



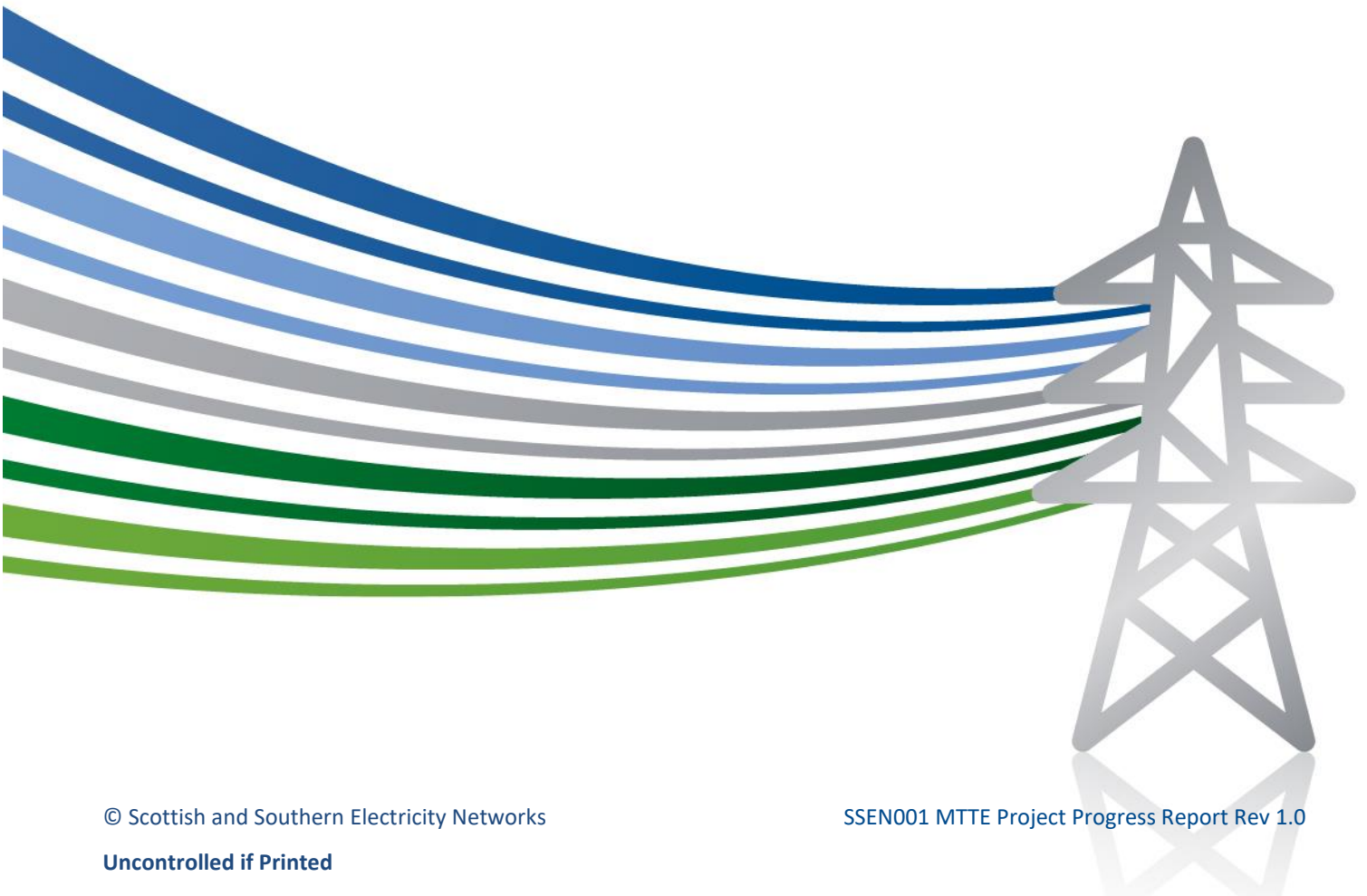
**Scottish & Southern**  
Electricity Networks

# SHE Transmission

**Multi-Terminal Test Environment for HVDC Systems (SSEN001)**

**Project Progress Report** (for reporting period June 2019 to May 2020)

June 2020



# 1) Executive Summary

## Overview of MTTE

The Multi-Terminal Test Environment for HVDC (MTTE) Project, has established 'The National HVDC Centre', which formally opened on 26 April 2017.

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.

## Success of the HVDC Centre

The Centre has developed into a critical component of Great Britain's (GB's) electricity infrastructure, enabling the delivery and integration of HVDC schemes onto the GB network; for example:

- The Centre supported the delivery of the Caithness-Moray (CM) HVDC project, and is now supporting its operation;
- The Centre has delivered work improving GB's future Black Start capability, through maximising the use of HVDC schemes to provide Black Start services (commissioned by the Scottish Government);
- The Centre is performing critical AC protection coordination testing for interconnector projects;
- The Centre is informing the ESO's Stability Pathfinder project, to improve the stability of the GB network using HVDC (commissioned by the ESO); and
- The Centre is helping to shape the future of off-shore wind and HVDC, through: the innovative EU PROMOTioN project, chairing OWIC's technology workstream and supporting the ESO's offshore coordination project.

