Technical recommendation for the purchase of an Active Network Management system

1 Purpose

The purpose of this document is to set out and describe the technical requirements developed, that enabled the purchase of the Active Network Management control system named the Grand Unified Scheme (GUS) as applied on the Northern Powergrid power distribution network that has been trialled on the Customer-Led Network Revolution project.

2 Scope

This recommendation details the technical requirements for the GUS control system to be used in the CLNR project to interact with network devices. References are made to the CLNR Data Warehouse in this document – the Data Warehouse is the subject of a separate recommendation.

Technical requirements are detailed within this document. Additional site specific data will be discussed with the potential supplier.

Contents

3 Technical Requirements

3.1 Overview of Technical Requirements

For the purposes of production of this recommendation, and not intended to bias the design approach, functional requirements are split into the following sections:

1) **Summary of Control System for the Customer Led Network Revolution**: Introduction to the CLNR test cells and control system;
2) **GUS Applications:** responsible for assessing the network state and calculating control actions for ENDs;
3) **Enhanced Network Devices (ENDs):** Physical devices connected to the distribution network;
4) **Remote Distribution Controllers (RDCs):** responsible for interfacing with Enhanced Network Devices (ENDs) and providing communications with the Grand Unified Scheme (GUS) Controller;
5) **GUS Controller:** responsible for managing communications, hosting or interfacing with GUS Applications, issuing control actions to/from RDCs and interfacing with other Northern Powergrid Systems; and
6) **General:** lists general requirements applicable to the control system as a whole.

3.1.1.1 As noted under section 2 above, there is a parallel recommendation on the Data Warehouse. It is recognised that system architectures may involve the Data Warehouse feeding this GUS, and vice-versa. The two recommendations should be read in conjunction. Again, the distinction is made for convenience in specifying functional requirements and should not be taken as inferring any particular architecture.

3.1.1.2 The CLNR GUS control system should have interfaces with the existing Network Management System (ENMAC™).

3.1.1.3 The CLNR GUS control system should be a separate standalone control system.

3.1.1.4 This CLNR GUS control system should not interfere with the operation of the existing Network Management System. The only permitted links are for the GUS Control System to extract network connectivity, if required by the supplier's chosen control algorithms (possibly through the ICCP interface), and pass relevant alarms to SCADA.

3.1.1.5 This CLNR GUS control system may, dependent on the supplier's chosen control algorithms, require full electrical network model data, as opposed to simple connectivity. Interfaces to live Northern Powergrid network models (IPSA, DINIS, and other vector models) are permissible.

3.1.1.6 Figure 1 provides an overview of the scope of supply. The GUS Control System supplier should be responsible for the integration of all connected equipment into the control system.

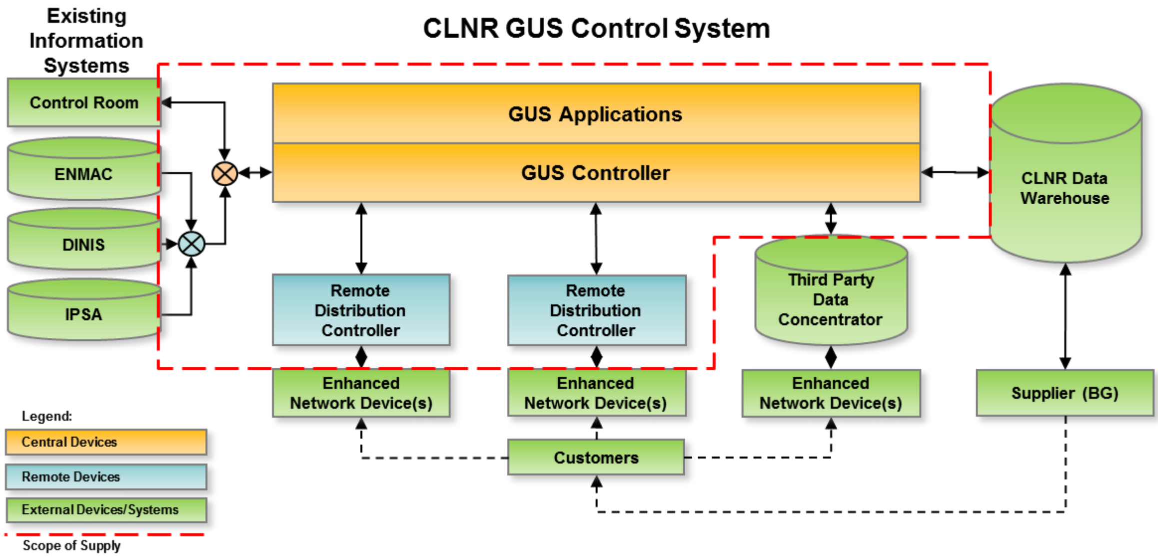

Figure 1 CLNR GUS Control System - Scope of Supply

3.2 Summary of Control System for Customer Led Network Revolution

3.2.1.1 The network flexibility trials under the CLNR project will establish a number of test cells on Northern Powergrid's distribution network. The purpose of the test cells is to assess the flexibility of the distribution network by introducing several novel network technologies.

3.2.1.2 The goal of the control system is to demonstrate improved network flexibility through the control and monitoring of ENDs. The system should be designed using a flexible approach such that alternative methods of control can be trialled.

3.2.1.3 Procurement of the GUS Control System does not necessarily seek to implement an enduring smart grid solution, but a platform on which various network trials can be undertaken, and a prototype for the enduring solution. An iterative approach to the development may be appropriate to trial alternative methods of operation. It is paramount that design and development activity is undertaken in collaboration with Northern Powergrid and its CLNR project partners such that the intent of the project is not lost.

3.2.1.4 The implementation of the control system should be appropriate for use in a trial and the temporary nature of the project. The design of the control system should be appropriate for ongoing use in the live environment, including but not limited to:

- Automatic update of network electrical and connectivity data, if required by the supplier's chosen control algorithms;
- Robust interfaces with the existing Network Management System (NMS);
- A simple, flexible user interface; and
- Scalability to multiple network segments.

The implementation of the control system should be such that the control system algorithms are independent from the control system platform. Access to all source code as necessary should be provided such that new or modified control algorithms may be used on the platform.

3.2.1.5 Suppliers should not take the structure of the functional specifications laid out in this document as inferring any preferred architecture for the GUS control system.

3.2.1.6 The CLNR project does not incorporate network automation (i.e. fault restoration or automatic switching). This should be implemented through the separate Network Management System: GUS must both be robust to such actions and not interfere with them.

3.2.1.7 ENDs include:

1) Real Time Thermal Rating (RTTR) solutions applied on primary and secondary transformers, underground cables (LV, HV and EHV) and overhead lines (HV and EHV);
2) Electrical Energy Storage (EES) installed at HV and LV;
3) Enhanced Automatic Voltage Control (EAVC) applied at primary transformers, HV regulators, distribution transformers and HV capacitor banks;
4) Network Monitoring equipment installed on remote network assets and at customers' premises; and
5) Demand Side Response (DSR) systems for domestic, industrial and commercial demand customers, and merchant generators.

3.2.1.8 Specific details of the ENDs are not defined at this stage. A procurement route that allows flexibility over the scope will be chosen for elements which are at present ill-defined.

3.2.1.9 Further information on ENDs can be found in section 3.4 of this recommendation.

3.2.1.10 This recommendation details the technical requirements of a control system to manage a series of geographically isolated test cells in the CLNR project. The test cells include three complex test cells with multiple monitoring and control points (Rural Low Density, Urban High Density and PV Cluster), and 17 simple systems that include a single monitoring point and a single control point.

3.2.1.11 These test cells may incorporate the following END technologies:

Urban High Density (see Figure 3 in Appendix-5:):
- EAVC at 2 locations;
- RTTR on around 8 assets;
- EES at 3 locations ;
- HV and LV monitoring at 10 locations.

Rural Low Density (see Figure 4 in Appendix-5:):
- EAVC at 4 locations;
- RTTR on around 10 assets;
- EES at 2 locations;
- HV and LV monitoring at 10 locations.

PV Cluster (see Figure 5 in Appendix-5:):
- EAVC at 1 location;
- EES at 1 location.
- LV monitoring at 3 locations.

10 x Thermal DSR test cells
- RTTR at 1 location;
- Link to DSR Aggregator(s)

5 x Voltage DSR test cells
- Voltage monitoring at 1 location;
- Link to DSR Aggregator(s)

1 x Voltage Heat Pump test cell
- EAVC at 1 location
- Voltage monitoring at 2 locations
- Link to DSR Aggregator

1 x Thermal Heat Pump test cell

- RTTR at 1 location
- Link to DSR Aggregator(s)

3.2.1.12 A control system is to be developed which integrates the separate END technologies into an overall scheme to manage the test cell networks to ensure network stability (e.g. limit hunting) and provide co-ordinated network responses utilising the ENDs in response to near real-time network conditions.

3.2.1.13 The goals of the control system will be to maintain supply voltage within (user-defined) acceptable limits, and to maintain power flows within asset thermal limits. The intent is thereby to increase network capacity. Initially, assets in the test cells are not expected to be operated outside static or statutory limits, as it is intended to operate within artificially tighter limits in order to demonstrate the performance of the control system and ENDs.

3.2.1.14 It is envisaged that up to 20 separate control systems are required, one for each test cell referred to in 3.2.1.11 above The control system design approach should be scalable and modular such that each system is an instance of a generic system.

3.2.1.15 The design approach should allow the complexity of the control system to be appropriate for the scale of the test cell, particularly where only a single monitoring point and actuator is present.

3.2.1.16 The design of the control system should be extensible and allow for additional test cells to be added at later stages of the project. The integration of additional test cells is not within the scope of supply of this recommendation.

3.2.1.17 The GUS control system should be designed such that it is capable of being scaled up to the entire Northern Powergrid distribution network.

3.3 GUS Applications

3.3.1 Purpose

3.3.1.1 The purpose of this GUS control system is to increase the number of control and monitoring nodes (ENDs) on the network, apply a wide-area control system to those ENDs, and thereby increase the capability of the network. This will be demonstrated in the test cells referred to in 3.2.

3.3.1.2 At present, control devices on the distribution network (primarily voltage control) are configured with one set of operating parameters (setpoints), designed to operate over a wide range of credible scenarios. The CLNR project will increase the number of control and monitoring devices (ENDs) on the network and introduce this GUS control system, which will be able to determine operating parameters (setpoints) that best suit the current state of the network, increasing network capability. The benefits of this control scheme are: access to a greater number of monitoring points; and holistic, integrated, wide-area control of a number of devices simultaneously in order to increase network capability.

