SSEN Transmission

The National HVDC Centre

Annual Report *(for reporting period April 2022 to March 2023)*

The HVDC Operators' Forum 2023 (14-15 June)

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1 Executive Summary

Background

This report is the second annual report for The National HVDC Centre, as part of RIIO -T2.

- The Centre's business model for RIIO-T2 can be found here: https://www.ofgem.gov.uk/sites/default/files/docs/2020/07/hvdc_centre_future_business_model_public.pdf
- Ofgem's associated determination can be found here: www.ofgem.gov.uk/publications-and-updates/decision-future-operation-hvdc-centre-following-end-nic-funding-period
- The previous annual report, together with prior MTTE Project progress reports and can be found here: https://www.hvdccentre.com/library-category/progress-reports/

Context

The National HVDC Centre is Great Britain's (GB's) simulation and training facility for HVDC, supporting the integration and successful operation of all HVDC schemes connecting to the GB Network.

The Centre is also the National hub for HVDC knowledge exchange, expertise and innovation.

The Centre uses state-of-the-art simulators to model and resolve potential issues in real-time before they impact on the delivery (or operation) of HVDC projects, to ensure the integrity and security of the GB Network.

As described in Ofgem's determination, the HVDC Centre's activities include:

1) Provide real-time and offline simulation to support the development and deployment of HVDC schemes.
2) Provide training programmes, for example specialist training courses for GB TOs, ESO, HVDC owners, developers and manufacturers to drive value across all areas of HVDC integration from a more informed stakeholder community.
3) Develop academic engagement projects to address key challenges to integration of HVDC projects into AC grids in collaboration with both the TOs and ESO.
4) Maintain a library of updated off-line and real-time simulation models, including all network components required to support the development and deployment of HVDC equipment. This includes FACTS devices deployed on the GB network, in particular STATCOMs.
5) Maintain models to facilitate system integration studies involving multiple equipment manufacturers whilst preserving Intellectual Property (IP) arrangements.
6) Proactively engage with industry groups and GB academic and research institutions to support the development of DC Grids.
7) Continue to manage the HVDC Operators' Forum and hold periodic events.
8) Continue to maintain the HVDC Centre website and keep it up to date.
9) Publishing reports into the outcome of project and other analysis activities on the SHET HVDC website (subject to Intellectual Property Rights (IPRs)).
10) Ensure the facility is appropriately resourced.

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1 Executive Summary

Overview

This second year of the HVDC Centre operation within RIIO-T2 has seen the Centre deliver a wide range of projects across the industry, while firmly establishing itself as the national centre of expertise for HVDC.

Over this time: the team has expanded to 14 people, Moyle Interconnector Replicas have been installed, the ASTI projects were confirmed, suppliers have engaged with the Aquila project, our first Patent was registered, the HVDC Operators' Forum returned, and we have hosted ministerial visits; a busy and exciting period for the Centre.

Below is a list of the activities undertaken at the Centre over the past 12 months.

April 2022

- The Centre published and submitted the MTTE project Closed Down Report and Successful Delivery Reward application.
- Our joint bid for EU HORIZON funding for the HVDC-WISE project has been successful (worth £635k over 3.5 years), as part of the overall £7m project.
- The 2 x Strategic Innovation Projects (SIF) that we are leading (Network-DC and INCENTIVE) completed their first phases ('discovery'), and developed plans/bids for their next phases ('alpha') which were submitted to Ofgem.
- Developed a proposal for a multi-vendor, multi-terminal interoperability demonstration, and engaged NGET, SPEN, ESO, Siemens, Hitachi Energy, Scottish Government and BEIS, with strong support across all stakeholders.
- The Centre was recognised at the US NASPI conference for our work with EPRI on the use of PMU data to manage converter led instabilities via Power Oscillation damping controls.
- Continuing to build the team at the Centre, to delivery our expanding portfolio of projects, welcoming two new Engineers to the team.
- The Centre published its Spring Newsletter, where we discuss our new EU projects, update on some of our existing projects, announced our Operators' Forum, and close-down the MTTE project: https://www.hvdccentre.com/library-category/newsletters/

May 2022

- The Centre participated in the READY4DC kick-off meeting, for which we sit on the Advisory Board.
- Also held the SIF Discovery "show and tell" for Network DC and INCENTIVE.

June 2022

- This month saw the return of our in-person Annual HVDC Operators' Forum at the Centre; themed on interoperability, lifetime support and delivering the future ambition of HVDC. The event was attended by 50 stakeholders from across the industry, with excellent feedback and participation, helping to reaffirm the Centre's role among industry experts and leaders.
- Project Aquilla/multi-vendor demonstration was announced as a Pathfinder project.
- A new Simulation Engineer joined the team.

July 2022

- This month saw the Centre extension being formally opened by Lord Offord (Parliamentary Under Secretary of State for Scotland).
- The Centre received all TOTEM High-Power PCs at the Centre and started their set-up with MHI (Manitoba Hydro International).

