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| Project Title / Location | Multi-Terminal Test Environment (MTTE) / The National HVDC Centre |
| Project Reference Number | SSEN001 |
| Date: | 10 April 2015 |

# Design Development Document

for

# The National HVDC Centre

| Version | Status | Distribution | Date of Issue |
|---|---|---|---|
| v1.0 | Draft for Internal Review | Project Team, Steering Group and Internal Stakeholders | 3rd April 2015 |
| v2.0 | Draft for External Review | Attendees of the Design Review Workshop (23/4/15) | 10th April 2015 |

## REVIEW & APPROVAL

### Reviewed by

| Name | Project Role | Date Reviewed/Issued |
|---|---|---|
| Norman MacLeod | Project Team (External Consultant) | 3rd April 2015 |
| Yash Audichya | Project Team | 3rd April 2015 |
| Colin Cameron | Project Team | 3rd April 2015 |
| Simon Marshall | Project Team | 3rd April 2015 |
| Jen Carter | Regulation | 3rd April 2015 |
| Brian Punton | Steering Group | 3rd April 2015 |
| Stewart Reid | Steering Group | 3rd April 2015 |
| Peter Dale | Steering Group | 3rd April 2015 |
| Dave Gardner | Steering Group | 3rd April 2015 |

### Signed-off by

| Role | Date Signed-off |
|---|---|
| SHE Transmission | 28/4/15 |
| National Grid (NGET & NETSO) | 7/5/15 |
| Scottish Power Energy Networks | 28/5/15 |

# CONTENTS

# 1 INTRODUCTION

## 1.1 Overview

The Multi-Terminal Test Environment (MTTE) for HVDC is an Electricity Network Innovation Competition (NIC) funded project which will create a facility to support the feasibility, specification, procurement, testing, operation and maintenance of HVDC transmission systems in GB and de-risk control interactions; using a real-time simulator and replica control panels of HVDC converter stations from HVDC vendors.

This will reduce the cost, increase the efficiency and de-risk GB's investment in HVDC systems.

The MTTE Project is funded through the Electricity NIC for 7 years; however the project aims to create a long-term facility to support the design, development and commissioning of HVDC systems in GB, as well as the ongoing operation of such assets.

The name of the facility that the MTTE project will create will be:

The National HVDC Centre

This name highlights the centre's collaborative intent, to support all HVDC projects across GB.

The National HVDC Centre will combine advanced real-time simulation capability with replica control panels from HVDC schemes, and will maximise the benefits of GB's significant investment in HVDC systems by:

- Supporting transmission planning and improve specification of HVDC schemes;
- Facilitating multi-terminal solutions and interconnected DC hubs;
- De-risking control interactions between converters connected in electrical proximity, and also with other fast acting power electronic controllers embedded within the AC network;
- Training and developing Transmission Planning and Operations Engineers;
- Undertaking post-commissioning scenario planning and network analysis; and
- Modelling multiple HVDC technologies.

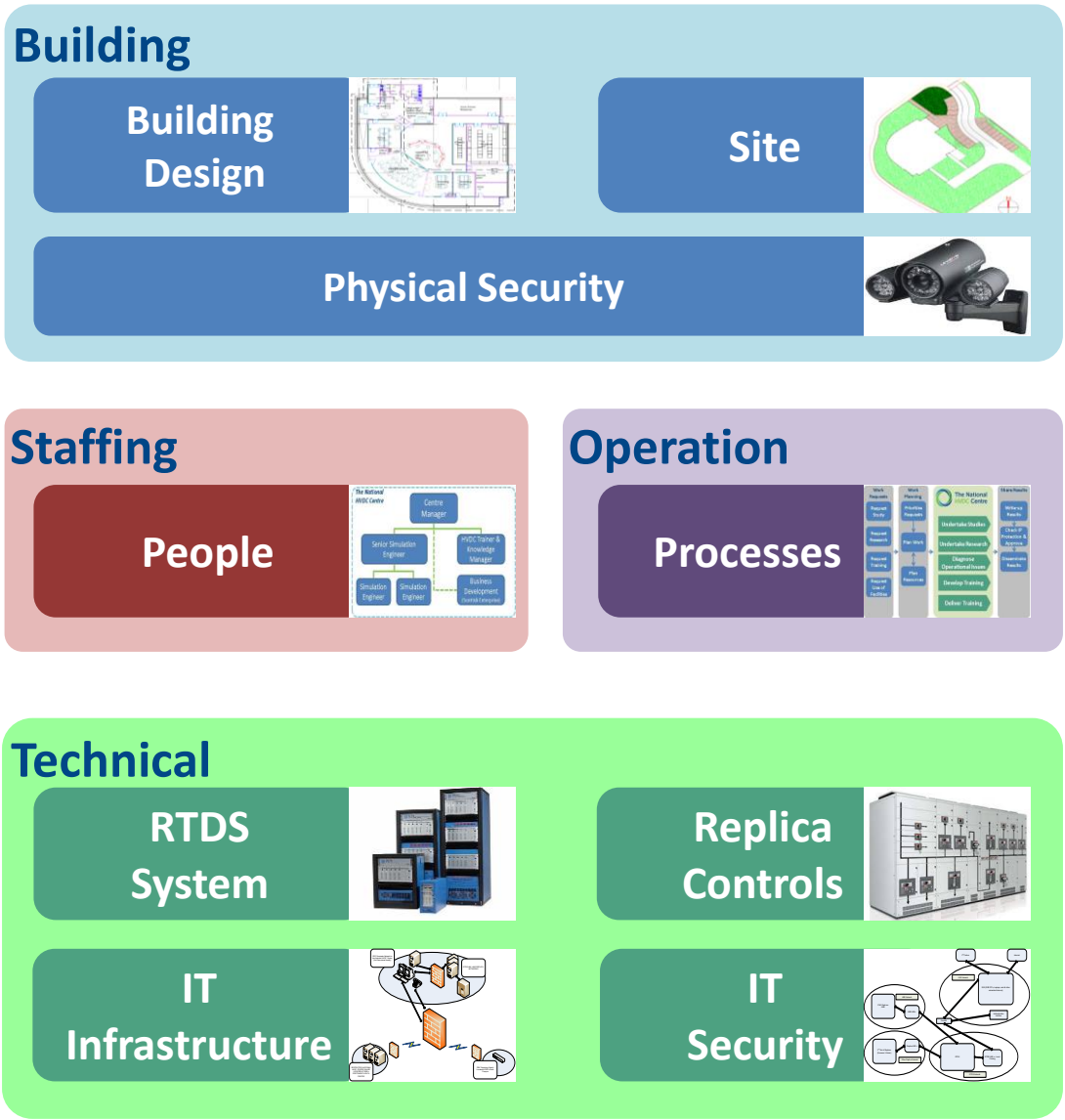
The National HVDC Centre will provide a facility where multiple HVDC schemes on the GB transmission network can be studied to anticipate and resolve potential issues, to ensure the integrity and security of the network.

# 2 DESIGN DEVELOPMENT SCOPE & OBJECTIVES

The design of The National HVDC Centre focuses on four areas:

a) Building Design;
b) Staffing/People;
c) Operation; and
d) Technical Design.

*As illustrated below.*



The scope of each of these areas, together with the objectives of each design, are described in the table below.

| Design Area | Design Scope | Design Objectives | Design Authority |
|---|---|---|---|
| **Technical Design** | IT infrastructure, Replica panels, RTDS system, Models, Data and IT Security. | Design a robust, resilient and flexible technical infrastructure which protects the IP and data whilst supporting users and is fit for purpose for a long-term expanding facility. | John Stapleton, Iain Bremner & Henrik Magnusson |
| **Building Design** | Site selection and the design of the building, external space and physical security measures. | Design The National HVDC Centre building to adhere to SSE Policies and the security commitments made to suppliers, whilst providing a safe, flexible and effective working environment for a range of current and future uses, and is designed for future expansion. | Mark Melling |
| **People** | Recruitment strategy, staffing requirements and training | Design the recruitment strategy, staffing requirements and training to ensure that appropriated skilled people are employed at The National HVDC Centre to deliver high-quality trusted outputs. | Brain Punton. |
| **Operations** | A high-level overview of the operation of the National HVDC Centre along with the key operational processes. | Design the operation of The National HVDC Centre to meet the needs of the stakeholders, while ensuring a safe, secure and effective operation. | Yash Audichya & Brian Punton. |

The Designs for each area will be approved by the relevant Design Authority.

In addition the MTTE Steering Group will constitute the 'Overall Design Authority' to ensure the integration and integrity of the combined Design.

### External Resources

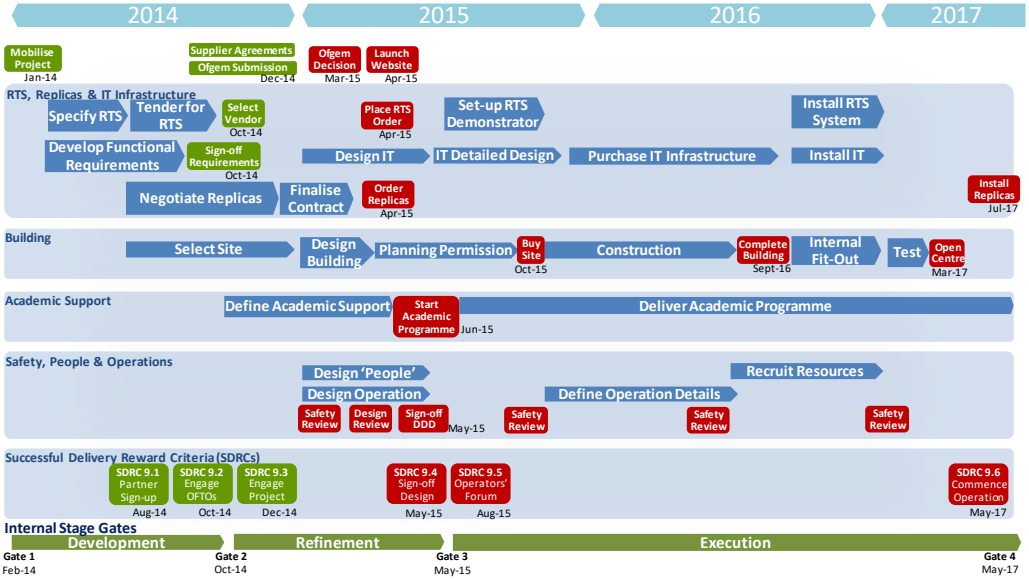
Parsons Brinkerhoff has been engaged as external support for the project. They will be commissioned to support the development of elements of the design and also to provide an external review.