These projects demonstrate how the Centre de-risks HVDC schemes, and beyond that can investigate the consequences of HVDC upon existing assets (such as protection & control) while ensuring the integrity of the GB grid.

Furthermore, the Centre is also supporting the development of the industry's knowledge, through:

- Delivering a programme of technical webinars;
- Delivering a range of training courses (incl: SHE Transmission Control Room training, RTDS® training, PSCAD training and HVDC fundamentals training);
- Running (and disseminating the results from) the annual HVDC research programmes;
- Engaging stakeholders and providing technical leadership (incl: the annual HVDC Operators' Forum, CIGRE (B4.82) Working Group, Grid Code Expert Working Group and IET's ACDC conference); and
- Supporting TOs on the design and development of new HVDC links planned in the next RIIO-T2 period.

The HVDC Centre has become a world-leading Centre of HVDC expertise and is providing critical support to projects in GB and the security of the GB network; directly benefiting GB's electricity consumers.

## Successful Delivery Reward Criteria (SDRCs)

The first seven Project SDRCs have been successfully completed in previous reporting periods.

During this period, the project successfully completed SDRC 9.8, submission of Future Business Model; which was submitted on 7 February 2020.

The project is on plan to complete the final SDRC 9.9, securing the next set of Replicas.

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# 1) Executive Summary

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## Progress within this Reporting Period

This has been the busiest period for the Centre, with the Centre delivering a range of high-profile projects for a range of stakeholders, including:

- Maximising HVDC Support for Black Start;
- Stability Pathfinder;
- NSL Protection Study;
- PROMOTioN;
- Eastern HVDC Support;
- Caithness-Moray Operational Support;
- Shetland Multi-Terminal Extension;
- Integrated Offshore Design;
- Offshore Coordination;
- Distributed ReStart (NIC);
- 2019 Innovation Programme; and
- 2020 Innovation Programme.

In addition, the Centre has delivered:

- Training;
- Grid Code Development;
- Stakeholder Engagement & Dissemination Activity;
- Webinar Events;
- Future Business Model for the Centre;
- Resourcing; and
- Business Continuity during Covid-19.

## 2) Project Manager's Report

### Project Summary

This section provides a summary of the Centre's main activity during this reporting period.

#### Maximising HVDC Support for Black Start

Commissioned by the Scottish Government, and supported by specialists from Scottish Hydro Electric Transmissions (SHE Transmission), Scottish Power Transmission (SPT) and National Grid Electricity Transmission (NGET), The HVDC Centre technical experts carried out an in-depth study of how HVDC schemes can support Black Start and system restoration.

On 4 December 2019, the HVDC Centre published the full report, which is available on our website:

[www.hvdccentre.com/our-projects/maximising-hvdc-for-black-start/](http://www.hvdccentre.com/our-projects/maximising-hvdc-for-black-start/)

#### Stability Pathfinder

Commissioned by National Grid Electricity System Operator (ESO), this project investigated the impact of declining system strength on the stability of HVDC links and other low-Carbon technologies that are connected through power electronic converters.

The Centre used power system simulation tools to model HVDC links and different low-Carbon technologies (including wind farms and battery inverters), to test their stability performance across a range of different system conditions on the electricity grid.

The outputs will inform the ESO on the fundamental principles of devices in HVDC links and low-Carbon technologies that could interact adversely with the electricity grid, to provide insights on system specifications and opportunities for improving system stability.

#### NSL Protection Study

Commissioned by SPT and 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 north east of England, to Kvilldal in Norway. To be confident that the AC protection operates correctly, the HVDC Centre tested the AC protection relays (using the actual protection hardware) in a Real-Time (Hardware-in-the-Loop) simulation environment.

#### PROMOTioN

SHE Transmission is leading Work-Package 9 of the European PROMOTioN Project (<https://www.promotion-offshore.net/>). This work package demonstrates the operation of the DC grid protection systems using hardware prototypes within a real-time simulation hardware-in-the-loop to test and demonstrate interoperability of DC Grid protection systems.

Progress this period has included:

- Completed deliverables D9.1 (report outlining test network) and D9.3 (internal to PROMOTioN demonstration event);
- Completed considerable testing utilising the Intelligent Electronic Devices (IEDs);
- Successfully tested operation of the prototype IEDs with the Replica Control and Protection panels of the CMS link;
- Prepared for final deliverable D9.4 (a public demonstration event), though this has been postponed due to Covid-19; and
- Published two papers based on this work.

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## 2) Project Manager's Report

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### Eastern HVDC Support

Commissioned by the SPT, NGET and SHE Transmission, the Centre is providing ongoing technical expertise and support to the Eastern HVDC project teams.

### Caithness-Moray Operational Support

The Centre continues to provide operational support for the Caithness-Moray HVDC scheme.

