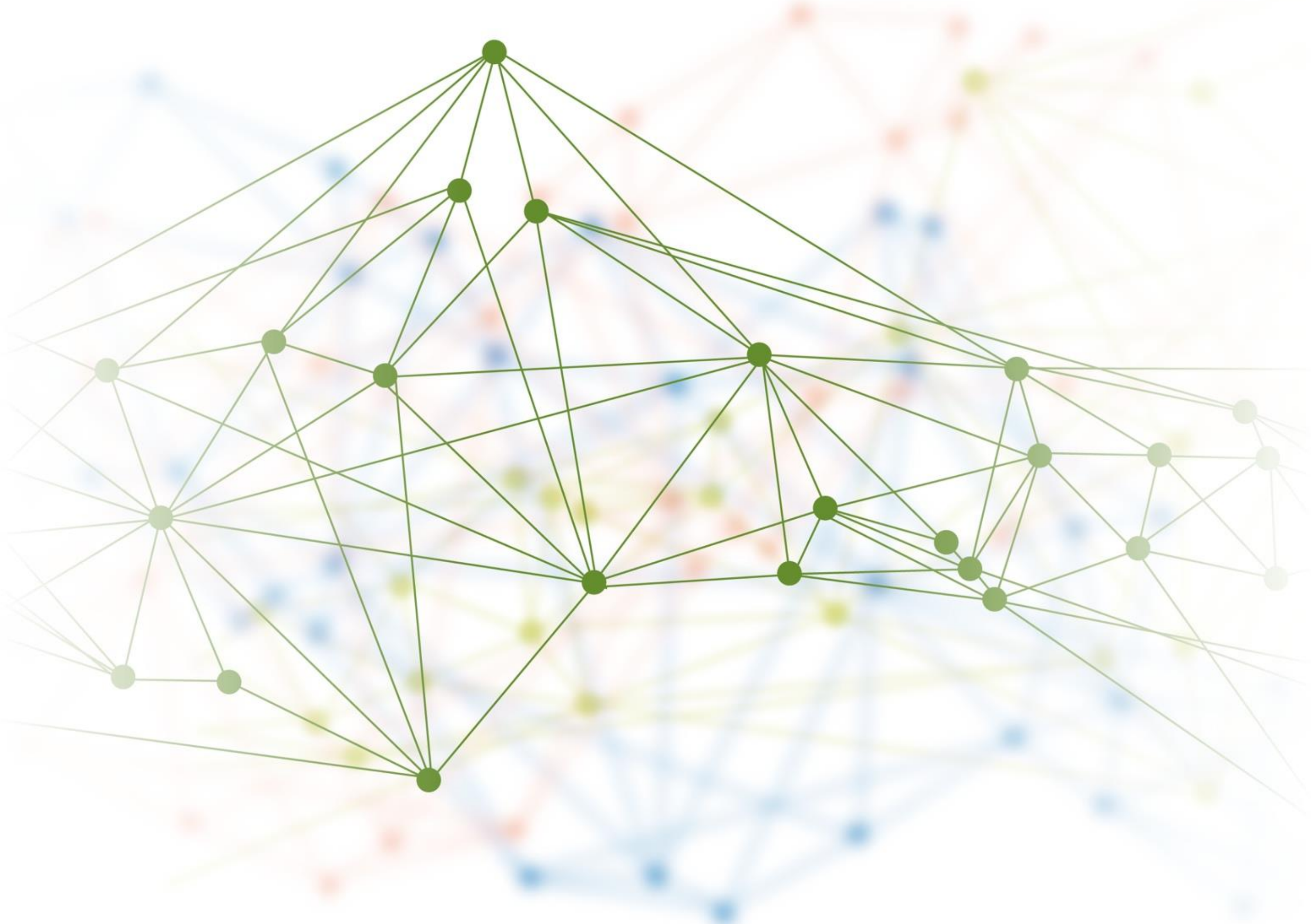
PHOENIX

Project Progress Report 2020



About Report		
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Contents

Executive Summary

SP Transmission (SPT), supported by project partners ABB, National Grid ESO, The University of Strathclyde and The Technical University of Denmark made a full proposal submission for the project, *Phoenix – System Security and Synchronous Condenser,* under the Network Innovation Competition (NIC) mechanism in 2016. Ofgem approved the proposal and issued the Project Direction on the 16th of December 2016. The awarded project budget is £17.64m.

Phoenix will demonstrate a sustainable design, deployment and operational control of a Synchronous Condenser (SC) with innovative hybrid co-ordinated control system combined with a static compensator (STATCOM) flexible AC transmission system (FACTS) device, referred to in the project as a Hybrid Synchronous Compensator (H-SC).The use of these devices is expected to mitigate serious system issues that are being re-introduced on the GB Transmission Network as a result of the progressive closure of synchronous generation plants.

The project will enable an efficient composite solution that will enhance system stability and security while maintaining power quality and supply to GB customers.

During the current reporting period, the main focus has been on closing out work package 1 which resulted in the successful completion of all construction works and the energisation of the world's first H-SC to the GB Network on 23rd October 2020. However, unfortunately the siteworks did suffer some delays as a result of the Covid-19 pandemic which restricted works from the end of Q1 2020, more about this within the Covid-19 section on page 11. Following energisation, the H-SC has now started it's Live Trial where we are working through a programme of agreed tests which will trial each operational mode. Data from the first set of tests is currently being analysed and will continue on a monthly basis through the next reporting period.

Project Highlights

This is the fourth annual progress report for the Phoenix project, covering the project delivery period January 2020 – December 2020, referred to within as *"the reporting period".*

The project delivery is no longer in line with the original time scales. During the last annual progress report, it was noted that there were slight delays related to the design of the innovative master control system. With the design closed out early in this current reporting period, the programme was aligned to start commissioning at the start of Q2. However, the Covid-19 pandemic and subsequent unforeseen restrictions meant that progress on site slowed down. Many of the issues suffered were linked to the new Phoenix Control Building, where both SPEN and ABB Site Teams had to work together in order to follow safe distancing protocols as well as reassessing the programme when some of the subcontractors on site were unfortunately put on furlough for a period of time. It should be noted that the delays suffered this year are still within the OFGEM NIC Terms & Conditions with regards to material delays.

In order to mitigate risks with regards to network outages that were booked for the energisation phase, a plan was conceived and agreed with all relevant stakeholders where the outage would be taken to only energise the Synchronous Condenser branch of the H-SC, drawing load through the main transformer in order to prove the new protection scheme. This plan eliminated the risk of securing another network outage, when at this time other major transmission projects were starting back up after lockdown restrictions were relaxed. With the 275kV transformer energised, protection proven, and SC commissioned this allowed us to focus on completion of the Phoenix Control Building and STATCOM branch to allow energisation of the world's first Hybrid Synchronous Condenser in late October 2020.

Given the challenges this year, the Phoenix team would like to extend a thank you to all who contributed during to the challenges faced this year.

Following on from the H-SC energisation, the Live Trial phase has now commenced. SPEN, ABB and NGESO collaboratively worked on an agreed programme of tests based on learnings from the Control System FAT and workshop earlier this year. There is now an agreed programme of tests in place for the first six months of the trial, with the view to assess and analyse all the data and learnings in order to decide the programme of tests for the latter six months of the trial phase.

The most significant SDRCs and updates which have been delivered and / or updated during the reporting period have been highlighted below:

<u>Work Package 1 - Technology (H-SC Design, Install & Build)</u>

- Report on site installation process, details and recommendations for future – Civil (SDRC 6.1)
- Report on SAT procedure and test results (SDRC 6.3)

<u>Work Package 3 – Commercial & Regulatory</u>

- Report on value evaluation of SCs/H-SCs based on pilot installation and performance (SDRC 2.4)

<u>Work Package 4 - Technology (H-SC Control System and Methodology)</u>

- Report on SAT test procedure and results of pilot hybrid co-ordinated control system (SDRC 3.6)

<u>Work Package 6 – Knowledge Dissemination</u>

- Phoenix Annual Progress Report (SDRC 8.4)

Project Risks

We monitor risks on a continuous basis with regular review at weekly Project Management Meetings and Monthly Project Team Meetings, as well as regular discussions with all project partners. The key risks are summarised below, with further details in Appendix 2.