3.3.1.3 At all times the GUS control system will be required to provide a co-ordinated control response to maximise the capability of the network, for the current state (i.e. connectivity and customer requirements) of the network. Broadly speaking, this GUS control system will:

- 3.3.1.3.1 Assess monitoring devices across the network to assess current operating conditions;
- 3.3.1.3.2 Assess the thermal or voltage utilisation of the network; and
- 3.3.1.3.3 Manage control devices across the network:
- 3.3.1.3.4 Firstly, to ensure that limits are not breached; then
- 3.3.1.3.5 Secondly, to deliver optimal solutions, such as minimising losses.

3.3.1.4 The GUS control system will operate continuously, however it is expected that it would issue few setpoint changes with the system intact. The more variable the power flows, the more active this GUS control system is likely to be. However, under an intact system, power flows are low relative to thermal capacity and system impedance, so little corrective action is likely to be required to maintain the network within voltage and thermal limits.

3.3.1.5 The GUS control system is expected to become more active in response to changes in network conditions, particularly post fault. On the redundant system, a fault means the loss of one network path, so power flows are high relative to thermal capacity and system impedance.

3.3.2 Overview of Control Philosophy

3.3.2.1 Within this recommendation, the more detailed requirements to enable wide area network control are held in the Control Algorithms section (3.3.4).

3.3.2.2 The default mode of operation of each control END will be to maintain some local parameter to a fixed set-point. For example, an individual voltage regulator would act to maintain the pressure at the local busbar within a defined tolerance of some pre-defined figure.

3.3.2.3 The management of the wider network will be the responsibility of the GUS control system. The GUS control system should manage the network by issuing revised setpoints to the ENDs. Further information on ENDs can be found in section 3.4.

3.3.2.4 The setpoint is the set of operating parameters for the device, the form of which may vary for different types of ENDs. A setpoint may include, but is not limited to, the following:

3.3.2.4.1 Target voltages with a bandwidth;
3.3.2.4.2 Disable line-drop compensation;
3.3.2.4.3 Modify time delays;
3.3.2.4.4 Target thermal utilisation (load current, power);
3.3.2.4.5 Voltage threshold to initiate a control or reporting action;
3.3.2.4.6 Thermal threshold to initiate a control or reporting action;
3.3.2.4.7 Real/reactive power charge/discharge (for EES/DSR);
3.3.2.4.8 Operating profiles (this is more so for EES devices where they have a cyclic operating characteristic;

3.3.2.5 Individual ENDs will have no visibility of the wider network. The closest will be line-drop compensation, which estimates conditions from local measurements.

3.3.2.6 The GUS control system should not issue direct control actions e.g. tap up.

3.3.2.7 The GUS control system should be able to change the operating mode of ENDs, as described in section 3.4.1.5.

3.3.2.8 Each control END is responsible for monitoring network parameters local to itself, reporting the state of the network to the GUS control system and performing local control actions to manage those local network parameters within given setpoints. Here “local” means “co-located”, e.g. at a primary substation.

3.3.2.9 A control END will perform actions that will affect a portion of the network. This should be referred to as the area of influence. Areas of influence will overlap within control END types and across different types of control ENDs

3.3.2.10 ENDs will report network parameters and device status to the GUS Control system (refer to Polling Methods section 3.7.5).

3.3.2.11 When monitoring ENDs indicate that the network is approaching defined thresholds, the GUS control system should identify one or more appropriate control ENDs with sufficient influence to address the non-compliance, and issue appropriate setpoint(s). As shown in 3.3.2.4, reporting may be on an alarm/exception basis, with GUS defining the reporting threshold as part of the monitoring END set-point.

3.3.2.12 Similarly, control ENDs (EAVC, EES devices and DSR aggregators), in addition to reporting utilisation of the network, should where appropriate, report on the utilisation of the control device, e.g. state of charge, or volume and duration of available response. The GUS control system should:

3.3.2.12.1 Calculate a solution for any given constraint, based upon user-defined parameters (cost, etc.); and
3.3.2.12.2 Recognise control ENDs that are depleting their resources, and issue appropriate setpoints to other control ENDs with overlapping spheres of influence to maintain the network within limits.

3.3.2.13 The GUS control system requires a method of implementing this control philosophy and the further control requirements detailed in the GUS Applications (section 3.3.4) of this recommendation. It is understood that a number of methods can be used to implement the requirement, ranging from Optimal Power Flow (OPF) models to systematic rule based methods, and that each of the different methods has varying levels of information (connectivity and electrical models) and operational/maintenance overheads. Solutions that minimise the amount of manual user intervention are preferred.

3.3.2.14 Northern Powergrid will make network connectivity and electrical models available. The supplier will be responsible for developing and implementing all data interfaces required to extract the data. The supplier shall ensure that all data interfaces connecting to Northern Powergrid systems comply with network security and access policies and do not disrupt the normal operation of Northern Powergrid systems.

3.3.3 Power-On Power-Down Procedure

3.3.3.1 The GUS Control System shall have a Power-Down procedure that includes:

- Gracefully transition all ENDs to their default local operating modes (refer section 3.4.1.5);

3.3.3.2 The GUS Control System shall have an emergency shut-down procedure that includes:

- Gracefully transition all ENDs to the disabled operating mode (refer section 3.4.1.5);

3.3.3.3 The GUS Control System shall have a Power-On procedure that includes:

- Gracefully transition all ENDs to the remote operating mode (refer section 3.4.1.5);

3.3.3.4 It shall be possible to invoke the Power-On Power-Down Procedure from the Control Room.

3.3.4 Control Algorithms

3.3.4.1 Overview

3.3.4.1.1 The following section outlines the functional requirements of the control algorithms that are required to control ENDs in the test cells. It is understood that more information may be required to adequately assess the workload to develop and implement the control algorithms and this may require tender pricing with both fixed and variable elements. Suppliers should refer to section 3.8.6 for procurement options which allow flexibility in the tendering approach.

3.3.4.1.2 The supplier should be responsible for developing the control algorithms through collaboration with project partners (Northern Powergrid, EA Technology and Durham Energy Institute).

3.3.4.1.3 The supplier should be responsible for the software implementation of all control algorithms and their integration into the overall scheme.

3.3.4.1.4 Control system algorithms are required to implement control schemes across the test cells. The algorithms should determine setpoints for the connected ENDs. The following requirements have been specified as a guide to the likely functions required of the control algorithms.

3.3.4.2 Voltage Profiling

3.3.4.2.1 The monitoring devices that will be provided to inform the voltage control algorithms are detailed in section 3.4.5, Figure 3, Figure 4 and Figure 5.

3.3.4.2.2 It is required that voltage is profiled in the controlled network to identify areas/nodes with voltage excursions (high or low levels). This would be achieved by a balance of network monitoring and estimation. The direction of power flow and the power factor should also be considered, to inform the determination of solutions and setpoints.

3.3.4.2.3 The overall goal is to maintain the voltage supplied to customers within defined bands. Such bands are to be configurable during the trial.

3.3.4.3 Voltage Control

3.3.4.3.1 The ENDs that will be provided to enable voltage control in each test cell are detailed in section 3.4.4, Figure 3, Figure 4 and Figure 5.

3.3.4.3.2 Voltage will be primarily controlled by EAVC devices, connected in series and parallel within the distribution network. EES systems (releasing both reactive and real power) and DSR also have the ability to alter power flows and hence voltage levels and these should be taken account of in the algorithms.

3.3.4.3.3 The algorithms should determine setpoints for each of the devices to:

- Keep voltage supplied to customers within user-defined limits; and
- Co-ordinate devices to limit hunting. This should include modifying characteristics such as line-drop compensation, time delays, and the choice of controlled busbar.

3.3.4.4 Thermal Profiling

3.3.4.4.1 The ENDs that will be provided to inform the real-time rating of assets in each test cell are detailed in section 3.4.2, Figure 3, Figure 4 and Figure 5.

3.3.4.4.2 The real-time rating of assets should be monitored for selected assets on the network such that the algorithms can enact appropriate control decisions to keep asset temperature within acceptable user-defined limits. Predictive, dynamic rating algorithms are not required: instead, limits should be set to take account of the likely rate of change of temperature and the likely response time of the selected control END(s).

3.3.4.5 Thermal Control

3.3.4.5.1 The ENDs that will primarily influence asset temperature are EES and DSR; these are detailed in section 3.4.3 and 3.4.6 respectively. The outline locations within the test cells where these devices will be installed are shown in Figure 3, Figure 4 and Figure 5.

3.3.4.5.2 Raising network voltage will reduce current for a given power flow; reducing the voltage supplied to customers may reduce demand. EAVC should therefore also be considered in thermal control algorithms.

3.3.4.5.3 The GUS control system should seek to reduce the load that assets are exposed to, in order to reduce the temperature where the RTTR devices highlight that assets are approaching their thermal limit.

3.3.4.5.4 The GUS control system should take cognisance of the likely rate of change of temperature, reflecting both power flow variability and asset thermal time constants, as it will be necessary to have appropriate reaction times. Specifically, if different types of control END may be selected to resolve thermal issues, then this GUS control system should implement flexible thresholds at which to invoke a control action.

3.3.4.5.5 The GUS control system should also determine when EES/DSR is no longer required, i.e. that thermal limits will not be breached if power flows are allowed to continue unmodified.

3.3.4.6 Resource Arbitration

3.3.4.6.1 Resource arbitration should maintain the stability of the control system and of the distribution network.

3.3.4.6.2 If multiple algorithms are calculating setpoints for the same area of network, different algorithms may attempt to push or pull the network in different directions. The GUS control system must be able to simultaneously control the network. The following issues must be considered:

- Interconnected or cascaded devices, e.g. where there is a need to coordinate devices to minimise hunting and step voltage changes.
- Managing conflicts, a real time decision making process that simultaneously considers multiple resource types to address network thermal and voltage compliance, e.g. thermal controllers requesting storage to discharge while voltage controllers are requesting storage to charge.
- Comparing the impact of each action. Such a comparison may be based on a combination of:
    - Expected results of the action (e.g. EES rating and charge level, expected/reported response level from DSR);
    - Device priority based on predefined cost (particularly for DSR).

3.3.4.6.3 For voltage control devices the control system must be aware of the need to co-ordinate operation of the voltage control scheme. New setpoints will need to be issued in a manner such that the system can gracefully adjust to the new control points. This will require careful consideration of time delay settings at voltage control ENDs including, where appropriate, modifying time delay settings.

