Replica Hosting at The National HVDC Centre Facilities Description

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1 Introduction

The National HVDC Centre ("HVDC Centre" or "Centre") – www.hvdccentre.com – is owned and operated by Scottish and Southern Electricity Networks Transmission (SSEN-T), which is a trading name of Scottish Hydro Electric Transmission plc. It works in partnership with National Grid Electricity Transmission (NGET), Scottish Power Transmission (SPT), and the National Energy System Operator (NESO), and collaborates with a wide range of industry stakeholders. The Centre hosts state-of-the-art real-time simulators that can be used in conjunction with HVDC and other replica control and protection systems to provide a realistic and flexible test environment to support and de-risk project delivery. The appendix provides more information on the benefits of replicas and real-time simulation.

The Centre provides a unique bridge between manufacturers, developers, Transmission Owners and NESO, enabling de-risking of the deployment and operation of HVDC and other new technologies by providing a real-time simulation environment where multiple parties can participate in a practical manner. The HVDC Centre is uniquely placed to host confidential equipment and models from various organisations and facilitate the required studies while ensuring the protection of confidential data and intellectual property. As the only place in GB hosting replicas of transmission-connected equipment, the HVDC Centre was created to provide a secure environment for testing that can, subject to agreement, include equipment from multiple owners in one simulation, providing a means of assessing interaction risks and exploring overall system behaviour more thoroughly.

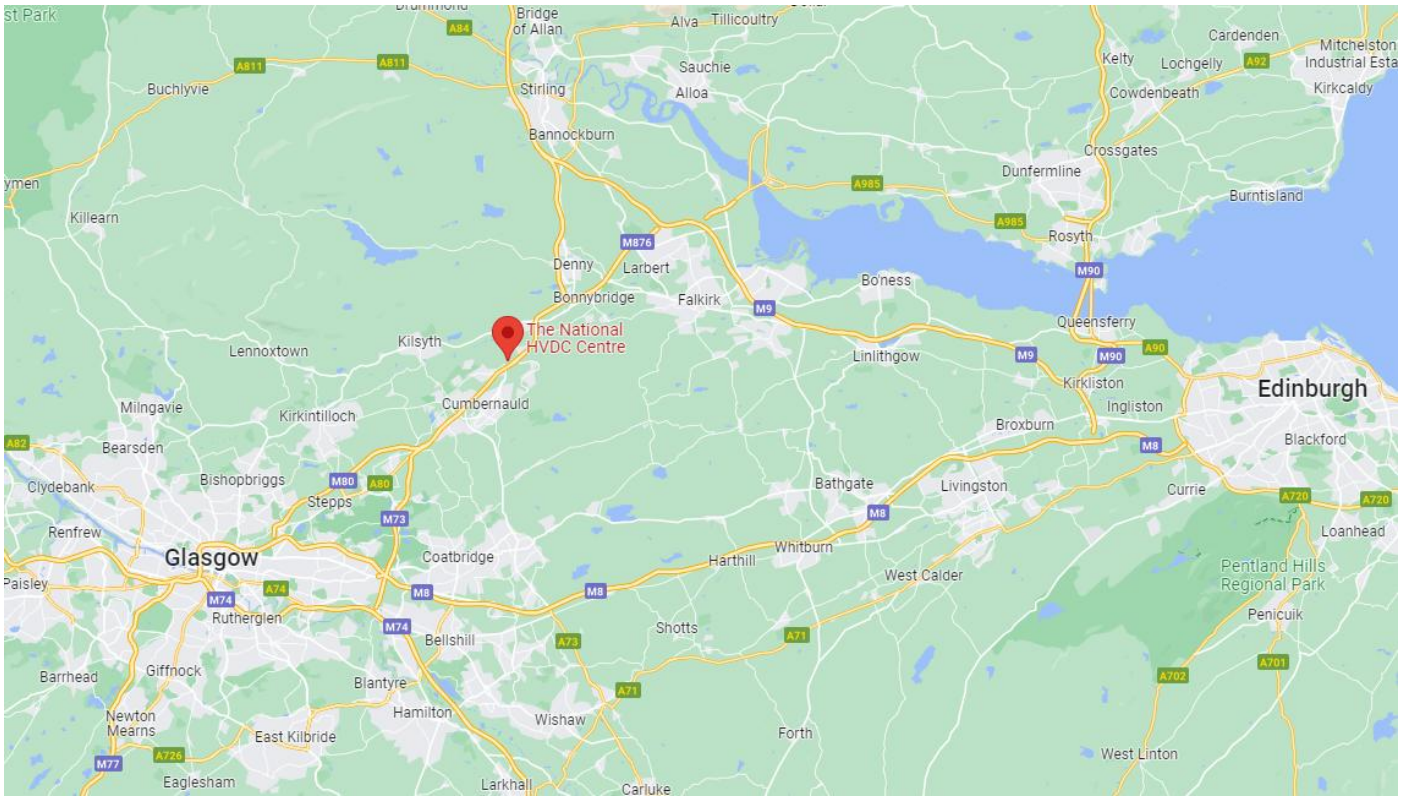
The HVDC Centre supports real-time simulations, using RTDS®/RSCAD® and OPAL-RT®/HYPERSIM®, and off-line analysis using PSCAD®, PowerFactory® and PSS/E®. It is at the global cutting edge of new developments in modelling and simulation of future power systems, having worked with various partners to develop and test new approaches like "software in loop" and hybrid modelling. The Centre is also a leader in training and knowledge dissemination on HVDC, related technologies, and advanced modelling, simulation and analysis.