BSP Architects has been commissioned by Property Services to develop the building designs and architectural plans.

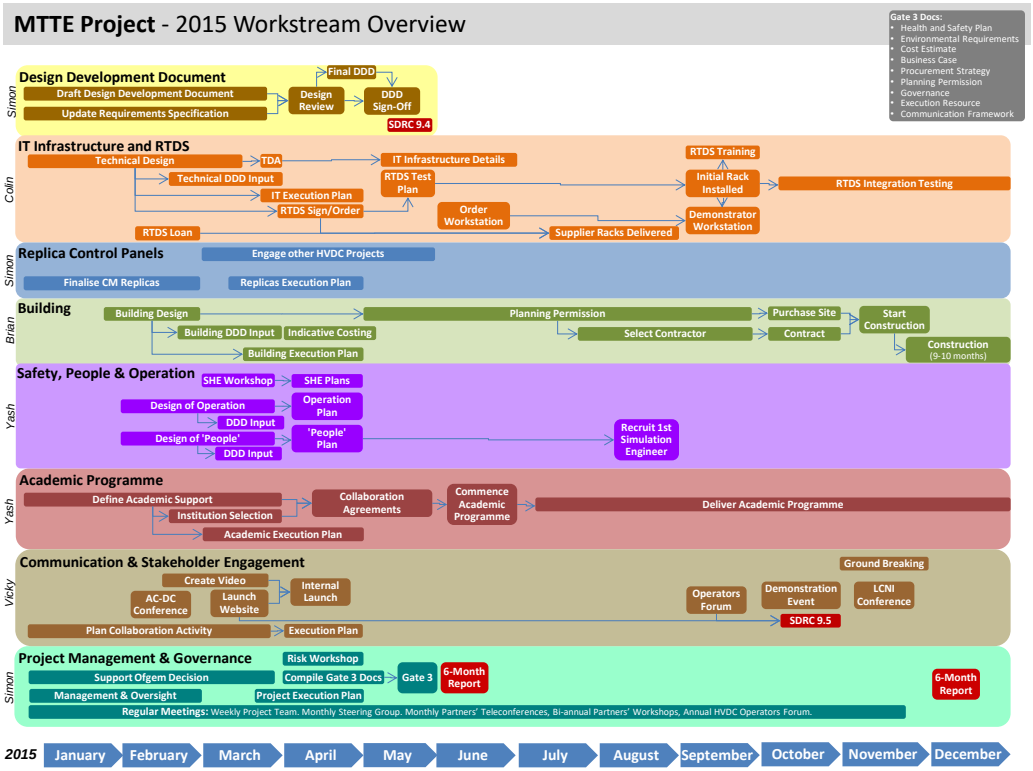
# 3 DESIGN PROGRAMME

The figure below provides an overview of the overall project plan.

The refinement stage of the project focuses on developing the design of The National HVDC Centre, and will be completed in May 2015.




The figure below provide more detail on the planed activity for 2015, and shows the project workstreams.




This plan was approved at the MTTE Steering Group meeting on 23rd January 2015.

# 4 INTELLECTUAL PROPERTY PROTECTION

Specific Intellectual Property Protection and Confidentiality Arrangements with each of the project participants are detailed in the respective collaboration agreements.

An overview of these arrangements is provided below, to describe the key principles.

## 4.1 Security Arrangements

SHE Transmission will implement the following security arrangements at The National HVCD Centre:

- The security arrangements of The National HVDC Centre will be no less than the high standards of similar facilities.
- Replica control panels will be segregated to protect against external cyber security threats.
- Software models will be securely managed.
- Appropriate Information Security policies will be implemented.
- Participating suppliers (ABB, Alstom & Siemens) will be consulted on the details of the planned building security prior to implementation [see section 5 for details of the planned physical security arrangements].
- Software within the replica panels will be inherently controlled, since the code will be compiled and will never leave the replica panels, and users would only have access to the control functions.
- Replica control panels at the National HVDC Centre will be kept in separate rooms (for each supplier), with access restricted to the supplier of the panels and SHE Transmission.

## 4.2 Intellectual Property Protection Arrangements

The Intellectual Property inherent within the control panel hardware and software is of significant value, and The National HVDC Centre will ensure that it is protected.

- The National HVDC Centre will conform to the default IPR arrangements as specified in Chapter 9 of the NIC Governance Document. In accordance with the IPR arrangements, required deviations from the default IPR arrangements may be requested to protect suppliers' background IPR.
- Each participant in the project retains all rights to their respective Background IPR.
- The results and reports produced by The National HVDC Centre and the Foreground IPR will be owned by SHE Transmission.
- The MTTE will produce study reports, as outputs from the studies it undertakes. These reports will be shared with the GB transmission licensees,

and summarised versions may be available to project partners and potentially publicly, ensuring that suppliers' IP is protected.

- The National HVDC Centre will not publish or disclose to third parties Suppliers' Background Intellectual Property (without the prior written consent).

## 4.3 Confidentiality Arrangements

- The National HVDC Centre will treat all Confidential Information from project participants as confidential and safeguard it accordingly; and will not disclose Confidential Information (without the prior written consent).

## 4.4 Relevant Policies

The National HVDC Centre will conform to the following SSE Policies:

- Information Security Policy ( PO-COR-IS-001)
- Information Security Risk Management Policy ( PO-COR-IS-003)
- Physical Security Standard ( MS-COR-IS-120)
- Procedure for PAC Security Access (PR-COR-017)
- Third Party Information Security & Privacy Process and Guidance Document (PR-COR-IS-101)
- I.T Centres Security Access (PR-IT-013)
- Future Networks Cyber Security Framework (PR-PS-FNP-002)
- Company Work Instruction - Information Security Requirements for External Web Hosting (WI-IIT-0648)
- Intellectual Property (PR-COR-034)
- Acceptable Use Standard (RS-COR-IS-061)
- Information Classification Standard (MS-COR-IS-020)
- Access Control Standard (MS-COR-IS-090)
- SSE Information Handling Standard (MS-COR-IS-21)
- SSE Data Protection Policy (PO-COR-DP-001)
- SSE Information Security for Network Segregation (WI-IIT-0493)

# 5 PHYSICAL SECURITY DESIGN

## 5.1 Scope and methodology.

The scope of this Security review was to develop a security strategy for the MTTE building proposed for construction at Napier road, Cumbernauld. This scope is designed to ensure compliance with the Asset Protection standards in terms of potential opportunities and challenges in terms of the Security of the site, people and assets in relation to current perceived threats and intelligence from Law Enforcement and other specialist agencies.

The review incorporated an assessment of the layered security from the outside inwards, concentrating on five main elements:

- Perimeter Security
- Man Guarding
- CCTV and Detection
- Access control
- Intruder Alarms

The report is designed to protect the site from three identified threat levels, Low, Medium and High.

**Low Level:**

- Unauthorised entry facilitating vandalism, malicious damage and general “thrill seeking”.

**Medium Level:**

- Unauthorised intrusion for the purposes of theft including plant, commodities, hardware and intellectual property.

**High Level:**

- Unauthorised intrusion or attack for the purposes of acts of terrorism, both international and domestic, with a view to disrupting the ability of the operation.

All three threat levels can pose a significant risk to the operation of site, and any subsequent cost of repair and replacement of key assets, not to mention the potential loss of revenue from operating profits.

The threats themselves come in the form of lone individuals, acting alone up to serious organised crime groups and environmental activists through to domestic and international terrorism.

The MTTE building predominantly lies within the Low and Medium threat levels.

## 5.2 Site Layout / Description / Locality

The site is located at: Napier Road, Cumbernauld within the Ward Park Industrial Estate located to the north of the B816 Castlecary Road.

A cursory tour of the neighbouring facilities indicates a moderate / high use of electronic security and detection systems, security fencing and intruder alarms.

Other organisations within the locality include Dessian Windows and Doors, Howden Joinery, Scottish Power, Electrical wholesalers and Logistics and Plant companies.

The proposed building provides accommodation comprising: entrance reception, meeting room, storage, replica rooms, canteen / WC, office, auditorium and control room.

At the time of writing, the plans are in a relatively fluid position and the proposals detailed within this report are pertinent to discussions in early February 2015 and based on drawing Number PSSE-14-117

## 5.3 Threat level, current threats, activity.

The threat from terrorist activity in the UK is currently “severe”, although it is felt that the threat to the energy sector is “low”. This is from an international terrorism threat perspective and not domestic.

Domestic terrorism, which includes environmental activist activity, is still ongoing on a regular basis although the current threat level is considered “low”

Although in the energy sector this is predominantly directed at coal fired power stations, such targeted activity must not be ruled out against SSE as a company and as a UK interest.

Unauthorised intrusion to site can be facilitated by tailgating, entry to restricted areas by staff / contractors / visitors or via activists / thieves forcing entry through the various entrances, cutting padlocks or fence destruction.

There have been a number of incidents within the locality in the past 12 months including vandalism, theft and malicious mischief.