3.3.4.6.4 Wherever practicable, staged interventions should be applied. For example, if the GUS control system decides that invoking DSR is (part of) the most appropriate resolution of any given constraint, it should call only that part of the DSR resource as is required to address the immediate issue. This will permit, for example, DSR to be tailored to the degree of thermal stress, rather than an all-or-nothing response.

3.3.4.7 Resource Optimisation

3.3.4.7.1 A resource optimisation function should be able to optimise the use of the GUS control system resources. This is an enhancement of the resource arbitration requirement to include other user-defined parameters such as minimising losses or reducing tap-change operations (although this last is, arguably, part of the resource arbitration requirement to consider the impact of each action).

3.3.4.8 Connectivity management

3.3.4.8.1 Distribution networks are dynamic, if slow-moving, constructs. While the fundamental architecture changes relatively slowly, the connectivity of the assets will change within day. It is essential that this GUS control system is robust to changes in both the underlying electrical characteristics of the distribution network and of connectivity (moves of open point etc.).

3.3.4.8.2 How this functionality is delivered will depend upon the supplier's choice of control algorithms. For example, algorithms that rely on network models will require those models to be updated. In contrast, self-learning algorithms that react to their inputs may require no explicit information on the state and nature of the distribution network. The supplier should provide detailed proposals for the control algorithms including the control method, input data requirements and ongoing maintenance requirements.

3.3.4.8.3 Access to Northern Powergrid electrical and connectivity models will be provided. It is the supplier's' responsibility to deliver whatever interfaces and algorithms are required to input and interpret those models.

3.3.4.8.4 Northern Powergrid's electrical network models are held in IPSA, DINIS and as vector records and will be made available to the control system supplier. The connectivity of Northern Powergrid's distribution network is held in the Network Management System ENMAC™ v5, supplied by General Electric.

3.3.4.8.5 Solutions that minimise the amount of manual input are strongly preferred. However, it is understood that in the project timescales this may not be feasible. Some options are presented below and the supplier is invited to submit proposals stating the expected cost and timescales. Alternative proposals are welcomed.

- Real-time Update – export of connectivity from Northern Powergrid systems, prompted when network is changed. GUS network models and algorithms are updated accordingly;
- Real-time Update – autonomous GUS operation (i.e. no link to Northern Powergrid systems), connectivity established through calculation (e.g. voltage setpoint change but monitoring value has not altered);
- Periodic Update – extract from Northern Powergrid systems daily or weekly, GUS network models updated accordingly;
- Manual Update – manual process to inform GUS Applications that connectivity or electrical characteristics have changed. GUS network models updated accordingly. If the method of implementing the control scheme dictates that electrical models of the network are used for the calculation of END actions, then a method of updating the model shall be provided by the supplier.

3.3.4.8.6 The solution chosen should be such that a future upgrade of the system to achieve a higher level of connectivity management would not result in significant redundancy of the initial prototype.

3.3.4.8.7 It is required that the control system has the ability to identify inconsistencies within the network model(s) held by the control system. This may be achieved by identification of anomalous control results, i.e. temperatures/voltages not responding as expected. In order to achieve this, the control system should be able to estimate the impacts of setpoint changes.

3.3.4.9 Feedback Validation

3.3.4.10 Feedback is a critical requirement for the GUS control system. The control system must have a method of understanding whether control actions instigated by the system have had the desired effect.

3.3.4.11 The GUS control system should calculate the estimated impact of the setpoint change with sufficient accuracy to decide whether the control action has been successful. Specifically, GUS should determine whether additional actions are required, or whether to generate an alarm and cease to attempt to resolve the constraint. Safeguards shall be put in place to prevent runaway, including user-defined limits.

3.3.4.12 How this functionality is delivered will depend upon the supplier's choice of control algorithms. For example, algorithms that rely on network models may produce a precise estimate of the expected response. In contrast, self-learning algorithms that react to their inputs may make a best guess, and then use the resulting observations to update their view on the state and nature of the distribution network, and then generate new setpoints. The supplier should provide detailed proposals for the control algorithms including the control method, input data requirements and ongoing maintenance requirements.

3.3.4.13 The network may take a period of time to migrate from the old setpoint to the new setpoints. Particularly for voltage control, if local voltage is still within the tolerance of the new set-point, then the control END will take no action. This GUS control system shall be robust to these effects.

3.3.4.14 This is closely linked to the connectivity management requirement, as an unexpected response from the real network may be due to an out-of-date view of the network within this GUS control system.

3.3.5 User Interface

3.3.5.1 A user interface is to be provided that allows access to the core functions of the GUS Control System. The specific design of the interface should be at the discretion of the supplier. The key interface requirements are:

- A logical layout with transparent design;
- A series of graphical displays to highlight device and system statuses;
- Access to data held in the GUS Controller;
- Access to the current Network Connectivity Model held in the GUS Controller;
- Access to configure, monitor and interrogate RDCs/ENDs;
- Manually issue setpoints to RDCs/ENDs;
- Access to configure and monitor Control Algorithms;

3.3.5.2 The user interface should be platform independent and able to run on Northern Powergrid's standard PC environment (Microsoft Windows 7 and Internet Explorer v8 or higher).

3.4 Enhanced Network Devices ENDs

3.4.1.1 This section is provided for suppliers' information only; the provision of the ENDs is subject to separate specifications and is not within the scope of supply for the control system.

3.4.1.2 The hierarchical architecture adopted for the project will require ENDs to operate independently of each other to achieve their network goals. The GUS control system shall be responsible for ensuring that the independent operations of ENDs are complimentary and capable of providing an efficient and co-ordinated response to changes in the network.

3.4.1.3 ENDs should include both control and measurement devices that are part of the CLNR control system. Many control devices also provide monitoring information.

3.4.1.4 ENDs that control the network will operate to achieve their given setpoints. This makes the control devices more resilient to temporary losses of communication.

3.4.1.5 ENDs should have four operating modes: local, remote, manual and disabled. Each of these modes should be capable of being the default mode of operation for the END.

- In local mode the END should be responsible for measuring local network parameters and managing local network parameters within a pre-defined default setpoint. The setpoint should enable passive co-ordination between ENDs. As ENDs are installed onto the network they will initially be configured to operate in local mode, before being connected to the wider GUS scheme.

- In remote mode the END should be responsible for measuring local network parameters and managing those parameters within a defined tolerance of a setpoint issued by the GUS

Applications. It is the responsibility of the GUS control system to issue these setpoints to ensure that parameters on the wider network are within limits.

- In manual mode the END will no longer be responsible for managing local network parameters and will not undertake any control actions.

- In disabled mode the end will revert to a pre-defined configuration where it has minimal impact on the network. For series devices this will be similar to a unity tap setting. For shunt connected devices the device will disconnect from the network.

3.4.1.6 A summary of the expected quantity and location of ENDs that may be installed on the network as part of the Grand Unified Scheme of the CLNR project are included in Figure 2. This information is for illustrative purposes only. Specific technical details of the ENDs that will be installed will not be available prior to tender award.

	RTTR								EES				EAVC					Monitoring				
Location	OHL EHV	OHL HV	GM Pr Tx	GM Sec Tx	UG Cables EHV	UG Cables HV	UG Cables LV	**RTTR Total**	1: 2.5MW, 5MWh	2: 100kW, 200kWh	3: 50kW, 100kWh	**EES Total**	1: Pr Tx Tapping	2: LV Regulation	3: HV Regulation	4: HV Sw Capacitors	**EAVC Total**	HV Feeder	LV Feeder	HV/LV Substation	Primary Substation	**Monitoring Total**
Rural																						
Grange Wood	2							**2**														
Denwick Primary	2		2					**4**					2				**2**				1	**1**
Brooks Field		1						**1**														
Broomhouse		1						**1**														
Scar Brae		1						**1**														
Whitehouse		1						**1**														
Glanton Regulator															1		**1**					
Hedgeley Moor Cap																1	**1**					
Hepburn Bell Regulator															1		**1**					
Remote HV Feeders																		7				**7**
Wooler St Mary's S/S											1	**1**								1		**1**
Wooler Ramsey S/S				1				**1**		1		**1**								1		**1**
Wooler Bridge S/S				1				**1**						1						1		**1**
Remote LV Feeders																			2			**2**
Totals								**12**				**2**					**5**					**13**
Urban																						
Rise Carr Primary			2		1	1		4	1			1	2				2					
Remote HV Feeders																		5				5
High Northgate S/S				1				1		1		1								1		1
Harrogate Hill S/S											1	1								1		1
Darlington Melrose														1			1			1		1
Totals								**5**				**3**					**3**					**8**
PV Cluster																						
Mortimer Rd S/S				1				1						1			1			1		1
Remote LV Feeders											1	1							8			8
Totals								**1**				**1**					**1**					**9**
Heat Pump Cluster 1																						
HV/LV substation				1				1												1		1
Totals								**1**				**0**					**0**					**1**
Heat Pump Cluster 2																						
HV/LV substation														1			1		2	1		3
Totals								**0**				**0**					**1**					**3**
DSR Voltage Test Cells																						
Remote HV Feeder																		1				1
Totals								**0**				**0**					**0**					**1**
DSR Thernal Test Cells																						
Remote HV Feeder			1																			
Totals								**1**				**0**					**0**					**0**

Figure 2. Schedule of GUS Network Devices and Expected Real Time Data

3.4.2 Real Time Thermal Rating (RTTR)

3.4.2.1 RTTR systems will be responsible for measuring local network and environmental parameters and calculating the temperature of the critical components of the asset (e.g. winding temperature).

3.4.2.2 For control purposes, the GUS control system will use the real-time calculated or measured temperature and/or rate of change of temperature of the asset with the loading to assess for thermal constraints.

3.4.2.3 The GUS control system will be responsible for addressing any thermal limitations.

3.4.2.4 The following RTTR solutions will be deployed across the test cells:

1) Overhead Line (OHL) EHV
2) OHL HV
3) Ground Mounted Primary Transformer
4) Ground Mounted Secondary Transformer
5) Underground Cable (UGC) EHV
6) UGC HV
7) UGC LV

3.4.2.5 The RTTR systems are essentially intelligent measurement devices and cannot directly perform control actions on the distribution network.

3.4.3 Electrical Energy Storage (EES)

3.4.3.1 EES provides a means to store energy and release it back onto the network. The default mode will likely be a pre-set diurnal cycle, or to maintain a given voltage. There may be an intermediate loop where EES reacts to a co-located monitoring device. The ability to source or sink real and reactive power makes EES a flexible resource for managing network voltage and providing demand control.

