Replica Hosting at The National HVDC Centre
Recommended Delivery Plan

Reference	TR-CORE-2405-403
Revision	A
Description	Prepared for public issue
Date of Issue	09-12-2025
Confidentiality	PUBLIC

Revision	Date	Authors	Reviewers	Approver
A	09-12-2025	Fabian Moore	Shangen Tian Nikhil Sharma Colin Foote	Ben Marshall

Contents

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 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

The document outlines the recommended delivery plan for hosting replica equipment at the HVDC Centre, detailing the necessary steps, timelines, and documentation to ensure successful installation, commissioning, and operation of HVDC replicas. It emphasizes early engagement, comprehensive documentation, and collaboration among all parties involved.

This document can be shared freely with all parties interested in the HVDC Centre replica hosting services. For further information, please contact the HVDC Centre.

2 Delivery Plan

The use of HVDC replicas and similar equipment in real-time, hardware-in-the-loop simulation is a highly complex endeavour requiring input from multiple parties. This document provides recommendations based on the HVDC Centre's experience hosting replica systems. It is suggested that these recommendations be incorporated into delivery plans for the procurement, installation, and commissioning of replicas. The Information Schedule provided in Section 3 suggests a timeline for when specific information and documents are required.

2.1 Involving the Replica Hosting Facility

Consultation with the replica hosting facility, such as the HVDC Centre, should begin as early as possible. The hosting facility can provide information and guidance useful to the specification and procurement of replica systems.

Contracts for replica hosting should be discussed and agreed well in advance of equipment being delivered to the hosting site. Ideally the discussions should start around 18 months before the scheduled equipment delivery, with the aim of reaching a signed agreement at least 12 months before the scheduled equipment delivery. This allows for suitable preparation of the hosting environment and involvement of the host facility in preparatory activities. Cybersecurity requirements have the potential to impact contracts, IT policies, and the required infrastructure at the host facility. It is essential that all parties discuss the cyber security requirements and data management requirements as early as possible. Supporting documents that confirm in more detail the scope of the hosting services and how services will be provided should be discussed and agreed at least six months ahead of the replica arriving on site.

It may be necessary for the hosting facility to be modified or reconfigured in some way, or for additional equipment to be installed to support the replica hosting. This should be confirmed, and activities commenced, ideally at least six months ahead of the replica arriving on site. If the replica installation requires modification to the utilities at the HVDC Centre, installation timelines may be out of the Centre's control. Therefore, internet connectivity and power supply requirements should be agreed at the earliest opportunity.

When specifying the replica, the replica owner should give careful thought about what features of the HVDC project they want to be made available at the hosting facility, and what equipment or features the vendor might not provide with their replica equipment by default. Replicas typically include hardware-user interface equipment like that installed on the main project site. This would typically include several Human Machine Interface (HMI) computers to operate the replica and examine event information, carry out engineering and maintenance tasks. Replica owners may also want equipment at the hosting facility to replicate the remote operator interface (e.g. a Network Management System like GE PowerOn), especially if the remote operator interface differs significantly from the user interfaces available on replica HMIs. These requirements should be discussed with the hosting facility.

It is typical for the control and protection equipment destined for site to undergo Factory Acceptance Testing (FAT) at the vendor's facility, witnessed and approved by the owner. The FAT provides an excellent opportunity for replica hosting facility staff to support the project and gain experience with the control and protection equipment. If possible, staff from the hosting facility should be invited to participate in the FAT. To meaningfully participate in the FAT, host facility staff will need access to all the test plans, network information, and relevant specifications in advance. This would require early engagement, in the initial project stages, and agreement between all parties.

The replica will be installed at the host facility by the replica vendor. The vendor will then need to carry out Site Acceptance Testing (SAT) to ensure that the replica operates correctly in the host facility. Staff at the host facility are expected to be available during the vendor's installation and testing to assist or witness the testing as required. After installation is complete, host facility staff will carry out a small selection of the acceptance tests to confirm that the replica functions satisfactorily. The vendor's plan for installation, commissioning, and testing of the replica equipment, should be agreed at least one month ahead of the replica arriving on site.

Host facility staff need to be familiar with the replica hardware, and the real-time simulation models provided with it. It is therefore essential that the vendor provides training and support to the staff at the hosting facility for a period after replica installation.