Technical Risks

The following technical risks relating to the H-SC Design and Operation have been identified during the current reporting period. Through risk mitigation meetings, we have control measures in place to manage these risks, as well as reviewing them monthly;

- Failure with Collaboration
- What if the H-SC model does not work for the ongoing studies?
- Plant and Equipment Compliance

In order to mitigate and control these risks, SPEN has been involved in regular communications with all project partners to ensure the models are accurate and work as planned when conducting system studies. Any issues with models are discussed, with updates made accordingly by the model creators.

From an equipment compliance perspective, SPEN Standards and Design team are involved in design review of all equipment and components, including witnessing many Factory Acceptance Tests (FATs) throughout the current reporting period.

Project Management Risks

The following Project Management risks have been identified during the current reporting period. Through risk mitigation meetings, we have control measures in place to manage these risks, as well as reviewing them on a monthly basis;

- Resource Planning
- Review of Deliverables
- Clarify and alignment of all programmes
- Covid-19

With regards to resource planning, review of deliverables and the alignment of programmes SPEN requested monthly updates from all partners which included a review of the programme and document registers. This information was then aligned monthly with all other works. The programme is reviewed on a monthly basis to proactively minimise delays by running site activities in parallel. However, given the global pandemic this year, there was additional emphasis on programme management to ensure works could happen whilst also following SPEN and Government guidelines with regards to safe distancing and hygiene protocols.

Site Work Risks

The following Site Work & Construction Risks have been identified within this reporting period. Through risk mitigation meetings, we have control measures in place to manage these risks, as well as reviewing them on a monthly basis;

- Outages Management
- CDM / H&S
- RAMS and site documentation
- Delays to Sitework / Commissioning Works

To mitigate and control these risks, SPEN Projects and ABB have been proactively reviewing the programme monthly to eliminate risk and delay, with the view run works in parallel as mitigation measures to delays.

ABB have taken on additional construction resource on site to assist with installation and commissioning works in order to minimise delays. In line with Covid-19, particular attention had to be taken to maintain 2m social distancing whilst working indoors. This put additional emphasis on the management of the Phoenix Control Building programme, working collaboratively between SPEN and ABB Site Teams.

Project Managers Report

This section highlights the projects' key activities, milestones, risks and learning over the fourth reporting period (January 2020 - December 2020).

Project Progress Summary

The significant achievements during the reporting period are as follows:

- **Control System Workshop at ABB's offices in Västerås, Sweden** – Following the Control System FAT in the previous reporting period, it was agreed between SPEN and ABB to have a follow-up workshop. The purpose of this workshop was for SPEN to further learn and understand how the new innovative MACH Control System works.
- **Auxiliary & Earthing Transformer FAT** – Due to some Covid-19 related delays in the supplier's factory in Portugal, it was agreed for SPEN to attend virtually. This was a new process for SPEN,

who had to adapt to travel restrictions. This FAT involved filming, photos and daily progress meetings.

- **Covid-19 Pandemic** – Phoenix was considered a critical project by SPEN Senior Management wi as its operation would help strengthen the grid, meaning that the construction works was allowed to continue throughout 2020. As a result, the Phoenix project team carried out a risk assessment of all ongoing and upcoming tasks on site and set out new rules. This included revised safe systems of work, installation of hand-wash stations, one-way systems, mandatory use of facemasks and reduced numbers within site offices.
- **Installation Works** – Due to Covid-19, the installation works suffered some delays throughout the summer. This was primarily a result of travel restrictions (UK and Europe) and subcontractors moving onto furlough. However, Phoenix continued to progress, albeit at a slower rate, which resulted in the installation works finishing several months behind schedule
- **Training –** Similarly to the installation works, this was affected by Covid-19. The H-SC training by ABB for the SPEN Transmission operatives consists of two parts; classroom training followed by on-site training. The classroom training was rolled out virtually via MS Teams which was well attended by SPEN Transmission operatives and Control Room Engineers. The safe distancing control measures introduced restrictions for the second half of the training, particularly within the new Phoenix Control Room on site. Therefore, it has been agreed that ABB will be rolling out the on-site training in early 2021.
- **Commissioning & Energisation** – following the installation delays to the Control Building (STATCOM branch), it was agreed between SPEN Transmission Ops and ABB to follow a unique approach and only energise the Synchronous Condenser branch of the H-SC at this stage. The reason for this approach was to take advantage of the network outage already booked with National Grid and mitigate any risks of having to book further outages at a time when other transmission projects were starting back after the initial Covid-19 restrictions were relaxed for construction sites. Following successful energisation of the Synchronous Condenser, the building works were completed, allowing successfully commissioning of the STATCOM branch and energisation of the world's first H-SC on 23rd October.
- **Live Trial –** Based on learnings from the Control System FAT and Workshop, there was a collaborative approach to the programme of testing for the trial period. SPEN, NGESO and ABB agreed a programme of tests which will work through each operational mode for the first six months, with changes agreed to take place every three to four days from the Control Room. The idea was to then have a meeting to review what tests we would like to see repeated or any new tests for the remaining six months.
- **Commercial Working Group** – The full Commercial Working Group met three times during the current reporting period. Due to the Covid-19 pandemic, the decision was made to host these meetings on-line throughout April, July and December to review progress on the ongoing commercial products (SDRC 2.5 and 2.7), as well as taking into consideration learnings from other industry processes such as NG's Stability Pathfinder.
- **Site Visits –** Fortunately, despite the Covid-19 pandemic and associated restrictions, there have been two knowledge dissemination visits to Neilston Substation. The first visit was from Edinburgh University pre-Covid in Q1 of the current reporting period and the second was a socially distanced visit from Statkraft
- **Video Footage –** The Phoenix team has been working closely with a design studio who have been capturing drone footage of the construction works since early 2019. This has been used to create a video which captures the full site works. The video also features Senior Management and Directors from both SPEN and ABB and was posted to LinkedIn and Social Media following successful energisation of the H-SC

Work Package Overview

Given the delays suffered this year, in Q4 Phoenix was energised to the network which concludes the end of the Implementation stage. The project has now entered the validated stage where the Live Trial has started. There is a programme of tests in place and agreed with both SPEN and NGESO Control rooms which is now being worked through, with SPEN, ABB and NGESO analysing data from the first tests carried out at the end of the current reporting period. The system studies looking at H-SCs of different capacities and locations with the GB Network are now being concluded where results will be published within Q1 of the next reporting period.