3.4.3.2 The following EES solutions will be deployed through the course of the CLNR project:

1) EES1 – Primary HV (estimate of 2.5MW, 5MWh), 1no.;
2) EES2 – LV Substation (estimate of 50kW, 100kWh), 2no.;
3) EES3 – Urban Distribution LV (estimate of 50kW, 100kWh), 3no.

3.4.3.3 EES has the capability to provide positive voltage support by discharging and negative voltage support by charging. The inverter/controller will also have the ability to inject reactive power if required. The EES local controller will have a default local mode of maintaining the voltage to local setpoints.

3.4.3.4 Local voltage support schemes such as this will need to be co-ordinated by the GUS control system with other EAVC resources with overlapping areas of influence.

3.4.3.5 The EES devices can be used to release energy to support thermally stressed assets. This function could be achieved through time of day activation. The device may also be locally paired with a co-located RTTR system to provide local network measurements.

3.4.3.6 It is critical that the device is at the appropriate State of Charge (SoC) to perform the required functions. This will involve charging or discharging the storage to a level which will allow the EES to operate optimally in its next planned regime. It will be necessary for the GUS control system to inform the EES of the most appropriate charge or discharge cycles.

3.4.4 Enhanced Automatic Voltage Control (EAVC)

3.4.4.1 Voltage control schemes already exist on the network. The existing schemes are passively co-ordinated so that the existing voltage controllers work in harmony to ensure that the voltage supplied to customers remains within acceptable limits.

3.4.4.2 The following EAVC solutions will be deployed through the course of this project:

1) EAVC1 - Primary Transformer OLTC
2) EAVC2 Secondary Substation Regulator
3) EAVC3 - HV In-line Regulator
4) EAVC4 - HV Shunt Switched Capacitor Bank
5) EAVC5 - LV Service Regulator

3.4.4.3 Each EAVC system under local operation will measure local network parameters (bar voltage and/or load for LDC) and adjust the secondary voltage output. Under remote control of the GUS control system, EAVC devices will accept setpoints and attempt to maintain these new setpoints irrespective of local conditions. Under this operating mode, it is the responsibility of the GUS control system to ensure that voltages on the wider network are within limits.

3.4.4.4 The EAVC devices will need to be co-ordinated by this GUS control system to limit hunting and provide the optimum network capacity.

3.4.5 Network Monitoring

3.4.5.1 A variety of dedicated network monitoring solutions will be deployed as part of the project, in addition to RTTR (which is an intelligent monitor), and data provided from control ENDs. The purpose of the network monitoring solutions is to provide the GUS control system with real-time measurements of remote nodes on the distribution network, to allow it to manage the voltage and thermal profiles of the distribution network, and to provide a record of network conditions for later analysis as part of the wider CLNR project.

3.4.5.2 The network monitoring data is to be archived in the Data Warehouse for offline analysis of the behaviour of the control system.

3.4.5.3 The following dedicated network monitoring solutions will be deployed through the course of this project:

1) Primary Substation;
2) Secondary Substation;
3) LV Feeder midpoint;
4) LV Feeder endpoint

3.4.5.4 The monitoring parameters which will be available for control purposes are:

1) Voltage;
2) Current;
3) Phase angle (360°).

A variety of other monitoring parameters will also be measured for analysis, dependant on monitoring type and location, and these may be used for control purposes.

3.4.5.5 The network monitoring solutions will be capable of generating and transmitting data at one minute intervals for voltage and ten minute intervals for all other measurements.

3.4.5.6 Some network monitoring equipment has already been installed within the test cells. Data generated by these solutions is transferred to an iHost database supplied by Nortech Management Ltd. The GUS Controller(s) is to access this data for use in the control scheme (refer section 3.6.3).

3.4.6 Demand Side Response (DSR)

3.4.6.1 DSR will be provided by a range of third party aggregators. DSR solutions will be provided for the following classes of customer:

- Domestic load control via British Gas Demand Response Management System (DRMS);
- Industrial and commercial load control through approximately 4 aggregators; and
- Commercial generation control through approximately 4 aggregators.

3.4.6.2 Each DSR end-user is considered as an END and each aggregator (including BG) is cindered as a third-party data concentrator. The GUS control system supplier will be responsible for developing and implementing an interface with each aggregator such that GUS can invoke a DSR response directly from the aggregators.

3.4.6.3 The full scope of the works to be undertaken by the GUS control system supplier will be defined during the detailed design phase.

3.4.6.4 The provision of DSR is in the design phase. The GUS control system supplier will be required to liaise and provide support as necessary to define the interfaces between the various systems.

3.5 Remote Distribution Controllers (RDCs)

3.5.1.1 Remote Distribution Controllers (RDCs) are responsible for interfacing with the ENDs and providing communications with the GUS Controller such that data is passed to the control system and control actions, such as setpoint changes, are passed to the ENDs.

3.5.2 Remote Distribution Controller Functions

3.5.2.1 The RDC has four key functions:

1) Upstream interface with GUS;
2) Local data storage and data handling;
3) Local control;
4) Downstream interface with ENDs.

The control system supplier will be responsible for ensuring that these functions are provided.

3.5.2.2 The END systems (procured separately) may have suitable hardware and/or software to provide some or all of these functions, in which case the control system supplier will be responsible for liaison with the END supplier to enable this functionality. Any costs borne from the END supplier to enable these functions do not form part of the scope of supply for the control system and will be met by Northern Powergrid.

3.5.2.3 The control system supplier will be responsible for providing a flexible solution to integrate all ENDs into the overall control scheme. Where control functions are provided by the END supplier they should not be unduly replicated by the control system supplier. For example where an appropriate Remote Terminal Unit (RTU) is provided by the END supplier, the control system supplier may use this to directly communicate with the GUS Controller. Flexibility may be achieved through either offering different hardware platforms with varying layers of capability or through flexible software on a single hardware platform.

3.5.3 Upstream Communications to GUS Controller

3.5.3.1 The preferred protocol for the project is DNP3, however the use of a different network/communications protocol is not ruled out. In any case, the protocol should be agreed with Northern Powergrid and be based on an accepted and mainstream industry standard.

3.5.3.2 Where the use of a proprietary protocol is accepted a full definition of the protocol and any licences or agreements for its use should be provided to Northern Powergrid.

3.5.3.3 The upstream communication system should be fit for purpose particularly with respect to:

- Being suitable for use in environments similar to substations (i.e. high level of electromagnetic interference);
- Having proven reliability for distributed control systems;
- Having bandwidth suitable for the available media;
- Being capable of uploading stored data to the GUS at configurable regular intervals, when particular thresholds are exceeded or when polled by the GUS Controller;
- Being suitably resilient to major incidents on or off the distribution network.

3.5.3.4 The following communication mediums are proposed for the link between the RDC and GUS:

- GPRS cellular communications (preferred);
- DSL communications.

3.5.3.5 The RDC should support periodic polling, remote polling and report by exception. The polling methods are defined in section 3.7.5.

3.5.4 Local Storage and Data Handling

3.5.4.1 The RDC should have the means to store all data points (to a resolution of one-minute average data) generated by the connected ENDs for 31 days to cater for failure in the communications system or the GUS control system.

3.5.4.2 Control Data is defined as data that is to be used directly by the control system to calculate control actions and this data should be collated and made available for upstream transfer within ten seconds from initiation. This data transfer may be initiated by polling from the control system, periodic auto-transfer or report by exception. Regardless of polling type the data must be presented to the communications system for transfer within ten seconds.

3.5.4.3 Archive Data is defined as data that is to be recorded for later analysis and consists of historic network conditions and the requested control actions of ENDs. The RDCs should store information on network conditions and actions taken by remote devices for later analysis. The transmission of this data is not necessary in real-time and may be passed infrequently to the Data Warehouse in bulk.

3.5.4.4 The RDCs and GUS Controller should have an automatic method of checking sent data for errors and re-transmitting data as appropriate.

3.5.5 Local Control

3.5.5.1 The RDCs should have the ability to provide a programmable environment capable of hosting logic/rule based algorithms for locally connected ENDs.

3.5.5.2 The RDC may be required to perform local tasks such as:

- Comparing local network measurements with network setpoints;
- Identifying exceptions;

- Initiating control actions for local ENDs;
- Initiating report by exception reporting to the GUS Controller

3.5.5.3 The RDC should have the capability to perform calculations based on data provided by ENDs including monitoring devices. Examples of such calculations are pre-processing data to providing ten minute average values from data obtained with other periodicity.

3.5.5.4 One local control loop that is required is the local integration of RTTR and EES: a simple control loop that reduces thermal stress on a transformer by discharge of EES during peak load. The EES would be charged during off-peak. These local control loops would operate autonomously (i.e. without the presence of the GUS Controller).

3.5.5.5 The RDCs should have the ability to remotely update and configure local control functions via GUS using an appropriate secure utility (refer to section 3.5.3).

3.5.5.6 Each data point should have remotely configurable threshold values to indicate the following device statuses:

- Data point value is normal;
- Data point value is abnormally high;
- Data point value is abnormally low;
- Data point value is an error value.

3.5.5.7 Based on such thresholds being exceeded, the RDC should have the ability to:

- Send an alarm message to the GUS control system (abnormal value);
- Report by exception the data value to the GUS Controller (if the control system is being operated in exception mode).

3.5.5.8 The RDC should be capable of generating and issuing alarms and/or fault reports to the GUS control system for all unexpected device events such as failures, lost communications and threshold breached values. This relates to events related to the RDC and of connected ENDs.

3.5.5.9 Fault reports and alarms should have a priority system to distinguish between (user-defined) tolerable and critical faults. Alarms should have priority over data in the communications system.

3.5.5.10 A method of automatically suppressing repeat alarm events should be provided so as to allow continued operation of the control system during tolerable faults.

3.5.6 Downstream Communication to ENDs

3.5.6.1 The RDCs should communicate directly with ENDs to:

- Pass operational changes to ENDs (e.g. device setpoints);
- Receive network measurements and device statuses from ENDs;
- Receive fault codes and/or error messages from ENDs.

3.5.6.2 The communications protocol between RDCs and the ENDs may vary between END suppliers. The GUS Control System supplier will be responsible for interfacing between the RDCs and ENDs. Any costs borne from the END supplier to enable these functions do not form part of the scope of supply for the control system and will be met by Northern Powergrid.

3.5.6.3 The RDCs should be capable of passing alarms from ENDs to the GUS Controller.

3.5.6.4 The RDC should be capable of supporting multiple ENDs that exist at a single location. The ENDs shall retain unique addresses.