## 5.4 Perimeter Security

[SECTION REDACTED FOR SECURITY]

## 5.5 Site Function

The site is to be used as a training facility and replication room for AC/DC conversion. It will be utilised predominantly by SSE staff but there will be a high frequency of visitors and contractors.

The accommodation capacity is 50 persons, but daily occupancy estimated at 6 persons.

With the exception of a bike rack, there is no storage proposed outwith the building.

## 5.6 Man Guarding

[SECTION REDACTED FOR SECURITY]

## 5.7 CCTV / Detection

[SECTION REDACTED FOR SECURITY]

## 5.8 PAC Access Control

[SECTION REDACTED FOR SECURITY]

## 5.9 Intruder Detection Alarms

[SECTION REDACTED FOR SECURITY]

## 5.10 General Observations / Recommendations

The following general security observations were made during the course of the design considerations:

Fastlane access control system to be discussed

Airlock system to incorporate cctv and “one door” operating procedure.

Visitor control to be discussed prior to agreed procedure

PAC door to be considered within the eastern corridor between tea prep and meeting room

Keyholders and alarm response to be discussed.

# 6 SITE FEASIBILITY

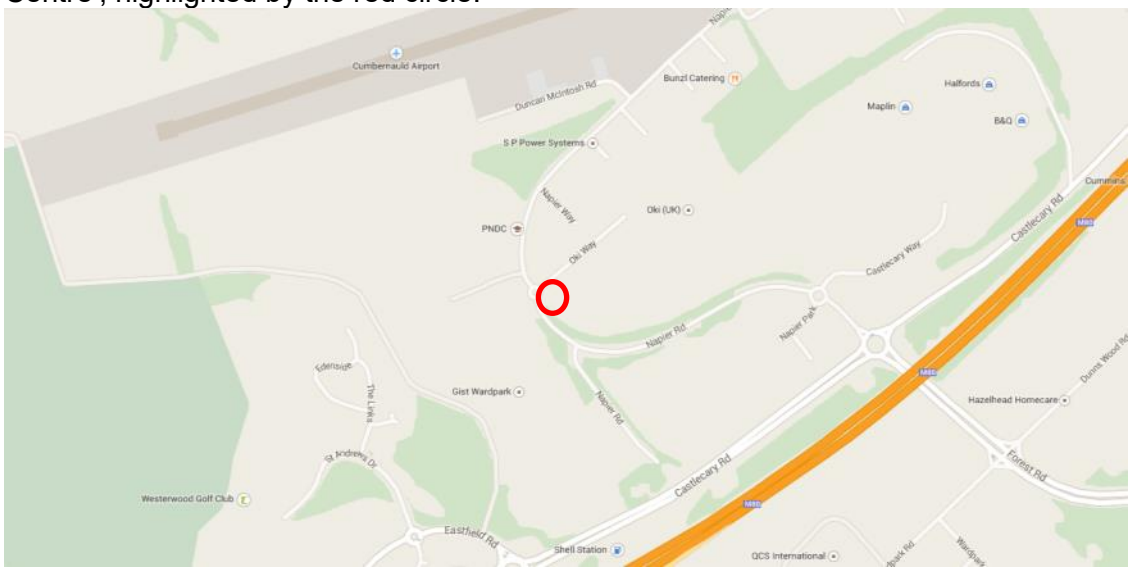
Following an exhaustive search and selection process, SSE Property Services have identified a site at Arches Business Park, Napier Road, Cumbernauld as the preferred location for The National HVDC Centre.

This decision was reached based on the following criteria:

- Expandability – The site is large enough to provide opportunity for future expansion.
- Commutability – The site is commutable from SHE Transmission's main offices at Perth and Glasgow.
- Accessibility for Visitors – Cumbernauld provides good access to external visitors, with good transportation link; close to motorway network, railway, and both Edinburgh and Glasgow Airports.
- Proximity to Edinburgh/Glasgow (for Recruitment) – Cumbernauld's proximity to Glasgow will ease recruitment.
- Proximity to existing SSE sites – The site is 5 miles from SSE's Tom Johnston House and 10 miles from SSE's logistics centre at EuroCentral.
- External Economies of Scale: The site offers potential sharing with Scottish Power and PNDC due to their proximity, with further developments planned nearby.
- Land is comparatively inexpensive.

The following map shows the location of Cumbernauld.

The following map shows the preferred location of the Site for 'The National HVDC Centre', highlighted by the red circle.




The following diagram shows the selected site.


The area of the site extends to 1.04 acres.

## 6.1 Surveys

The following surveys shall be carried out once agreement has been reached on the land purchase to confirm the suitability of the site:

- PERA;
- QERA;
- Site Investigation;
- Topographical;
- Utilities; and
- Underground Services.

Details of the surveys will be held within the Project Files on Content Server (folder 5b).

# 7 BUILDING DESIGN

## 7.1 Building plans

BSP Architects have been commissioned by Property Projects to develop the building designs, architectural plans (for Planning Submission and Building Warrant).

JAR Martin will be commissioned to design the Structural and Civil elements of the design.

M&E Consultants will be commissioned to design the M&E services within the building once the architectural plans are completed. They will work with SSE Contracting to ensure that the design is in keeping with the SSE standards and similar projects of this nature.

## 7.2 Design requirements/key considerations

The Building (Scotland) Regulations 2004 will be used to define the compliance parameters for the Erection of the Building/Structure, with reference to Schedule 5 (Building Standards applicable to Design and Construction) which defines the levels of compliance required to obtain a Warrant to erect a development proposal.

When the Local Council accepts that the proposed development complies with the above regulations and standards, a Warrant to erect the building will be issued. We have currently received the Warrant for the building and it is signed off.

An EPC rating of a 'B' is to be achieved for the building but there is no requirement for any BREAAM rating.

The internal fit-out standards will be as per the Property Projects standard specification document ref. 'SSE Standards Document Issue 1 November 2013'

The structure must be designed around the stakeholder requirements and the specific use it is being constructed for. Consideration must also be given to future expansion, including ease of construction, safety and security during these works and the incoming utilities having sufficient capacity for additional loading.

It will be the responsibility of the SSE Property Project Manager (PPM) to manage the preparation and circulation of all design reports between the various members of design team for the project.

Once the main contractor has been appointed a meeting will be held on site to agree the reporting format for the project and the frequency of the reporting etc.

## 7.3 Building maintenance arrangements (incl cleaning, catering, consumables, etc.).

The design will consider future maintenance and incorporate this in all elements in order to simplify this and minimise ongoing operational costs. This will be part of the regular design team reviews organised by the PPM and attended by all external design contractors. These meetings will feed into stakeholder review meetings and

the feedback from both will be disseminated to all parties by the PPM. There will be a crossover in these meetings with the external contractors attending stakeholder meetings to discuss issues and ideas.

Once a design has been agreed the PPM will liaise with SSE FM to confirm suitability and allow FM to begin planning for taking over on handover.

The project records for maintenance purposes will be as detailed within the project H&S File. These will be provided as 2 paper copies and 2 electronic copies at the end of the project.

Additional project records will be kept in the Project File in Content Server as used by Property Projects

Catering will be a small kitchen in the breakout area with a microwave, coffee machine, sink, fridge, dishwasher, storage cupboards and hydro-boil supplemented by vending machines stocked by an external provider.

## 7.4 Safety and Fire provisions

The building design will take all safety matters into consideration and contain sufficient emergency egress points as defined in the building regulations. Matters such as change of floor heights will be minimised and where possible be done by sloping ramps rather than steps.

An L2 fire alarm system will be installed with local fire suppression systems for server and replica rooms.

## 7.5 Security and access restriction arrangements

SSE Asset Protection will have input to the design process and carry out the system specific designs for the CCTV, intruder alarm, PAC Access and intercom.

The front entrance will have PAC Access on 2 door sets in a vestibule and access to the central work are will be via a secure airlock type set-up. All PAC Access doors will be centrally monitored and these will include the server and replica rooms; where considered necessary doors can also be fitted with audible alarm systems.

Access to the building and all internal areas will be via SSE identity cards with personnel only admitted to areas pre-authorised. Visitors will be issued with a card on entry and this will only allow access to the breakout area, auditorium and main corridor with access to any other areas only permitted when escorted by an approved individual.

[Refer to Section 5 for details of the Physical Security design].

## 7.6 Disabled access

The design will be fully DDA compliant with level/ramp access, omission of steps where possible and provision of appropriate toilet, sign in, office, workstation and leisure access.