### Shetland Multi-Terminal Extension

Commissioned by SHE 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.

### Integrated Offshore Design

Commissioned by the Offshore Wind Industry Council (OWIC), the Centre has developed and delivered a report on the design of integrated offshore connections.

Also, the Centre contributed to an industry report on enabling efficient development of offshore transmission network, submitted by OWIC to Ofgem.

Building on established technologies, the Centre developed a toolkit of flexible integrated solutions for the connection of offshore Wind, at the scales required within the future offshore development zones.

Incorporating innovative Bi-pole based solutions, these designs minimise the extent of offshore infrastructure, providing consent and cost benefit; and have been considered against current industry technical codes and standards, and provide the ESO and TOs with options for providing increased boundary capacity to the onshore network.

### Offshore Coordination

Following-on from the Integrated Offshore Design work; the ESO issued a Tender on Offshore Coordination, to develop the conceptual technical designs and undertake the cost-benefit analysis for integrated solutions within and across the Offshore development zones connecting to GB. This work supports Action 3 of Ofgem's Decarbonisation Programme Action Plan (3 February 2020).

The Centre (in collaboration with DNV-GL) submitted a response to this Tender, where the Centre focused on the technical design, technology maturity assessment and technology de-risking work (focusing on HVDC technology and multi-terminal HVDC deployment).

DNV-GL and the Centre have been successful in this competitive Tender, and will be delivering this high-profile project over the coming months.

### Distributed ReStart (NIC)

Following an approach from SPT's Distributed ReStart team (and as approved by the Centre's Technical Advisory Board) the Centre has commenced work on Phase 1 of its Distributed ReStart project support.

Phase 1 involves 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.

A 'Day-in-the-life' illustrative simulation across the stages of restoration will also be constructed to support training and stakeholder engagement for the project.

## 2) Project Manager's Report

### 2019 Innovation Programme

In this reporting period, three innovation projects have been completed:

- Coordination of AC network protection settings during grid energization from HVDC schemes (with EPRI), to assess the suitability of existing AC protection for Black Start from HVDC;
- Stability assessment and mitigation of converter interactions in HVDC schemes (with University of Strathclyde), modelling the impedance of HVDC converters for system stability studies; and
- Improving Grid Code Compliance of existing and upcoming HVDC Schemes in GB (with Cardiff University), to assess and test HVDC Grid Code compliance using simulation and experimental tools.

### 2020 Innovation Programme

The Centre ran a call for innovation proposals (which attracted 18 full proposals from 12 institutions/consortiums), all of which were strong, relevant and of high-quality.

Of these proposals, the Centre's Technical Advisory Board selected three projects:

- Protection Performance Overview and Validation in Low Strength Areas (with Manitoba Hydro International);
- Adaptive Damping of Power Oscillations using HVDC (with EPRI); and
- Evaluation of HVDC with Synchronous Condenser impact on AC Protection (with the University of Strathclyde).

These project have been initiated and will be completed by March 2021.

Descriptions of all of our innovation projects are available at: [www.hvdccentre.com/innovation/](http://www.hvdccentre.com/innovation/)

### Training

The following training courses have been delivered:

- On 4 September 2019, the Centre conducted Operator/Control Room training for the operation of the Caithness-Moray scheme.
- On 5 September 2019, the Centre delivered its 'Introduction to HVDC' course.
- On 5-7 November 2019, the Centre held the third RTDS® training session of the year, with attendees from Transmission Owners (TOs) and the ESO. Across the course, trainees were taught how to use the RTDS platform alongside our practical experience of conducting analysis and integrating Hardware-in-the-Loop with simulations.
- Across the 12-14 November 2019 the Centre hosted (with Manitoba Hydro International) training on PSCAD, one of the premier platforms for EMT analysis; attended by 18 power system engineers from across all TOs and the ESO.

### Grid Code Development

The HVDC Centre is supporting the expert working groups on three key modifications:

- GC0137: Grid forming converters/ Virtual Synchronous Machines;
- GC0138: Compliance and modelling processes; and
- GC0141: Improvements to data, modelling and compliance processes based on the 9 August 2019 power loss incident.

These are code change areas which seek to address many of the considerations of the review of the 9 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 the largest technical changes in the 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.

## 2) Project Manager's Report

### Stakeholder Engagement & Dissemination Activity

**HVDC Operators' Forum (26 June 2019):** The Centre continues to host this prominent annual event to share knowledge and experience; and facilitate industry collaboration (though the 2020 forum has been postponed due to Covid-19).

**HVDC Innovation Day (27 June 2019):** During this day, the Centre shared the progress on our collaborative innovation projects, with presentations from academia and HVDC suppliers.

**Demonstrating the Protection of DC Grids (22 August 2019):** As part of the PROMOTioN Project, the Centre led a demonstration of how multi-terminal HVDC Grids can be protected. The event brought together project partners to demonstrate HVDC protection by integrating protection hardware within a simulated model of an HVDC Grid, combined with direct current circuit breaker (DCCB) real-time simulation models.

