Substation Security

20.1 Site / Compound requirements

20.1.2 All 132kV substations are deemed to have a level 1 security ranking* and therefore shall be equipped with the following security measures;

- Proprietary Intruder Detection Systems (IDS) complying with EN 50131 linked to the NGED Managements Systems (presently PowerON). (1)
- CCTV intruder surveillance system to Standard Technique: SR4B.(1)
- Electric pulse perimeter fence to Standard Technique: SP5C – completely encompassing NGEDs compound.
- Minimum height of 2.4m galvanised steel security palisade fence and gates to BS 1722 Part 12, enhanced to National Grid Electricity Distribution specification document EE SPEC 20.
- Display sufficient safety signs and a substation ownership sign displaying a permanently attended telephone number (for the majority asset owner) as per ESQC Regulations.

Notes;

(1) The procurement and installation of the security system shall be deemed to be contestable by an NGED approved contractor, however, the commissioning of the system to the wider NGED communication system shall be deemed to be non-contestable.

The design of the security system shall remain non contestable with a typical layout design detailed on the linked PDF.

The typical camera / security column layout and dimensions are show on the linked PDF.

*The level 1 security ranking has been determined by risk assessment as all 132kV sites are deemed to be ‘critical’ to national security.

20.1.3 Sufficient space shall be made available for the mounting and opening of the electric pulse fence control panel, the supply cubicle is typically 1600mm(h) x 800mm(w) x 400mm(d).

The cubicle shall be mounted within the control building ideally located near the Power On RTU.

20.1.4 Sufficient space shall be made available for the mounting and opening of the security and lighting control equipment, the supply cubicle is typically 1300mm(h) x 600mm(w) x 800mm(d).

The cubicle shall be mounted within the control building adjacent the electric pulse fence control panel with the security system distribution board mounted above.

20.1.5 Electrified fences require a galvanised welded security mesh installed between the electrified fence and palisade fence to mitigate inadvertent contact with debris.

20.1.6 A 1.2m high stock proof fence is require to be installed a minimum of 2m from the boundary of the palisade fence, this will mitigate nuisance alarms from animals / wildlife. Guidance shall be sought from NGED in respect of the materials used i.e. use conductive or non-conductive materials.

20.1.7 The 2m wide maintenance strip between the palisade fence and stock proof fence shall be of hard standing to facilitate a maintenance path and to mitigate vegetation incursion.

20.1.8 Where an Electric pulse perimeter fence is deemed not to be suitable, an alternative security measure, deemed appropriate and acceptable to the site location (such as INTREPID MicroPoint fence detection) may be implemented. The Policy Engineer responsible for Physical Security can advise on site specific alternative security solutions.

20.1.9 Managers of Critical Network Infrastructure sites shall also give consideration to internal Perimeter Intruder Detection System (PIDS) to work alongside the electric fence to help detect intruders on site that may have evaded the electric fence.

20.2 Building requirements

20.2.1 The enclosure shall be constructed with no areas of glazing and designed to prevent any unauthorised entry or access to the electrical plant / equipment. Appropriate safety / warning / danger signs and notices shall be permanently displayed.

20.2.2 All double / single leaf entrance doors shall be outward opening, of robust / vandal resistant / durable / low flammability / maintenance free hardwood, steel or GRP construction meeting an **LPS1175 SR2** security rating. They shall be fitted with a secure locking arrangement (with panic exit provision) capable of receiving a Euro profile locking cylinder which will be supplied and fitted by NGED. All door hinges shall be vandal resistant / heavy duty with concealed fixings.

20.2.3 Double leaf entrance doors, where required, shall be designed such that the right hand leaf (viewed from outside) will open first. The meeting stiles shall be rebated / overlap or otherwise be resistant to prising. The left hand leaf shall be fixed internally by short top and bottom sliding bolts into receptors within the frame head and cill.

20.2.4 Heavy duty door restraints shall be fitted at the head of each door leaf and shall be capable of holding the doors open at 90 degrees.

20.2.5 Internal doors within a closed electrical operating area are not required to have locks.

20.3 Alarm requirements

20.3.1 The substation building shall be provided with a fixed security alarm system of Grade 3 as defined within EN50131.

20.3.2 The alarm system will be discrete to the NGED substation and will not extend into the metering room or IDNO / customer switchroom

20.3.3 The Control Panel will be located inside and near to, the main entrance to the building.

20.3.4 All NGED accommodation will be covered by a sufficient number dual-tech sensors that allow for complete coverage of the monitored area, giving due consideration to the position of any internal objects, structures and/or equipment that could potentially mask the Field of View (FoV) of the sensor(s). Consideration will be given the location of access and egress points and the potential for entry by breach of the fabric of the building and where necessary sensors will cross FoVs to reduce any opportunity for tamper. All access and egress points will be fitted with appropriate alarm system contacts.