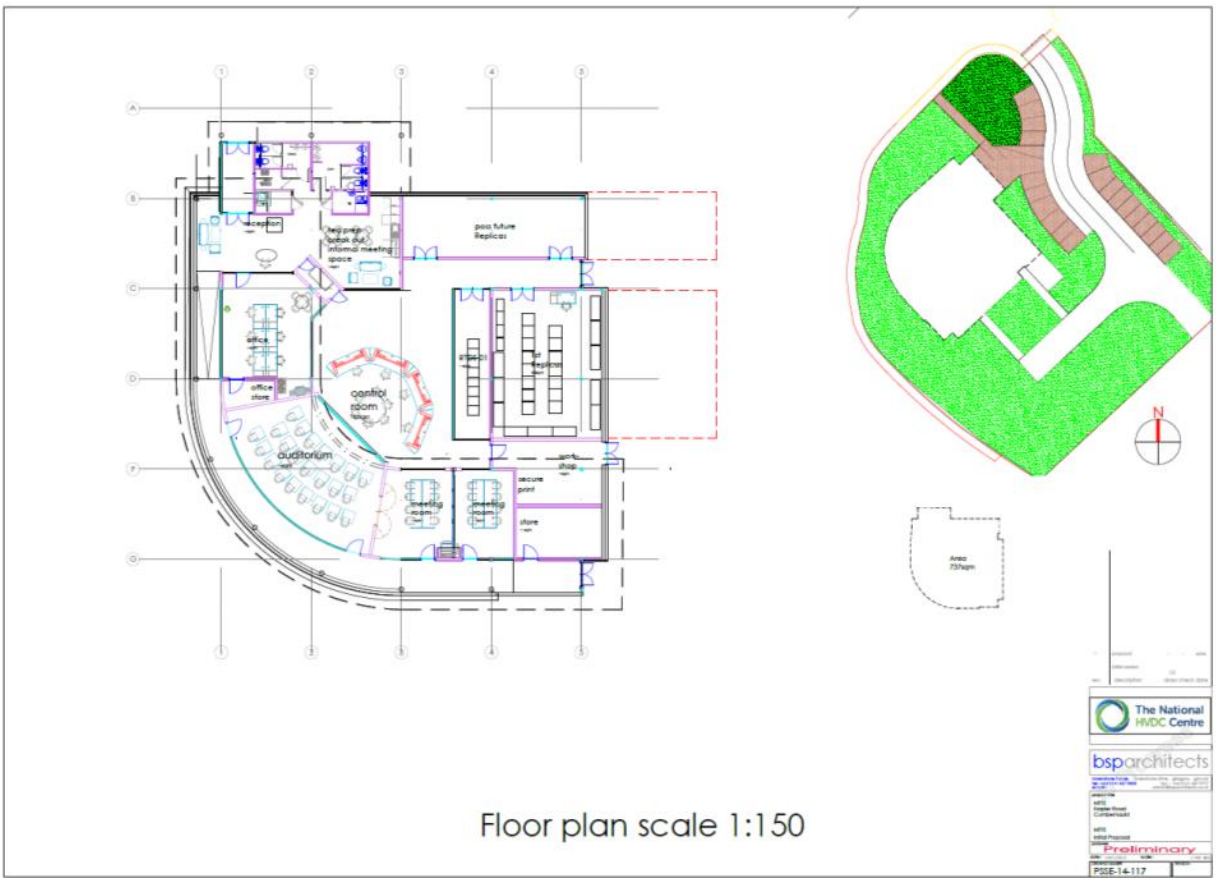
## 7.7 Risk Management

The PPM will be responsible for producing a risk register specific to the design and construction of the building and this will be updated on a regular basis throughout the construction phase.

## 7.8 Building Plans

The latest draft of the building plans are shown below, these will be consulted on with the project stakeholders at the Design Review Workshop (23rd April 2015), following which they will be finalised and submitted for planning permission.

This also shows the orientation of the building on the Site together with the external arrangements.



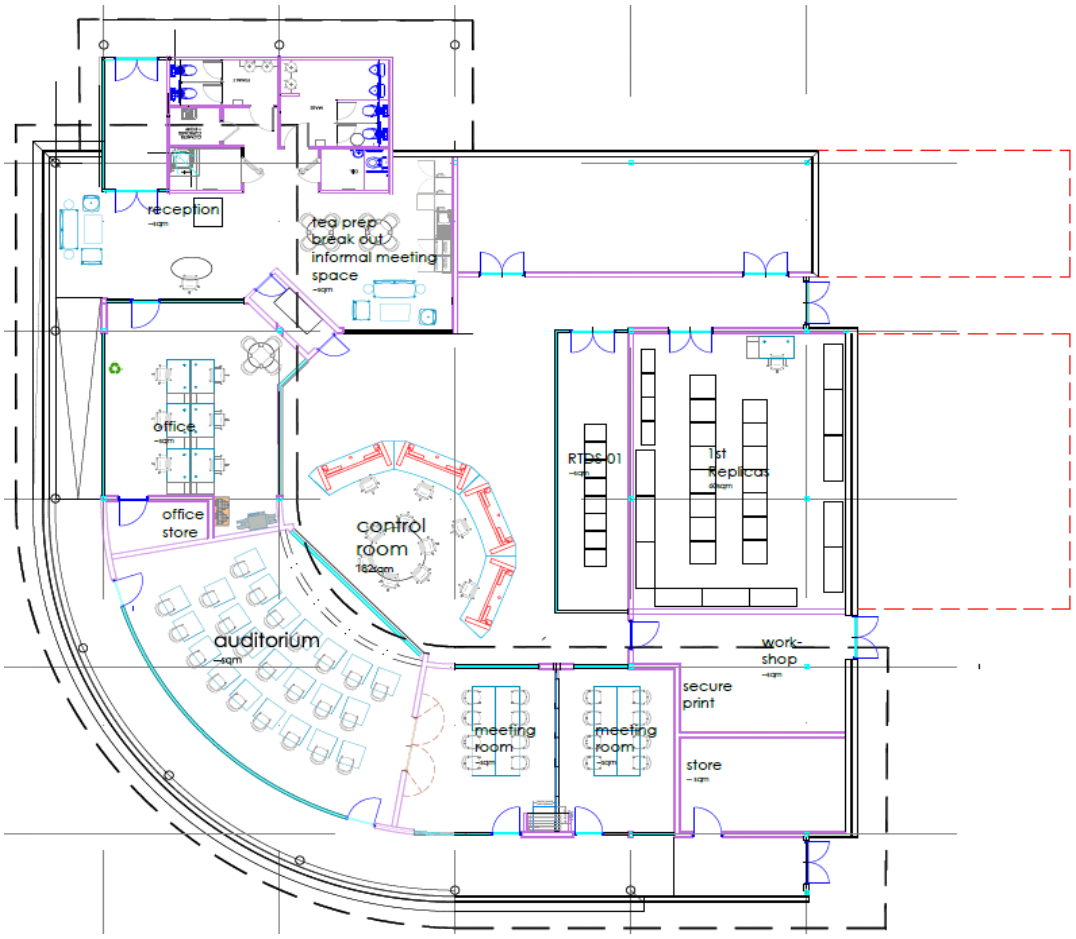
## 7.9 Building Layout

The building is designed to have 'Visitors' areas where visitors to the centre are permitted access, and 'Secure' areas where access is restricted to SHE Transmission employees (3rd Parties can only access secure areas if escorted by a SHE-Transmission employee).

The key elements within each area are described below.

| Visitors Areas | Secure Areas |
|---|---|
| ○ **Office:** Enabling visitors to work at the Centre.<br>○ **Auditorium:** Enabling training and other large events.<br>○ **Meeting Rooms:** Flexible sub-dividable meeting rooms.<br>○ **Facilities:** Breakout area, kitchen, WCs, Shower and Stores. | ○ **Control Room:** Accommodating the simulation workstations.<br>○ **RTDS Room:** Accommodating the RTDS system.<br>○ **1st Replica Room:** Accommodating the replicas from the Caithness-Moray Project.<br>○ **Future Replicas Room(s):** Accommodating replicas from future projects/suppliers. |

The internal layout of The National HVDC Centre is shown below.



# 8 BASES OF OPERATIONAL STRATEGY

This section describes how The National HVDC Centre will operate.

## 8.1 Operational Overview

The prime role of The National HVDC Centre is to undertake studies of specific operating scenarios on the GB transmission network, requested by GB Transmission Licensees, i.e:

- Scottish Hydro Electric Transmission (SHE Transmission);
- National Grid Electricity Transmission (NGET);
- Scottish Power Transmission (SPT);
- National Grid Transmission System Operator (NGTSO); and
- Offshore Transmission Owners (OFTOs).

However, it is also intended to be able to support other HVDC organisations, including:

- Current HVDC Interconnectors (IFA, Moyle, BritNed & EWIC);
- Planned HVDC Interconnectors (Nemo, Eleclink, NSN, IFA2, Fablink);
- Academic institutions;
- External research/consultancy companies;
- HVDC system suppliers; and
- Merchant transmission licensees, as defined by the recent Ofgem ITPR.

Such studies will make use of Replica Control Panels supplied by HVDC vendors in conjunction with a reduced model of the GB transmission network implemented on a Real Time Simulator (RTS) facility. For each study the combination of single or multiple hardware controllers and the network model will be adjusted to comply with the specific study scenario under investigation.

It is anticipated that occasionally other organisations, such as merchant developers, research institutions and academic institutions may request access to the Centre's facilities. Such access is within the remit of the Centre, but will be subject to different operational regimes and will need to comply with the priorities of the Centre.

The Centre will be operated by SHE Transmission and will come under the operational management of the company, including all working practices and staff recruitment and working conditions.

## 8.2 Operational Processes

At the highest level, The National HVDC Centre undertakes work following a request, and then shares the results (whilst protecting IP).

The following high level processes have been identified for The National HVDC Centre.

**Request & Plan Work**

- Request Study
- Request Research, Training or Use of Facilitates
- Prioritise Requests, Plan Work and Plan Resources.

**Undertake Work**

- Undertake Studies or Research
- Develop & Deliver Training

**Disseminate**

- Write Up Results
- Check IP Protection & Approve
- Disseminate Results

**Other**

- Procurement of Replica Panels
- Operator Training
- Replica Maintenance
- Visitors

Each of these processes are described below.

### *8.2.1 Request Study*

A Transmission Licensees or HVDC Interconnector would make a formal request for a system study to The National HVDC Centre.