1 Executive Summary

- Finalised with Moyle and Siemens the planned replica delivery later this year.
- Supplier engagement on data exchange mechanism for GB HVDC Interoperability and offshore functional design.
- Two new Senior Simulation Engineers and a Simulation Engineer joined the team.

August 2022

- This month saw the successful completion of Hitachi's FST testing of the Shetland controls (using the Replicas at the Centre), including the Operator Training.
- The Centre submitted a joint tender with RTEi to the Carbon Trust on control resonance management, and plan to submit a joint tender with DNV in the next month to support co-ordinated offshore development & design in South Korea.
- The Grant Agreement for HVDC-WISE (Horizon Europe) was signed this month.
- The Centre was awarded £1.34 million, as 100% of the Successful Delivery Reward for the MTTE project.
- This month the Centre hosted the Demonstration event for Distributed ReStart, the ScotWind Round-Table, and hosted visits from Stuart McDonald MP, Vattenfall, and SSEN's summer placement students.
- A new Simulation Engineer joined the team.

September 2022

- The Centre is leading on interoperability for project Aquila, and have developed an innovative multi-terminal controls system, which we are planning to patent.
- Held the first interoperability forum with all major suppliers, all TOs and the ESO.
- The Centre presented 5 projects at the Energy Innovation Summit in Glasgow (28th-29th).
- Our pipeline of new projects continues to grow, with Orsted requesting a follow-on project, collaborating with RTEi on a new project with Carbon Trust, responding to a KEPCO (South Korean TO) tender with DNV, and National Grid Ventures have commissioned a new MPI project with the Centre.

October 2022

- The Centre published its Autumn Newsletter: www.hvdccentre.com/wp-content/uploads/2022/10/HVDC-Centre-Newsletter-October-2022-FINAL.pdf
- The Centre continues to win external projects, the latest being: KEPCO (South Korean TO) to complete a Holistic Network Design of their future network (with DNV) over the next 3 years; and Carbon Trust, to undertake the Resonance Stability Project, in collaboration with RTEi.
- The Centre has been nominated for the Innovation Award in this year's Utility Week Awards for their leadership work in HVDC technology.
- The Centre is in the process of registering a patent, on their innovative design of interoperability control (for Project Aquila), and engaged IP lawyers to support.
- The Distributed ReStart Stakeholder Advisory Panel (composed of independent and notable experts from the industry) have commended the project as excellent, a level above other innovation projects.
- The Centre held its Strategy Workshop, to develop the plans for the Centre out to 2040.
- Presented at the Offshore Grid Infrastructure group.
- Attended the kick-off meeting for HVDC-WISE project in Lyon, and our application for funding for the project to UKRI has been approved.

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November 2022

- November saw the huge milestone of the delivery of the Moyle Interconnector Replicas; we are now working to commission these, while we also finalise the contracts for our first offshore wind Replicas.
- The HVDC-WISE grant application has been finalised.
- We have developed the Centre's long-term strategy, which we shared with our Governing Board and Technical Advisory Board.
- Met with Manchester and Strathclyde universities to develop collaborative plans to further develop HVDC skills in GB.
- The Centre submitted 2 papers to IET's ACDC Conference (on Impedance Assessment of Offshore Wind Farm and HVDC Interoperability).

December 2022

- In December the Centre registered its first patent "Multi Terminal HVDC Control Methods and Systems"; while also returning £387k of the revenue generated by the MTTE Project to customers.
- The Replicas for the Moyle Interconnection were installed at the Centre.
- Application submitted for the Engineering Technical Programme (ETP) student with Edinburgh university.
- Successful submission of the SIF projects INSIGHT and BLADE we are supporting into discovery phase.
- Successfully replicated and analysed a network events in the CMS Replica, and reported the findings.

January 2023

- The Centre hosted a three-day training course on real-time simulation with attendees from University of Manchester and National Grid ESO giving a foundation in use of the RTDS platform for hardware-in-loop analysis.
- RFQ's for Aquila Replicas have been formally issued to the 4 suppliers involved in interoperability testing
- New ElectroStatic Discharge (ESD) Operational Guidelines have been approved to support its extended equipment portfolio.
- The INCENTIVE report has been published; this is our main output for this SIF project.

February 2023

- The Centre continues its important work on HVDC multi-vender interoperability with ongoing engagement to secure replicas from OEM converter suppliers.
- The Centre published research paper 'Towards HVDC Interoperability – Assessing Existence of Equilibrium with reference to Converter terminal behaviour': https://www.hvdccentre.com/library/towards-hvdc-interoperability-assessing-existence-of-equilibrium-with-reference-to-converter-terminal-behaviour/
- Secured 2 graduate PhD students (one through the IDCORE programme with Edinburgh University, and one through the ETP programme with Strathclyde) focussed on HVDC control and HVDC design optimisation respectively.
- Very positive feedback from NGV on the progress of the MPI project illustrating real-time realistic control and protection behaviours.
- Proposal for Centre standardised "products" support to HVDC projects presented to the Technical Advisory Board (TAB).

