



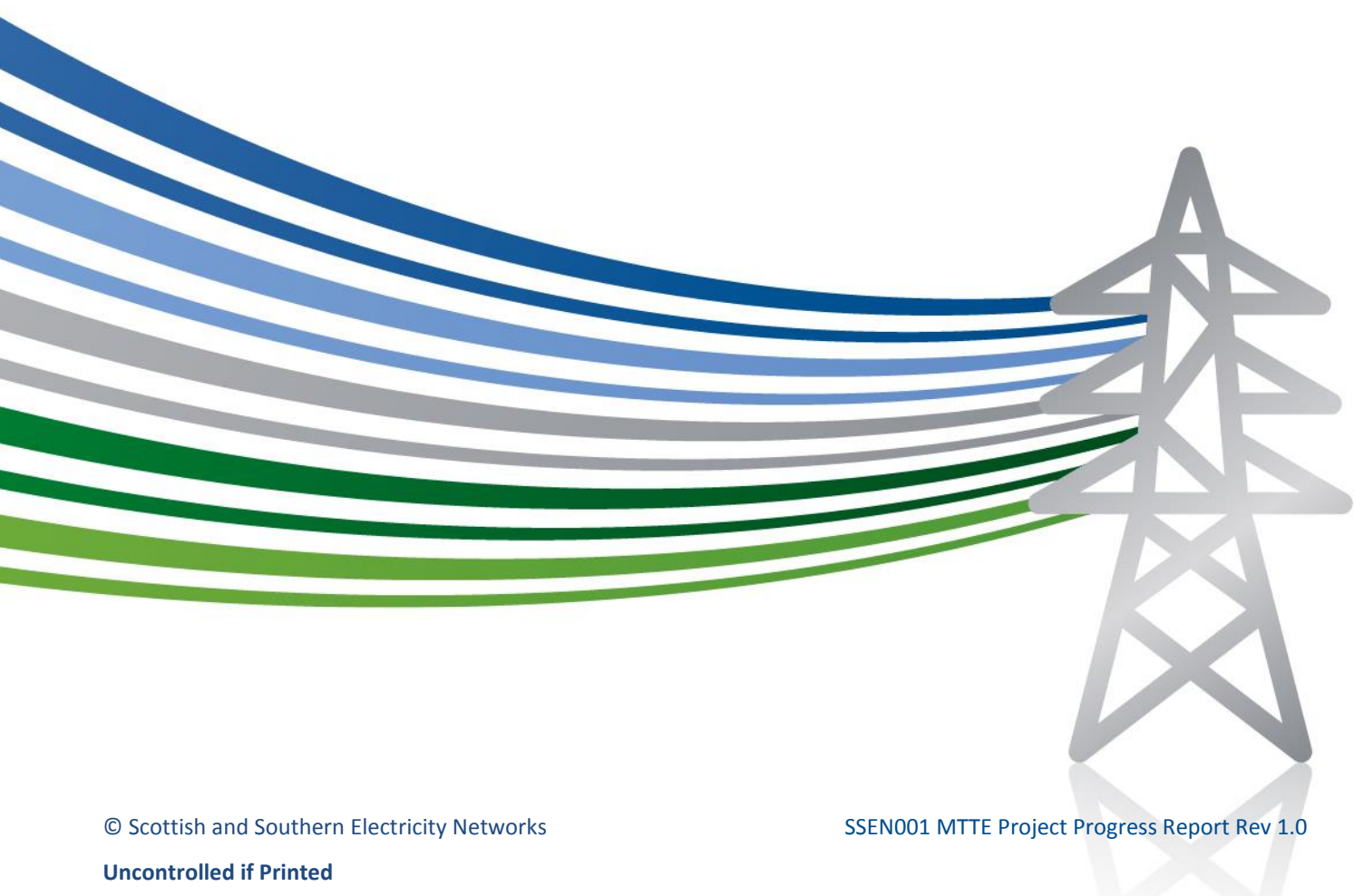
Scottish & Southern
Electricity Networks

SHE Transmission

Multi-Terminal Test Environment for HVDC Systems (SSEN001)

Project Progress Report

June 2018



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 a simulation and training facility, supporting the integration and successful operation of all HVDC schemes connecting to the Grid Network.