1.1 This Document

This document is intended to inform the design and deployment of replica equipment to be hosted at the HVDC Centre. It can be shared freely with all parties interested in the HVDC Centre facilities. For further information, please contact the Centre.

2 Location

The National HVDC Centre is a purpose-built facility, opened in April 2017, located in central Scotland at 11 Auchindoun Way, Wardpark, Cumbernauld, G68 0FQ. The location is easily accessible by road from Glasgow, Edinburgh and Stirling.



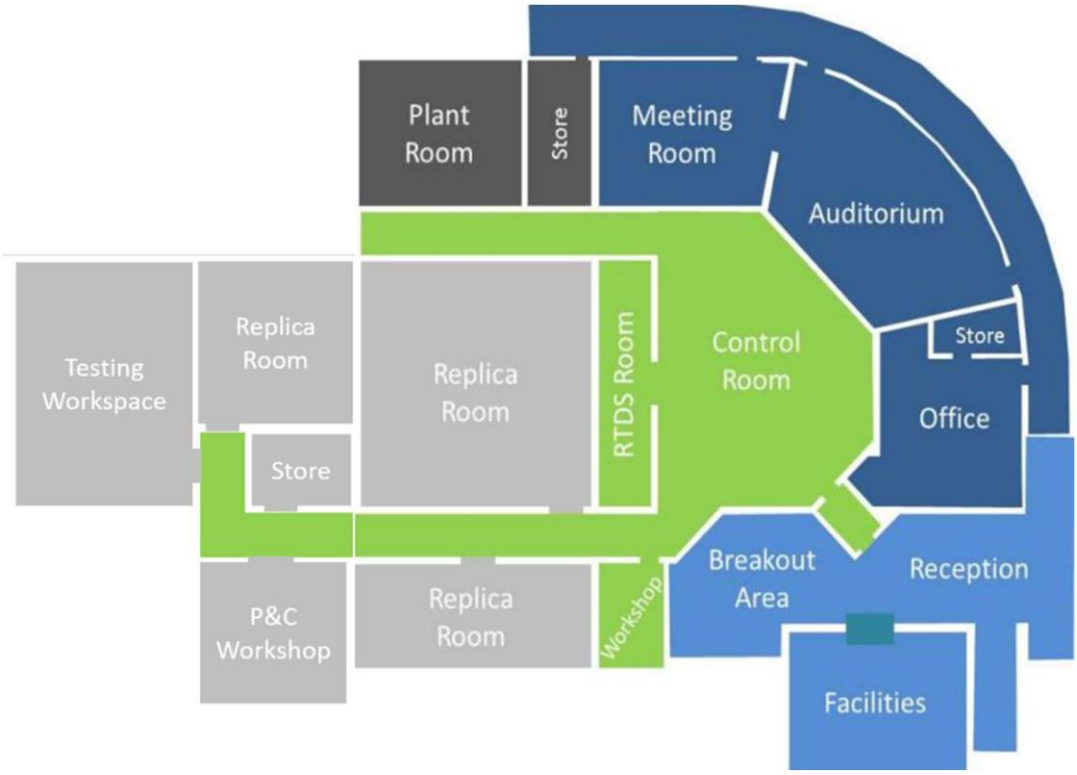
3 Layout

External views of the Centre

The Control Room and breakout area.

The Auditorium and main corridor.

The building is designed to have ‘Visitor’ areas where visitors to the Centre are permitted access, and ‘Secure’ areas where access is restricted. The internal layout of the Centre is shown below.



Visitors Areas (highlighted in Blue)	Secure Areas (highlighted in Green and Grey)
○ **Office:** Enabling visitors to work at the Centre. ○ **Auditorium:** Enabling training and other large events. ○ **Meeting Room:** Flexible meeting room space. ○ **Facilities:** Breakout area, kitchen, WCs, shower and stores.	○ **Control Room:** Accommodating the simulation workstations. ○ **RTDS Room:** Accommodating the main real-time simulator system. ○ **Replica Rooms:** Accommodating replicas from different projects. ○ **Workshop:** Store and workstation for IT and equipment maintenance. ○ **Protection Workshop:** Testing protection and other hardware. ○ **Testing Workspace:** Flexible space useable as an office or for replicas or other equipment.

4 Security and Protection of Intellectual Property