**Black Start Stakeholder Event (17 September 2019):** A stakeholder consultation workshop was held at the HVDC Centre to review and agree the recommendations of the report. These recommendations will help to maximise the contribution of HVDC schemes to GB Black Start.

**LCNI Conference (30-31 October 2019):** The Centre attended and presented at the LCNI conference.

**ACDC Protection Essentials of the Future (19 February 2020):** The Centre presented the output of recent PROMOTioN activity on DC protection relay testing, and on the broader challenges associated with protection design and testing for a convertor dominated environment; to this conference held at the Technology University of Delft, Netherlands.

**DPSP Conference 2020 (9-12 March 2020):** The Centre presented/supported the following papers, at the Developments in Power System Protection (DPSP) conference:

- Demonstration of Partially Selective HVDC Grid Protection System with Hardware-in-the-loop IEDs;
- Coordination of ac protection settings during energisation of ac grid from a VSC-HVDC interconnector; and
- Multi-vendor interoperability tests of IEDs for HVDC grid Protection.

**CIGRE Working Group (B4.81):** The Centre has joined this working group to investigate interactions between HVDC schemes and FACTS devices in close proximity.

**CIGRE (Paris) Paper:** The Centre has had a paper accepted for presentation at the Cigre 2020 e-session and to be published at the Cigre 2021 centennial session on: Multi-terminal extension of existing HVDC schemes.

**Newsletter:** Editions of the Centre's Newsletter were published in: July, September, December and March, providing updates on the activity at the Centre [refer to Appendix I for copies of the Newsletters]; and

**Website (hvdccentre.com):** The website continues to be updated to support knowledge dissemination, with all output reports published on the site.

**Stakeholder Engagement Sessions:** During this period, the Centre conducted a series of 1-2-1 stakeholder engagement sessions, with the Centre's key stakeholders, to understand how the Centre can support their HVDC projects.

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## 2) Project Manager's Report

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### Webinar Series

The Centre's webinar series informs and facilitates knowledge exchange on a variety of HVDC-related topics.

These webinars have been very well attended (with typically over 100 attendees at each) from across the industry, and have been well received.

**12 November 2019:** The growing relevance of Electromagnetic Transient (EMT) analysis in particular with respect to network stability and device interaction assessment; led by Dr Dharshana Muthumuni (co-developer of PSCAD).

**12 December 2019:** Follow-up webinar on Subsynchronous Torsional Interaction analysis; led by Dr Dharshana Muthumuni.

**13 February 2020:** HVDC Black Start and impacts on protection function from weak networks; hosted by the HVDC Centre & EPRI.

**27 February 2020:** Small signal and Frequency dependant impedance techniques for identifying HVDC interaction risk; hosted by the HVDC Centre & University of Strathclyde.

**20 March 2020:** HVDC challenges in meeting current GB Grid Code in a weak network; hosted by the HVDC Centre & Cardiff University.

**16 April 2020:** Practical Use of Real Time Simulation for De-risking HVDC Integration; co-hosted with RTDS Technologies.

**24 April 2020:** Repeat of 'Practical Use of Real Time Simulation for De-risking HVDC Integration' (as the previous webinar was over-subscribed).

**13 May 2020:** Demonstration of DC Grid Protection - PROMOTioN WP9 Results so Far.

### Future Business Model

On 7 February 2020, the Centre submitted its 'Future Business Model' to Ofgem.

This report describes the HVDC Centre's plans for 2021-2026 (aligning with the RIIO-T2 period) to provide critical support to HVDC projects in GB and support the security of the GB network.

Ofgem are currently consulting on these plans.

### Resourcing

The Centre has recruited Ben Marshall as the HVDC Technology Manager, to provide technical oversight to the Centre's work; the Centre has benefited from his expertise.

- **Ben Marshall:** Ben has had a long and varied career within National Grid with a broad range of experience, particularly with respect to the analysis of the operation and design of the AC and DC transmission systems. He has developed deep technical skills relating to dynamic stability of power systems and the performance specification of HVDC convertors.

The Centre is currently recruiting a 'Technical Project Officer' to provide technical and project management support to the projects delivered by the Centre.

### Building

To accommodate future projects, the Centre is planning to expand. Planning permission and building warrant have been approved, and the tender pack for this work is currently being finalised.

### Business Continuity during Covid-19

Based on Government advice the Centre closed on 23 March 2020, except for necessary work and essential maintenance, and plans to re-open in line with Government advice.

The Centre's IT infrastructure has enabled the team to productively work from home during this time, with no significant impact on delivery.



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## 3) Business Case Update

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### Business Case

The Future Business Model (7 February 2020), provides details of the future business case for the Centre.