This will provide, as a minimum, the following information:

a) An outline description of the network scenario to be studied.

b) Details of the HVDC (or other controlled devices) to be included in the study. This may include replica panels or digital models implemented within the RTS processors. This should clearly define the connection points of these devices, their power and/or reactive power ranges.

c) Any digital models which need to be implemented on the RTS processors will need to be provided under an appropriate NDA.

d) Details of the operational boundary conditions, which apply to any controlled devices, in terms of power, reactive power, voltage, frequency, etc.

e) Details of HVDC operational topologies to be considered in the study, e.g. monopole or bi-pole configurations, multi-terminal configurations, including any anticipated future additions to the network to be considered

f) Requirements of the study cases to be considered, such as routine line switching, transformer switching, AC system faults, DC system faults, HVDC scheme power reversal, etc.

g) An indication of the signals (AC, DC and status) to be monitored during the studies, which may be subject to change during the course of the investigation.

h) Details of the phenomena on the AC or DC systems which are to be studied and analysed in the work. This may include responses of the controllers during steady state, dynamic and transient conditions to check compliance with design parameters. The study may look for indications of incipient instability or full instability following system perturbations.

i) Off-line dynamic studies will be required to develop a reduced bus model of the GB network and demonstrate it equivalence to the full GB model. Such off-line studies may be carried out by SHE Transmission personnel or by other Transmission Licensees.

Other organisations may also request studies, including Academic collaborators; external research/consultancy companies, and HVDC suppliers. The operational processes for such work would be the same as described above.

Note: The Transmission Owners Code (STC) describes the use of GB transmission model, which may restrict its use with some organisations. Agreement will be required with SHE Transmission on the use of the GB transmission model or reduced versions for the specific study work requested.

Where studies require the use of digital models developed by HVDC vendors, permission should be sought from the vendor before their use.

### *8.2.2 Request Research, Training or Use of Facilitates*

Organisations may also request:

- **Research:** the Centre can undertake a wide range of research.
- **Training:** either the creation of a new training course/programme, or a place on an existing course/programme.
- **Use of The National HVDC Centre facilities**: while access to the replica controls is restricted to SHE Transmission employees, the use of the Centre's other facilities (e.g. meeting rooms and training facilities) is available for use by other stakeholders.

### *8.2.3 Prioritise Requests, Plan Work and Plan Resources*

The Centre Manager will be responsible for prioritising requests, planning the work undertaken at The National HVDC Centre, and managing the resourcing.

Prioritisation will be done based on the criteria agree with the Centre's Governing Board. Priority will be given to Transmission Licensees, and will be based on the benefit to customers.

The work programme will be published on the Centre's Web-Site, and the requesting organisation will be kept informed with the status of their request.

The Centre will be designed to be able to undertake studies concurrently, to maximise its capacity. For example, the RTDS processors consist of multiple racks (9 are planned) and segregation of the processor capacity is possible, i.e. part of the centre's computation capability could be devoted to studies for transmission licensees, while another part is use for outside organisations.

### *8.2.4 Undertake Studies or Research*

The study process in the centre will be multi-faceted requiring a number of sources of data as inputs to a study and a number of skill sets to execute the work.

a) The replica panels will be installed and set up by the OEM and software up-grades will also be implemented by them. However, the Centre staff will need to have a basic familiarity with the operation of the panels, e.g. power supplies, start-up, changing of control modes, shut-down, fault finding, etc.

b) The RTS processor racks, including the auxiliary racks for specialised VSC converter modelling will, after initial training, become the prime responsibility of the Centre operation staff. They will need to be familiar with the routine operation of this equipment to execute studies.

c) Interface cabling between the replica panels and the RTS processors represent the key communication paths between the equipment. Any issues with different vendors' hardware and communication protocols must be well understood.

d) AC and DC system models must be built-up in the RTS to match the requirements of the specific study, as per Section 8.2.1. These models and

the subsequent computation of the study are executed in RSCAD, a variant of PSCAD/EMTDC developed by the RTS supplier (RTDS Technologies). Familiarity with this software tool and the (graphical) development of AC and DC circuits is a requirement for the Centre operation staff.

e) The AC network model will be a sub-set of the full GB model, but reduced to a limited number of nodes to allow the RTS processors to operate in real time. Off-line studies will be required, typically using PSS/E or Power Factory to check that the reduced model has the same steady state and dynamic performance as expected from the full GB network model. See Section 8.2.1 i). It is anticipated that such studies would be performed by the Centre's staff and supervised by the transmission licensee requesting the study.

f) The GB transmission model or the reduced bus model will not be released by the Centre's personnel, either explicitly or embedded within study reports.

g) Study cases are executed from the HMI station of the RTS facility, where the operator is able to set-up the scenarios to be studied, as discussed in Section 8.2.1 e) to h).

### *8.2.5 Develop & Deliver Training*

The National HVDC Centre will develop bespoke HVDC training courses, based on the requirements of its stakeholders.

Training will be delivered at The National HVDC Centre, by the Centre's staff, or external experts as required. Depending on the nature of the course, some will be restricted to a specific organisation(s), and others open to a wider audience.

### *8.2.6 Write Up Results*

The simulation engineer(s) who undertake the study work, will also be responsible for writing up the results.

The study reports from the work undertaken at the Centre will clearly outline the specific network location being considered and the operational scenarios being studied. A network diagram will aid the understanding of the reader. The details of the system data and modelling should be provided in the report introduction, in an addendum or as a separate report if the amount of data is large. The study cases included in the report should be listed and grouped in a logical form to aid the reader in locating specific cases. Recognising that bus names and signal names are not always self-explanatory a clear list should be included in the report introduction. For each group of related studies a short narrative should be provided to highlight any results of specific interest, whether correct behaviour of the system or anomalous behaviour. The National HVDC Centre will generate many study case results and this can lead to very large reports, sometimes running to many hundred pages. Annotation of the study results is critical in aiding the understanding of the reader.

In addition, a Study Summary report will also be written along side the main study report, which will be suitable for public publication.

### *8.2.7 Check IP Protection & Approve*

Each report will be peer reviewed and the reviewed and approved by the lead engineer.

The simulation engineer will highlight any areas of the report which potentially contain background Intellection Property of other organisations, or could infringe on the STC arrangements.

The lead engineer will be responsible for ensuring that the final report does not contain background Intellection Property of other organisations, or infringes on the STC arrangements. Or, if required, seek permission from the appropriate organisation to share their background IP.

The Centre Manager is ultimately accountable for authorising the reports before they are shared or published, and ensuring that all the contractual obligations are met.

### *8.2.8 Disseminate Results*

The primary purpose of dissemination is sharing the study results with the organisation that requested the study. This is envisaged as being done in person at The National HVDC Centre, with the simulation engineers can describe the work undertake, results and insights; and issue the study report.

Furthermore, the Centre aims to share its study results. The summary reports for all studies undertaken will be published on the Centre's Web-site (where possible).

### *8.2.9 Procurement of Replica Panels*

As the presence of replica panels is one of the key rationales for the Centre, their procurement is a key activity. Ideally a transmission licensee will procure such panels as part of the main order for an HVDC system, such that they are built and tested with the main equipment. The panels may also be procured during the manufacturing and construction phase of a contract or retrospectively for a scheme which is already in commercial service. Here some synergies will be lost in the manufacturing and testing process, which will add to the costs involved.

The National HVDC Centre will engage with HVDC manufacturers to understand the degree to which the replica hardware platform is common to several projects, requiring only a software change, or even only parameter changes, to allow one set of panels to represent other HVDC projects provided by the same supplier

### *8.2.10 Replica Maintenance*

The replica panels are a reduced set of the panels which the manufacturers will supply on a commercial contract. However, they will not operate in the same environment, as they are used in a laboratory for specific tests and potentially will be switched off during night and week-end periods and periods when no specific tests are being run. The replica panels will be housed in a working laboratory environment, with more human interaction than equipment in a converter station. Their commercial equivalents will operate 24 hours a day and 365 days per year, but typically in an un-manned environment. Like their commercial equivalents the replica panels will require routine maintenance, which will be detailed in the manufacturers' operation and maintenance manual. This is mainly checks on the status of the control cards and power supplies, with attention to any components which need replacing. Any cooling fans and air filters will need checking. Spare components, as proposed by the manufacturer should be held at the Centre and immediately replaced if used up, to maintain the stock level. Modern digital control systems will last the lifetime of a converter station (30 – 40 years), but replacement control cards may become unobtainable in 15 – 20 years due to obsolescence and advancement of technology. This is an issue for a commercial station, which may undertake a major mid-life control system replacement, requiring the Centre's replica panels also to be up-dated.