2.2 Documentation

The provision of appropriate documentation is essential to the successful installation, commissioning, and operation of replica systems. The Information Schedule (Table 1) in Section 3 outlines the required documentation and recommended timing for each item. Replica owners are encouraged to ensure all documentation is provided in accordance with the schedule to support efficient integration and long-term support of the replica system.

Documents should be maintained throughout the project from the date they are provided (before replica delivery), during installation and commissioning, and for the life of the replica so that they remain up to date.

2.3 Real-Time Models

Real-time, hardware-in-the-loop simulation requires suitable models for interfacing with the replica system and facilitating the required simulation and analysis of behaviour. The HVDC Centre supports real-time simulations, using RTDS/RSCAD and OPAL-RT/HYPERSIM.

To support replica hosting it is necessary that the vendor provide documentation describing the models and their usage. The required documentation is detailed in Table 1.

Each real-time model will have specific computing hardware requirements, e.g. the number of processing cores or their distribution across separate hardware components. The HVDC Centre recommends:

- The replica owner should confirm what real-time simulation hardware will be supplied with the replica.
- Real-time computing hardware requirements shall be agreed in advance of the replica being delivered.
- If possible, models are configured to run on a standard hardware configuration at the Centre.
- The model timestep should be discussed and agreed to ensure compatibility with other models and systems for which there may be a desire to run joint simulations.

Depending on the real-time computing hardware requirements, it may be necessary for the HVDC Centre to charge for additional computing resources (hardware or software licences) to enable models to be run in a timely and efficient manner.

2.4 Offline Models

To support replica hosting it is recommended that the vendor provide associated offline models, which can play a useful role in supporting verification and troubleshooting of replica systems and their associated real-time models. The HVDC Centre does not need to host the offline models on behalf of the customer, but recommends that the customer obtains copies, with sufficient documentation, and ensures they are available for future use if needed.

The HVDC Centre uses the PSCAD software for offline electro-magnetic transient simulation, which is the market leading platform used by most of the main HVDC vendors. The Centre also uses PowerFactory and PSSE for phasor domain (root mean square (RMS)) modelling and analysis and MATLAB/Simulink for detailed controller modelling and analysis.

If the HVDC Centre is to host, use, or work on offline models, it will require an electronic copy of all required models (in agreed format and version, including all supporting software, e.g. PSCAD version, Visual Studio version and Fortran Compiler Version). It is necessary that the vendor provide documentation describing the models and their usage. The required documentation is detailed in Table 1.

Depending on the specific software version requirements of the offline models, it may be necessary for the HVDC Centre to charge for additional software or compiler licenses to enable models to be run.

3 Information Schedule

To successfully install and host a replica, the HVDC Centre recommends providing information as described in Table 1.

Table 1 – Replica Information Schedule

Item No.	Title	Details	Timing (relative to installation time)
1	HVDC Project and Replica Documentation		
1.1	Project Timeline	Replica owners should provide an overview of the project timeline, including expected replica installation dates.	T-18 months
1.2	Documentation Management, Sharing, and Storage	Replica owners and vendors will need to provide the HVDC Centre with numerous documents and models to support the installation, operation, and maintenance of the replica. Replica owners and the Centre must mutually agree how documents, models and data are: - shared securely - managed and updated throughout the life of the project	T-12 months
1.3	IT/Cyber	IT and security requirements: - Data management - Will the hosting facility need to manage dongles / memory cards / disks on site? - How test records (e.g. TFR, event logs, and print screens) can be exported from the replica for analysis/dissemination. - How code is uploaded to the replica - Specific information, data, and cyber security requirements - Policy on the management of user credentials / logins - How remote or internet access should be managed	T-12 months
1.4	Signed Replica Hosting Agreement (Contract)	The replica owner and host facility need to have a contract describing their roles and responsibilities. Ideally the contract should be signed 12 months before the planned installation date, to give both parties certainty. The host facility will need to commit time and resources to preparatory work. The replica owner needs to be sure there is somewhere for the replica to go once the vendor is finished with it.	T-12 months
1.5	Support Agreements	- Details of support contracts with the vendor. - Warranty and spares arrangements - Spares inventory and spares storage requirements	T-6 months