March 2023

- The month started on a high, with the Centre's high-profile at the ACDC conference (with congratulations to Dong Chen for winning the 'Best Paper' award): https://www.hvdccentre.com/library/towards-hvdc-interoperability-assessing-existence-of-equilibrium-with-reference-to-converter-terminal-behaviour/.

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- Overall the ACDC was a great success; with the HVDC Centre (and project Aquila) credited in most of the presentations, demonstrating the high profile the Centre has across the industry (the Centre also hosted the Technical visit on day 1 of the conference).
- The Centre also published the ACDC 2023 special edition newsletter: https://www.hvdccentre.com/library/acdc-2023-special-edition-newsletter/; highlighting its tutorials and conference paper contributions
- The Interoperability workstream for Aquila is progressing well, with the new RTDS hardware purchased. We have been brought in to advise TSOs on interoperability within INTEROPERA, and are advising the US Department of Energy in these same areas.
- Our latest SIF projects (BLADE and INSIGHT) have both formally commenced, following their Ofgem approval; while our prior SIFs (Network-DC and INCENTIVE) are progressing to applications for their Beta Phases.
- The CMS Replicas at the Centre are now being used to test the Noss Head Stage 2 Commissioning.
- Excellent visit and tour of Spittal converter station by the HVDC Centre team.
- Delivered a guest lecturers at Strathclyde and Manchester Universities; generating lots of interest from the students.
- Frequency Dependent Screening Workshop delivered to ESO, and TOs, with separate sessions delivered for developers on a one-one basis.
- Siemens hosted training on the Moyle Replicas, for the team.

2 Update on Project Delivery

Project Delivery

The projects are categorised as Core, Chargeable or Commercial; this relates to the definitions in the Centre's Business Model:

- **Core** (Core TOs/ESO Services): The Centre delivers these services on behalf of the TOs/ESO (within the Centre's available resource);
- **Chargeable** (Additional Chargeable TOs/ESO Services): The Centre will incrementally charge, above the baseline funding, the TOs/ESO for these additional services; and
- **Commercial** (Chargeable Services for Other Organisations): The Centre would charge for services provided to 3rd party organisations.

To deliver on the objectives, the HVDC Centre is delivering a range of technical projects:

Project/Activity	Progress	Client	Core/ Chargeable/ Commercial*
AC Protection Solutions in Converter Rich Network (NIA)	SSEN are leading a Network Innovation Allowance project supported by the Centre as Subject Matter Expert which is delivering an open loop demonstration of vendor solutions for new protection approaches designed to account for HVDC and other converter connections dominating fault current in a low strength network. The vendor solutions are being tested by the HVDC Centre, and their tuning and specification critiqued, and within open loop installation in service experience will be complemented with simulation in order to unlock how to type approve and implement and test such new solutions.	SSEN Transmission	Core
Aquila HVDC Switching Station Peterhead	SSEN is commencing an offshore network reinforcement in the east coast of GB to enable massive utilization of offshore wind power. The ambitious plan will inter-connect multiple HVDC lines to form an unprecedented multi-terminal DC grid connecting the landing points of both Scotland and England. To de-risk the supply chain and procurement, the equipment must be supplied by multiple vendors. The Centre is working closely with principal vendors of HVDC converters to provide a solution of interoperability without opening up the IP of internal design of HVDC converters. To date, the Centre has led a working group with all relevant vendors, i.e. GE, Hitachi Energy, Siemens Energy, and Mitsubishi, TSOs, SSEN and NGET, and the ESO to generate an agreeable principle of interoperable HVDC grids. The principle will be to design the specifications of HVDC converters as "black boxes". The Centre is developing methodologies of the fore cited principles, which are underpinned by patent files and academic publications, and then building up models and relevant protocols for test validations.	SSEN Transmission	ASTI (Accelerated Strategic Transmission Investment)