## 4) Progress Against Plan

### Summary of Progress This Reporting Period

During this reporting period, The National HVDC Centre has delivered the following programme of work, all delivered on plan:

- Maximising HVDC Support for Black Start;
- Stability Pathfinder;
- NSL Protection Study;
- PROMOTioN;
- Eastern HVDC Support;
- Caithness-Moray Operational Support;
- Shetland Multi-Terminal Extension;
- Integrated Offshore Design;
- Offshore Coordination;
- Distributed ReStart (NIC);
- 2019 Innovation Programme; and
- Training;
- Stakeholder Engagement & Dissemination Activity;
- Grid Code Development;
- Webinar Events; and
- Future Business Model for the Centre.

### Key Activities Next Reporting Period

The Key Activities during the next reporting period are planned to be:

- Finalising the arrangements for the future operation of the Centre with Ofgem;
- Deliver the Offshore Coordination project (in collaboration with DNV-GL);
- Completing the PROMOTioN (WP9) Project;
- Supporting the operation of the CM Project;
- Supporting the Shetland multi-terminal extension of the CM Project;
- Conducting simulations and analysis for Scottish Power's 'Distributed ReStart' NIC project;
- Next phase of support on NSL system integration;
- Supporting the developed of Integrated Offshore Designs;
- Completing the Centre's 2020 innovation programme;
- Deliver the 'Composite Testing' project;
- Integrate the SCADA system with the Replicas, to enhance the training simulation environment; and
- Finalising the provision of Replicas, as part of an Interconnector project.

### Risks

Refer to Appendix III for an extract of the project risk Register.

There are currently no 'high' risks, however there are two 'medium' risks which are highlighted below:

- **R004 A sustainable business model is not achieved for the HVDC after the NIC funded period:** A robust future business model has been developed, and submitted to Ofgem.
- **R030 Covid-19 may impact on the Centre's ability to deliver on its commitments:** Currently, the new working arrangements have had no significant impact on project delivery.

## 5) Progress Against Budget

The table below details the spend (& revenue) to date against the Project budget for each cost category.

Cost Category <sup>(9)</sup>	Total Budget	Budget to Date <sup>(1)</sup>	Spend to Date <sup>(2)</sup>	Comment <sup>(1)</sup>
<b>Labour</b>				
Project team resource costs	£2,181.68k	£2,023.96k	<b>£1,506.91k</b>	25.5% below plan (refer to Note 3)
MTTE resource costs	£2,032.13k	£1,449.94k	<b>£999.78k</b>	31% below plan (refer to Note 3)
<b>Contractors</b>				
Project team resource costs	£288.44k	£275.08k	<b>£202.74k</b>	26.3% below plan (refer to Note 3)
<b>IT</b>				
IT Infrastructure (incl RTS and Replica Panels)	£3,828.21k	£3,828.21k	<b>£3,627.27k</b>	5.2% below plan
Annual Running Costs of the MTTE	£304.37k	£238.59	<b>£175.11k</b>	26.6% below plan (refer to Note 8)
<b>Travel &amp; Expenses</b>				
Travel & Expenses	£197.40k	£166.46k	<b>£66.83k</b>	59.9% below plan (refer to Note 4)
<b>Other</b>				
Academic Support	£827.07k	£720.81k	<b>£616.28k</b>	14.5% below plan (refer to Note 5)
Learning & Dissemination	£165.41k	£144.16k	<b>£44.42k</b>	69.2% below plan (refer to Note 6)
MTTE Building Facility	£2,916.20k	£2,916.20k	<b>£2,887.16k</b>	1% below plan (refer to Note 7)
Annual Running Costs of the MTTE	£515.09k	£403.78k	<b>£180.30k</b>	55.3% below plan (refer to Note 8)
Recruitment & Training	£137.90k	£122.72k	<b>£16.43k</b>	86.6% below plan (refer to Note 6)
<b>Total</b>	<b>£13,393.91k</b>	<b>£12,289.92k</b>	<b>£10,323.23k</b>	16% below plan
<b>Revenue</b>		<b>Budgeted Revenue</b>	<b>Revenue to Date</b>	<b>Comment</b>
Revenue Generated		£0	<b>£51.62k</b>	Revenue received from Scottish Enterprise and Training Courses (refer to Note 11)
<b>Net Total</b>			<b>£10,270.91k</b>	(refer to Note 10)

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## 5) Progress Against Budget

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### Notes:

- 1) Budget-to-date is calculated as a pro-rata of the annual budget in the Full Submission Spreadsheet (to May 2020). The percentage below plan refers to spend-to-date as a percentage of the budget-to-date.
- 2) Project Spend as extracted from the finance system (Harmony) on 4 June 2020.
- 3) Current spend on project team/MTTE resource costs is lower than planned, however an additional resource is being recruited.
- 4) Travel and expenses spend is being kept to a minimum.
- 5) Academic support projects started on 1 June 2016, later than assumed in the Full Submission Spreadsheet.
- 6) Current spend on Learning & Dissemination and Recruitment & Training is lower than planned.
- 7) Spend on the Building is below plan, however building work is planned that will take this above plan.
- 8) Annual running costs (both IT and non-IT) are currently below plan.
- 9) There is no Project budget nor Project spend under the Cost Categories: Equipment, IPR Costs, Payments to Users, Contingency and Decommissioning.
- 10) Up to 31 May 2019 the project had a net spent of £8,899,582 since then the project has spent £1,371,330 (net), up to 31 May 2020; totalling net spend of £10,270,912 (as detailed in the table above).
- 11) Revenue has been received from Scottish Enterprise as part of their support of Business Development for the Centre; and from training course participants.