The Centre is also:

- GB's real-time testing facility for HVDC schemes using replica hardware to study and resolve network interactions; and
- A 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.

SDRCs

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

During this reporting period, the project successfully completed SDRC 9.7: Publishing the first set of reports on a specific Transmission Licensee led project, on the MTTE members' website.

Progress within this Reporting Period

The key progress this period has been:

- **August '17:** Visit to China State Grid (China) and Mitsubishi (Japan) to discuss Replicas and IEDs (Intelligent Electronic Devices) for protection interoperability testing and real-time simulation;
- **27 October '17:** Delivery of the Eastern HVDC Technology Report to Scottish Power Energy Networks;
- **7 November '17:** Technical Advisory Board (with Scottish Power & National Grid);
- **15 November '17:** Training Course for HVDC Operators;
- **19-22 November '17:** RTDS® Training Course;
- **15 December '17:** Issuing the detailed real-time network RTDS® model to ABB;
- **8 January '18:** Business Development Manager starts in post;
- **2 February '18:** Completion and witnessing of the Factory System Testing (FST) of the CM Replicas (with ABB in Ludvika);
- **23 February:** Completion of the 1st phase of the University of Strathclyde project (Modular Multilevel Voltage Source Converter: Fundamentals and Synthesis of Different Models);
- **15 March '18:** Ofgem published the modified Project Direction (allowing the Project to generate revenues);
- **30 March '18:** Confirmed completion of SDRC 9.7 with publication of reports;
- **26 April '18:** Stakeholder event on the anniversary of the Centre's opening; and
- **30 May '18:** Delivery of the replica control panels for the Caithness Moray project.

2) Project Manager's Report

Project Summary

Now that the HVDC Centre is operational, the focus is on delivering the programme of technical work.

Caithness-Moray Support

The Centre's initial focus has been on de-risking the integration of the Caithness-Moray (CM) Link with the evolving AC network, this has included:

- Reviewing the dynamic performance study report;
- Defining test cases for the CM HVDC Factory System Testing (FST);
- Witnessing and reviewing the FST test results;
- Defining test cases for CM Replicas Factory System Testing;
- Witnessing of CM Replica Factory System Testing; and
- Studying mode transition.

Eastern HVDC Support

The Centre is providing support to the Eastern HVDC project. The first report (HVDC Technology Capability) was delivered in October '17.

PROMOTiON

SHE Transmission is leading Work-Package 9 of the European PROMOTiON Project. This work package will demonstrate the operation of the DC grid protection systems using hardware prototypes with real-time simulation to test and demonstrate DC Grid protection system's interoperability.

Work on this work package formally started on 1 June 2018.

Training

The Centre has delivered a number of training courses (including operator training and RTDS training).

Further training courses are in development.

Research

The Centre continues to engage with academic institutions, and commissioned the University of Strathclyde to investigate "Modular Multilevel Voltage Source Converter: Fundamentals and Synthesis of Different Models".

Business Development

The Centre's Business Development Manager (funded through Scottish Enterprise), was recruited in January '18.

The Centre's communication and marketing strategy has been developed.

The Centre has engaged directly with most of the HVDC Schemes (planned or in operation) in GB.

Communication & Stakeholder Engagement

- **Anniversary Event:** Stakeholders were invited to a tour of the Centre on the anniversary of the opening on 26 April '18.
- **Technical Advisory Board:** On 7 November '17, the Technical Advisory Board meeting was held, which brought together Scottish Power Energy Networks, National Grid (TO & SO) and SHE Transmission to discuss the Centre's activity and plans.
- **3rd HVDC Operator's Forum:** Following the success of the 1st (October 2015) and 2nd (April 2017) Forums, the 3rd HVDC Operators' Forum is being held at the Centre on 21-22nd June 2018; bringing together owners and operators of HVDC schemes in GB to share knowledge and experiences.