The HVDC Centre was created to provide a safe and secure environment for hosting and testing of replicas, other hardware, and software representations of HVDC and related technologies from a range of different suppliers. The Centre is designed and operated to enable separation of equipment hosting and working areas, supported by secure computing and network facilities. As a trusted partner, the Centre can host sensitive intellectual property, embedded in hardware or software, from multiple parties and facilitate collaborative working to the benefit of all.

The protection of intellectual property is underpinned by contracts and agreements specific to each project. The HVDC Centre is part of SSEN Transmission (a trading name of Scottish Hydro Electric Transmission plc) and the exchange of data with other transmission licensees in GB is governed by the STC (System Operator Transmission Owner Code).

Physical Security: There are a number of physical security measures in place to control access to the HVDC Centre site and building, as well as individual replica rooms. The Centre is happy to share specific details with individual customers on request.

Access arrangements are typically based on the following principles:

- Equipment owners and suppliers would have access during normal office hours (9am-5pm, Mon-Fri).
- In emergency situations (e.g. in response to an event), the Centre could support out-of-hours working (detailed arrangements and costs to be agreed).
- The Centre will facilitate equipment owners and suppliers to undertake studies using their equipment, with the Centre's engineers ensuring that confidentially is maintained.
- The Centre may request permission from equipment owners and suppliers to use the equipment for other studies (e.g. research projects or interaction studies).

Fire safety: A category L2 fire alarm system is installed. There is no fire suppression system but during out-of-hours periods, hosted replica equipment is typically protected by an automatic electrical cutoff linked to the fire alarm system. This ensures that if smoke is detected, replica equipment is powered off until it can be inspected before it is switched back into service.