Item No.	Title	Details	Timing (relative to installation time)
1.6	Replica Documentation Directory/List	Provide a directory/list of all documents associated with the replica system. (To be maintained throughout the Project)	T-6 months
1.7	HVDC Project Basic Information	Basic information on the HVDC project: 1. Summary information on the HVDC scheme (capacity, technology, topology, voltage, rated capacity) 2. Single Line Diagram (SLD) 3. Device / circuit parameters for the HVDC scheme	T-3 months
1.8	Control & Protection Specifications/Strategy	Documents describing the HVDC control and protection systems: 1. Overview of C&P architecture 2. Description of individual control and protection functions 3. Description of parameters/settings available to operators 4. How control code updates are managed (version control for both the replica and the main system)	T-3 months
1.9	Study Reports	Study reports for relevant studies, e.g. dynamic performance studies, interaction studies. This helps to understand the HVDC scheme, the replica, and the models.	T-3 months
1.10	Replica Overview Information	Overview of replica system, typically as block diagrams and descriptions (the various components: C&P hardware, HMI, TFR, servers and software, interfaces and applications used for operation and maintenance, cubicle/device connectivity, and interfaces between simulator and replica hardware)	T-3 months
1.11	Replica Instruction Manuals	1. Detailed description of the simulator interfaces (hardware, I/O cards, I/O signals with descriptions, replica specific hardware) 2. Any specific hosting requirements (restrictions in use, ESD, temperature / humidity, safety measures) 3. Startup and shut-down procedures 4. Debugging, fault-finding and diagnostic guides 5. User manuals for all systems expected to be used / operated (HMI, TFR, Event Logs, Engineering / Support PC, etc.) 6. Maintenance manuals for all systems to be maintained (HMI, TFR, Event Logs, Engineering / Support PC, etc.) 7. Any risk assessments for working on or near the replica equipment	T-3 months
1.12	Previous Test Procedures and Results	Replicas are typically used to assess the performance of new control and protection code updates. It is useful to provide a record of previous tests undertaken on the replica, during factory acceptance and commissioning periods. Test specifications, test procedures, associated models, and associated results (TFRs and event logs) should be provided as a record of the baseline performance of the replica system.	T-3 months

Item No.	Title	Details	Timing (relative to installation time)
2	Replica Hardware Installation Information		
2.1	Replica Room Physical Space Requirements	To ensure an appropriate physical space can be provided at the HVDC Centre, the physical space requirements need to be known: - Number of cubicles - Cubicle dimensions, and weight - Space required for HMI/operator desks - Details of any additional auxiliary equipment	T-18 months
2.2	Replica Electrical Requirements	To ensure adequate power and air conditioning can be provided at the HVDC Centre, the electricity requirements need to be known: - Electricity demand for individual devices/cubicles - Overall replica power consumption - Number of underfloor 16A 230V 2P+E Blue Industrial “commando” sockets required. - Socket requirements for HMI/operator desks - Humidity and temperature requirements for the replica equipment - Earthing requirements for equipment - Information about any batteries inside the equipment	T-18 months
2.3	Internet Connection Requirements	If remote access is required, this needs to be known at the earliest opportunity. Solutions may take significant time to implement, and will depend on several factors: - Ownership of the connection The replica owner can opt to install their own infrastructure to the HVDC Centre site. If remote access is to be provided using HVDC Centre assets, agreeing and putting in place suitable infrastructure and cyber security measures may take time. - Physical Connection Requirements (e.g. bandwidth) The replica might require similar physical hardware and systems to those used on site. - Vendor Support Requirements If the vendor is required to provide rapid/24hr response in supporting to the replica, they are likely to need remote access to the replica hardware to achieve this.	T-18 months
2.4	GPS/Comms Antenna Requirements	Information about the number and type of antennas that will need to be installed externally, and details of any corresponding antenna cables.	T-8 months