2 Update on Project Delivery

Project/Activity	Progress	Client	Core/ Chargeable/ Commercial*
BLADE (SIF)	The Centre is working with SP Energy Networks, the University of Strathclyde and the Carbon Trust on this innovation project. The project's aim is to develop using offshore wind to support system black start. The Centre is contributing to the technical workstream and is responsible for a specific deliverable on exploring the benefits and risks of using the offshore coordinated network (HND) for system restoration. We are currently in the discovery phase but plan to submit an application to extend the project in an alpha phase.	SP Energy Networks	Chargeable
Coordinated Offshore Functional Designs	The aim of this project is to provide an environment to support the ESO, manufacturers, developers, and transmission owners to develop and test coordinated solutions for offshore wind. This will provide a foundation of power system models and insights across the range of co-ordination approaches that can inform whilst supporting vendor and developer work and onshore network development activities. https://www.hvdccentre.com/our-projects/coordinated-offshore-functional-designs/	ESO	Core
Distributed ReStart (NIC)	The Centre supported SP Energy Networks, TNEI and National Grid ESO with the Distributed ReStart project, which involved the construction of a real time model of the distribution system being restored and the associated resources available to black start, allowing work already underway within the project to be complemented by the more detailed view of resource control and protection that our real time environment provides. This allows traditional and non-traditional sources of Black Start resource performance to be compared. The project has conducted analysis of the energisation paths from a given black start generator, supported protection system review, and undertook the testing of a distributed resources controller, intended to better support black start. https://www.hvdccentre.com/innovation-projects/distributed-restart/	SP Energy Networks	Core (early stages) Chargeable (late stages)
East Coast Interaction Study	The Centre has performed a wide interaction study in the area of the Yorkshire coast, where many power electronic resources (both existing and planned) are expected to connect; these include a range of offshore, potentially co-ordinated HVDC connections and at least one of the east coast interconnections at Drax 400 kV substation. As Great Britain transitions to net zero, existing conventional generation resources lending this area network stability may operate with lower availability presenting a greater potential of interaction within a more converter dominated area of the network. This study informed what impact different technology options for offshore wind farm connection might have upon potential network interaction risks, and what the nature of the types of interactions across projects in this area of the network might be.	Offshore Wind Developer	Commercial

2 Update on Project Delivery

Project/Activity	Progress	Client	Core/ Chargeable/ Commercial*
Eastern HVDC Support	Commissioned by SPT, NGET and SSEN Transmission, the Centre is providing ongoing technical expertise and support to the Eastern HVDC project teams including identifying technology opportunities, and recommended testing and modelling needs. https://www.hvdccentre.com/our-projects/eastern-link/	SPT, NGET and SSEN	Core
Incentive (SIF)	The Centre is working with SSEN, the University of Strathclyde and the Carbon Trust on this innovation project. The project's aim is to develop the technical and business case for co-locating grid forming devices with offshore wind to provide stability services, specifically inertia. The Centre is contributing to the technical workstream to model the performance of the solutions. We completed the alpha phase demonstrating feasibility and have submitted an application to extend the project in a beta phase for a demonstration.	SSEN Transmission	Chargeable
INSIGHT (SIF)	The INSIGHT project (Innovative Network Status Intelligence Gathered by Holistic use of Telemetry and Simulation) aims to develop a real-time alert and control system that can monitor and mitigate different types of oscillation events experienced on the network. The Centre has supported the Discovery phase to build understanding of the problem and global best practice using a questionnaire issued to a wide range of stakeholders. We have also supported work by Strathclyde University to investigate models and tools that may be used to simulate network oscillation patterns and assess their suitability. Project outcomes will be reviewed before deciding whether to progress to an Alpha phase application.	SSEN Transmission	Chargeable
HVDC Connected Offshore Wind Farms: Controller interaction and grid stability study	In September 2021, the Carbon Trust commissioned the *HVDC-connected OWFs: controller interaction and grid stability (HVDC-CI) study* as part of Stage IV of the Offshore Wind Accelerator programme. The Centre formed a collaboration with the French TSO, RTE International (RTEi), to deliver the project. This project investigates the risks associated with the integration and interaction of HVDC-connected Offshore Wind Farms (OWFs). The project aims to identify the key contributing factors of controller interactions and their associated risks with focus on HVDC-connected OWFs power system infrastructures, also considering nearby generators and potential sub synchronous torsional interaction (SSTI) phenomena. It then builds on these findings to develop a scope of study to efficiently assess these risks across project design stages as well as investigate mitigation actions. https://www.hvdccentre.com/our-projects/hvdc-connected-offshore-wind-farms-controller-interaction-and-grid-stability-study/	The Carbon Trust	Commercial