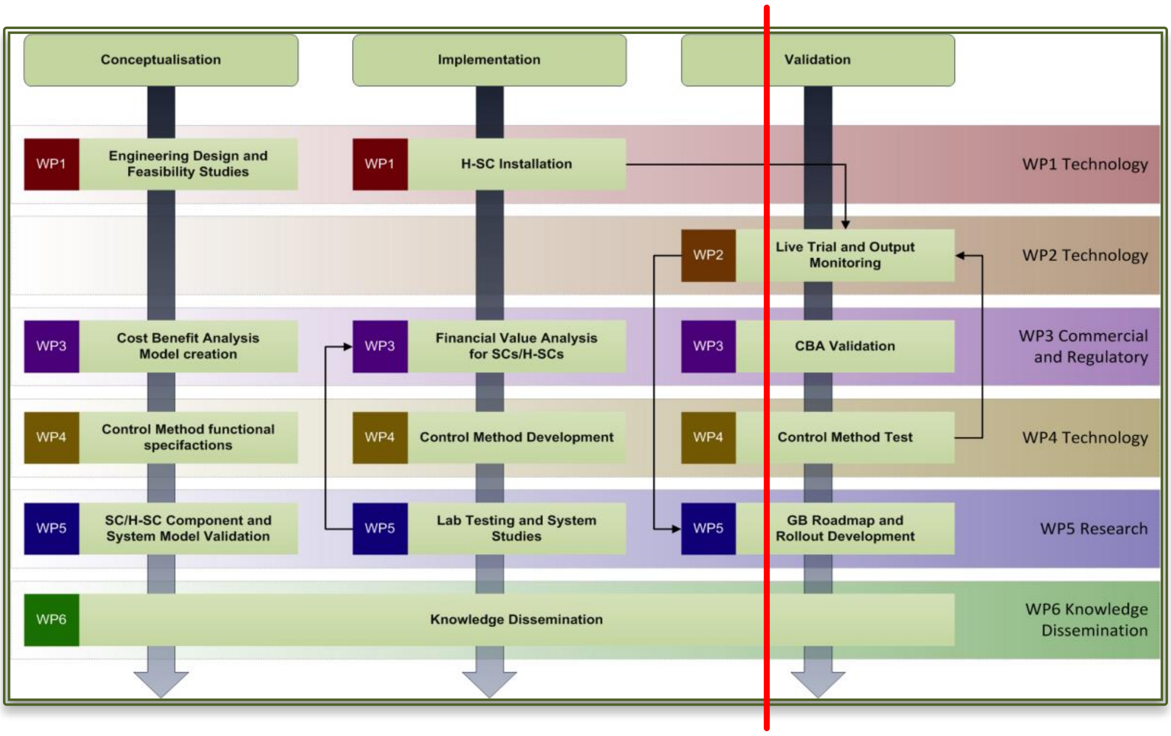


Figure 1 – Phoenix Work Packages

<u>Work Package 1 – H-SC Design, Install & Build</u>

- The installation works concluded, despite challenges faces by the Covid-19 Pandemic
- Commissioning was successfully completed which allowed the world's first energisation of an H-SC in late October 2020

<u>Work Package 2 – Live Trial</u>

- The Live Trial phase has now begun, following successful commissioning period
- SPEN, NGESO and ABB worked collaboratively to create a programme of tests to be carried out during the Live Trial, which has been agreed between both SPEN and NGESO Control Rooms.
- A "virtual" working group between the three parties has been set-up to review any issues during the trial when it comes to switching between different operational modes and tests

Work Package 3 – Commercial & Regulatory

- Further work on commercial impacts and regulatory considerations reports which make up both SDRC's 2.5 and SDRC 2.7. These reports were drafted for review at the end of the current reporting period and have been issued to the Commercial Working Group for their final input.
- Further work on wider value assessment (SDRC 2.6).
- Due to the Covid-19 pandemic, the Phoenix Commercial Working Group met three times via MS Teams in April, July and December. During these meetings the group reviewed and had input to producing SDRC 2.5 and 2.7.

Work Package 4 – H-SC Control System and Methodology

- Following a successful workshop between SPEN and ABB, the Control System philosophy is now further understood where all teething issues were resolved regarding visibility from the H-SC to SPEN's SCADA system
- All learnings from the FAT and workshop were captured, which aided the creation of the Live Trial programme of tests. This helped the Phoenix project team understand what the Control System could do, with these learnings captured within monthly reports during the trial phase

Work Package 5 – Research

- System Studies have progressed well during the current reporting period and includes:
    - Assessing the impact of synchronous condensers geographical allocation to system inertia in both the SPT region and the whole GB network
    - Assessing the contribution of synchronous condensers and Battery Energy Storage System (BESS) together
    - Assessing different ratings of H-SC
- Component Studies have progressed well during the current reporting period and includes:
    - Further development of the BESS model and analysing this through simulations assessing Grid forming converter control application its performance during current limit activation

Work Package 6 – Knowledge Dissemination

- Fortunately, despite the Covid-19 pandemic and associated restrictions, we were able to hold two knowledge dissemination visits to Neilston Substation in 2020. The first visit was from Edinburgh University MSc students pre-Covid in Q1 of the current reporting period and the second was a socially distanced visit from Statkraft to learn more about the construction works as they are involved in a similar project
- SP Energy Networks has been working closely with a design studio who have been capturing drone footage of the construction works since early 2019. This has been used to create a video which captures the full site works. The video also features Senior Management and Directors from both SPEN and ABB and is available via SP Energy Networks LinkedIn and Youtube.

Covid-19

The effects of the Covid-19 this year have been well documented causing disruption both personally and in our work lives. The UK Government introduced restrictions and protocols at the end of Q1 meaning everyone moved from offices to working from home which included the shutdown / postponement of major construction projects. Fortunately, as one of SPEN's flagship Transmission Innovation projects, Phoenix was deemed essential works due to the potential significant benefits such as strengthening the network, maintaining security and quality of supply to customers. This decision, made by SPEN Senior Management and agreed with ABB, allowed works to commence on site albeit at a slower rate. The main issue that faced the Phoenix project related to subcontractors who were furloughed meaning their works had to stop or could not start, primarily in and around the new Phoenix Control Room. Additionally, the travel restrictions in place meant that subcontractors from both UK and Europe could not come to site as planned and / or had to obtain additional paperwork as they were deemed essential workers in line with the decision to make Phoenix an essential project.

The major focal point from a SPEN perspective was to ensure the Site Welfare facilities were safe and correctly followed all UK Government guidelines. This included enhanced daily cleaning, social distancing measures, one-way systems and reduced numbers in site offices. Together, with collaboration from all contractors on site, this allowed Phoenix to progress all tasks on an adjusted programme to suit the above protocols.

This is credit to the positive approach from both SPEN and ABB site teams as well as all subcontractors on site who made the effort to continue working ensuring full compliance with UK Government guidelines and public health advice.

Some photographs have been included below showing examples how Phoenix ensured compliance include reduced room capacity, followed two metre spacing, tape markings to reinforce boundaries and a one-way system in the site offices.

Figure 2 – Photos showing Covid-19 site control measures

Construction and Installation Works

This section summaries the site works activities carried out at Neilston 275kv Substation. At the start of the current reporting period, Phoenix was scheduled to complete the final installation works by the end of Q1 before then commencing commissioning. As mentioned in previous sections, this is around the same time when the Covid-19 pandemic hit the UK meaning offices and construction sites were starting to close as a result with many major projects postponed. However, the Phoenix project was classed as essential works given the benefits to the network and the unique position where any issues would also not cause effect to the surrounding transmission network. As a result, both SPEN and ABB Site teams were required to assess the programme, mitigate risks in accordance with t SPEN/UK Government Covid-19 protocols. and take actions in a pragmatic way to ensure works continued safely.

One of the main issues that effected Phoenix at this stage were subcontractors who were being put onto the furlough scheme, therefore not being able to start and/or finalise their works at site. Additionally, SPEN and ABB Site teams had to follow the Government guidelines which were put in place at site such as restricting the number of persons at site and working in a safe manner following distancing rules, particularly in the Phoenix Control Room. Lastly, due to the travel restrictions in place, contractors from both UK and Europe were not in the position to travel as originally scheduled.

As a result, these challenges meant that work slowed down on site to ensure all tasks were completed safely in line with UK Government guidelines and naturally there were delays to the start of commissioning and subsequently the energisation of the H-SC and start of Live Trial.

Installation

In the first half of the current reporting period SPEN and ABB Site Teams continued with the installation of the main transformer, synchronous condenser and its noise enclosure, whilst progress on the STATCOM building and Phoenix Control Room slowed in order to manage the challenges highlighted above. One of the last installation activities was the installation of the two smaller transformers (Auxiliary & Grounding Transformer and the Earthing Transformer) which was complete end-May.

Figure 3 – Installations Works

Commissioning & Energisation

Considering that there was a network outage booked and the risks associated with missing this, it was agreed between SPEN SAP, Transmission Ops, SPEN Site Team and ABB to progress with commissioning of the Synchronous Condenser branch only at this stage. This approach allowed Phoenix to continue with the scheduled outage booked with National Grid and mitigate the potential risks of having to arrange another outage at the time when other transmission projects were given the go-ahead to start back on site after the initial Covid-19 restrictions were relaxed. Following successful energisation of the Synchronous Condenser, the building works were completed allowing the commissioning of the STATCOM branch and Master Controller to allow the world's first energisation of an H-SC on 23rd October.

Figure 4 – Final Drone photographs of Phoenix H-SC

Live Trial

The planning for the Live Trials started in March 2020 with SPEN, ABB and NGESO working collaboratively on understanding the capabilities in order to plan the testing to be undertaken. Following several meetings, the test procedures were then drafted in a report and programme so ensure Phoenix was ready to start the Live Trial upon energisation.