2) Project Manager's Report

- **Website (hvdcentre.com):** The website has been updated to reflect the transition from a delivery project, to an operational centre.
- **Newsletter:** The tenth, eleventh, and twelfth, editions of the Centre's Newsletter were published in August, December and March, providing updates to stakeholders and other interested parties [refer to Appendix I for copies of the Newsletters].

Governance

- Bi-monthly Governing Board meetings continue to oversee the work of the Centre (in addition to the Technical Advisory Board meetings).

SDRCs

The Project has previously met the first six Project SDRCs (which are detailed in prior Progress Reports).

During this reporting period, the project successfully completed SDRC 9.7: Publishing the first set of reports on a specific Transmission Licensee led project, on the MTTE members' website, on 30 March 2018.

4 reports were published on the 'Operators Library' section of the Centre's website (hvdcentre.com):

- Commissioning & Operational Support;
- The Replica Project Initial Report;
- Rational for Replicas; and
- HVDC Technology Capability.

Note: There are also a number of other reports that have been shared in the Operators' Library section of the Website.

3) Business Case Update

No changes have been made to the Business Case for the MTTE Project, described in the NIC Full Submission document.

4) Progress Against Plan

Summary of Progress

The project has delivered the operational HVDC Centre within budget, ahead of schedule, and with no safety incidents.

The project is now delivering the technical programme of work, which comprises:

HVDC Projects Support

- Eastern HVDC Support
- Caithness-Moray Project Support
- Spittal Fault Studies
- Model Validation
- FST4 Testing

PROMOTioN

- Work Package 9 (PROMOTioN)
- DC GIS (PROMOTioN)

Training

- Training Course Development
- Operator Training
- Dissemination Activity

Research

- Strathclyde Studies
- Research & Academic Work

Internal

- RTDS Set-up
- Replicas Installation & Commissioning
- Business Development

Risks

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

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

- **R004 A sustainable business model is not achieved for the MTTE after the funded period:** From the start of the Project, it was intended that a self-sustaining business model for the Centre would be developed with the Project partners. Scottish Enterprise has employed a Business Development Manager for the Centre, whose role will include developing the long term operating model.
- **R005 The planned multi-terminal links in GB are cancelled; no other multi-terminal links in GB go ahead:** If no multi-terminal HVDC links are built in GB, the benefit of the MTTE is reduced. However, most of the benefits are applicable to point-to-point links.
- **R012 Lack of continuity in the project team resource during the project:** Project team members are working closely together and sharing knowledge so that knowledge is not held by a single individual.
- **R015 Insufficient external utilisation of the facility:** The Centre team is actively engaged with a number of organisations to specify work, and has already secured the European PROMOTioN project. Furthermore, we have recruited (through Scottish Enterprise) a dedicated Business Development Manager.

4) Progress Against Plan

The following risks have been closed:

- **R009 The Caithness-Moray HVDC project does not supply replica control panels to the MTTE, or the use of the supplied panels is contractually limited.** Since the CM replicas have been installed at the HVDC Centre.
- **R014 The estimated costs are substantially different than actual costs.** Since all major cost items have been procured.
- **R019 The Caithness-Moray (CM) Project is delayed with a knock-on delay to the provision of replicas to The National HVDC Centre:** Since the CM replicas have been installed at the HVDC Centre.

Focus This Reporting Period

As reported in the June 2017 Progress Report, the focus over this reporting period has been:

- Delivering the work plan of studies, and disseminating their results; and
- Developing further work for the Centre.

Both of these activities are progressing well, with the publication of the first set of reports, and significant business development activity.

Key Activities Next Reporting Period

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

- Commissioning of the CM Replicas at the HVDC Centre;
- Supporting the commissioning of the CM HVDC Link;
- PROMOTioN (WP9); and
- Developing further work for the Centre.