Item No.	Title	Details	Timing (relative to installation time)
2.5	Simulation Interface and Comms Requirements	Information about what comms cables will be required to connect the replica to devices elsewhere in the Centre: - Location of simulator I/O cards within the replica cubicles - Number of fibre optic (FO) cables required to connect the replica cubicles to the real-time simulator hardware - Comms/ethernet cables required to connect the replica to remote internet access router hardware - Number and type of KVM or comms cables for servers and HMI/operator interface computers (if HMI equipment is to be in a separate room from replica C&P cubicles) - Connectivity requirements for any remote access or SCADA equipment to be installed with the replica	T-8 months
2.6	Simulation Hardware Requirements	Details of the real-time simulation hardware: - The chosen real-time simulation platform - The minimum hardware needed to run simulations with the replica (this is likely to be model dependent) - What simulation hardware is being supplied with the replica	T-8 months
2.7	Room Layout Plan	Confirmation of the layout of replica equipment (layout of P&C cubicles, comms equipment, HMI/operator desk layout).	T-8 months
2.8	Hardware Drawings	Cubicle General Arrangement (GA) and Cubicle Schematic Drawings	T-2 months
2.9	Installation and Commissioning Plan	Provide an installation plan that includes method statements and risk assessments to: - Manage the delivery, offloading, and movement of equipment at the HVDC Centre - Identify and manage specific risks (e.g. moving heavy plant, electrical work) - Agree roles & responsibilities for the work at the Centre	T-2 months
2.10	Site Acceptance Test (SAT) Plan	After installation, the vendor is expected to carry out a selection of functional and dynamic tests to ensure that the replica, and real-time models are working correctly in the hosting facility. These are typically a sample of the factory acceptance tests. HVDC Centre staff expect to be on hand to witness and provide support during SAT testing.	T-2 months
3	Real-Time Models and Associated Documentation		
3.1	Real-Time Models	An electronic copy of all required real-time models in agreed format and version (the HVDC Centre recommends the use of the latest RSCAD software)	T-6 months

Item No.	Title	Details	Timing (relative to installation time)
3.2	Model Documentation and User Guide	Documentation describing the real-time models in detail, including: 1. A list of all models (Thevenin equivalents and any more detailed models) 2. Purpose of model (What was it built for? What are its limitations?) 3. Simulation hardware and software requirements 4. Simulation timestep requirements 5. Contents of model and description of model components 6. Confirmation of model validation and performance 7. Data sources 8. Ownership of intellectual property, data, and confidentiality requirements 9. Model user guide / description of user interface 10. Details of user scripts (e.g. startup and test scripts) 11. Known issues / bugs / limitations	T-6 months
4	Offline Models and Associated Documentation		
4.1	Offline Models	(If offline models are to be hosted by the HVDC Centre.) An electronic copy of the offline models in agreed format and version (the HVDC Centre typically uses PSCAD for offline EMT studies).	T-6 months
4.2	Model Documentation and User Guide	(If offline models are to be hosted by the HVDC Centre.) Documentation describing the offline models in detail, including: 1. A list of all models (Thevenin equivalents and any more detailed models) 2. Purpose of model (What was it built for? What are its limitations?) 3. Simulation hardware and software requirements 4. Simulation timestep requirements 5. Contents of model and description of model components 6. Confirmation of model validation and performance 7. Data sources 8. Ownership of intellectual property, data, and confidentiality requirements 9. Model user guide / description of user interface 10. Details of user scripts (e.g. startup and test scripts) 11. Known issues / bugs / limitations	T-6 months

Item No.	Title	Details	Timing (relative to installation time)
5	HVDC Centre Staff Activity Information		
5.1	Pre-Installation Support Activities	The HVDC Centre is keen to support your project and become familiar with the project/replica at the earliest opportunity. Potential activities include - Participation in FAT testing	To be agreed during initial planning.
5.2	Post-Installation Acceptance Tests	HVDC Centre staff expect to be available during installation and commissioning of the replica at the HVDC Centre to assist or witness testing as required. After installation, HVDC Centre staff will carry out a selection of functional and dynamic tests with the replica. These are typically a sample of the factory acceptance tests and site acceptance tests.	Provision of customer/vendor test plans: T-3 months
5.3	Post-Installation Training	Provision of training and support after replica installation is essential. A training plan needs to be agreed to ensure HVDC Centre staff: - Are familiar with the HVDC project, and its overall design - Can start-up and shut-down the replica hardware - Are familiar with the HMI operator screens, and how the HVDC scheme is operated - Understand the real-time models provided with the replica, and how to use and modify them.	Training Plan: T-6 months (Delivery post-installation)