The main purpose of the live trial tests is to verify the H-SC master controller's performance to control the hybrid devices. The key master controller functions developed in the project are:

a) Co-ordinated Voltage Control and Reactive Power Sharing/drop
b) Power Loss Minimisation- Q setpoint or slope to minimize loss
c) Fast Transients Compensation-fast transient compensation
d) Inertia Support Maximisation
e) Losses Calculation –calculate H-SC loss
f) Slow MVAr Control –supplementary slow VAR control

Scope

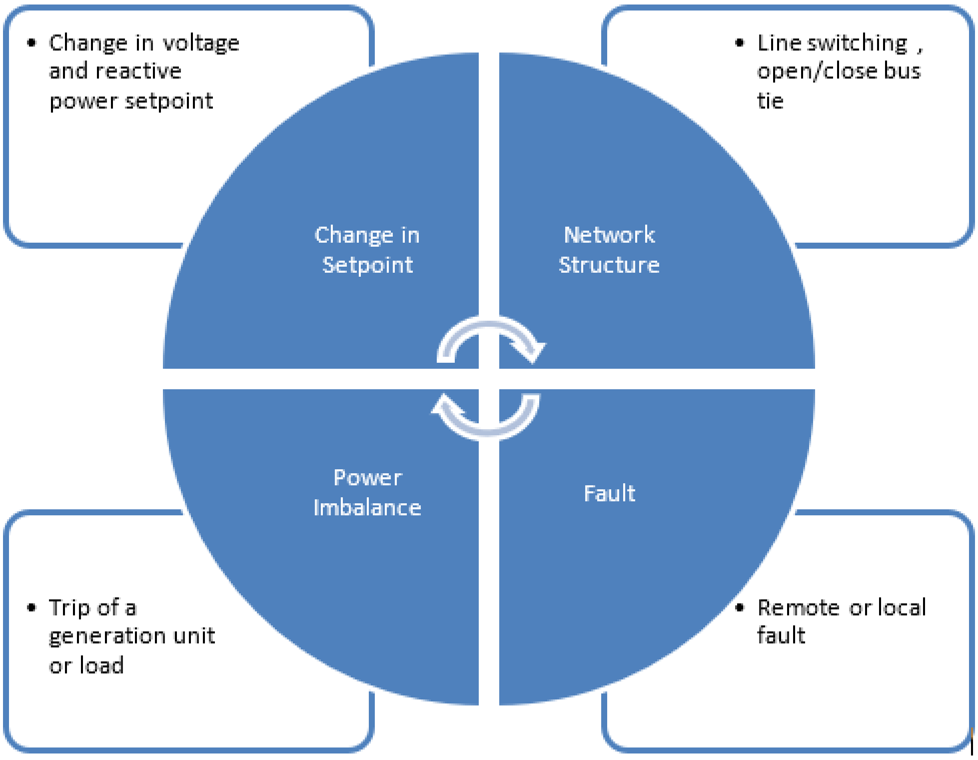
The scope of the live trial is limited to:

a) Setpoint: This is related to the change in setpoint for the H-SC bus from the operator. The setpoint could be voltage or reactive power reference.
b) Network structure: Here the switching of the lines, bus tie and other switching events (e.g. reconfiguration) in the network are considered. The aim is that the change in network structure would have an impact on the H-SC bus voltage and so the H-SC device responds to that event.
c) Power imbalance: a generator trip or larger load switching event can result in frequency drop in the system and these cases are ideal scenarios to investigate the inertial contribution of the H-SC device
d) Fault: The fault in the network would initiate H-SC to react. While for a distant fault, the H-SC is expected to see a voltage drop, for a local fault at the H-SC bus the SC should inject its contribution to the fault current and STATCOM must go into the current limitation mode (limited at 1.19 p.u.)

Test Scenarios for Live Trial

The test scenarios and test methods for master controller functions are identified within Figure 5 to Figure 7 below.

Figure 5 - Test Scenarios (in circle) and how they can occur (outside circle)



Scenarios / Master controller functions	Change in setpoint	Network Structure	Power Imbalance	Fault
a. Co-ordinated Voltage Control and Reactive Power Sharing/droop	X	X		
b. Power Loss Minimization- Q setpoint or slope to minimize loss	X	X		
c. Fast Transients Compensation- fast transient compensation	X	X		X
a. Inertia Support Maximization			X	X
b. Power Loss calculation of H-SC*	X		X	
f. Slow MVAr Control – supplementary slow VAR control	X	X		

Figure 6 – Verification of Master Controller Functions

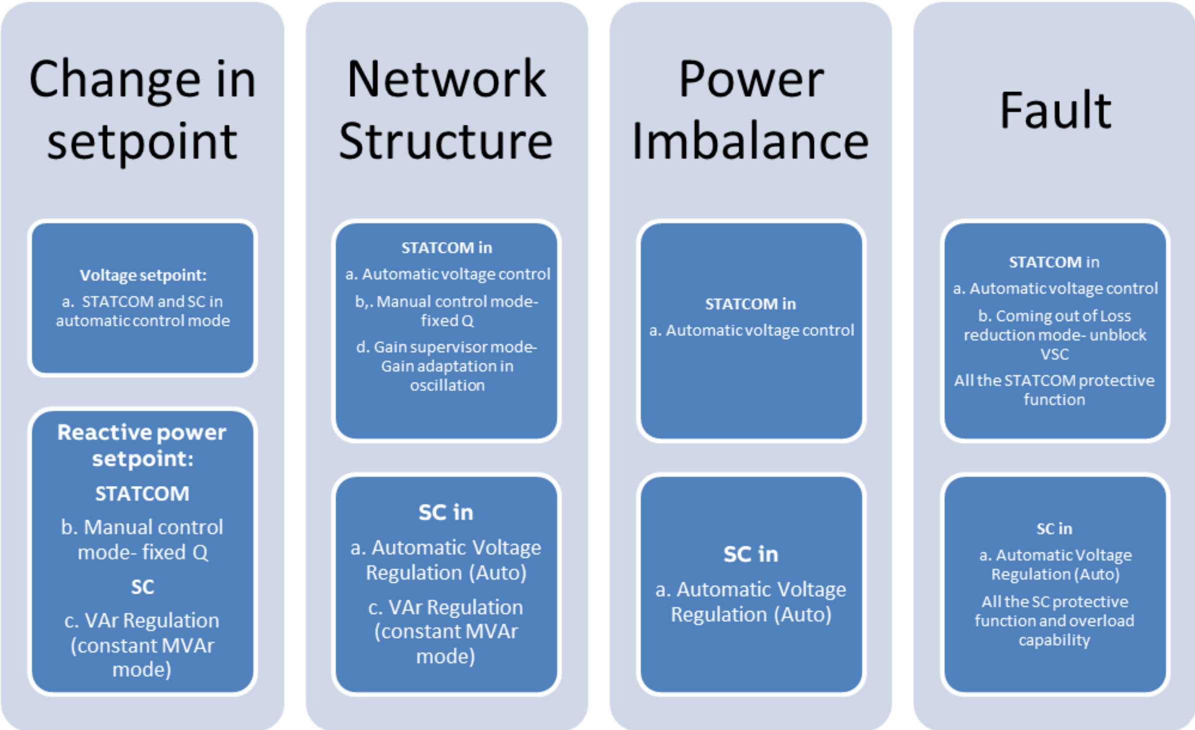


Figure 7 – Control Modes of STATCOM and SC in Various Scenarios

Data Monitoring and Analysis

The performance monitoring of the H-SC is done through the MACH control system which is supplied with an integrated Transient Fault Recorder (TFR). In addition, the Control System HMI comes with software tools to display and record historical trends and lists of events, alarms and faults. Secondly, the other source is data is the SPEN supplied Wide Area Monitoring (WAM) unit installed within the Phoenix Control Room. Together, both sources of data will be collected by SPEN and issued to ABB and NGESO for analysis. The high- and low-resolution data from the TFR is shown below in Figure 8. The programme of tests has been created for the first six months with the Phoenix Project team to assess data and agree the second half of testing based on monthly reports produced by ABB.