5) Progress Against Budget

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

| Cost Category ⁽⁹⁾ | Total Budget | Budget to Date ⁽¹⁾ | Spend to Date ⁽²⁾ | Comment ⁽¹⁾ |
|---|--------------------|-------------------------------|------------------------------|---|
| Labour | | | | |
| Project team resource costs | £2,181.68k | £1,633.83k | £1,167.24k | 28.6% below plan (refer to Note 3) |
| MTTE resource costs | £2,032.13k | £455.75k | £400.03k | 12.2% below plan (refer to Note 3) |
| Contractors | | | | |
| Project team resource costs | £288.44k | £244.06k | £44.70k | 81.7% below plan (refer to Note 3) |
| IT | | | | |
| IT Infrastructure (incl RTS and Replica Panels) | £3,828.21k | £2,051.08k | £2,247.47k | 9.6% above plan (refer to Note 4) |
| Annual Running Costs of the MTTE | £304.37k | £85.82k | £79.71k | 7.1% below plan (refer to Note 8) |
| Travel & Expenses | | | | |
| Travel & Expenses | £197.40k | £107.99k | £35.68k | 67% below plan (refer to Note 5) |
| Other | | | | |
| Academic Support | £827.07k | £474.019k | £210.05k | 55.7% below plan (refer to Note 6) |
| Learning & Dissemination | £165.41k | £94.80k | £20.83k | 78% below plan (refer to Note 7) |
| MTTE Building Facility | £2,916.20k | £2,916.20k | £2,782.12k | 4.6% below plan |
| Annual Running Costs of the MTTE | £515.09k | £145.23k | £14.25k | 90.2% below plan (refer to Note 8) |
| Recruitment & Training | £137.90k | £87.46k | £2.45k | 97.2% below plan (refer to Note 7) |
| Total | £13,393.91k | £8,296.24k | £7,004.54k | 15.6% below plan (refer to Note 10) |
| Revenue | | Budgeted Revenue | Revenue to Date | Comment |
| Revenue Generated | | £0 | £6.25k | Revenue received from Scottish Enterprise |

5) Progress Against Budget

Notes:

- 1) Budget-to-date is calculated as a pro-rata of the annual budget in the Full Submission Spreadsheet (to May 2018). 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 5 June 2018.
- 3) Current spend on project team/MTTE resource costs is lower than planned, however additional resources are being recruited; and the total spend is forecast to be within 5% of the total budget.
- 4) Spend is above plan since payment for the replicas was originally planned for 2019-20.
- 5) Travel and expenses spend is being kept to a minimum.
- 6) Academic support projects started on 1 June 2016, later than assumed in the Full Submission Spreadsheet; the total spend is forecast to be within 5% of the total budget.
- 7) Current spend on Learning & Dissemination and Recruitment & Training is lower than the average spend profile assumed in the Full Submission Spreadsheet.
- 8) Annual running costs (both IT and non-IT) are currently below plan; however the total spend is forecast to be within 5% of the total budget.
- 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 5 June 2017 the project spent £4,397,509, since then the project has spent £2,607,031 (up to 31 May 2018); totalling spend of £7,004,540 (as detailed in the table above).

6) Bank Account

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 | Formal Agreement with Project Partners. 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. | Completed (SDRC met) 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 | OFTOs and Renewable Developers Event 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. | Completed (SDRC met) 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 | Engagement with 1st HVDC Project 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. | Completed (SDRC met) 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 | Complete Design of MTTE Facility 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. | Completed (SDRC met) 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 | Establishing HVDC Operators' Forum and Website A key component of our knowledge and dissemination strategy is the establishment of | The establishment of the HVDC Operators' Forum (including holding the 1 st event), together with the publishing of the MTTE | Completed (SDRC met) The first HVDC Operators' Forum event was held on 8 October 2015, the second |