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## 6) Bank Account

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**A copy of the current project bank account statement is provided in Appendix II.**

## 7) SDRCs

### An update on the Project's SDRCs is provided below.

The MTTE identified eight Successful Delivery Reward Criteria (SDRC) which span both the objectives and the lifecycle of the Project. Furthermore Ofgem's decision letter, dated 27 March 2015, added an additional criteria (SDRC 9.9).


The following table lists each SDRC in chronological order and details the Project's progress towards their achievement.

SDRC	Due	Description	Evidence	Status
9.1	31/8/2014	<b>Formal Agreement with Project Partners.</b> The success of this Project will be crucially dependent on the involvement of the Project partners & stakeholders. Therefore, an early indication of success of the Project is the establishment of formal agreements with the Project partners (National Grid, Scottish Power and NETSO) and HVDC expert support.	Signed agreements with Project partners (National Grid, Scottish Power and the NETSO) (note, agreement will include IP security requirements) and HVDC expert support.	<b>Completed (SDRC met)</b> Formal agreements with Scottish Power and National Grid were signed and concluded on 29 August 2014. Parsons Brinkerhoff was engaged as external HVDC expert support in February 2014.
9.2	31/10/2014	<b>OFTOs and Renewable Developers Event</b> Given the anticipated number of HVDC schemes in GB for connection of offshore renewable, the engagement of OFTOs and Renewable Generators is important to ensure the benefits of the MTTE are maximised, therefore the MTTE Project will hold an event to inform and encourage their participation.	Holding an event to which all OFTOs and Renewable Generators are invited, to inform and encourage their participation in the MTTE.	<b>Completed (SDRC met)</b> The OFTOs and Renewable Generators Event was held in Glasgow on 11 September 2014. In addition, the Project presented to the ENA's OFTO Forum on 20 August 2014.
9.3	31/12/2014	<b>Engagement with 1st HVDC Project</b> The purchase of the 1st set of replica control panels for the MTTE will be key to its success, and the panels will be purchased through an HVDC Project. Therefore the formal engagement of the initial HVDC Project is an important early milestone.	Formal agreement between the MTTE Project and an HVDC Project, which includes the intention to purchase/supply replica control panels through the HVDC Project's procurement process.	<b>Completed (SDRC met)</b> A memorandum of understanding has been signed, between the MTTE Project and the Caithness-Moray Project, confirming the arrangement for the provision and use of replica control panels.
9.4	31/5/2015	<b>Complete Design of MTTE Facility</b> The completed design of the MTTE facility, both technical design and physical design, and the agreement of this design with the Project stakeholders (including vendors), is a key milestone for the Project. The detailed design will be consolidated within the Design Development Document, and will adhere to the requirements defined in the requirements specification.	Design development document and requirements specification for the MTTE facility endorsed by participating vendors and signed-off by SHE Transmission, NGET, NETSO and SPT.	<b>Completed (SDRC met)</b> The Design Development Document and Functional Specification were reviewed at the Design Workshop on 23rd April 2015, following which each stakeholder provided written confirmation of their endorsement.
9.5	31/10/2015	<b>Establishing HVDC Operators' Forum and Website</b> A key component of our knowledge and dissemination strategy is the establishment of	The establishment of the HVDC Operators' Forum (including holding the 1 <sup>st</sup> event), together with the publishing of the MTTE	<b>Completed (SDRC met)</b> The first HVDC Operators' Forum event was held on 8