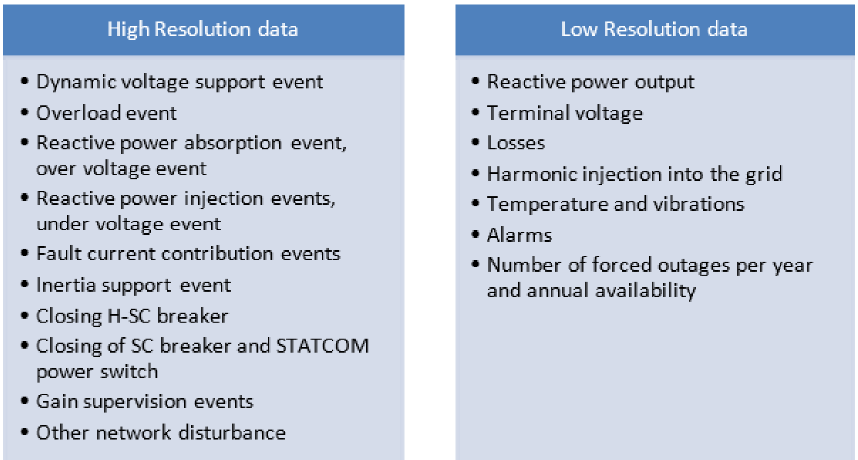


Figure 8 – TFR Data

Commercial Work Package

Introduction

This section summarises work on the Phoenix commercial work package during the current reporting period. This includes work to assess the value that H-SCs and similar equipment could bring to GB consumers through system support services, and work to consider how this value is best accessed in the GB market through options for asset ownership and commercial service development.

The commercial work package is supported by an independent Commercial Working Group representing a range of GB stakeholders and by wider international experience of similar assets and services. The main elements of the work to assess and access value are illustrated in Figure 9 below. Work on SDRCs 2.1, 2.2 and 2.3 was completed during previous reporting periods.

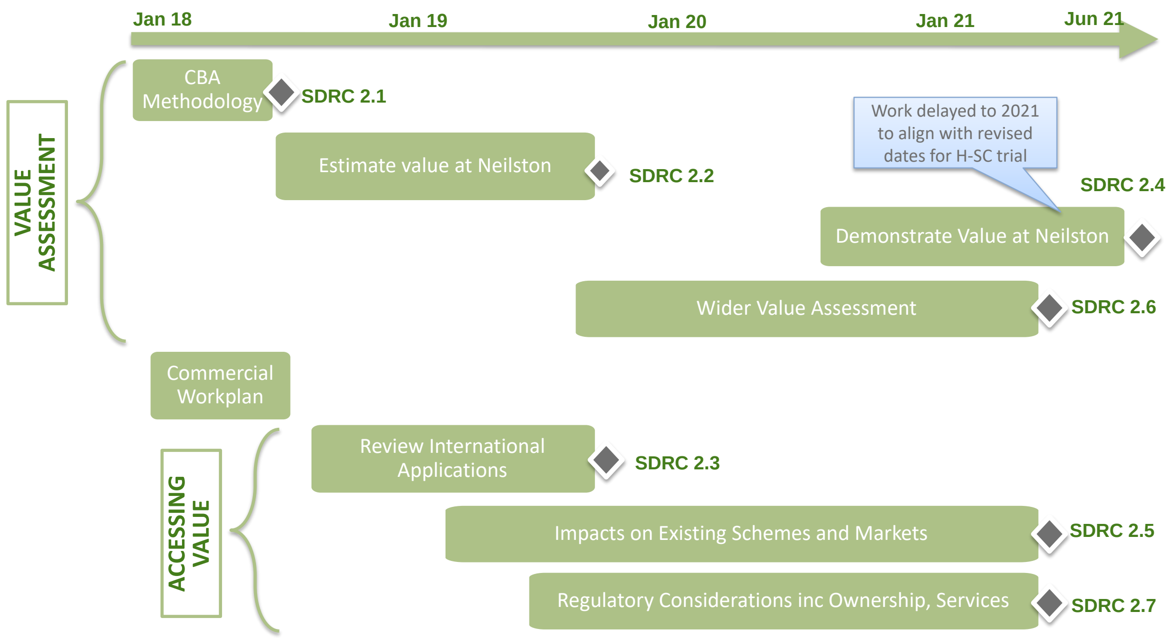


Figure 9 – Commercial Work Package programme

Work Carried Out in 2020

During the current reporting period, the main areas of work have been:

- Further work on commercial impacts and regulatory considerations (SDRC's 2.5 & 2.7) including the issue of draft reports.
- Further work on wider value assessment (SDRC 2.6).
- Input and review from the Phoenix Commercial Working Group.

These areas are summarised in the further sections below.

Substantive work on SDRC 2.4 has not been carried out during 2020 as the installation and commissioning of the H-SC installation at Neilston was delayed due to the Covid-19 pandemic. The approach to the H-SC trial was updated to the Commercial Working Group in December 2020, and work to complete SDRC 2.4 will be carried out during 2021.

Further work on commercial aspects (SDRC's 2.5 & 2.7)

The work during the current reporting period has focussed on areas associated with the delivery of SDRC 2.5 and SDRC 2.7. This has included further scoping of these deliverables, considering how the commercial landscape has moved on since the deliverables were originally conceived, an assessment of ownership models for SCs/H-SCs and a comparison of the different approaches to how SCs/H-SCs might be deployed on the GB transmission network.

With the introduction of the Stability Pathfinder service in late 2019, a new commercial mechanism to provide inertia and system strength services was introduced in GB. This continues to be developed by NGESO, where there are currently SC based solutions being delivered in line with Stability Pathfinder Phase One.

The report for SDRC 2.5 (Impacts on Existing Schemes) has been drafted to consider how SC/H-SC deployment might impact existing balancing schemes, and whether the existing and developing routes to deploy SCs/H-SCs (e.g. via Networks Options Assessment or Stability Pathfinder) are likely to be effective. The report for SDRC 2.7 (Regulatory Considerations) further considers whether these existing routes to deploy SCs/H-SCs are sufficient and what improvements should be made.

Following review and further input from the Commercial Working Group, these reports are scheduled to be completed in the early part of 2021.

Further work on wider value assessment (SDRC 2.6)

Studies to assess the wider benefits of H-SC and SCs installations across GB have continued through 2020 and will continue through to the end of Q1 2021.

The studies have focused on the installation of higher rated H-SC's and SCs compared to the trial H-SC installed at Neilston. For the installations in Scotland, the studies have demonstrated potential benefits to transmission boundary transfers through improved voltage performance, and potential benefits to operation of the Western HVDC link through increased short circuit levels.

Other areas of the GB network where the benefits of larger H-SCs and SCs are being assessed include the North of England, the South West of England and the South Coast. The results of these assessments will be detailed in the final report for SDRC 2.6 due at the end of Q1 2021.

Phoenix Commercial Working Group

The Commercial Working Group formed during 2018 has continued to provide wider input to the commercial aspects of the Phoenix project. The group is chaired by our Market Specialist and, as well as NGESO, the group includes representatives of several organisations outside of the Phoenix project including project developers, industry trade bodies, networks and policy makers.

The full Commercial Working Group met three times during 2020. Due to the Covid-19 pandemic, the decision was made to host these meetings on-line throughout April, July and December to review progress on the ongoing commercial products. The group also considered the interactions with other industry developments including NGESO's "Stability Pathfinder" service. There was also the opportunity to review other areas of Phoenix work including DTU's work on modelling a hybrid SC and Battery Energy Storage System.

As well as the full Commercial Working Group meetings, a shorter webex meeting was held with some members of the group in January to help develop a "Commercial Impacts" assessment.

Through 2020 the Commercial Working Group members have provided specific input in areas including:

- Scoping the reports for SDRC 2.5 (Impacts on Existing Schemes and Markets) and SDRC 2.7 (Regulatory Considerations).

- Feedback on the draft report for SDRC 2.5 (Impacts on Existing Schemes and Markets).
- Feedback of different perspectives of the Stability Pathfinder Phase 1 tender to provide inertia and system strength services.
- Members working group are actively engaged in developing SCs including SC based solutions for Stability Pathfinder. Some key aspects of the development of an SC based solution for Stability Pathfinder Phase 1 were discussed with the group.
- Different ownership models for H-SCs / SCs were reviewed. The work group members brought non-network company perspectives on ownership models and identified how apparent weaknesses in ownership models might be mitigated.