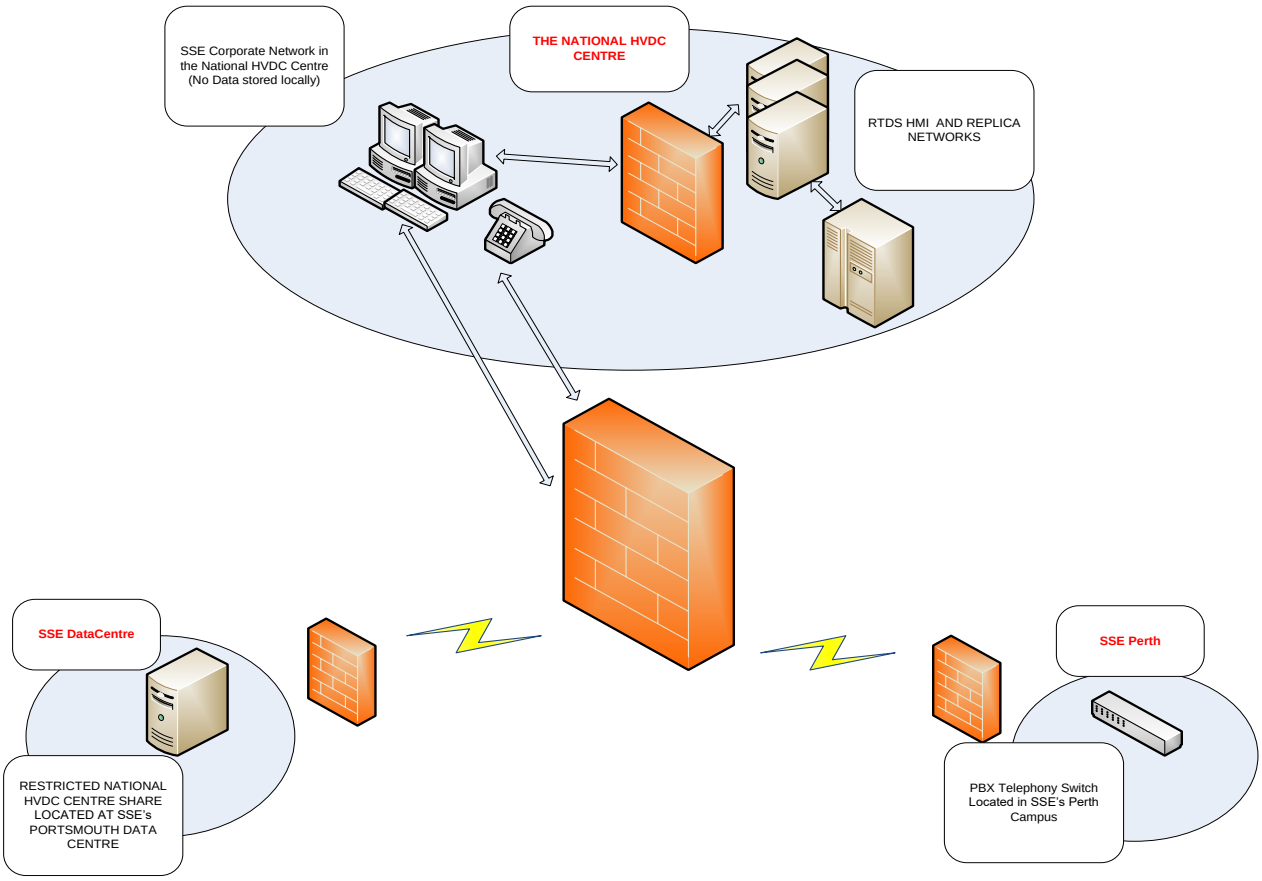
### *8.2.11 Visitors*

The unique nature of the Centre within in the UK power transmission business will have the inevitable outcome that many individuals and organisations will wish to visit the facility. This may be as part of an on-going collaborative study with transmission licensees or other organisations, joint activity with academic collaborators, visits from colleagues in SSE, or open visits organised by outside technical bodies such as the IET, IEEE and CIGRE. Protocols will be in place to handle such disparate visitors, to ensure that the operation of the Centre is not disturbed, the results of any on-going studies are secure and that the IP of the suppliers of replica control panels is not compromised. The physical layout of the Centre has been designed to accommodate such visitors, without interfering with the operation of the centre.

# 9 TECHNOLOGY OVERVIEW

The technological overview outlines the proposed functional and non-functional requirements for the IT systems at the National HVDC Centre. Full details of the technology design can be found in the internal Technical Architecture Design Document.

A high level overview is represented in the diagram below:




Details of the design for each area of the IT Infrastructure are described below.

## 9.1 PC and Server Architecture

- No Local Server Infrastructure - Authentication servers all hosted at SSE data centre in Portsmouth.
- Standard SSE PC and Printer Hardware
- SSE Win 7 build on the PCs (Except Replica PC's)

## 9.2 Data

- File and data storage all hosted at SSEs data centre at Portsmouth.

## 9.3 Data Management

- The data being used and generated at the centre can be categorised
  - Offline GB Network Models (Stored and managed as per SHE Transmissions obligations)
  - Real Time GB Network Models (Stored and managed as per SHE Transmissions obligations)
  - Studies and reports (Access restricted as per our SHE Transmissions obligations and also as per the centre's IPR agreement with the manufacturers.
- Data access on shares restricted by Active Directory permissions. These permissions offer a great deal of flexibility and will allow to the Centre's data and reports to be restricted and controlled.
- Access to Data will be managed through SSE's IT request system and final approval has to be given by the data owner. (Access to the data can be revoked as well as added)
- The reports and files used and created by the MTTE will be backed up as per SSE's backup and file retention policy.

## 9.4 Network and Telephony

- Network separation between SSE, RTDS and each manufactures replica controls.
- Firewalls to restrict and control data flows between each of the segregated networks.
- WIFI access for guests to The National HVDC Centre.
- IP Telephony.
- Reduces Structured Cabling requirement by 50%.
- Remote PBX and call routing through SSE Perth Hub.

## 9.5 Operational Technology

- 9 Rack RTDS real time simulator.
- 15 MMC Support Units.
- Connected to Replica Control Panels.

## 9.6 Applications

- RSCAD – Real time power system simulation software that interfaces with the RTDS real-time simulator hardware.
- PSS/E – Is offline power system simulation software (SHE Transmission currently uses PSS/E models of the GB network). Some of the current PSS/E models will be converted into RSCAD.
- MS-Office Standard 2010.
- Adobe Standard – This will allow finalised reports to be converted to PDF format.

## 9.7 Information Security

- Safeguards built into technology design to ensure that the IPR of vendors and transmission operators is secure.
- A full overview for the Information Security requirements for the National HVDC Centre can be found in the Basis of Design section of this document.

**The following are the Non-Functional requirements of the IT Infrastructure:**

## 9.8 Supportability

- Leveraging services and technology from SSE IT and telecoms to ensure that the technology on site is supportable.
- Authentication Servers, Data storage and telephony PBX all remotely hosted.

## 9.9 Expandability

- Where possible the IT infrastructure is modular, this is to ensure that the centre can be expanded over time without having to have a major IT re-investment.
- Vertical Scalability – The RTDS is highly scalable and we can increase the power of the system by adding additional RTDS racks and processor cards
- Horizontal Scalability - The capacity of the RTDS system can be increased by addition additional IO cards, this allows the RTDS to connect to more Replica Control Panels.

## 9.10 Redundancy (Duplication of components)

- Since the Centre is not part of the Transmission critical infrastructure, there is not a requirement to include redundancy into the design of the IT infrastructure, however the systems that are hosted externally (Authentication

servers, Data Storage and telephony systems etc.) all have built in redundancy.

## 9.11 Availability

- The Centre is a non-operational facility and as such the technology design doesn't require systems that have high availability. In fact the operational impact of small to medium scale planned and operational outages are minimal.

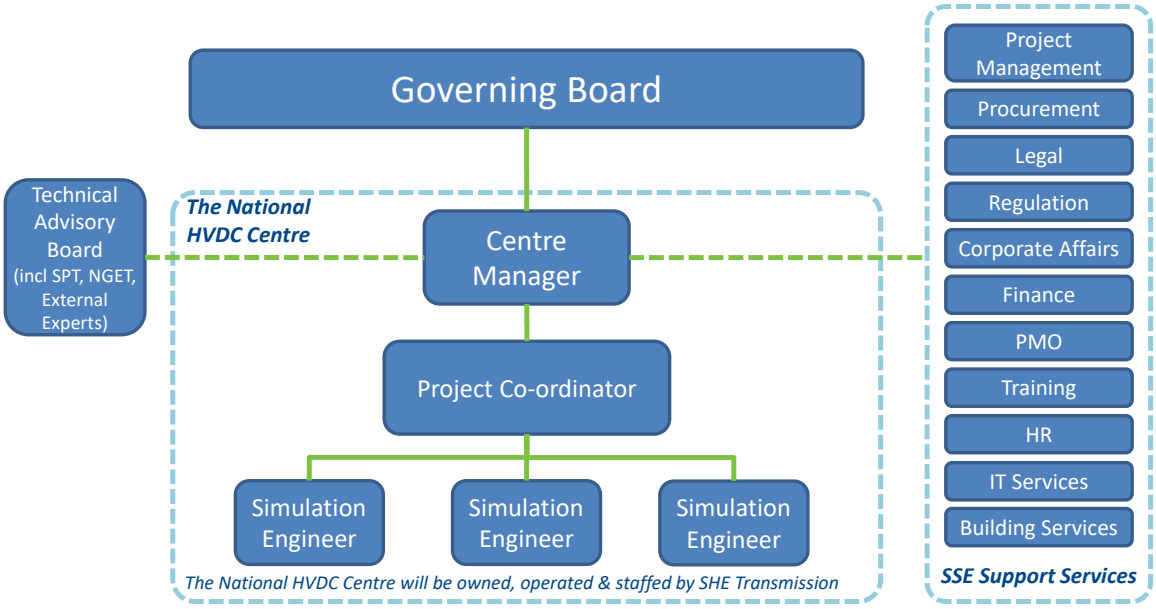
## 9.12 Risks

- The authentication servers, data storage and telephony PBX are all hosted remotely. If the centre lost connectivity to the SSE network a significant proportion of the IT infrastructure would be unavailable to a user working at the Centre.
  - The site is non-operational and the impact of a network outage at the centre was deemed to be minimal.
  - This model is used in all SSE depots and smaller sites and has proved to be robust and cost effective.
- Possible high cost of using SSE IT and Telecoms Infrastructure in the centre's design.
  - If the costs are prohibitive then the design of the centre could by modified to be standalone site with no reliance on SSE infrastructure.

Both risks have been documented in the Project Risk register.

# 10 PEOPLE

The National HVDC Centre will be staffed by up to 5 FTEs, overseen by SHE Transmission, as illustrated in the diagram below.




Each of the roles in the Centre are described below:

## 10.1 Centre Manager

The Centre Manager is responsible for the day-to-day management and operation of The National HVDC Centre, including:

- Safe operation of the facility.
- Managing all of the staff at the Centre.
- Delivering the commitments made to Ofgem (through the NIC process).
- Ensuring that the Centre meets the MTTE Project's SDRCs.
- Ensuring that the Centre does not infringe on the STC arrangements, or the IP protection commitments to supplier.
- Developing the long-term business model for the Centre.
- Promoting the use of the facility.
- Interfacing and reporting to the Centre's governing board.
- Drawing on SSE's support services, as required.
- Building & IT Maintenance.