3.5.6.5 The RDCs should provide an interface with ENDs to allow network data to be provided to the RDC and control data to be passed to the END. Specific technical details of the ENDs that will be installed will not be available prior to tender award. Section 3.4 of the specifications provides some information on the ENDs.

3.5.6.6 ENDs will be selected that communicate using mainstream protocols and media. The control system supplier should be responsible for liaising with the END suppliers to develop and implement the interface to the GUS control system. Each individual END supplier will be obliged to facilitate the integration and any costs borne from the END supplier will be met by Northern Powergrid.

3.5.6.7 The control system supplier should provide a utility, either through separate hardware and software or contained within the RDC, to allow any diagnostic and configuration functions to be undertaken in the locality of the device.

3.5.6.8 The RDC is required to communicate with the ENDs shown in Figure 2. The ENDs will be located in geographically isolated test cells and may be located in any of the locations listed in section 3.7.10.

3.5.7 Configuration and Supporting Utilities

3.5.7.1 It should be possible to configure the following parameters locally or remotely:

- Sample rate for import of network data;
- Disable and enable the transmission of specific data points;
- Data threshold values for which alarms are generated;
- Data threshold values for which control actions are generated;
- Configuration data specific to the END if remote configuration is supported by the device.

3.5.7.2 The configuration utility for the controllers should be capable of running on Northern Powergrid's standard PC environment (Microsoft Windows 7 with Internet Explorer v8 or higher).

3.5.7.3 General configuration requirements are detailed in section 3.7.6.

3.6 GUS Controller

3.6.1.1 The GUS Controller is responsible for:

- Managing communications and data transfer with all connected RDCs;
- Managing communications and data transfer with all third party data concentrators;
- Passing relevant alarms generated by the GUS control system to existing Network Management System;
- Hosting or interfacing with GUS Applications;
- Holding the data buffer for real-time network control;
- Interfacing with the Data Warehouse; and
- Issuing control actions to ENDs, including external DSR resource, and interfacing with other Northern Powergrid Systems.

3.6.2 Connection to RDCs

3.6.2.1 The GUS Controllers should be responsible for providing reliable delivery of information from GUS Applications to ENDs via RDCs and vice versa.

3.6.2.2 The data packet sent from the GUS Controller to the RDC should be referred to as an END Request. It is desirable that a common message structure is adopted for all ENDs. An example packet structure of an END Request is given for consideration in Table 1.

Table 1 – Example END Request Packet

Network Device Request
Location
Device id
Device type
Request type
New goal / set point
Change operating mode
Change device updates
Payload (i.e. new goals/mode)
Change operating mode
Local - Original settings (passive coordination)
Manual - lock settings
Remote - Gus oversight
Disable - no network impact
Change Device Settings
Timing
Poling
Exception set point
New goal / set point
Target load / current
Target Voltage
Operating Profiles
Request Timing
Start
Stop

3.6.2.3 The data packet sent from the RDC to the GUS controller should be referred to as an END Update. An example packet structure of an END update is given as a guide in Table 2.

Table 2 – Example END Update Packet

END Update
Location
Device id
Device type
Device status
Health
Alarms
Help - cannot maintain setpoint
Device control headroom
Network parameters (analogues)
Voltage
Current
Load
Power factor
Wind
Environmental temperature
Asset temperature

Network Headroom

3.6.2.4 The polling types that the control system should support are periodic (auto) polling, remote polling and report by exception. Polling types are detailed in section 3.7.5.

3.6.2.5 The GUS control system should control the network by issuing setpoints to ENDs, as described in 3.3.2.4.

3.6.2.6 The GUS Controller should be responsible for communicating setpoint changes to ENDs by issuing an END Request.

3.6.2.7 The GUS control system should be able to remotely change the operating mode of ENDs. All ENDs will be capable of operating in four modes, as described in section 3.4.1.5.

3.6.2.8 The GUS Controller should ensure that all END Requests initiated by GUS Applications are made available to the Data Warehouse. The GUS Control System supplier should liaise with the Data Warehouse supplier to facilitate the import of the information into the appropriate schema.

3.6.3 Connection to Third Party Data Concentrators and Aggregators

3.6.3.1 iHost is a SCADA application provided by Nortech Management Ltd. This system is used to collate data in near real-time from a number of monitoring devices located in the test cells. It is proposed to use this monitoring data to inform GUS Applications to calculate the network state. iHost is capable of communicating using DNP3. Not all monitoring data will be provided through iHost.

3.6.3.2 The GUS Controller should be capable of receiving monitoring data derived from devices connected through the iHost application.

3.6.3.3 The iHost server will be co-located with the GUS Controller in Northern Powergrid's northern control facility in Penshaw. Connection is expected to be via DNP3 over Ethernet.

3.6.3.4 Additional third party data concentrators and aggregators may be used during the project. The GUS Controller should be capable of receiving data from third party data sources using common interfaces such as ODBC. Any costs borne from the third party data concentrator to enable these functions do not form part of the scope of supply for the control system and will be met by Northern Powergrid.

3.6.4 Connection to GUS Applications

3.6.4.1 The GUS Controller should either provide an operating environment capable of hosting GUS Applications or directly link to a separate GUS Applications system. The applications will require access to the real time data that is generated by ENDs and Monitoring Devices and passed through from the GUS Controller.

3.6.4.2 GUS Applications may be hosted directly on the GUS Controller or another platform. Where the GUS Applications are held outside of the GUS controller an interface will be required to the GUS Controller.

3.6.5 Connection to Data Warehouse

3.6.5.1 The Data Warehouse will be the central data archive for all relevant data generated as part of the CLNR project. It will store all relevant data to allow analysis of the project as a whole and will be located in Northern Powergrid's northern control facility in Penshaw. The Data Warehouse itself is not part of the scope of this specification.

3.6.5.2 The GUS Controllers are responsible for periodically passing data to the Data Warehouse. The data shall include:

- Measurements and parameters from ENDs;
- Measurements from Monitoring Devices (directly connected to GUS Controllers);
- Control data (e.g. setpoint change requests, device operational change requests);
- Any device or algorithm configuration files.

3.6.5.3 The GUS Controller should have an ODBC link with the Data Warehouse.

3.6.5.4 The Data Warehouse will perform the Extraction, Transformation and Loading processes necessary to store the data in the appropriate schema; however, the GUS Controller shall pass the data with the necessary information to enable this. The information (in addition to the actual data point / measurement) should include:

- Test Cell Reference;
- Location Reference (e.g. Primary Transformer, LV Feeder Mid);
- Asset type (e.g. EAVC HV Regulator, RTTR HV Overhead Line).

3.6.5.5 Data generated within the GUS controller is to be passed to the Data Warehouse periodically with an approximate period of one hour.

3.6.6 Local Data Handling and Data Interfaces

3.6.6.1 The GUS Controller should buffer all data generated by ENDs that is required for real-time use by GUS Applications and/or required to be stored by the Data Warehouse for a period of 24 hours.

3.6.6.2 Suppliers' chosen architecture will vary. It is recognised that: data may be gathered in the warehouse and passed to or extracted by GUS applications; or that data will be passed directly to GUS Applications, and then archived to the warehouse.

3.6.6.3 ENDs and RDCs will be capable of generating fault reports and alarms and should have a priority system to distinguish between tolerable and critical faults. The GUS Controller should be capable of passing critical faults to the Northern Powergrid's main SCADA system (ENMAC™).

3.6.6.4 A method of automatically suppressing repeat alarm events should be provided so as to allow continued operation of the control system during tolerable faults.

3.7 General

3.7.1.1 This section lists the general requirements of the GUS Control System that are applicable to the system as a whole. Individual requirements for each of the sub-systems are specified in separate sections.

3.7.1.2 This recommendation is written under the assumption that the physical location of the three main elements are as follows:

- Remote Distribution Controllers – local to ENDs (feeders, primary and secondary substations) spread across the test cells (Denwick, Rise Carr, Maltby and the DSR/Heat Pump sites);
- GUS Controller – centrally housed within Northern Powergrid control facility (Penshaw, Tyne and Wear);
- GUS Applications – centrally housed within Northern Powergrid control facility as separate hardware or hosted on the same hardware as the GUS Controller.

3.7.2 Implementation Approach

3.7.2.1 The implementation of the control system should be developed in stages to allow a phased approach of the control system. Works towards completion of the stages is not to be sequential as demonstration of successful completion of one phase does not necessarily preclude work on the next.

3.7.2.2 The delivery stages are as follows:

Stage 0 – Enabling Works

- Detailed design and development: to be undertaken by the supplier with support from CLNR project partners;
- Liaison with END suppliers: procurement of ENDs is ongoing, once specific manufacturers and products are identified, it will be necessary to define the interfaces between the ENDs and the GUS control system;
- Install all hardware: installation of hardware should be a priority as the CLNR project has specific measured targets related to this;
- Commissioning of the Data Warehouse (subject of separate specification).

Stage 1 – Connection and Data Transfer

- Establish communication links and data transfer between RDCs and GUS Controller(s);
- Establish communication links and data transfer between RDCs and directly connected ENDs (i.e. ENDs that are installed in the same location as RDCs);
- Establish communication links and data transfer between GUS Controller(s) and ENDs connected through third party data concentrators (i.e. data transfer between iHost and GUS Controller(s));
- Transfer data from the GUS Controller(s) to the Data Warehouse.

Stage 2 – Implement Local Control Loops

- Use GUS Applications to calculate / deduce local network issues from END measurements;
- Demonstrate control of individual ENDs (pass setpoints);
- Develop algorithms to control devices in isolated loops, for example:
    - Using transformer RTTR to inform control of EES;
    - Using feeder monitoring to determine EAVC setpoint.

Stage 3 – Full Control

- Calculate test cell wide network issues from END measurements;
- Demonstrate co-ordinated control of multiple ENDs.

3.7.3 System Security and Failure / Alarm Handling

3.7.3.1 The GUS control system is to be implemented without increased risk of loss of supply or excursion outside statutory limits. Sufficient fail safe mechanisms and switch-off routines should be built into the system so devices can be inhibited or reverted back to normal operation. The mechanisms should include:

- Automatic means: such as when the control system detects, or is alerted to, a critical issue;
- Manual means (controlled): a method of gracefully inhibiting the control system and reverting devices back to safe operation in an orderly way;
- Manual means (emergency): immediately stop all control system functions.