Research and Studies

System Studies

This section summarises of the system studies conducted by the University of Strathclyde and National Grid ESO during the current reporting period. The aim of the system studies carried out this year was to:

1. Assess the impact of synchronous condensers geographical allocation to system inertia
2. assess and quantify the contribution of synchronous condensers and Battery Energy Storage System (BESS) units to system inertia and frequency response
3. Investigate the impact and quantify the contribution of Synchronous Condenser units and the Enhanced Frequency Control Capability (EFCC) scheme to system inertia
4. Assess different ratings of H-SC
5. Assess multiple H-SCs within the SPT Region
6. Assess different regions for H-SC installation within the GB System

Impact of Synchronous Condenser units to System Inertia

Four different configurations as defined in Figure 10 have been considered (the total Synchronous Condenser capacity has been set to 4 GVA which corresponds to 5 GVAs considering a 1.25 inertia constant).

Configuration	Description
1	Total capacity of Synchronous Condenser units is connected only at Zone 1
2	Total capacity of Synchronous Condenser units is equally allocated at Zones 01 to 05
3	Total capacity of Synchronous Condenser units is equally allocated at Zones 06 to 10
4	Total capacity of Synchronous Condenser units is equally allocated at Zones 01 to 10

Figure 10 – Description of configuration considering different capacity allocation of Synchronous Condenser units

The sum of active power output for each configuration has been calculated and is depicted in 11. As a general observation, active power output from Synchronous Condenser unit at Zone 01 (which is notably the location of the LoG event) is highly oscillatory. On the contrary, as the total Synchronous Condenser capacity is concentrated far away from the location of LoG event, the Synchronous

Condenser active power output is smoother. Effectively, the placement of a Synchronous Condenser unit at the location of LoG event, introduces a damped oscillatory behaviour.

Frequency traces for different LoG events has revealed that by connecting a total of 4 GVA Synchronous Condenser units (which corresponds to 5 GVAs considering 1.25 s inertia constant), the maximum infeed loss can be increased by 50 MW, considering a 49.2 Hz frequency nadir limit (i.e. refer to 12 below).

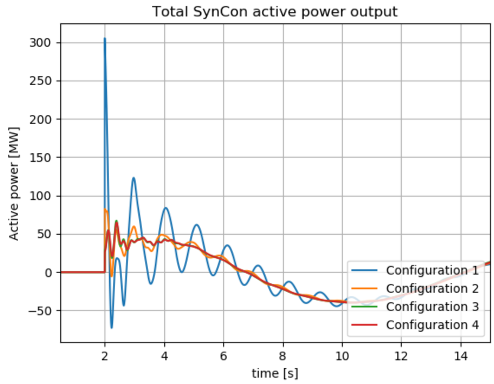


Figure 11 – Total Synchronous Condenser active power output for a 675 MW LoG event (configurations 1 to 4).

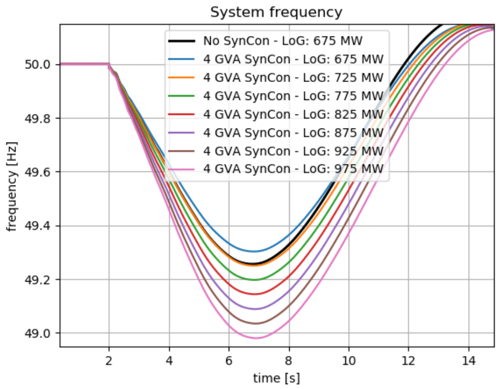


Figure 12 – Frequency traces for different LoG events.

Impact of BESS units to system inertia

Active power output from BESS units is not affected significantly by their geographical allocation. Considering a 100 MW BESS unit and a 675 MW LoG event, different frequency droop characteristics had different impact on the frequency nadir. Specifically, for frequency droop settings 0.016 p.u., 0.02 p.u. and 0.04 p.u., the frequency nadir is improved by 0.08 Hz, 0.06 Hz and 0.03 respectively (refer to Figure 13).

Considering a maximum infeed loss limit, it has been found that by connecting 100 MW BESS unit with frequency droop setting at 0.016 p.u., the maximum infeed loss can be increased by 50 MW, considering a 49.2 Hz frequency nadir limit (Figure 14).

By combining SynCon and BESS units the frequency nadir (i.e. 4 GVA of SynCon and 100 MW of BESS) can be elevated by approximately 0.15 Hz and the maximum infeed loss can be increased by 100 MW, considering a 49.2 Hz frequency nadir limit (refer to Figure 15 and Figure 16 below).

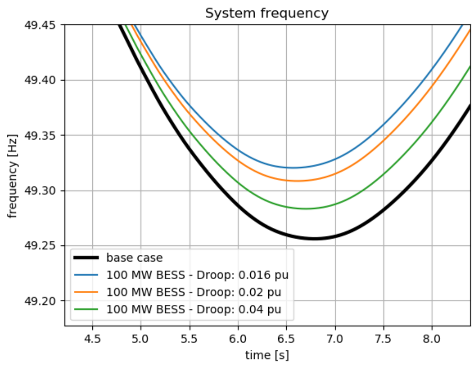


Figure 13 – Frequency traces for a 675 MW LoG event at Zone 01 utilising a 100 MW BESS unit with different frequency droop characteristics (figure zoomed at frequency nadir region)

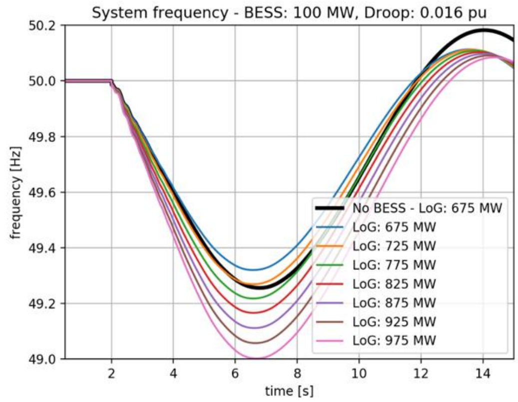


Figure 14 – Frequency traces for different LoG events utilising a 100 MW BESS unit

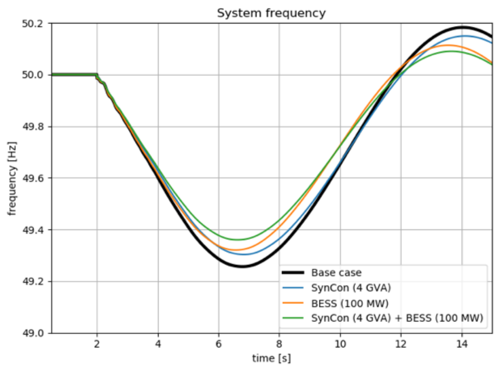


Figure 15 – Frequency traces for a 675 MW LoG event

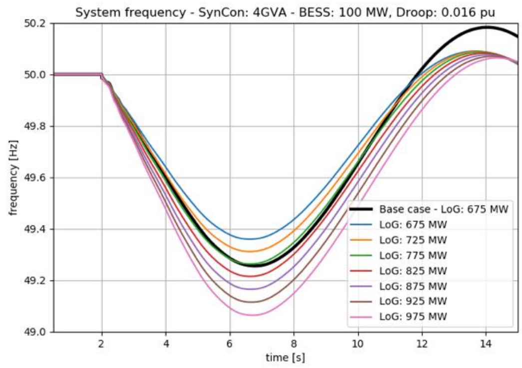


Figure 16 – Frequency traces for different LoG event utilising a 100 MW BESS unit and 4 GVA of SyCon

Impact of SynCon units

SynCon units totalling 4 GVAs and the EFCC scheme under different configurations have been put forward to investigate their contribution.

Considering a frequency nadir of 49.2 Hz, it was found that different LoG events can be sustained by different combinations of the EFCC scheme and SynCon units, as follows:

- LoG: 675 MW, without EFCC and SynCon untis
- LoG: 725 MW with 5% of EFCC and without SynCon units
- LoG: 775 MW, with 10% of EFCC and without SynCon units
- LoG: 775 MW, with 5% of EFCC and with SynCon units
- LoG: 825 MW, with 10% of EFCC and with SynCon units
- LoG: 925 MW, with 25% of EFCC and without SynCon units
- LoG: 975 MW, with 25% of EFCC and with SynCon units

Further sensitivity analysis indicated that SynCon units can bring certain savings to the active power required from synchronous generators and the EFCC scheme (refer to Figure 17 and Figure 18 below).These results highlight that the capacity of the EFCC scheme and SynCon units need to be carefully selected to achieve satisfactory frequency control performance.