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. | on 27 April 2017. The website (hvdccentre.com) was launched in April 2015. |
| 9.6 | 31/5/2017 | <p>Commence Operation of the MTTE</p> <p>The criteria consolidates the:</p> <ul style="list-style-type: none"> ○ Completion of the building/upgrade of the MTTE facility; ○ Commissioning of the IT/RTS infrastructure; ○ MTTE Resourcing; ○ Management structure in place; ○ Processes and procedures agreed; ○ Data sets of the AC network received (from NETSO); and ○ Plan of studies and tests agreed. <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. | Completed (SDRC met) 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>Publishing Studies & Test results</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. | Completed (SDRC met) The first set of four reports was published on the Centre's Website on 30 March 2018. <i>[refer to Appendix IV for details]</i> |
| 9.8 | 31/3/2020 | <p>Future Business Model</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. | On Target |
| 9.9 | 31/3/2021 | <p>Second Replicas</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. | On Target |

 Completed (SDRC met)

 Emerging issue, remains on target

 SDRC completed late

 On target

 Unresolved issue, off target

 Not completed and late

8) Learning Outcomes

The following learning objectives have been set for the MTTE Project:

- **Support Transmission Planning of HVDC schemes:** The National HVDC Centre will produce analysis and reports on the development scenarios investigated, and will share these with the other TOs/OFTOs to increase the understanding of the impact of HVDC development scenarios on the existing network. In addition, the models developed will be shared with Network Licensees.
- **Improve Requirement Specification of HVDC schemes:** The National HVDC Centre will produce analysis and reports advising Network Licensees on the specification of HVDC schemes. These reports will be shared with other Network Licensees to increase their understanding.
- **Facilitate Multi-Terminal HVDC solutions:** The National HVDC Centre will produce analysis and reports on the Multi-terminal scenarios, and will share these with the other TOs/OFTOs to increase the understanding of Multi-Terminal HVDC.
- **Facilitate Competition and Multi-Vendor HVDC schemes:** The National HVDC Centre will produce reports on multi-vendor compatibility to inform the development of HVDC standards and interoperability. Acceptance testing reports will also be produced.
- **De-risk Control interactions between co-located and electrically connected converters, and with other active controlled equipment:** The National HVDC Centre will produce reports on the impact of planned HVDC systems, providing detail on any control interactions with converter stations in close proximity and active controlled equipment. These reports will be shared with all Licensees to improve sector-wide understanding of the associated issues. This would include reports on the integration of generators into HVDC networks and the associated risk of adverse control interactions and their control protocols and strategies.

- **Train Transmission Planning and Operational Engineers:** The National HVDC Centre will provide on-site training (available to all Transmission Licensees) and will share the associated training material.
- **Undertake Post commissioning scenario planning and operational optimisation:** The National HVDC Centre will produce recommendation reports on specific HVDC schemes to enable optimisation which will be shared with all Licensees.
- **Model New HVDC Technologies:** The National HVDC Centre will produce analysis and reports on the performance, impact and interactions of new HVDC technologies or active controlled devices in accurately simulated GB situations and their suitability for specific applications / locations.

Learning during this reporting period

During this reporting period 4 reports were published on the 'Operators Library' section of the Centre's website (hvdccentre.com):

- Commissioning & Operational Support;
- The Replica Project Initial Report;
- Rational for Replicas; and
- HVDC Technology Capability.

9) IPR

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

10) Risk Management

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.

11) Accuracy Assurance Statement

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 by an NIC Project Manager;
- Reviewed by the Centre Sponsor; and
- Approved by the Project Director and Regulation.

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.