## 10.2 Project Co-ordinator

The project co-ordinator manages work requests, plans the work, and co-ordinates the studies, training and dissemination undertaken by the simulation engineers, i.e:

- Requesting Studies, Research, Training or Use of Facilitates,
- Prioritising Requests, Planning Work and Resources.
- Undertaking Studies and Research.
- Developing & Delivering Training.
- Writing Up Results.
- Checking IP Protection & Study Report Approval.
- Disseminating Results.

This role would have all of the competencies described for the Simulation Engineers below, together with experience managing teams and co-ordinating work.

## 10.3 Simulation Engineer

The simulation engineers are key to The National HVDC Centre, they will undertake the studies, interpret the results to gain insights, write-up the results, and disseminate them. Therefore they will require a blend of technical expertise together with non-technical skills, which are described below.

### *10.3.1 Technical Competencies*

Essential:

- Thorough knowledge of LCC and VSC HVDC technologies and their integration into AC systems.
- Experience of performing system integration studies and transmission planning studies using both RMS and EMT tools.
- Knowledge of grid codes and transmission planning standards.
- Real-time modelling and simulation using industry leading platforms such as those supplied by RTDS or Opal-RT.

Desirable:

- Knowledge of multi-terminal HVDC scheme principles and modelling.
- Experience developing models for FACTS devices and wind turbines.
- Programming and scripting skills using Python, C/C++ and Fortran.
- Experience of working with HVDC control system hardware.

### *10.3.2 Non-Technical Competencies*

Essential:

- Excellent written and oral presentation skills.
- Experience of managing relationships with clients and working within teams formed from multiple organisations.

Desirable:

- Experience of knowledge transfer activities (e.g. delivering short courses or technology demonstration).
- Experience of working with sensitive intellectual property.

# 11 MAINTENANCE AND INSPECTION

The critical building and IT services at the centre will be maintained and inspected as per operational and regulatory guidelines, a summary of which is detailed below.

## 11.1 Mandatory Building Maintenance

Water Management

- Legionella (BS8580, BS7592 & BS6700)
- Quality Water for Human Consumption (BS806 & BS6700)

Fire

- Fire Alarm (BS5839)
- Fire Detection (BS5839)
- Fire Extinguishers (BS5306)
- Fire Suppression (BS5839)
- Fire Hose Reels (BSEN694)
- Sprinkler Systems (BS5306)
- Escape Route Pressurisation Systems (BS9999 / Replaced BS5588)

Electrical

- Fixed Wiring (BS7671)
- Portable Application Testing (BS7671)
- Emergency Lighting (BS5266)
- Lighting Protection (BS6651)

Asbestos (BS10175): Not Applicable

Lifts – Passenger and Goods (BSEN81): Not Applicable

Gas Systems

Flourinated Gas (SI2009-261 / BSEN378)

- CEN / TC 156 will also apply if > 12kW

## 11.2 IT System Maintenance

OS and Application Security Updates

- Fixes security vulnerabilities and other software bugs, improving the usability and performance of the computers at The National HVDC Centre.

AV definition updates

- Ensures that the computers at The National HVDC Centre run the latest version of Anti Virus software and minimises the likelihood of malicious software affecting machines within the centre.

UPS System

- As per manufacturers guidelines to check the integrity of the of the UPS checks should include visual inspection and an electrical system components test, such as testing transfer switches, circuit breakers, and maintenance bypasses.

Data Security

- Regular data security audits to ensure that no one has unauthorised access to any data or reports used in The National HVDC Centre.

Printer Maintenance

- Maintenance and Servicing every 100,000 prints or as per the service schedule.

RTDS

- Regular review of system logs to ensure that the all the components are working optimally.

# 12 BASIS OF DESIGN

The National HVDC Centre's network boundaries and information security specifications have been designed to ensure that the IP and proprietary data for all stakeholders is safeguarded – Full details of the design can be found in the internal Technical Architecture Specification Document.

A summary of which is detailed below

## 12.1 The following Network boundaries have been specified in the technical design

SSE Corporate Network

- All traffic between SSE Network and the RTDS Network will be routed through a firewall

RTDS Network

- Remote logon will be possible from an authentication hop box. This will ensure that only users with the correct credentials can access the RTDS network from the SSE network.
- Restrict certain type of traffic to and from the RTDS network – e.g. Internet, Citrix, E-mail traffic
- Mechanisms to allow files to be moved from the RTDS network to the SSE network and vice versa.

ABB Replica Network

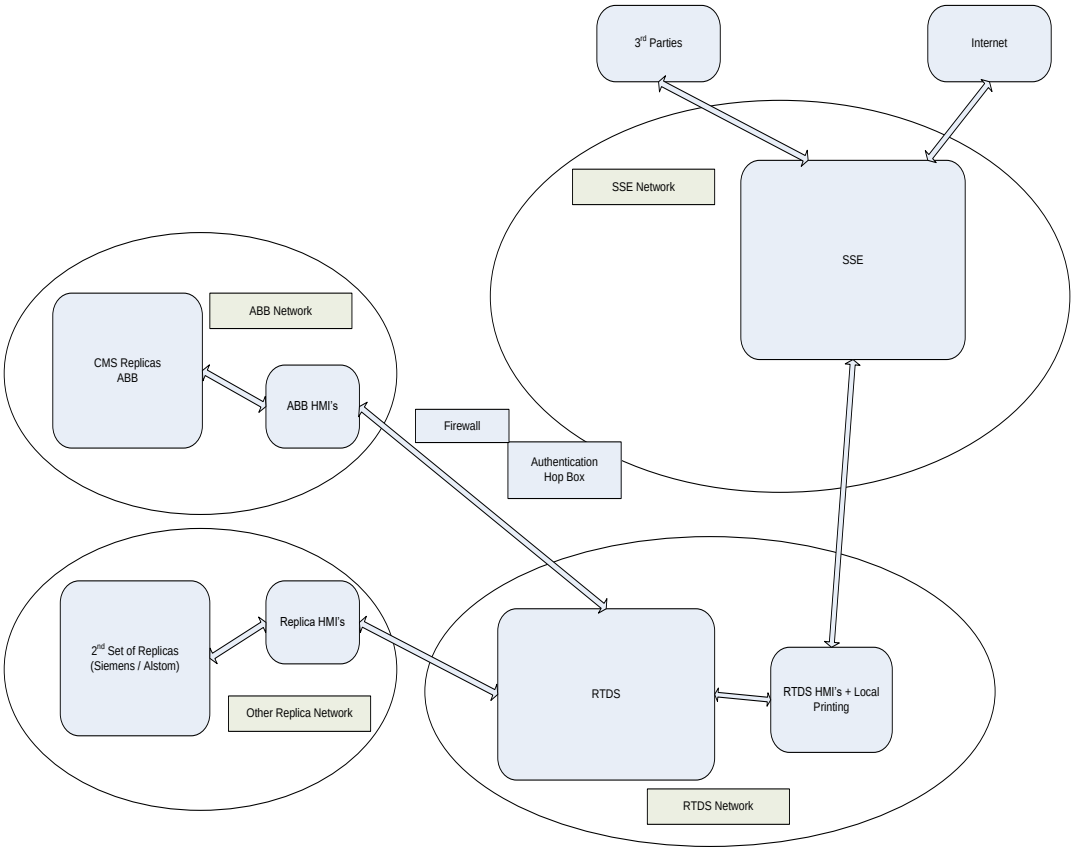
- Access to the RTDS network restricted to the RTDS simulator.
- No access to the SSE Network or the Internet

Internet

- All traffic between the local SSE network and the Internet will restricted by the SSE perimeter corporate controls.
- RTDS HMI machines will have no access to the internet.