## 7) SDRCs

SDRC	Due	Description	Evidence	Status
		the HVDC Operators' Forum (to which all Network Licensees, including OFTOs will be invited), the associated members' Website (which provides a secure area to share the MTTE outputs with Transmission Licensees), and the public Website.	Websites.	October 2015, the second on 27 April 2017. The website (hvdccentre.com) was launched in April 2015.
9.6	31/5/2017	<p><b>Commence Operation of the MTTE</b></p> <p>The criteria consolidates the:</p> <ul style="list-style-type: none"> <li>o Completion of the building/upgrade of the MTTE facility;</li> <li>o Commissioning of the IT/RTS infrastructure;</li> <li>o MTTE Resourcing;</li> <li>o Management structure in place;</li> <li>o Processes and procedures agreed;</li> <li>o Data sets of the AC network received (from NETSO); and</li> <li>o Plan of studies and tests agreed.</li> </ul> <p>When all of these are in place, the MTTE will be able to commence operations, therefore this is a key milestone and measure of success of the Project.</p>	Commencement of MTTE Operations.	<b>Completed (SDRC met)</b> The facility was formally opened on 26 April 2017. The building, IT infrastructure, resourcing, governance, processes, data/models and work plan were all in place to enable operation to commence.
9.7	31/3/2018	<p><b>Publishing Studies &amp; Test results</b></p> <p>The key outputs from the MTTE are the reports on specific scenarios which are completed within the MTTE, which will be disseminated to transmission licensees. Therefore, a key success criterion is the publishing of studies or test reports on the MTTE members' Website.</p>	Publishing the first set of reports on a specific Transmission Licensee led Project, on the MTTE members' Website.	<b>Completed (SDRC met)</b> The first set of four reports was published on the Centre's Website on 30 March 2018.
9.8	31/3/2020	<p><b>Future Business Model</b></p> <p>At least 12 months prior to the end of the funded operation of the MTTE (i.e. by end of March 2020), the MTTE management team will submit a proposal for the future operation and funding of the MTTE (post NIC funding), to Ofgem.</p>	Submission of proposal regarding MTTE ongoing operation and funding to Ofgem.	<b>Completed (SDRC met)</b> The Future Business Model report was submitted to Ofgem on 7 February 2020.
9.9	31/3/2021	<p><b>Second Replicas</b></p> <p>Use reasonable endeavours to secure the provision and testing of a second set of replica control panels for the MTTE from a second vendor. The panels would be provided by an HVDC Project, a transmission Licensee or a second vendor.</p>	Submission of evidence of the use of reasonable endeavours for the provision and testing of the second vendor's replica control panels at the MTTE facility; by the end of March 2021.	<b>On Target</b>

 Completed (SDRC met)

 Emerging issue, remains on target

 SDRC completed late

 On target

 Unresolved issue, off target

 Not completed and late

## 8) Learning Outcomes

### Learning during this reporting period

During this reporting period, the HVDC Centre has produced a significant number of reports, held a number of dissemination events, and run a number of training courses to share the project learnings.

These are categorised against the project's learning objectives below.

Learning Objective	Reports, Events & Training
<b>Support Transmission Planning of HVDC schemes</b>	<ul style="list-style-type: none"><li>○ Published a report on maximising HVDC support for Black Start;</li><li>○ Provided technical support to relevant Grid Code modifications;</li><li>○ Co-authored a paper on impact of HVDC energisation on AC protection at the IET DPSP conference in March 2020;</li><li>○ Contributed to industry report on enabling efficient development of offshore transmission networks submitted by OWIC to Ofgem; and</li><li>○ Delivered a large number of relevant webinars.</li></ul>
<b>Improve Requirement Specification of HVDC schemes</b>	<ul style="list-style-type: none"><li>○ Facilitated sharing of knowledge and lessons learnt at the Operators' Forum;</li><li>○ Supporting the technical specifications of the Eastern Link projects;</li><li>○ Chaired the Technology Workstream for OWIC; and</li><li>○ Published offshore transmission technology report.</li></ul>
<b>Facilitate Multi-Terminal HVDC solutions</b>	<ul style="list-style-type: none"><li>○ Demonstrated multi-terminal operation as part of the PROMOTioN Project; and</li><li>○ Developed innovative multi-terminal designs as part of the integrated offshore design work for OWIC;</li><li>○ Facilitated the multi-terminal extension of the Caithness-Moray scheme; and</li><li>○ Authored a paper on multi-terminal extension of HVDC schemes accepted by Cigre 2020 e-session and 2021 centennial session.</li></ul>
<b>Facilitate Competition and Multi-Vendor HVDC schemes</b>	<ul style="list-style-type: none"><li>○ Published and presented two papers on multi-vendor testing of HVDC grid protection at the IET DPSP conference in March 2020; and</li><li>○ Developed scope for investigating multi-vendor (composite) system testing.</li></ul>
<b>De-risk Control interactions between co-located and electrically connected converters, and with other active controlled equipment</b>	<ul style="list-style-type: none"><li>○ Investigated control interaction, as part of the Stability Pathfinder project for the ESO; and</li><li>○ Contributed to CIGRE B4.81 working group to investigate interactions between HVDC schemes and FACTS devices in close proximity.</li></ul>
<b>Train Transmission Planning and Operational Engineers</b>	<ul style="list-style-type: none"><li>○ Delivered Operator/Control Room training;</li><li>○ Delivered RTDS training course; and</li><li>○ Delivered PSCAD training course</li></ul>
<b>Undertake Post commissioning scenario planning and operational optimisation</b>	<ul style="list-style-type: none"><li>○ Involved in the analysis of operational events on the Caithness-Moray scheme.</li></ul>
<b>Model New HVDC Technologies</b>	<ul style="list-style-type: none"><li>○ Tested and demonstrated the operation of IEDs (Intelligent Electronic Devices for HVDC Grids) together with models of HVDC circuit breakers, as part of the PROMOTioN project.</li></ul>



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## 9) IPR

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### IPR

No relevant IPR has been generated or registered during this reporting period.

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# 10) Risk Management

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## Risk Management Plan

The Project has a Project Risk Management Plan that describes how Project risks are managed throughout the Project.