20.3.5 The alarm system shall have a facility to present suitable volt-free contacts through which alarm activation may be relayed to our Control centre via the RTU.

20.3.6 All security systems shall be connected via the dedicated consumer unit with a 63A rated incomer.

20.3.7 The alarm control panel shall be configured to be disarmed via a 4 digit key code (rather than the 6 digits normally attributed to a Grade 3 system). This is to ensure compatibility with the regional PIN codes customarily adopted across our network.

21.0 Responsibility Schedule

21.1 Responsibility schedule requirements

21.2 In order to comply with the Distribution Planning and Connection Code DPC 5.4.3 of the Distribution Code a Site Responsibility Schedule (SRS) should be prepared by NGED in conjunction with the connection owner.

21.3 The SRS shall clearly indicate the ownership, operational and maintenance responsibility of each item of equipment at the interface between the Distribution Network and the IDNO / Customer network, and should include an operational diagram so that all persons working at the interface have sufficient information so that they can undertake their duties safely and to minimise the risk of inadvertently interrupting supplies.

21.4 The SRS shall also detail the ownership and responsibility for buildings, WC facilities, foul water treatment facilities, communication infrastructure, vehicle charging infrastructure, fresh water facilities and access roads or similar infrastructure.

21.5 The SRS should also record the agreed method of communication between the DNO and the IDNO / Customer and the contact information shall be kept up to date.

21.6 The operational diagram should be readily available to those persons requiring access to the information contained on it. For example, this could be achieved by displaying a paper copy at the Connection Point, or alternatively provided as part of a computer based information system to which all site staff has access.

A magnetic operational control mimic shall also be made available where switching operations can be ‘dressed’ on the diagram.

21.7 The most appropriate form for this information to be made available should be agreed as part of the connection application process.

22.0 IDNO / Customer Interface

22.1 NGED-IDNO / Customer agreed interface arrangements

22.1.1 NGED follow the general principles as outlined within the Energy Network Association (ENA) Engineering Recommendation (EREC) G88 which details the Principles for the planning, connection of electricity distribution networks between network operators (DNOs) and independent distribution network operators (IDNOs).

However, a high level view of requirements are noted below.

22.1.2 NGED shall retain ownership of all items of plant and apparatus required to retain operational control of the NGED network. Meaning that NGED shall own and operate all asset required to retain a resilient and robust distribution network for the provision of power to third party connections.

22.1.3 The interface arrangement should be designed to minimise the operational access and supervision burden of NGED, however, NGED reserve to right of remuneration where expense is incurred for operational works, access and supervision.

The point of isolation does not have to be located at the same interface point.

22.1.4 NGED require ownership and operation of a suitably rated isolator near the Point of Supply (interface) to retain operation control of the wider NGED system. There shall also be an ability to apply a portable Earth at the isolator position.

22.1.5 There shall be sufficient separation between the NGED point of isolation and the IDNO or Customers Point of Connection asset to ensure that there is operational independence between the assets i.e. there must be sufficient work and access clearance for work to be undertaken safely at the IDNOs asset, where only the associated isolator is required to be operated to facilitate the works.

22.1.6 Where appropriate for a shared use site, the ESQCR responsibilities of the site will belong to the majority asset owner.

22.1.7 Where NGED own / operate a standalone building and/or compound, NGED will retain ESQCR responsibilities for the areas within NGED ownership.

22.1.8 NGED do not meter 132KV connections, however, will require operational monitoring, *see clause 4.2*.

22.1.9 NGED will agree all interface protection arrangements on a site by site basis. Where NGED are to own, operate and maintain the protection scheme across an ownership boundary, the scheme shall to be designed to NGED specifications and standards. In this situation NGED shall provide the IDNO / Customer with a trip signal either via a boundary interface panel, or where the equipment is mounted on the IDNO / Customer owned switchgear, the signal may be directly provided to the circuit breaker.

22.1.10 LV auxiliary supply details are noted in section 8, however, it shall be noted that an IDNO is a Network Operator and not a customer and therefore is permitted to provide LVAC supplies at a site deemed to be 'Critical'.

22.1.11 All connection arrangements shall be noted within a Bilateral Connection Agreement that includes a Responsibility Schedule.

22.1.12 Where IDNO or Customer assets are installed within NGEDs substation compounds, appropriate legal consent shall be obtained for the installation, maintenance and replacement of the works.