Cybersecurity: Within the HVDC Centre, we have a separate computer network domain for working with replica equipment, the real-time simulator hardware, and sensitive models and data. It is a segregated domain that is not connected to the internet to provide a high level of cybersecurity. File transfer is managed through a specially configured firewall.

Publications: The Ofgem-agreed funding of the Centre means that we must aim to disseminate learning through publications, webinars, etc. However, any dissemination activities involving replica equipment would be approved in advance by the equipment supplier or owner as appropriate.

5 Replica Hosting

The HVDC Centre accommodates replica equipment and other hardware for testing within dedicated and secure spaces designed for that purpose. The Centre provides replica rooms with power and environmental control. The specific details will depend on which room is used.

5.1 Responsibilities and Interfacing

For a Hardware-in-Loop (HiL) configuration, it is assumed that the equipment supplier will provide all the replica or test hardware, including suitable racks and associated equipment like power supplies, all the required RTDS or OPAL-RT input/output (I/O) cards, and the fibre optic cables that connect the I/O cards to the real-time simulator. Most projects are expected to utilise the Centre's simulator hardware but it is also possible for projects to supply their own simulator. Latencies for interfacing will be managed by respecting maximum fibre optic communications distances to the existing simulator, or simulator hardware will be installed in the replica room. The HVDC Centre team will connect the fibre optic cables to the simulator and bring the cables into the replica room. The interface point shall be where the fibre optic cables terminate onto the I/O cards; the equipment supplier shall be responsible for making the terminations.

For any Software-in-Loop (SiL) configuration, the specific responsibilities and interface requirements depend on hardware platform requirements. If a dedicated hardware platform is required to run the SiL replica, this hardware might best be accommodated in a replica room as with HiL equipment, subject to review and confirmation of the practicalities. Alternatively, if the SiL replica can be run on established simulation hardware available at the Centre, such as the RTDS NovaCor or GTSOC hardware, a replica room is unlikely to be required.

As is normal practice for the supply of replicas for interfacing to a real-time simulator environment, it is assumed that the equipment supplier will provide suitable models that accommodate the connection of all HiL and SiL components. It is expected that this will include modelling of the equipment or system under test to an appropriate level of detail to the connection point to the wider power system. It is expected that the model will include at least a Thevenin equivalent source (or similar) to represent the wider power system, sufficient to enable basic testing of the replica system. Although it is worth noting that performance and integration studies increasingly require models of larger networks areas and the Centre team is happy to discuss how we might support this.

On installation of new equipment, the Centre will support testing to demonstrate the functioning of the whole HiL or SiL system. This stage will also involve completion of any training from equipment suppliers on usage.

To assure owners that the replicas and simulation environment are complete and ready for use, the HVDC Centre will normally review all hardware, software, data, models, training and supporting documentation, producing a report that highlights any shortcomings. The complexity of replica systems is such that it is likely this report will identify some further work to be completed, most likely by the equipment supplier, before the Centre can recommend to the owner that the system is fully installed and ready.

5.2 Replica Room Facilities

Photos and descriptions below provide further information on typical replica room facilities. If a room is lacking a required service or function then we are happy to discuss what changes are necessary to satisfy the requirements of each project.

PAC & Cut-off Switch

Each room has PAC controlled access, and an external power cut-off switch.

The same power cut-off system is linked to the fire alarm system during out-of-hours periods. This ensures that if smoke is detected, replica equipment is powered off until it can be inspected before it is switched back into service.

Grounding

A grounding bar can be provided (and the metal floor is also grounded).

Power Supply

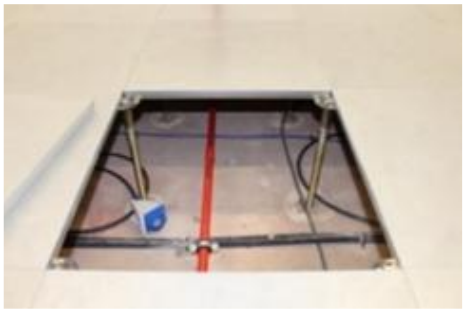
Power supplies (50 Hz, 230 V, 16 A) are fitted.