2 Update on Project Delivery

Project/Activity	Progress	Client	Core/ Chargeable/ Commercial*
HVDC Phasor Based Monitoring (NIA)	The Centre has worked with SSEN Transmission and GE to investigate the potential to use a variety of PMUs (and other devices) to inform wide area control as key metrics of local system strength change within the onshore transmission system. The Centre has undertaken comparative evaluations of devices, with these and a new Phasor Controller platform being used for detailed RTDS-HiL evaluation of the proposed system and device responses to it. https://www.hvdccentre.com/innovation-projects/phasor-based-monitoring-with-hvdc-control-nia-funded-project/	SSEN Transmission	Core
HVDC R&D Strategy and Supply Chain Review (Coordinated Offshore)	BEIS and Ofgem requested that the Centre deliver two reports to inform the 2050 net zero targets: • An HVDC R&D strategy to enable the delivery of a coordinated approach to offshore connections to meet 2050 net zero targets; and • A technical report describing the components, and other technology, that will be required to deliver a coordinated approach to offshore connections to meet 2050 net zero targets, and an overview of the associated supply chains. https://www.hvdccentre.com/library/hvdc-rd-strategy-coordinate-offshore/ https://www.hvdccentre.com/library/hvdc-supply-chain-overview-co-ordinated-offshore/	BEIS and Ofgem	Core
HVDC-WISE	The goal of HVDC-WISE is to support further development of hybrid AC/DC transmission grids by developing new reliability and resilience (R&R) oriented planning and analysis tools and identifying HVDC-based grid architectures and technologies that can be readily deployed to improve system performance and facilitate the integration of new renewable sources. HVDC-WISE is an EU Horizon project engaging 14 partners from 11 countries covering the academic (5), TSO (4) and industrial worlds (5). The Centre is participating as an Associated Partner through the legal entity of Scottish Hydro Electric Transmission plc. UK Research and Innovation (UKRI) funding for HVDC-WISE is provided under the UK government's Horizon Europe funding guarantee [grant number 10041877]. In the first six months of the project, from October 2022 to March 2023, the Centre led the work package delivering two major reports, on R&R needs and key performance indicators.	UKRI	Commercial
Moyle Interconnector Controls Refurbishment Project	The Centre has agreed to host the replicas of the control and protection system of the Moyle HVDC Interconnector (refurbishment project) from 2022 onwards. The replicas were installed in January 2023 and work is now progressing with Mutual Energy and Siemens Energy on a range of activities. https://www.hvdccentre.com/our-projects/moyle-interconnector/	Mutual Energy	Commercial

2 Update on Project Delivery

Project/Activity	Progress	Client	Core/ Chargeable/ Commercial*
MPIs and low SCL	The objective of this project is to investigate the performance of multi-purpose interconnectors (MPIs) with voltage source converter (VSC) based HVDC technology and offshore windfarms connected to multiple weak AC grids with significantly low short circuit levels (SCLs). We are currently halfway through the project having built and validated the models. The remainder of the project will be demonstrating the performance of the MPI under different network events.	National Grid Ventures	Commercial
Network DC (SIF)	Network DC is exploring the possible use of Direct Current Circuit Breaker (DCCB) technologies within the development of future HVDC networks in Great Britain. The Centre led on definition of a project use case based on the development of a DC hub with multiple connections, where the introduction of DCCBs will further expand the capability of the DC hub. DCCB models previously developed as part of the PROMOTioN project were collated and modified by the Centre for re-use in Network DC. Those models were then used to study the performance of hybrid and mechanical DCCBs within network models that represent the project use case. These models were developed, and simulations performed, in the RSCAD software for real-time simulation. The Centre has played a leading role in successful completion of the Discovery and Alpha phases of the project and supported an application for a Beta phase that proposes further development and testing of networks with DCCBs utilising our unique real-time simulation facilities.	SSEN Transmission	Chargeable
NSL Protection Study	Commissioned by SP Transmission (SPT) and National Grid Electricity Transmission (NGET), this project tested the coordination of protection for the connection of the North Sea Link (NSL). NSL is a new HVDC interconnector connecting Blyth in the northeast of England, to Kvilldal in Norway. To be confident that the AC protection operates correctly, the Centre tested the AC protection relays (using the actual protection hardware) in a Real-Time (Hardware-in-the-Loop) simulation environment. https://www.hvdccentre.com/our-projects/north-sea-link-protection-coordination-testing/	SP Transmission (SPT) and National Grid Electricity Transmission (NGET)	Core
Shetland Multi-Terminal Extension	Commissioned by SSEN Transmission, the Centre is providing technical support for the multi-terminal extension of the Caithness-Moray HVDC Scheme to Shetland. The multi-terminal extension of the Caithness-Moray link to Shetland will require testing against the detailed model of the Shetland network (and utilising the Shetland Replica controls that the Centre hosts) to avoid adverse effects on the AC and DC networks. https://www.hvdccentre.com/our-projects/support-for-the-shetland-extension-of-the-caithness-moray-hvdc-link/	SSEN Transmission	Core

2 Update on Project Delivery

Project/Activity	Progress	Client	Core/ Chargeable/ Commercial*
Transmission Operator Tools for EMT Modelling (TOTEM)	The three GB Transmission Owners and National Grid ESO have completed an NIA project to build a whole GB simulation environment within PSCAD. The Centre advised on hardware and software needs and is hosting the high-performance computing facilities used by the Scottish TOs. https://www.hvdccentre.com/innovation-projects/totem-transmission-owner-tools-for-emt-modelling/	All TOs and ESO	Core

*Refer to the Centre's Business model for details on these terms:
https://www.ofgem.gov.uk/sites/default/files/docs/2020/07/hvdc_centre_future_business_model_public.pdf

3 Update on Activities

Activities that support the Centre's objectives are described below.

Grid Code Development

The HVDC Centre has supported the completion of the expert Grid Code working groups on three key modifications:

- GC0137: Grid forming convertors/ Virtual Synchronous Machines; this has resulted in non-mandatory code reform, a GB best practice guide and a CIGRE B4/C4.93 working group to progress international common definitions, practice testing and modelling; all of which the Centre has supported.
- GC0138: Compliance and modelling processes; this is now been approved and is supporting remote compliance testing.
- GC0141: Improvements to data, modelling and compliance processes based on the 9th August 2019 power loss incident. This was implemented on 5th Jan 2023.