3.7.3.2 The method of stopping all control system functions and reverting ENDs back to default operation should be provided for use by Control Room staff at Northern Powergrid's Penshaw facility.

3.7.3.3 The control system should be designed to respond to a failure of a component (or multiple components) with a reduction in functionality that is proportional to the severity of the failure. Examples of events that should precipitate such reductions in functionality may include but are not limited to the following:

- The GUS Control System is intentionally powered down;
- Failure of, or lost communications to, the GUS control system;
- Loss of the data from one phase of a three phase measurement point;
- Loss of the data from two phases of a three phase measurement point;
- Failure of a connected monitoring point;
- Failure of, or lost communications to, an END;
- Resource exhausted.

3.7.3.4 Additional alarms shall include but are not limited to:

- High volts;
- Low volts;
- Thermal limits exceeded;
- END failure to respond as expected;
- GUS unable to resolve constraints.

3.7.3.5 The control system supplier should propose methods of implementing fail safe mechanisms and switch-off routines for consideration by Northern Powergrid during the detailed design phase.

3.7.3.6 The control system should pass critical alarms generated from ENDs to Northern Powergrid's SCADA system (ENMAC™).

3.7.4 Communications

3.7.4.1 Communications to/from remote locations (e.g. feeders, substations) should use public networks. The control system supplier should be responsible for provision of all communication links with GPRS being used where possible. Where GPRS is unavailable or unsuitable then DSL should be used.

3.7.4.2 Communications between the GUS Controller and other locally installed systems are to be through use of Northern Powergrid's existing corporate Ethernet network. Other local systems that the GUS Controller is to communicate with are the Data Warehouse, Northern Powergrid's Network Management System and GUS Applications.

3.7.4.3 The preferred communications protocol between RDCs and the GUS Controllers is DNP3 using TCP/IP. However the use of an alternative network/communications protocol is not ruled out. In any case, the protocol shall be agreed with Northern Powergrid and be based on an accepted and mainstream industry standard.

3.7.4.4 The GUS Control System supplier should submit a security policy related to the hardware and software intended to be installed for agreement with Northern Powergrid. The policy should define the methods proposed to prevent unauthorised access and control of the assets and should include password controlled user privileges and mainstream methods of security whilst using public networks (e.g. VPN, HTTPS).

3.7.4.5 The communication frequency (sampling rate) should be configurable to attempt to mitigate against latency or low communications bandwidth.

3.7.5 Polling Methods

3.7.5.1 The polling types that the control system should support are periodic (auto) polling, remote polling and report by exception.

Periodic Polling

3.7.5.2 In this operating mode a snapshot of control data points from all ENDs (including monitoring points) in the test cell should be transmitted to the GUS in fixed periods.

3.7.5.3 The sampling frequency should be remotely configurable between one minute and thirty minutes in one minute increments.

Remote Polled

3.7.5.4 In this operating mode a snapshot of control data points associated with the RDC should be transmitted to the GUS Controller. The request will be initiated by the GUS Controller.

Report by Exception

3.7.5.5 In this operating mode the RDC should initiate data transfer triggered by a data point threshold being exceeded.

3.7.6 Configuration

3.7.6.1 A global Configuration Utility should be provided such that RDCs and ENDs (subject to the specification of the device) can be configured from a remote location.

3.7.6.2 The Configuration Utility should be a single system with capability to configure all relevant devices within the GUS.

3.7.6.3 The Configuration Utility should be able to configure groups of RDCs in a single operation.

3.7.6.4 The Configuration Utility should have the ability to change key parameters such as:

- Sampling rate for import of network data;
- Disable and enable the transmission of specific data points;
- Data threshold values for which alarms are generated;
- Changes to local control loops;
- Configuration data specific to the END if remote configuration is supported by the device.

3.7.6.5 The Configuration Utility for the controllers should be capable of running on Northern Powergrid's standard PC environment (Microsoft Windows 7 and Internet Explorer v8 or higher). Software required by the Configuration Utility is to be provided by the supplier.

3.7.6.6 The Configuration Utility should have a security facility to prevent unauthorised changes being made by use of login names and passwords with levels of access privileges. Access privilege levels shall include:

- User: Read only access;
- Administrator: Read/write access.

3.7.6.7 The configuration utility should be capable of saving and/or loading the configuration and/or data files to disk and have the ability to restore the configuration locally and remotely.

3.7.6.8 The configuration utility should be capable of saving a plain text file formatted version of the equipment settings.

3.7.6.9 Devices configuration files or settings should be passed to the Data Warehouse with a timestamp of when the changes were made.

3.7.6.10 All information developed as part of the CLNR project which is necessary to enable future modifications and upgrades to be undertaken via competitive tender (such as source code and configuration information) should be openly provided to Northern Powergrid.

3.7.7 Time Synchronisation

3.7.7.1 The time reference of all devices supplied by the GUS control system supplier should be synchronised to Northern Powergrid's NTP (Network Time Protocol) Server at least once a week.

3.7.7.2 Data should be time stamped with the time the measurement was taken.

3.7.7.3 Where possible the time reference of other connected devices will also be synchronised to NTP server through its connection to the GUS control system.

3.7.8 Device Identification

3.7.8.1 The control system should have a method of relaying the unique identity of each connected component so data and control actions can be logically referenced.

3.7.8.2 The unique identifier or address of each component should be consistently referenced throughout the GUS control system and be unique across all three test cells. Dependent upon the device and location, this could either be provided as part of the communications protocol as a device reference, by using fixed IP addresses, or be provided by a separate additional unique identifier data field.

3.7.9 Environmental Conditions

3.7.9.1 The equipment should be of a robust design and environmentally tested in accordance with BS EN 60529 Specification for degrees of protection provided by enclosures (IP code). The housing should be proven and certified intruder resistant where appropriate.

3.7.9.2 All equipment should be capable of operating under conditions of shock and vibration normally encountered in service.

3.7.9.3 All equipment should be capable of continued operation whilst exposed to ambient temperatures in the range -25°C to +55°C and humidity levels of between 0 – 90% non-condensing. Any equipment should be UV stable with testing carried out in accordance with BS 2782-5: method 552A.

3.7.10 Equipment Location

3.7.10.1 The equipment should be designed for retrofit application to the following nodes:

- Primary substations
- Secondary substations
- Remote feeder sites
- Control rooms

3.7.10.2 It is a strong preference that installation of equipment is carried out without the need for interruption to associated line and supply. Alternative solutions offered by the manufacturer should be included in the tender reply.

3.7.11 Equipment Housing

3.7.11.1 The control system supplier should be responsible for provision of all equipment housings, which should be designed to accommodate, as a minimum, the following equipment:

- Communications Interface (e.g. ADSL modem/ GSM modem)
- Distribution Controller (e.g. RTU/PLC)
- Power Supply (Battery and Charger Unit)
- Solid state data storage

3.7.11.2 Where equipment is to be installed in a substation, the housing and contents should meet the requirements of BS EN 60439 Part 1: Low Voltage Switchgear and Control Gear Assemblies.

3.7.11.3 IP rating refers to ingress protection as defined in IEC60529:2004 Degrees of Protection Provided by Enclosures. Equipment housings should have a minimum IP rating of IP54 for equipment to be installed at indoor and substation locations.

3.7.11.4 Equipment housings should have a minimum IP rating of IP67 for equipment to be installed outdoors.

3.7.11.5 Equipment housings should also meet the requirements of BS EN 60439 Part 5: Particular Requirements for Assemblies for Power Distribution in Public Networks

3.7.11.6 With reference to BS EN 60439, the following items should be subject to agreement between supplier and user:

- BS EN 60439 – 6.2.3. Heavy pollution of the air by salt is likely to occur in coastal regions
- BS EN 60439 – 6.2.4. Exposure to a strong electric and magnetic field is likely
- BS EN 60439 – 6.2.6. Attack by fungus and by small creatures is likely

3.7.11.7 Equipment housings should be of adequate size to contain all equipment components and associated terminal connections. Tender replies should include maximum dimensions for the following parameters: height (h), width (w), depth (d) and mounting method.

3.7.11.8 The housing should be designed so that no maintenance requirements are required for the duration of the trial installation (3 years).

3.7.12 Power Supplies

3.7.12.1 Loss of line supply, battery supply or low battery volts should not be detrimental to the data stored. Data collection should automatically resume upon restoration of power supply.

3.7.12.2 The incoming power supply unit will be capable of operating at 230V AC +10% / -6% at a frequency of 50Hz. Alternative arrangements for 110V ac and 110 and 48V DC should also be possible.

3.7.12.3 Solutions incorporating battery backup will be considered. Graceful degradation of the equipment function when power is lost is a key requirement of the system. The data stored should not be lost and the unavailability of the unit signalled to other systems. Upon restoration of supply, the unit should announce its availability, resynchronise to the host clock and continue monitoring without manual intervention.

3.7.13 Electromagnetic Compatibility

3.7.13.1 Control system equipment should be compliant with the requirements of the EMC directive.

3.7.13.2 Control system equipment should also be tested in accordance with the following generic EMC Standards:

BS EN 61000-4-2 Electrostatic Discharge Immunity Test
BS EN 61000-4-3 Radiated radio frequency electromagnetic field immunity test
BS EN 61000-4-4 Electrical fast transient/burst immunity test
BS EN 61000-4-5 Surge immunity test
BS EN 61000-4-8 Power frequency magnetic field immunity test

3.7.13.3 The Control system equipment should meet the requirements of BS EN 55022 for RF emissions.

3.8 Installation, Operation and Maintenance

3.8.1 Access

3.8.1.1 All installation should be in accordance with Northern Powergrid's policies and procedures.

3.8.1.2 All installations, regardless of application, should be securely positioned so as to prevent interference or vandalism.

3.8.2 Safety

3.8.2.1 Potential suppliers should comply with their statutory obligations under the Construction (Design and Management) Regulations 2007, in particular to avoid foreseeable risks to those involved in the installation and further use of the equipment.

3.8.2.2 Manufacturers should provide method statements, risk assessments and be prepared to work with Northern Powergrid to train personnel to defined competency levels and update their policies and procedures.

3.8.3 Maintenance

3.8.3.1 All equipment should operate for the duration of the trial (approximately 3 years). All equipment should operate without any intervention or maintenance. Manufacturers should provide details of any maintenance required after 3 years and the expected lifetime of the equipment

3.8.4 Training Requirements

3.8.4.1 It is important that Northern Powergrid personnel acquire sufficient knowledge to properly install and operate the control system. The manufacturer should detail appropriate training such that Northern Powergrid personnel can operate the equipment under normal service conditions.