**These Network Boundaries can also be represented in a data flow diagram**

## 12.2 Data Flow Diagram

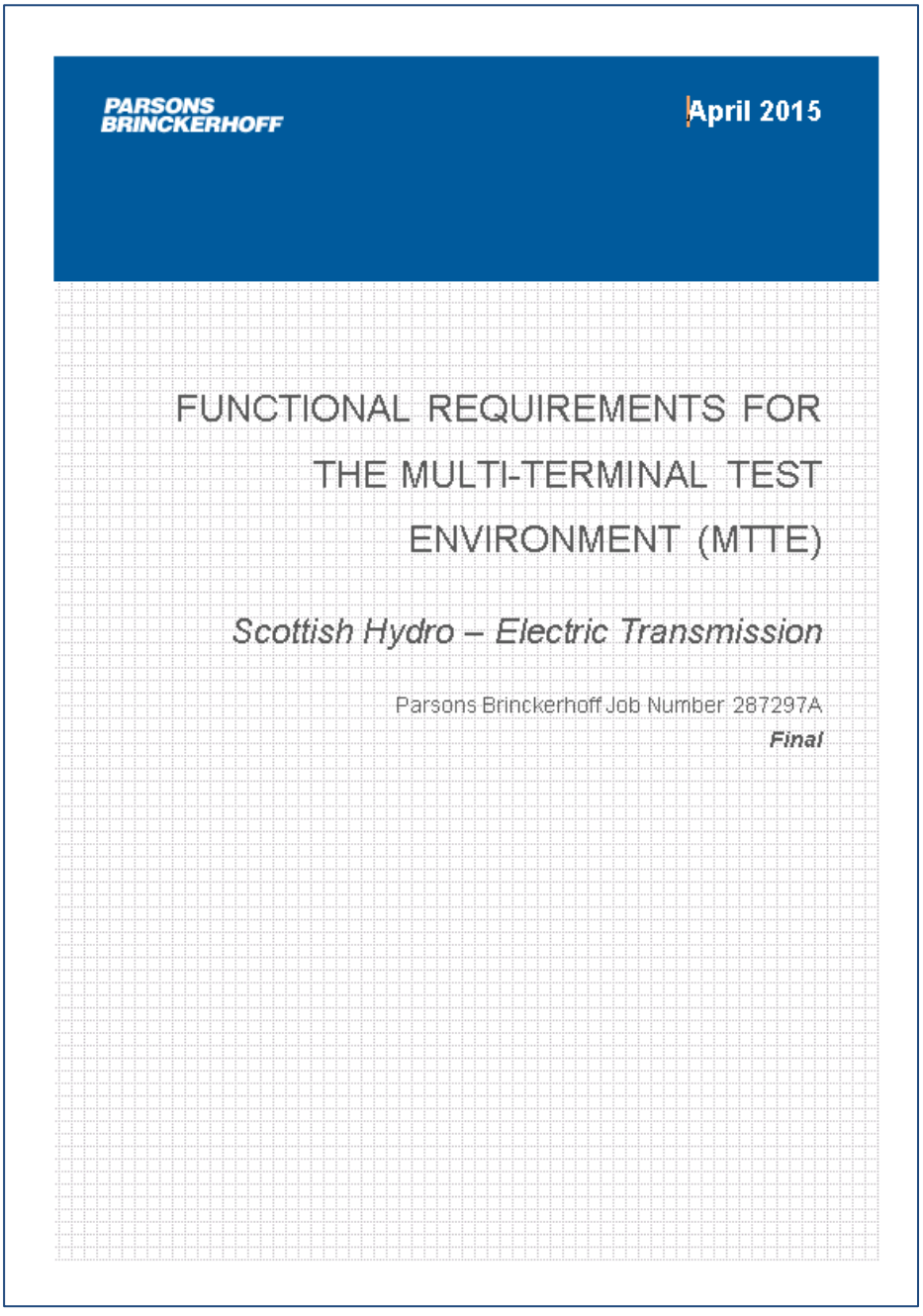



## 12.3 Future Network Boundaries

- New Network boundaries will be created each time Replicas from another HVDC scheme are installed at The National HVDC Centre. These future boundaries would have the same restrictions as the ABB Replica Network.

# 13 DESIGN REQUIREMENTS

The design requirements for The National HVDC Centre are detailed in 'Functional Requirements for the Multi-terminal Test Environment (MTTE)' (April 2015).


PARSONS BRINCKERHOFF

April 2015

FUNCTIONAL REQUIREMENTS FOR THE MULTI-TERMINAL TEST ENVIRONMENT (MTTE)

*Scottish Hydro – Electric Transmission*

Parsons Brinckerhoff Job Number 287297A

***Final***

# 14 COMMUNICATION STRATEGY

The Communication Strategy for The National HVDC Centre is designed to use a range of communication channels to keep stakeholders and interested parties informed as the project develops, and to communicate the outputs of the work undertaken at the Centre.

## 14.1 Dedicated website

A dedicated website will be created for The National HVDC Centre in 2 phases:

- The first phase will provide information on the development of the Centre as the project progresses, this will be kept up-to-date but with limited interactive functionality;
- The second phase will introduce, library functionality for sharing documents, secure areas for sharing confidential information, and forum functionality to facilitate discussion/debate.

## 14.2 Video

Videos will be produced to act as a visual aid, capturing events and key milestones. These videos will shared through the website.

## 14.3 Newsletter

A quarterly newsletter will be published to provide regular updates to people who have signed-up for the newsletter. During the development of the Centre, the focus will be on progress updates; when the Centre is operational, the focus will be on sharing the key learnings from the work undertaken at the Centre.

## 14.4 Social Media

Where appropriate, project updates will be communicated on LinkedIn and Twitter, which should also gain exposure from those outside the project. This will be to headline information, which will be discussed in further detail on the website.

## 14.5 HVDC Operators Forum

An operators' forum will be set up to provide a platform for knowledge exchange between relevant GB network licensees. All TOs and OFTOs will be entitled to membership for the duration of the project. It will be run in a similar way to the Energy Storage Operators Forum scheme managed by EA Technology Ltd. and will build on Scottish and Southern Energy Power Distribution Limited (SSEPD)'s experience of delivering and participating in knowledge sharing activities for network innovation projects.

Annual face-to-face events at the Centre, supplemented with an on-line forum and on-line events will facilitate formal and informal discussions.

# 15 REGISTER OF CODES AND DESIGN STANDARDS

## 15.1 IT

SSE IT Technical Architectural Governance follows TOGAF (The Open Group Architecture Framework) this comprises an IT architecture methodology called ADM (Architecture Development Method), which has been widely adopted by businesses across different sectors. SSE-IT Architecture use TOGAF and ADM to manage architectural development from reasoning strategy within the business to modelling infrastructure design.

## 15.2 Telecoms

SSE Telecoms management systems are ISO27001 certified. This methodology helps to identify the risks to important information and put in place the appropriate controls to minimise the risk.

## 15.3 Building Standards

The Building (Scotland) Regulations Act 2004 will be used to define the compliance parameters for the Erection of the Building/Structure, with reference to Schedule 5 (Building Standards applicable to Design and Construction) which defines the levels of compliance required to obtain a Warrant to erect a development proposal.

- Disabled Requirements BS 8300
- Fire Safety BS 9999
- Construction Management BS 6079-4
- Facilities Management Planning in Construction BS 1192
- Fire Alarm BS 5839
- Electrical BS 7671 17th Edition
- Mechanical and Plumbing BS 6700, 6798, 14825 & 5925

# 16 DESIGN REVIEW

In additional to the design authorities, the following internal and external reviews of both the functional requirements and the design development document are planned.

| Design Area | Internal Review | External Review |
|---|---|---|
| **Functional Requirements** | The functional requirements were approved in October 2014. | The functional requirement will be issued on 10th April 2015 for external stakeholder review; and discussed at the Design Review Workshop on 23rd April 2015. |
| **Technical Design** | Each design will be drafted by 3rd April as part of the Design Development Document and issued for internal review to the project team and steering group. | Each of the design areas together with the overall design will be captured in the Design Development Document.<br><br>The Design Development Document will be issued on 10th April 2015 for external stakeholder review; and discussed at the Design Review Workshop on 23rd April 2015.. |
| **Building Design** | | |
| **People Design** | | |
| **Operational Design** | | |
| **Overall Design** | | |

# 17 CONSTRUCTABILITY AND OPERABILITY DESIGN REVIEWS

## 17.1 Building

Regular design team meetings and reviews will be organised by the SSE Property Project Manager (PPM) and attended by all external design contractors. These meetings will feed into stakeholder review meetings and the feedback from both will be disseminated to all parties by the PPM.

There will be a crossover in these meetings with the external contractors attending stakeholder meetings to discuss issues and ideas.

The PPM will organise the date, time and venue for the meetings and be responsible for setting the agenda and issuing post-meeting minutes to all attendees. The schedules shall be agreed with the attendees and wherever possible arranged to suit everyone involved.

The meetings will clarify all requirements and allow issues to be discussed and addressed in timely fashion to avoid any delays to the project. The PPM will also set up email lists for design and stakeholder groups and regularly update each on any relevant matters. These communications will include progress reports with photographs regular updates on safety, procurement and risk.

## 17.2 IT Support

The IT support for the centre can be sub divided into 3 separate categories which are aligned to the technology boundaries.

- **SSE Corporate** – The systems and technologies on the SSE corporate network will be supported by SSE IT and SSE Telecoms.
- **RTDS** – The RTDS simulator and RSCAD software will be supported by RTDS.
- **ABB** – All the equipment in the CMS replica room will be supported by ABB.

All the Replicas for any other HVDC scheme that is installed at the will be supported by the manufacturer of the equipment.

Full details of IT Support Arrangements will be described in the Internal Technical Architecture Specification Document.

## 17.3 High level overview of the IT Build and Testing Schedule

| IT Deliverable | Date |
|---|---|
| Delivery of 1 rack RTDS cubicle | Sept 2015 |
| RTDS single rack Testing and Integration | Sept 2015 – Sept 2016 |
| Place Order for IT Equipment | July 2016 |
| Deployment of IT Equipment at HVDC Centre | Oct 2016 – Dec 2016 |
| Full RTDS Installation at Centre | Jan 2017 |
| Testing of RTDS and IT Equipment | Feb 2017 |
| Installation of ABB Replica Control Cubicles | May 2017 |
| Final testing of all the technology infrastructure at the centre. | Jun 2017 |

# 18 DESIGN QUALITY

All design records will be handed over to the Centre Manager, and stored in the document library as part of the commissioning process. The National HVDC Centre will have its own document management policy.

During the execution phase of the project, all documentation relating to the project will be stored in the following network folder [\\dfswz002\Shared\Groups\Future-Networks:\B - Research & Development_NIC Current Projects\NIC 2013\SSEN001 MTTE - Project Delivery].

Only paper copies of signed documents will be filed, and these will be kept by Legal Services. All other relevant paper copies will be scanned and filed electronically.

On completion and close-down of the MTTE project, the documentation will be archived, and retained based on the 'Records Management Retention Period Guidelines' [REF-COR-004].

# 19 MANAGEMENT OF DESIGN CHANGE

Any material changes to any aspect of the design will be managed through the approved change control work instruction for Future Networks – 'WI-PS-FNP-011 FN Change Control v1.01'.

The project partners and participating suppliers will be consulted on any material changes to the Design.

# 20 DESIGN AS BUILT

Project Services will be responsible for ensuring that the 'as built' building design is captured, stored in the document library, and handed over to the Centre Manager.

The project team will ensure that the IT Infrastructure 'as built' design is captured, stored in the document library, and handed over to the Centre Manager.

# 21 PROJECT DESIGN REPORTING

The overall design will be captured in this Design Development Document, which will be circulated, reviewed and approved by the relevant stakeholders (refer to page 2 for details), and is the responsibility of the Project Manager.