These are Grid Code change areas which sought to address many of the considerations of the review of the 9th August 2019 system event and areas in which the HVDC Centre has specific practical expertise in its de-risking of HVDC and related technology.

The recommendations in total represent one of the largest technical changes in the Grid Code's history, potentially increasing the extent and range of analysis required for compliance activity, increasing the extent of data shared, enabling a greater range of analysis to be deployed and specified and project performance expectations to be further clarified across the life of the project.

The Centre is currently supporting:

- GC0154: Interconnector ramping solutions to minimise ancillary services impact.
- GSR0030: SQSS changes to accommodate design optimisations possible in HVDC bipole designs to provide greater connection capacity and reliability.
- GC0xxx: (as yet un-numbered expert working group) informing technical code changes for the implementation of offshore designs together with offshore grid code recommendations for DC and AC connection interfaces.

Particularly the last of these represents one of the largest changes to Grid Code to date and is informed by the Centre's ability to study these designs in real-time EMT simulation across their range of operation and of Project Aquila to inform the design of practical DC interface requirements.

Further to GB codes, the Centre has also been supporting READY4DC and INTEROPERA projects in their shaping of relevant interoperability solutions for the EU, with many of these findings also transferrable to GB codes. We have also, within the EU project HVDC-WISE, set out in our WP2.1 reporting objectives for the enhanced reliability and resilience of future HVDC networks; on completion of that project relevant approaches shall be reviewed for development into codes.

3 Update on Activities

Dissemination Activity

A continual key focus of the HVDC Centre is on knowledge dissemination.

The Centre undertakes extensive engagement/ dissemination activity to ensure that we:

- Keep potential users of the Centre informed of our capabilities;
- Ensure that the work we undertake is developed in collaboration with relevant stakeholders; and
- Effectively disseminate the knowledge gained at the Centre to the right people.

We do this through a range of engagement activities:

- Workshops and hybrid events for the industry around specific topics and techniques developed at the Centre;
- Actively disseminated information, experience, and developed consensus, to interoperability though our Advisory Board roles in READY4DC and INTEROPERA work and contributions to their publications;
- Disseminated across the SIF projects and HVDC WISE projects our outputs and learnings;
- Hosted a range of technical visits; and
- Supported grid code initiatives relevant to HVDC- see above

Our dissemination events are discussed further below in more detail.

Films

The Centre has produced a range of short films to communicate project learning in an accessible format: https://www.hvdccentre.com/technical-films/

We have published the following Project Aquila video and SIF project videos- see below.

Project Aquila on Vimeo

Project INCENTIVE - YouTube

NETWORK-DC - YouTube

Ofgem SIF Discovery project: SIF Blade - YouTube

Ofgem SIF Discovery project: INSIGHT - Bing video

In addition, Mutual Energy produced an excellent film on their recent upgrade project, that features the HVDC Centre, which can be found here: https://www.mutual-energy.com/electricity/watch-moyle-interconnector-control-system-upgrade/

Website

The Centre's website continues to be updated to support knowledge dissemination.

The website contains details of all the technical projects the Centre has undertaken, our innovation programme, and library of publications.

https://www.hvdccentre.com/

3 Update on Activities

Newsletter

This year the Centre produced 4 quarterly newsletters and distributed to all our Stakeholders, shared with our Linked-In followers, and published on our website.

https://www.hvdccentre.com/library-category/newsletters/

Linked-In

The Centre uses Linked-In to share key outputs with a wide range of interested parties.

https://www.linkedin.com/company/the-national-hvdc-centre

HVDC Operators' Forum (annual)

The Centre has established this forum as a regular annual event, where HVDC projects in GB, relevant TOs and the ESO come together to share experience and lessons learnt.

The Centre's annual HVDC Operators' Forum re-started after a Covid gap, with a highly successful event on 21-22 June 2022; details of the event (together with all of the presentations) can be found here:

https://www.hvdccentre.com/library-category/operators-forum-2022/

This year's HVDC Operators' Forum is planned for 14-15 June 2023, and is expected to be the largest so far.

Dissemination Events

The Centre's Events and Webinars inform and facilitate knowledge exchange on a variety of HVDC-related topics. These events and webinars have been very well attended from across the industry, and have been well received.