22.1.13 A simplified ownership boundary drawing is available <here>.

22.2 Available interface arrangements

22.2.1 Outgoing Terminal of a Line Isolator within compound

The Point of Supply (POS) may be provided at the outgoing termination of a line isolator to an IDNO / Customer (busbar connection), when all of the following requirements have been satisfied;

- The arrangement permits NGED to retain operational control of the wider NGED distribution system.
- The IDNO / Customer has appropriate accreditation for the operation and ownership of the assets.

22.2.2 **Ownership boundary beyond substation boundary fence – Notional Location**

The Point of Supply (POS) may be provided at a notional location beyond the boundary fence line where the ownership of the cable transfers to an IDNO or Customer, where all of the following requirements have been satisfied;

- The installed cable shall be verified for compliance with EE Specification 77 for 66kV & 132kV cable and accessories, with particular verification of shrink back, stress test (long term aging) and cable bonding compliance.

- The IDNO shall determine the appropriate thermal rating of the cable and ensure that the appropriate cyclic or sustained rating is utilised for the relevant installation methodology.

NGED will undertake the works within the substation (POC works) and up to the notional location. Where NGED only own a short length of cable from the substation to the notional location adjacent the boundary fence, this cable does not have to be sized in accordance with ST: SD1H. For other situations, the cable shall be designed in accordance with ST: SD1H.

22.2.3 **Ownership boundary beyond substation fence line – Transition Joint**

The Point of Supply (POS) may be provided at a transition joint owned and operated by the IDNO / Customer, where all of the following requirements have been satisfied;

- The IDNO / Customer specify the cable beyond the transition joint

- The IDNO / Customer do not require NGED to provide maintenance and fault repair works for works outside of the source substation.

NGED will undertake the works within the substation (POC works) and up to but not including the transition joint. Where NGED only own a short length of cable from the substation to the transition joint located adjacent the boundary fence, this cable does not have to be sized in accordance with ST: SD1H. For other situations, the cable shall be designed in accordance with ST: SD1H.

22.2.4 **Cable Sealing End – Termination onto NGED overhead structure**

The Point of Supply (POS) may be provided at the busbar clamp (termination point) onto an IDNO owned and operated cable sealing end, when all of the following requirements have been satisfied;

- The Point of Connection is onto a proposed new asset i.e. not an existing owned and operated asset of NGED.

- The IDNO has appropriate accreditation for the operation and ownership of the assets.

- The IDNO is responsible for inspection, maintenance and replacement activities of the cable and cable termination.

- The POS is not required to facilitate the future development of the NGED Distribution system.

- The IDNO accepts remuneration for operational access works.

Note,

This arrangement is not available for NGED - Customer boundary arrangements.

22.2.5 The above arrangements are available in picture form <here>.

23.0 Vehicle Charging

23.1 All 132kV substations shall include a Mode 3 vehicle charger accessible to all parties with a minimum rating of 32A single phase.

23.2 Where it is unachievable to locate a vehicle charger within a single location accessible to all parties, more than one vehicle charger will be required.

23.3 The positioning of the vehicle charger shall be located in a non-operational location that does not impede general access to the site or influence a degradation in security of the site.

23.4 The earthing arrangement of the vehicle charger shall comply with Standard Technique: TP21KA.

23.5 The NGED owned and operated vehicle charger shall be metered and shall include RFID facilities to enable the management of use. See Standard Technique: LO4P for more detail on requirements and charging regimes.

APPENDIX A

EARTHING DESIGN CHECKLIST FOR 132kV CIC SITES

SUBSTATION		REF	

OK?	ITEM	CONSIDERATIONS
	Report	
	Soil Wenner test data?	Provided?
	Soil data valid?	Parallel with PILC/electrode? Representative? Large enough traverse?
	Soil model valid?	Not a uniform or two-layer soil where clearly multi-layer?
	Earth resistance: DNO substation?	Provided?
	Earth resistance: DNO s/s + cable e/w?	Provided?
	Integrated earthing design?	Segregated unlikely to work.
	Earth impedance: Combined?	Provided?
	Earth Potential Rise?	Provided? Transferred voltage considered if cable connected direct to BSP? Impact of other sources of EPR considered (e.g. 400kV towers through site)?
	Earth Potential Rise minimised?	Minimised to avoid Hot classification? Minimised hot zone so far as is reasonably practicable? Below 3kV?
	Hot/Cold Classification?	Provided?
	430V/1150V 650V/1700V plot?	Provided?
	Hot Zone Plot on appropriate map?	Google image not satisfactory. Separable from main report?
	Hot Zone Plot considered combined electrode system?	Has the IDNO / Customer electrode been included?
	If Hot, voltage not transferred to external LV IDNO / Customers?	Existing LV PV connected to non-dedicated PMT?
	Safety voltage: limits based on NGED protection times?	
	Modelled using CDEGS?	Contours + safety voltages.
	MALT/MALZ used appropriately?	MALZ required for large systems.
	Safety voltages: DNO S/S Plot?	Plot overlaid on electrode?
	Safety voltages: DNO S/S safe?	Clearance times provided by NGED and not assumed? Compliant? If compliant with chippings check drawing shows this.
	Safety voltages: IDNO / Customer safe?	Confirmation that touch & step safe? IDNO / Customer installation considered? Fence considered?
	Electrode surface area calc?	Pass with 7200A for 3s?