3.8.5 Support and Development Requirements

3.8.5.1 The equipment should form part of an overall smart grid system. Parameters, algorithms or communications may require alteration during the trial. Manufacturers should detail appropriate support services that they offer.

3.8.6 Procurement Method

3.8.6.1 The procurement method will be predominately under a fixed price contract. It is understood that elements of this specification are ill-defined to allow firm costs to be allocated. Where suppliers cannot deduce the scope of works for specific requirements, these should be highlighted and a day rate cost given instead.

3.8.6.2 Suppliers are requested to provide a comprehensive breakdown of costs for all individual components including:

- Remote Distribution Controller;
    - Hardware;
    - Develop Enhanced Network Device interfaces;
    - Software development including licensing;
    - Installation and commissioning;
    - Remote support;
    - On-site call-off support;
    - Training.

- Communication network
    - Hardware;
    - On-going costs;
    - Installation and commissioning;
    - Remote support;
    - On-site call-off support;
    - Training.

- GUS Controller
    - Hardware;
    - Design and develop data interfaces;
    - Software development including licencing;
    - Installation and commissioning;
    - Remote support;
    - On-site call-off support;
    - Training;

- GUS Applications
    - Design and development of applications;
    - Implementation of applications in software;
    - Remote support;
    - On-site call-off support.

4 References

The products described within this recommendation should comply with all current versions of the relevant International Standards, British Standard Specifications current at the time of supply.

4.1 External Documentation

Reference	Title
EMC Directive 2004/108/EC	Electromagnetic Compatibility
Low Voltage Directive 2006/95/EC	Harmonisation of the laws of Member States relating to electrical equipment designed for use within certain voltage limits
BS EN 55022	Information Technology Equipment, Radio disturbance characteristics, Limits and methods of measurement
BS EN 61000-4-2	Electromagnetic Compatibility (EMC) - Part 4-2 Testing and Measurement Techniques – Electrostatic discharge immunity test
BS EN 61000-4-3	Electromagnetic Compatibility (EMC) - Part 4-3 Testing and Measurement Techniques – Radiated radio frequency electromagnetic field immunity test
BS EN 61000-4-4	Electromagnetic Compatibility (EMC) - Part 4-4 Testing and Measurement Techniques – Electrical fast transient/burst immunity test
BS EN 61000-4-5	Electromagnetic Compatibility (EMC) - Part 4- 5 Testing and Measurement Techniques – Surge immunity test
BS EN 61000-4-7	Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and inter-harmonics measurements and instrumentation, for power supply systems and equipment connected thereto
BS EN 61000-4-8	Electromagnetic Compatibility (EMC) - Part 4-8 Testing and Measurement Techniques – Power Frequency magnetic field immunity test
BS EN 61000-4-15	Electromagnetic Compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications
BS EN 61000-4-30	Electromagnetic compatibility (EMC) - Part 4-30: Testing and measurement techniques – Power Quality measurement methods
BS EN 61340-5-1	Electrostatics. Protection of electronic devices from electrostatic phenomena. General requirements
BS EN 61508	Functional safety of electrical/electronic/ programmable electronic safety-related systems
BS EN 60439-1	Part 1: Low Voltage Switchgear and Controlgear Assemblies
BS EN 60439-5	Part 5: Particular Requirements for Assemblies for Power Distribution in Public Networks
BS EN 60529	Degrees of protection provided by enclosures
BS EN 61508	Functional safety of electrical/electronic/ programmable electronic safety-related systems
BS 2782-5	Methods of testing plastics. Optical and colour properties, weathering. Determination of changes in colour and variations in properties after exposure to daylight under glass, natural weathering or laboratory light sources
BRE-LPS 1175 level 1	Building Research Establishments Loss Prevention Standard

As part of the tender submission, the supplier should provide full technical details of the equipment offered and should indicate any divergence from these standards or specifications.

Appendix-1: Technical Specification

GUS Control System Technical Specification	
Spec Ref	**Requirement**
3.1	Overview of Technical Requirements
3.2	Summary of Control System for Customer Led Network Revolution
3.3	GUS Applications
3.3.1	Purpose
3.3.2	Overview of Control Philosophy
3.3.3	Power-On Power-Down Procedure
3.3.4	Control Algorithms
3.3.5	User Interface
3.4	Enhanced Network Devices ENDs
3.4.2	Real Time Thermal Rating (RTTR)
3.4.3	Electrical Energy Storage (EES)
3.4.4	Enhanced Automatic Voltage Control (EAVC)
3.4.5	Network Monitoring
3.4.6	Demand Side Response (DSR)
3.5	Remote Distribution Controllers (RDCs)
3.5.2	Remote Distribution Controller Functions
3.5.3	Upstream Communications to GUS Controller
3.5.4	Local Storage and Data Handling
3.5.5	Local Control
3.5.6	Downstream Communication to ENDs
3.5.7	Configuration and Supporting Utilities
3.6	GUS Controller
3.6.2	Connection to RDCs
3.6.3	Connection to Third Party Data Concentrators and Aggregators
3.6.4	Connection to GUS Applications
3.6.5	Connection to Data Warehouse
3.6.6	Local Data Handling and Data Interfaces
3.7	General
3.7.2	Implementation Approach
3.7.3	System Security and Failure / Alarm Handling
3.7.4	Communications
3.7.5	Polling Methods
3.7.6	Configuration
3.7.7	Time Synchronisation
3.7.8	Device Identification
3.7.9	Environmental Conditions
3.7.10	Equipment Location
3.7.11	Equipment Housing
3.7.12	Power Supplies
3.7.13	Electromagnetic Compatibility
3.8	Installation, Operation and Maintenance
3.8.1	Access
3.8.2	Safety
3.8.3	Maintenance
3.8.4	Training Requirements
3.8.5	Support and Development Requirements
3.8.6	Procurement Method

Appendix-2: Technical Schedule / Declaration of Technical Performance to be completed by the manufacturer

Not applicable

Appendix-3: Self Certification Conformance Declaration

Monitoring devices for LV distribution networks shall be supplied against this specification. These devices shall comply with the latest issues of the relevant British and International Standards specified. The following tables are intended to amplify and/or clarify the requirements of elements of these Standards but do not preclude meeting all requirements of the standards.

The manufacturer shall declare conformance or otherwise, clause by clause, using the following levels of conformance declaration codes.

Instructions for completion

- When Cs1 code is entered no remark is necessary.
- When any other code is entered the reason for non-conformance shall be entered.
- Prefix each remark with the relevant ‘BS EN’ ‘IEC’ or ‘ENATS’ as appropriate.

Conformance declaration codes

N/A = Clause is not applicable/ appropriate to the product
Cs1 = The product conforms fully with the requirements of this clause
Cs2 = The product conforms partially with the requirements of this clause
Cs3 = The product does not conform to the requirements of this clause
Cs4 = The product does not currently conform to the requirements of this clause, but the manufacturer proposes to modify and test the product in order to conform.

Manufacturer:

Product Reference:

Name:

Signature:

Date:

Paragraph No.	**Requirement**	**Conformance Code**	**Remarks / Comments**
3.1	Overview of Technical Requirements		
3.2	Summary of Control System for Customer Led Network Revolution		
3.3	GUS Applications		
3.3.1	Purpose		
3.3.2	Overview of Control Philosophy		
3.3.3	Power-On Power-Down Procedure		
3.3.4	Control Algorithms		
3.3.5	User Interface		

Paragraph No.	**Requirement**	**Conformance Code**	**Remarks / Comments**
3.4	Enhanced Network Devices ENDs		
3.4.2	Real Time Thermal Rating (RTTR)		
3.4.3	Electrical Energy Storage (EES)		
3.4.4	Enhanced Automatic Voltage Control (EAVC)		
3.4.5	Network Monitoring		
3.4.6	Demand Side Response (DSR)		
3.5	Remote Distribution Controllers (RDCs)		

Paragraph No.	**Requirement**	**Conformance Code**	**Remarks / Comments**
3.5.2	Remote Distribution Controller Functions		
3.5.3	Upstream Communications to GUS Controller		
3.5.4	Local Storage and Data Handling		
3.5.5	Local Control		
3.5.6	Downstream Communication to ENDs		
3.5.7	Configuration and Supporting Utilities		
3.6	GUS Controller		

Paragraph No.	Requirement	Conformance Code	Remarks / Comments
3.6.2	Connection to RDCs		
3.6.3	Connection to Third Party Data Concentrators and Aggregators		
3.6.4	Connection to GUS Applications		
3.6.5	Connection to Data Warehouse		
3.6.6	Local Data Handling and Data Interfaces		
3.7	General		
3.7.2	Implementation Approach		

Paragraph No.	Requirement	Conformance Code	Remarks / Comments
3.7.3	System Security and Failure / Alarm Handling		
3.7.4	Communications		
3.7.5	Polling Methods		
3.7.6	Configuration		
3.7.7	Time Synchronisation		
3.7.8	Device Identification		
3.7.9	Environmental Conditions		
3.7.10	Equipment Location		

Paragraph No.	Requirement	Conformance Code	Remarks / Comments
3.7.11	Equipment Housing		
3.7.12	Power Supplies		
3.7.13	Electromagnetic Compatibility		
3.8	Installation, Operation and Maintenance		
3.8.1	Access		
3.8.2	Safety		
3.8.3	Maintenance		
3.8.4	Training Requirements		

Paragraph No.	**Requirement**	**Conformance Code**	**Remarks / Comments**
3.8.5	Support and Development Requirements		
3.8.6	Procurement Method		

Appendix-4: Addendum to Supplier Requirements

Project specific installation and protection requirements will be provided by Primary Engineering Projects for inclusion in this appendix.

Appendix-5: Draft Test Cell Diagrams

The following draft test cell diagrams are illustrative only and are included for supplier information. Specific technical details of the ENDs and their locations that will be installed will not be available prior to tender award.