The Project risk register is regularly reviewed by the Project team and the key Project risks are highlighted and discussed at the steering group meetings, where mitigating actions are agreed.

## Risk Register

An extract of the current Project Risk Register is provided in Appendix III.

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# 11) Accuracy Assurance Statement

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## PPR Preparation Steps

To ensure that the information contained in this report is accurate and completed, the following steps have been taken, the report has been:

- Prepared by the Centre Manager;
- Peer Reviewed;
- Reviewed by the Governing Board; and
- Approved by Regulation and Data Assurance representatives.

## Sign-off

As the senior manager responsible for the MTTE Project, I confirm that the processes in place and steps taken to prepare this PPR are sufficiently robust and that the information provided is accurate and complete.



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**Stewart A Reid**  
Head of DSO and Innovation,  
Scottish and Southern Electricity Networks

*8<sup>th</sup> June 2020*

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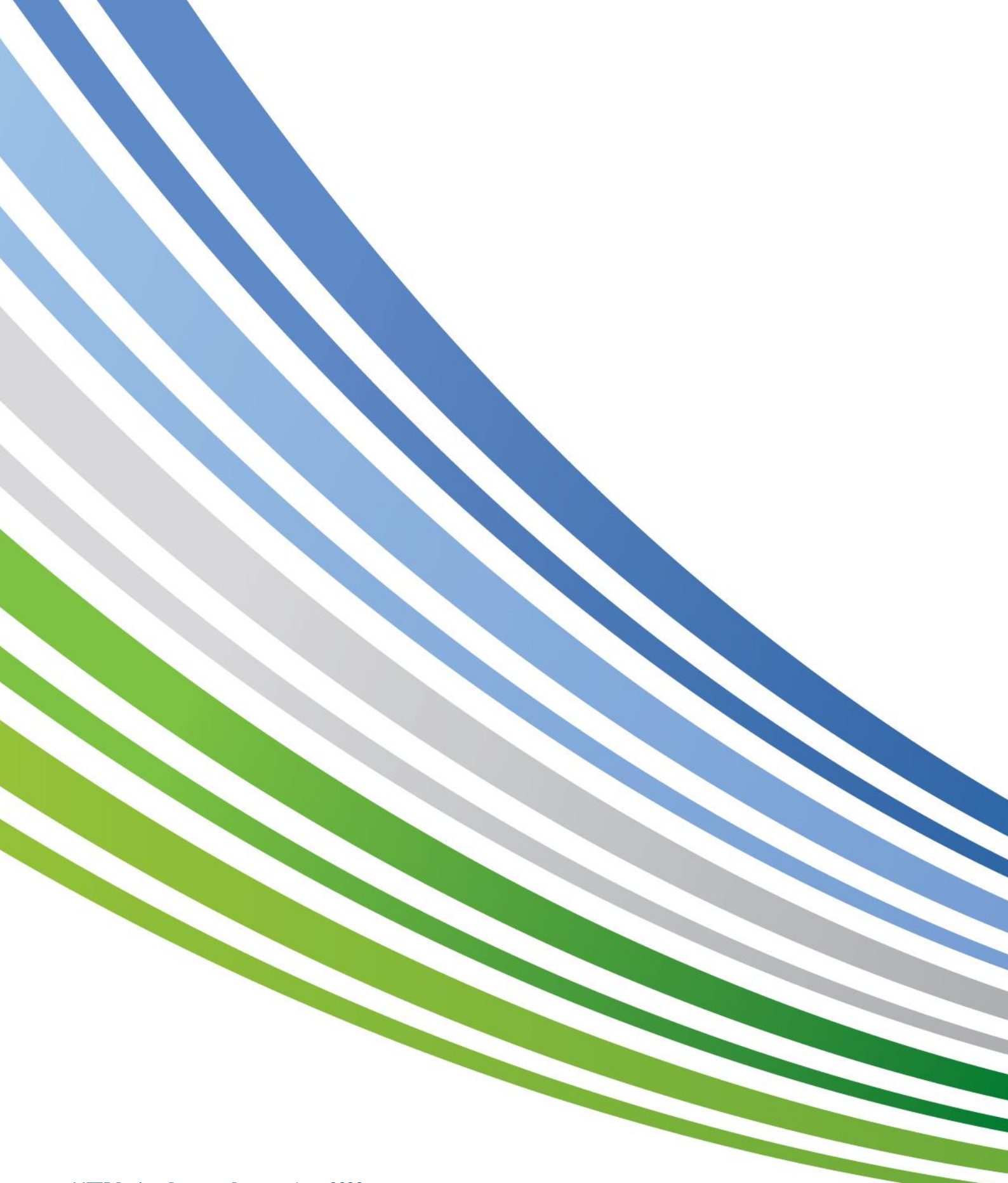
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## 12) Appendices

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<b>Appendix I</b>	Newsletters
<b>Appendix II</b>	Project Bank Account Statement
<b>Appendix III</b>	Project Risk Register



## MTTE Project Progress Report – June 2020

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