Power supply sockets are under the floor, or there are also wall-mounted sockets and ethernet points for workstations.

Floor Panels & Power Sockets

The metal floor panels are easily removed, giving access to a floor void that is 455 mm deep.

The floor has load bearing capability of 4.5 kN (over 300 mm x 300 mm)



Air conditioning

An air conditioning and filtering system is installed or can be installed or modified as required to satisfy specific requirements.

Inside the room there will be:

Light switch, door release, door release override, electrical cut-off, and fire extinguishers (Foam & CO2).

Fire Detection

A sensitive Stratos-Micra air sampling smoke detector is fitted (which detects smoke both in the room and under the floor).

External Antennas

Replica equipment may require externally mounted antennas for communication purposes, such as receiving GPS time signals. These can be accommodated on metal framework located adjacent to the building.

Cabling

The design of the HVDC Centre provides easy access to the floor void to allow cabling to be installed between rooms. This will normally utilise the installed under-floor cable trays, although there is scope to lay cables directly if required.

Installation Access

There is a loading bay to the rear of the building, with shallow ramped access (no steps) to the large access door.

6 Appendix: The Benefits of Replicas and Real-Time Simulation

High Voltage Direct Current (HVDC) converters and similar technologies used in modern power grids rely upon highly complex control and protection systems that are typically implemented on specialist hardware running proprietary software code. Replicas are copies of the actual hardware and software systems that have been deployed on site and can be used in conjunction with a real-time simulator for hardware-in-loop simulation and analysis, supporting a wide range of performance studies, testing and training.

The primary real-time environment at The National HVDC Centre is based on the Real Time Digital Simulator (RTDS) product range supplied by RTDS Technologies Inc. (www.rtds.com)

Replicas, together with the RTDS, provide a very accurate representation of the system, including latencies and hardware effects, without the modelling simplifications often necessary in other simulation tools. This enables the performance of the system to be tested across a range of conditions where the replicas give a true representation of real-world behaviour.

Replicas provide an ability to validate and benchmark commissioned designs, above and beyond the Factory Acceptance Test (FAT) stage. HVDC, wind farm and other systems can evolve as control systems are tuned based on in-service experience, and the amended tuning may not be included in any manufacturer offline models. Replicas can be updated with the same software/firmware as implemented on site, providing a true representation without modelling compromises or delays.

The use of replicas enables efficiencies in the design, Functional System Testing (FST) and commissioning stage of a project by providing the capability for detecting and correcting network integration and compliance issues before they cause costly project delays.

By accurately representing the real protection and control behaviour, replicas allow interactions between different systems to be fully considered. They can be used to support demonstration of interoperability with the rest of the system and nearby converter-based projects. By reflecting the real injection of current into a fault or other disturbance, they can be used to accurately inform AC and DC protection operation and inform the accurate behaviour of a system to supervisory controls. Replicas can help to verify protection and wide area controls, supporting project connection but also potentially providing an improved overall performance of closely located devices to support higher onshore network capacities and project output during a variety of operating conditions.

Post commissioning, use of replicas helps to ensure that any on-site setting modifications can be assessed and understood. Replicas can be used to test future control system modifications within a simulated environment ahead of planned deployment. They also support accurate and validated model exchanges with transmission owners and the system operator, supporting planning studies and management of network risk.

A replica can help address operational issues rapidly, reviewing operational risks before they happen, and allowing system events to be re-played through them to rapidly support any incident investigation. Throughout project lifetime, replicas can assist in assessing upgrades and performance against evolving network conditions, as well as facilitating fault investigation to allow a rapid return to service, all aimed at minimising potential down-time.

Replicas typically use the same human machine interface (HMI) screens as operators would have on site. They therefore provide a safe and controlled environment for training and offline exercises.