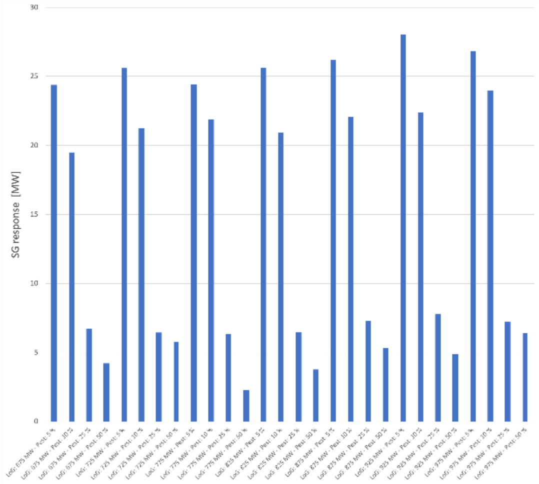


Figure 17 – Active power response savings from SGs when SynCon units are connected.

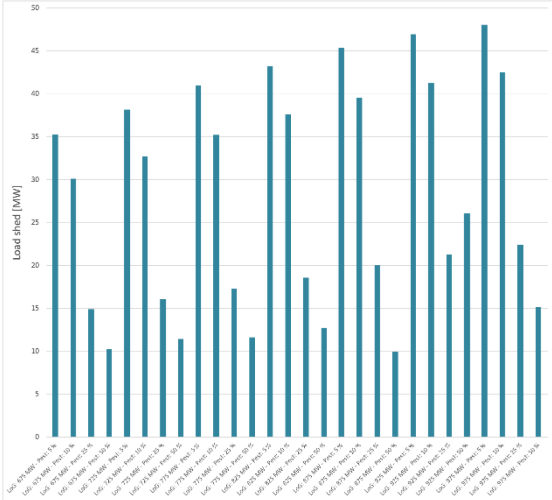


Figure 18 – Active power response savings from EFCC scheme when SynCon units are connected.

Studies with Different Ratings of H-SC

In the previous reporting, the benefit of Neilston H-SC (SC 70 MVA, STATCOM 70 MVA with hybrid control) was analysed compared against the following options:

- SC only (140 MVA)
- STATCOM only (140 MVA)
- SC (70 MVA) and STATCOM (70 MVA) without hybrid control

During the current reporting period, further analysis has been carried out assuming the rating of these devices as 280 MVA and 420 MVA, at Neilston 275kV substation. These study results showed the increase in boundary transfer capabilities with the increase in size of the devices. The system study results have been presented to Commercial Work Group (CWG) and SPEN. These results are still being finalised at the time of writing this report and will be published within Q1 2021.

Studies with Multiple H-SCs in SPT Region

Further analysis has been carried out looking at H-SC devices at six different strategic locations within the SPT area (including Neilston). These study results showed that with the increased number of SC/H-SC installations, the system Short Circuit Level (SCL) increases and this will ultimately have the impact on operation of the HVDC links in the region. Hence, with multiple SC/H-SC devices, the additional boundary transfer capability could be achieved. These results are still being finalised at the time of writing this report and will be published within Q1 2021.

Studies for Different Regions in GB System

To evaluate the further opportunities for the installation of SC/ H-SC devices outwith the SPT area and looking at the GB network as a whole, the following regions have been investigated:

- North West of E&W
- North East of E&W

- South West of E&W
- South Coast of E&W

The study work on steady state analysis for these regions, with different rating of the device, has been completed. The dynamic analysis for the year 2023 has been completed. Currently, the dynamic analysis for year 2027 is in progress and is expected to finish by January 2021. At the time of writing, these results are still being finalised and will be published within Q1 2021.

Component Studies

This section summarises of the component level studies conducted by the Technical University of Denmark during the current reporting period. The main tasks completed this year to carry out studies included:

1. Hybrid SC model: A model of the Hybrid SC including a Battery Energy Storage System (BESS) has been developed in PowerFactory v15. The model includes coordinated control of SC and BESS in terms of voltage and reactive power control.
2. Co-simulation for faster prototyping for new designs and controls: A co-simulation platform was developed in the project using power-hardware-in-the-loop method. A physical converter stack equipped with customizable control was connected with real time simulation and was able to be used to testify the control designs, eg grid forming and grid following.

R&D activities

Based on the project development work a number of research activities have been carried out in this year from DTU,

- Development of a Hybrid SC model with coordinated control for SC and BESS and development of a grid-forming control strategy for BESS

A Hybrid SC system including BESS was developed in PowerFactory. Additionally, DTU developed a grid-forming Hybrid SC and performed a comparative study between the different technologies. The criteria for comparison were based on the speed of the response, overloading capability, and performance in weak and strong grids. The idea was to test each technology and control strategy against voltage and frequency disturbance, voltage angle jump, and short circuit.

- Grid forming converter control application for BESS and its performance during current limit activation

Grid forming converter (GFC) control has a voltage source characteristic and can provide inertial active power and instantaneous fault current, in theory. An investigation on the impact of the inner loop on the grid forming converter's ability to behave as a voltage source behind a passive impedance in the frequency range of 5 Hz-1kHz is carried. The analysis conducted is based on a small signal stability perspective and the quality to response of converter against grid events. The research work is ongoing on developing an enhanced current limit mode for GFC without switching back to PLL based current limit.

- Stability and performance for a grid supporting converter equipped with BESS under stressed power system scenario

The study investigates a grid supporting converter's stability and performance under a stressed power system scenario, including a faulted case. The major component in a grid supporting converter control is cascaded control of power and current control loops and PLL. There are also additional filters present in the converter control. At first, a small signal analysis of a grid supporting converter is carried out. Design conditions for all the converter control parameters which ensures a large enough stability margin and less interaction with synchronous machine is found. The stability impact of mode changes caused by the triggering of limiters present in the converter control is also investigated. Furthermore, the converter's performance during fault, focusing on PLL dynamics affected by the additional filters employed in the voltage measurement, is investigated.

Conclusions

Based on the R&D activities given above the following learnings can be concluded;

- It has been demonstrated that BESS can provide the same functions as STATCOM in terms of voltage support, while providing frequency support in two different timescales, namely the fast frequency control (RoCoF based control) and the droop control. We have shown the effect of three functions of BESS in terms of frequency support and the results can be seen in figure below. The RoCoF function has an influence on the slope of frequency change and the resulting nadir. The frequency droop control has an impact on the frequency nadir and the steady state. The RoCoF function acts fast to arrest the frequency drop, while the droop function response is slower, affecting the frequency nadir and especially the new steady state value of the frequency. The effect of both strategies can be observed in the bottom right plot where we compare the different strategies with the base case (no frequency support) at the same droop/RoCoF coefficient.