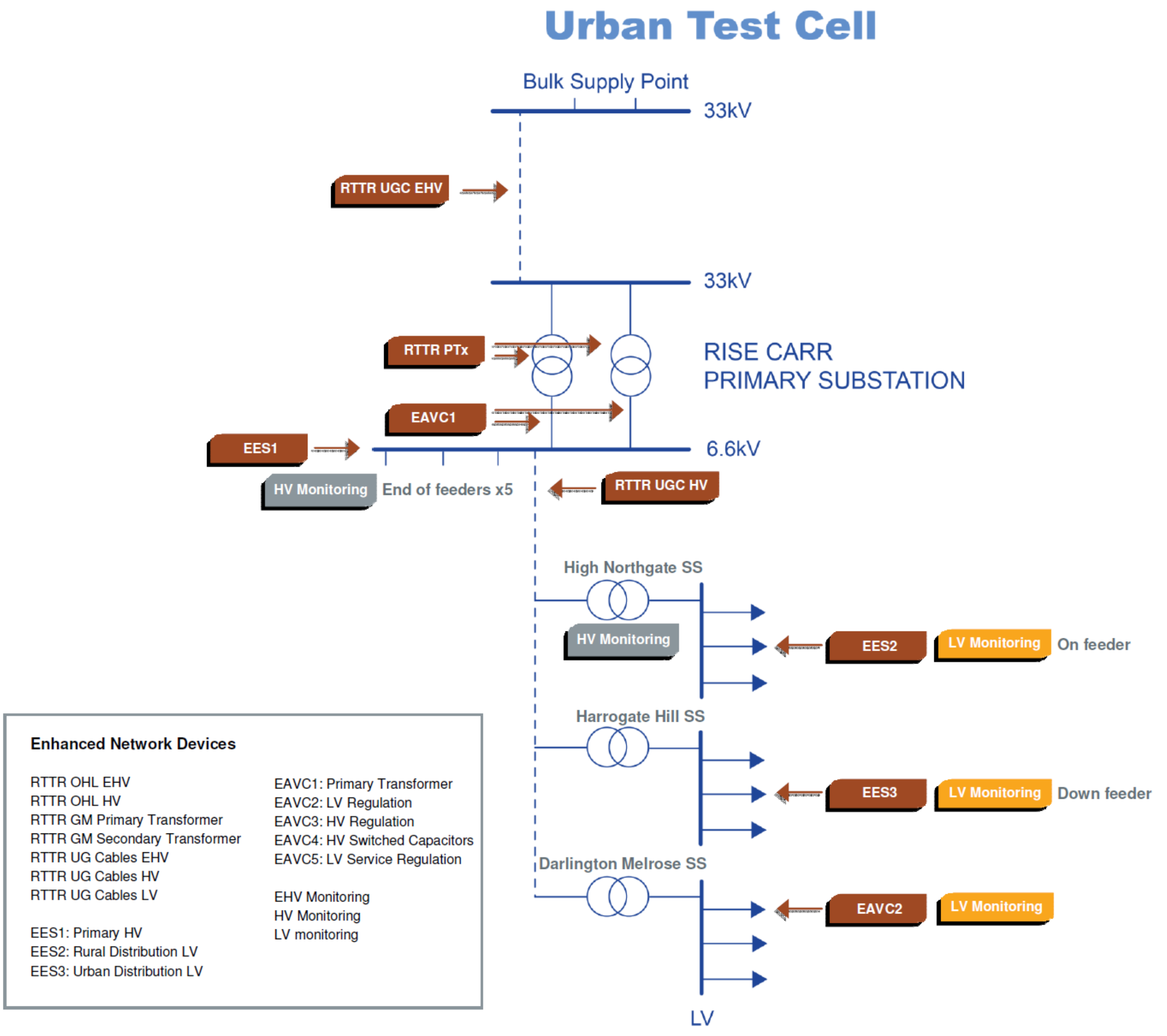

Figure 3 Urban Test Cell Diagram

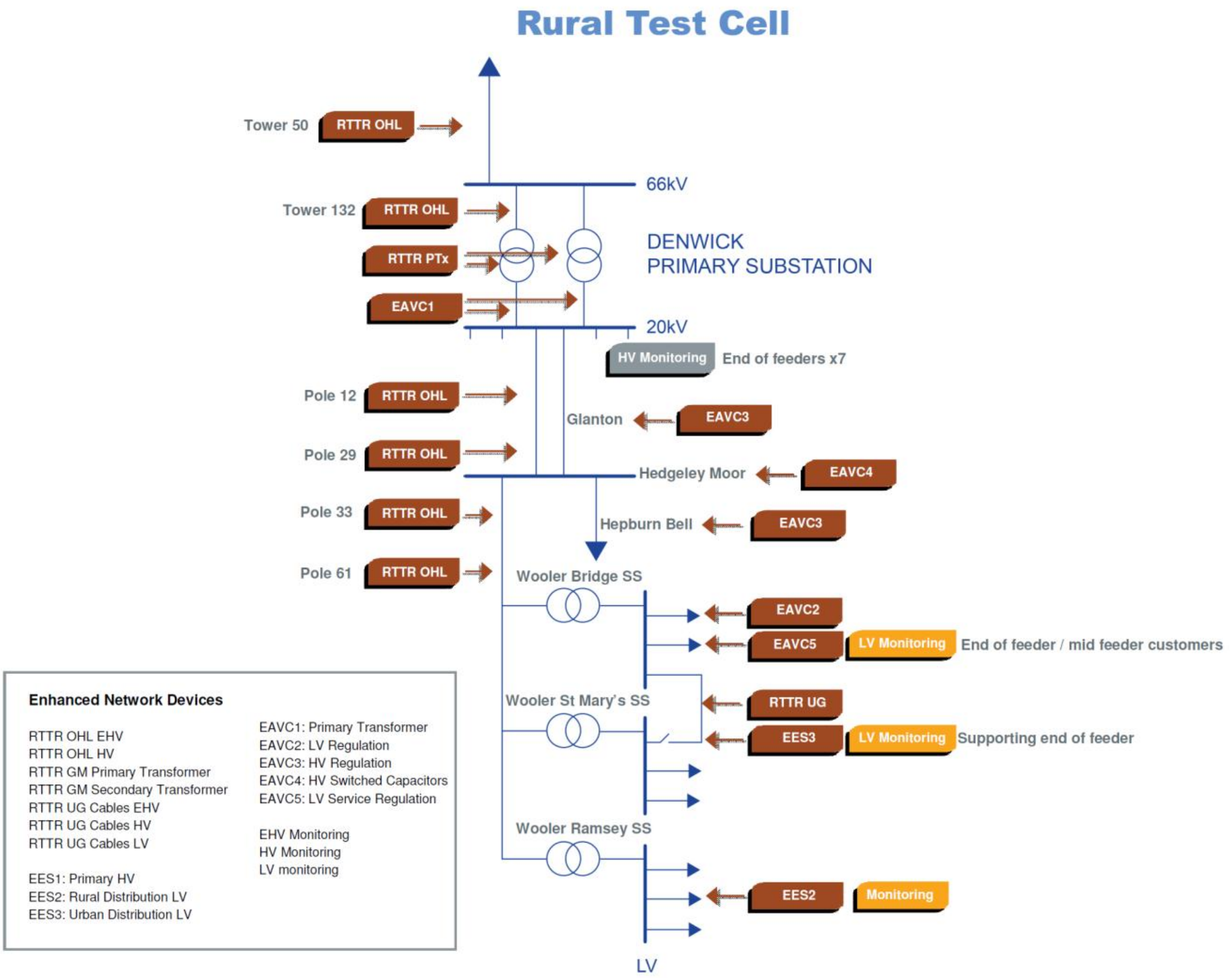

Figure 4 Rural Test Cell Diagram

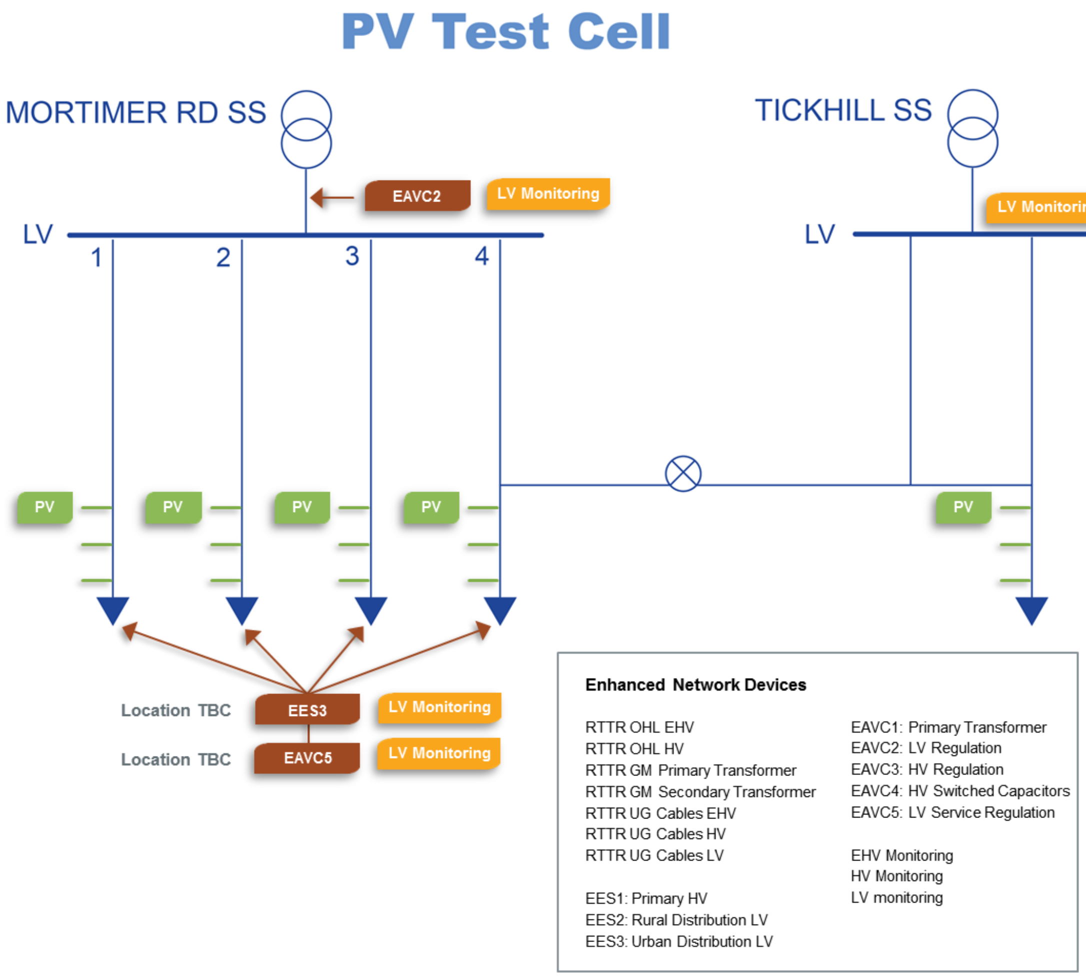

Figure 5 PV Cluster Test Cell Diagram