	Drawings	
	NGED earthing conductor: rating compliant and duplicated?	NGED earth bar to NGED S/S perimeter electrode rated for I_{swgr} = 25/31.5/40kA x 3s as appropriate? Duplicate fully rated?
	NGED earthing conductor: material & dimensions for corrosion/mechanical reasons compliant?	For rating see above. Copper tape to BS 1432? Stranded HDC to BS 7884? Minimum size met (≥3mm thick tape, ≥3mm strand diameter)?
	Interconnection earthing conductor: rating compliant and duplicated?	NGED earth bar to IDNO / Customer earth bar/perimeter ring electrode rated for I_{swgr} = 25/31.5/40kA x 3s as appropriate? Duplicate fully rated or single fully rated and parallel fully rated path via cable sheath?
	Interconnection earthing conductor: material & dimensions for corrosion/mechanical reasons compliant?	For rating see above. Copper tape to BS 1432? Stranded HDC to BS 7884? Minimum size met (≥3mm thick tape, ≥1.7mm strand diameter)?

	IDNO / Customer earthing conductor: rating compliant?	Rated for 7200A x 3s (e.g. 70sqmm Copper)?
	IDNO / Customer earthing conductor: BS 7430 compliant dimensions for corrosion/mechanical reasons?	Minimum size met (copper: ≥2mm thick tape, ≥1.7mm strand diameter & ≥50sqmm)?
	NGED earth electrode ring around NGED building?	1m out? Continuous? NGED S/S perimeter ring rated for 60% I_{swgr}? Copper tape to BS 1432? Minimum size met (≥3mm thick tape)?
	NGED earth electrode laid with cable?	70sqmm HDC 7/3.55 to BS 7884? Full length shown on drawing?
	Earth rods at corners of NGED earth electrode ring around NGED building?	Present? Copper-clad steel ≥12.5mm diameter to ENA TS 43-94?
	IDNO / Customer earth electrode: size and material suitable?	≥50sqmm HDC? ≥1.7mm strand diameter?
	IDNO / Customer earth electrode: material suitable without detailed corrosion assessment?	Copper, not galvanised steel?
	IDNO / Customer earth electrode: duplicate connections between split parts?	Where the site is physically separated (e.g. PV in multiple fields that are not adjoining), duplicate fully rated or single fully rated and parallel fully rated path via cable sheath?
	Electrode depth defined?	600mm?
	Joints approved?	Bolted are not approved underground nor for rebar. With respect to Customer electrode joints note that joints to BS EN 50164-1 (Lightning Protection Components) are not rated for power frequency current x 3s but only lightning impulse current; thus they are not suitable to be relied upon by NGED.
	Rebar bonded?	Design report may require rebar to be bonded for touch control. Two or more bonds?
	Test pits removed?	We do not require test pits.
	Chippings?	If design report requires chippings for safety are they provided? Is type of chippings specified and compliant with our spec?
	Fence safe?	Abutting substation without insulated panel? Independently earthed but inadequate separation from electrode? Fence earthing defined?
	Insulated fence panel design?	Insulators at both ends? Suitable insulators?
	CDEGS	
	Files?	
	Post-installation	
	Test report?	Measured resistance/impedance interpreted via appropriate CDEGS software?
	Design report revised?	Hot zone updated? Still safe?

APPENDIX B

SUPERSEDED DOCUMENTATION

This document supersedes Standard Technique: SD2A/0 dated May 2024 which has now been withdrawn

APPENDIX C

ASSOCIATED DOCUMENTATION

Standard Technique: SD1G regarding communication infrastructure
Policy Document: SP5 regarding substation security
Standard Technique: OS5F regarding complex substations
Standard Technique: OH1A regarding overhead line clearances
Standard Technique: HS15N regarding use of MEWPs
Standard Technique: HS14A regarding working in confined spaces

APPENDIX D

RECORD OF COMMENT DURING CONSULTATION

Comments – ST: SD2A

APPENDIX E

KEY WORDS

132kV design, BSP, 132kV Connections