Stewart A Reid

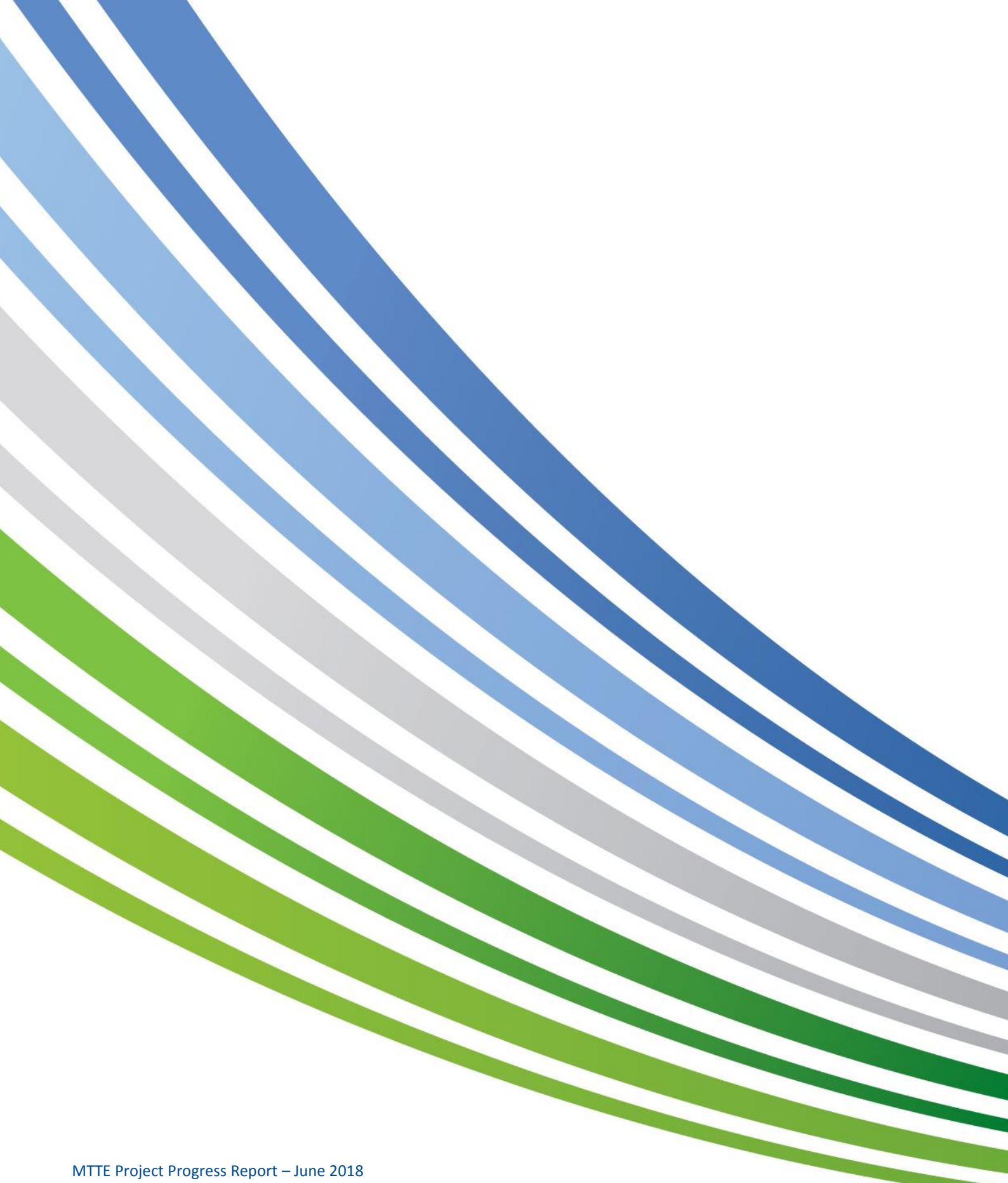
Head of DSO & Innovation
Scottish and Southern Electricity Networks

14 June 2018

Date Date

12) Appendices

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|---------------------|---|
| Appendix I | August 2017, December 2017 and March 2018 Newsletters |
| Appendix II | Project Bank Account Statement |
| Appendix III | Project Risk Register |
| Appendix IV | First Set of Reports |



MTTE Project Progress Report – June 2018

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