Examples of dissemination events this year include:

- Tasnet Visit to the Centre (18-Apr-22)
- NREL: US co-ordinated offshore project engagement (06-May-22)
- Peterhead switching station development meeting (project Aquila) (11-May-22)
- BEIS Visit to the Centre (12-May-22)
- CO Power Grid Japan Meeting (12-May-22)
- GB Expert working group on Multi-vendor interoperability- kick-off (12-May-22)
- Ready4DC workgroup kick-off Event (16-May-22)
- Phasor Based Monitoring for HVDC Applications webinar (with GE) (18-May-22)
- BEIS call on Project Aquila and interoperability (19-May-22)
- SIF Network-DC "Show and Tell" webinar (23-May-22)
- SIF INCENTIVE 'Show and Tell' - Flexibility & Hydrogen webinar (23-May-22)
- HVDC Operators' Forum (21-22-Jun-22)
- KEPCO-KEPRI Visit (23-24-Jun-22)

3 Update on Activities

- ACDC China key note presentation (02-Jul-22)
- Distributed ReStart DRZC Testing (11-Aug-22)
- Network DC project kick-off meeting (25-Aug-22)
- RTDS Introductory Training Course (12-16-Aug-22)
- Energy Innovation Summit (28-29-Sept-22)
- Braco Development & Training Centre Visit (04-Oct-22)
- Visit to RTE (Lyon) (03-Nov-22)
- Visit to Supergrid (Lyon) (04-Nov-22)
- University Collaboration Disucssion (04-Nov-22)
- CT/Imperial College integrator event on inertia (11-Nov-22)
- BEIS event on HVDC co-ordinated offshore designs (08-Nov-22)
- Bilateral meeting with GE on multivendor- multiterminal (08-Nov-22)
- ZIV Automation Visit (15-Nov-22)
- ENTSO-e Grid forming requirements webinar (23-Nov-22)
- ENTSO-e Inverter dominated stability workshop (23-Nov-22)
- HND deliverability forum (24-Nov-22)
- EA3 replica hosting and offshore support scheme meeting (24-Nov-22)
- Burns & McDonnell engagement (25-Nov-22)
- Distributed Restart - DRZC Testing (Live demonstration at the HVDC Centre) (01-Dec-22)
- Orsted Project Meeting (Teams) (02-Dec-22)
- Lecture Delivered at Strathclyde: "Industry experience in HVDC" (17-Jan-23)
- RTDS Training Course delivered at the Centre (25-Jan-23)
- Technical Advisory Board Meeting (30-Jan-23)
- ESO Offshore Team Visit (16-Feb-23)
- IDCORE (Edinburgh University), Presenting the HVDC Centre to Students. (23-Feb-23)
- Technical Visit to the HVDC Centre as part of IET's ACDC Conference. (01-Mar-23)
- Presenting at the IET's ACDC Conference (2-3-Mar-23)
- GB HVDC Interoperability Expert Working Group (Aquila Interoperability Package) (06-Mar-23)
- Manx Utilities Visit (07-Mar-23)
- Frequency dependent screening methods workshop (13-Mar-23)
- ESO Network Operability Team Visit (15-Mar-23)
- Lecture Delivered at Strathclyde: "Industry experience in HVDC" (24-Mar-23)
- Presented at Elia, 50Hz, Energinet and Amprion workshop on interoperability (31-Mar-23)
- Presented at "DRZC Independent System Testing Webinar" hosed by NGESO (19-Apr-23)
- HVDC-WISE General Meeting, Dublin (25-26-Apr-23)

4 Financial Report

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5 Technical Advisory Board

Overview of the TAB meetings/schedule

TAB meetings across 2022/23 were held on 30th April 2022, and with individual TSOs between 1st and 20th June 2022 via roadshow presentations. Impromptu TAB meetings were held during the 2022 Operators' Forum in person 21st-22nd June with the most recent session on 30th Jan 2023, held virtually. TAB meetings are a mixture of hybrid physical and virtual attendance. Meetings are normally between 2.5-3.5hrs long, and a typical agenda is:

- Introductions, actions from last meeting;
- Overview of past 6 months of activity (highs and lows);
- Centre resourcing and current commitments;
- Specific project updates;
- Specific topics for discussion needing new innovation/ new focus;
- R&D activities; and
- Actions, Recommendations, AOB.

The meetings serve as a strategic discussion to more routine project focussed discussions across the TAB organisations over the year. Some key areas TAB moved the Centre's work forward over 2022/23 include:

- Agreeing to the scope of and importance of kicking off functional offshore design modelling work; and
- Taking Centre developed techniques, such as those of "software in the loop" and frequency scanning techniques, forward into delivery.

Relevant to the above, the Centre now hosts a "software in the loop" model of the Viking windfarm, and also is set to host "virtual" HVDC replicas of vendor code as part of Project Aquila later this year. We also successfully held a follow up to TAB workshop on 13th March to roll-out small signal analysis techniques for frequency scanning to de-risk converter connections. This was held at the Centre and virtually and was attended by c. 20 representatives across the TOs and ESOs to build familiarisation with both theory and practice, and included training on the use of the technique, based on a worked example.

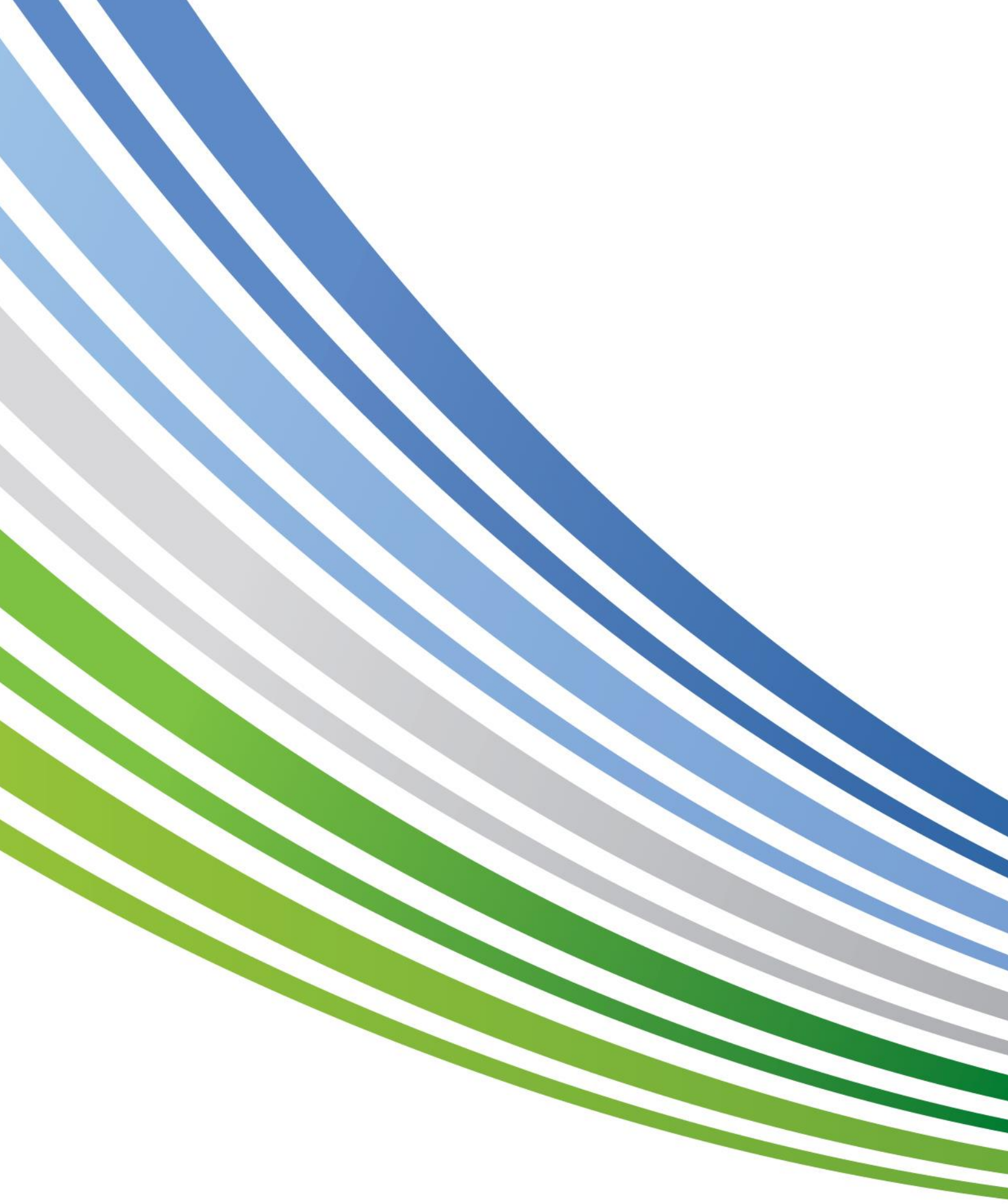
Non-Networks Representative

Professor Tim Green from Imperial College, London has continued as our non-networks representative. Tim is the Director of the Energy Futures Lab at Imperial and Professor of Electrical Power Engineering. He specialises in areas of power electronic control in particular in HVDC and its simulation. Tim is also active within the Global Power System Transformation consortium, seeking to generate international best practice in the development of key power system competencies for the future, including in HVDC. Tim was appointed TAB representative formally at the 17th February 2021 TAB ahead of the Centre entering BAU. He has served it with distinction since then and has been re-elected to serve across 2022/23.

6 Key Decisions

Over the course of FY 2021-22, the following key decisions have been made:

- To recruit additional engineers to the Centre, to ensure the Centre is able to meet demand for its services;
- To support Scottish Power Energy Networks BLADE SIF project;
- To progress the INSIGHT SIF Project;
- To deliver the Aquila project, and use the NZARD allowance to fund the HVDC Centre's interoperability workpackage for Aquila;
- To include the Centre's proposed expansion and project support as part of the SSEN allocated ASTI funding;
- To registered the Centre's first patent "Multi Terminal HVDC Control Methods and Systems" (note: we are in the process of registering another 2 patents on interoperability);
- To approve the Centre's short, medium and long term strategy; with the strategic purpose to "Deliver world-leading simulation, training and innovation; to de-risk, accelerate and enhance GB's efficient transition to a resilient Net Zero Network."



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