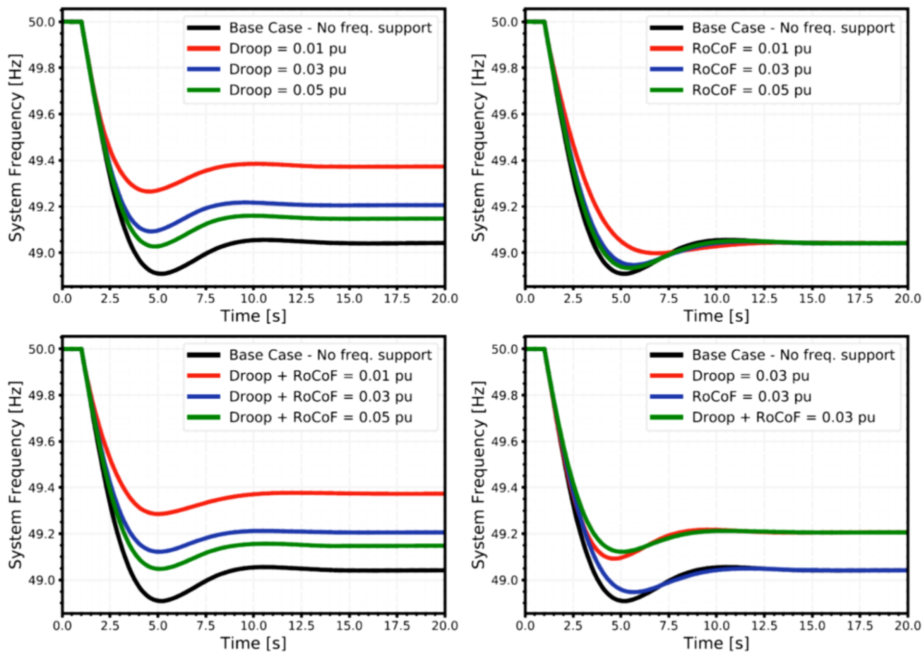


Figure 19 – BESS Frequency response for Three Different Control Strategies

- A summary of the performance of the technologies considered in the study is shown in the table below. The instantaneous response measured at the half-cycle period, and the dynamic response, which is assessed based on the technology's response quality, are ranked from best to worst. The Syncon adds more robustness due to its notable overload capability, whereas the converter's current limiters can introduce a discrete response to large transients. The grid-forming converter-based solutions provide the most balanced response in terms of frequency support as they provide very fast response and in many ways are similar to the synchronous machine. In terms of voltage support, the solutions with synchronous condenser are dominant due to the significant overloading capability of the SC. The slower SC response can be compensated by faster converter control, which gives an advantage to the hybrid solution. Similarly, for short-circuit events, the solutions with synchronous condenser provide the best solution in terms of short-circuit current contribution, while the converter-based solutions provide balanced post-fault response. Based on the findings in this work, we can conclude that the hybrid concept with grid-forming control brings the most balanced performance overall for grid support.

- It is found that a GFC with cascaded voltage and current innerloop can cause stability issues in weak grid. The triggering of current limit in either active power channel or reactive current channel introduces upward jump in dynamic impedance of and for the BESS-VSC in the low frequency range, such an effect could be detrimental to the system stability. It is also found that a proportion of Synchronous condenser (SC) be maintained in the system to ensure reliable system operation during stressed power system case.

- The presence of filtering stage before the phase locked loop can introduce coupling between the magnitude and phase of the input voltage which deteriorate the PLL accuracy during fault. A compensator to remove this coupling has been proposed

Knowledge Dissemination & Stakeholder Engagement

Neilston Substation Site Visits

At the end of the previous reporting period, there were plans in place to continue the knowledge dissemination site visits. Fortunately, despite the Covid-19 pandemic and associated restrictions, there were two knowledge dissemination visits to Neilston Substation. The first visit was from Edinburgh University pre-Covid in Q1 who reached out to SPEN to understand further about how the H-SC works and the services it can provide to the network in a world of increased renewable installations. The second visit to Neilston Substation was a socially distanced visit from Statkraft who are involved in the installation of a Synchronous Condenser in the North of Scotland. This trip was well received where many of the learnings during construction and commissioning were discussed.

- UoS submitted a conference paper entitled *"Provision of Voltage Ancillary Services through Enhanced TSO-DSO Interaction and Aggregated Distributed Energy Resources"* to the IEEE Transactions on Sustainable Energy Conference

- UoS submitted a conference paper entitled *"Impact of Synchronous Condensers on Transmission Line Protection in Scenarios with High Penetration of Renewable Energy Sources"* to the IET – Developments in Power System Protection (DPSP) Conference

Look Ahead to the Next Reporting Period

Looking ahead to the next reporting period, the following key activities are expected:

Live Trial

As highlighted earlier, the Live Trial phase has now started as of November 2020. There is an agreed programme in place for the first six months of the twelve-month trial period. The view we have is for SPEN, ABB and NGESO to collaboratively review the learnings and findings which will then form what should either be tested further, tested for longer or perhaps new tests that should be performed during the second half of the live trial.

ABB will be producing monthly reports analysing the data that is sent from SPEN with the view that these reports will be collated and expanded on to produce the SDRCs planned for the next reporting period.

Research and Studies

Further analysis has been and will continue to be carried out during the next reporting period assessing H-SC devices at six different strategic locations within the SPT area (including Neilston). Additionally, there will be studies continuing to evaluate further opportunities for H-SC installation out with the SPT area. These studies have started and will continue into the next reporting period looking at strategic locations within England and Wales. For each of these locations, both SPT and GB network, the studies will analyse the network at the agreed key dates including 2023 and 2027. These results are still being finalised at the time of writing this report and will be analysed further before being published next year.

Commercial Work Package

In addition to the system studies listed above, the further opportunities for H-SC in GB system will be analysed by carrying out commercial analysis within different part of the GB system. The studies have focused on the installation of higher rated H-SC's and SCs compared to the trial H-SC installed at Neilston. For the installations in Scotland, the studies have demonstrated potential benefits to transmission boundary transfers through improved voltage performance, and potential benefits to operation of the Western HVDC link through increased short circuit levels. Together these works form SDRC 2.6 which will be completed within the next reporting period.

Works to finish the reports associated with SDRC 2.5 and 2.7 will be concluded within Q1 2021 with final inputs from the Commercial Working Group. However, the scheduled work for SDRC 2.4 looking at demonstrating value at Neilston was postponed during the current reporting period due to the associated delays starting the Live Trial, therefore this will be a focus for next year as data and learnings are gathered throughout the trial and analysed by the project team.

Knowledge Dissemination

Where possible, in line with SPEN and Government guidance around Covid-19, the plan is to continue to invite stakeholders to Neilston for progress presentations and site tours. Any Knowledge Dissemination events on site will, of course, take into consideration safe distancing and reduced numbers.

Looking ahead to Q2, SPEN will be organising a Stakeholder Engagement event to summarise all the learnings from the live trial period to date and how this was commissioned and tested on site. The focus of this event will be on the Live Trial and the findings and results from the various system studies looking at increased capacities of H-SC and different locations with the GB Network. Given the potential for Covid-19 restrictions still being in place, the logistics and venue of this is currently under review.

Lastly, in line with project completion in Q4 2021 the Phoenix Project Team will schedule a close-down event. This event will detail all progress, leanings, findings from both the studies and the live trial period.

Consistency with Full Submission

At this stage of the project, it can be noted Phoenix is no longer in line with the original time scales. The Covid-19 pandemic and subsequent unforeseen restrictions meant that progress on site slowed down. Many of the issues suffered were linked to the new Phoenix Control Building, where both SPEN and ABB Site Teams had to work together in order to follow safe distancing protocols and react to subcontractors being put onto furlough. However, despite the challenges faced this year the Phoenix H-SC was energised in October 2020 officially starting the twelve-month Live Trial Phase. The delays suffered this year means there is a seven-month delay to original timescales, where the final reports and SDRCs will be delivered in Q4 2021.

It should be noted that the delays suffered this year are still within the OFGEM NIC Terms & Conditions with regards to material delays.

Successful Delivery Reward Criteria

The Successful Delivery Reward Criteria (SDRC) set out in the Project Direction links with the Project Milestones and the identified targets directly. This SDRC can be used to check the progress of the project delivery and position the progress against the original proposal. A full list of the SDRC is provided in Appendix 2 for reference.

The table below lists all the required SDRCs which were delivered within reporting period of 2020:

Successful Delivery Reward criterion	Evidence
2) Financial Value Evaluation and Regulatory Recommendations Develop and demonstrate a commercial framework to financially incentivise services provided by synchronous condenser. Enable service providers to participate in a new market for inertia and other ancillary services provided by SCs. Create recommendations for regulatory considerations for future roll-out of SCs/H-SCs.	4. Report on value evaluation of SCs/H-SCs based on pilot installation and performance
3) Control Methods Development and Testing Innovative control methods to maximize benefits of SC/H-SC installations in different network conditions and different locations across GB. Simulation of co-ordinated control schemes with other network components such as SVCs, STATCOMS and battery storage. Development and on-site testing of hybrid control scheme for H-SC.	6. Report on SAT test procedure and results of pilot hybrid co-ordinated control system
6) Pilot Installation and Operational Trial	1. Report on site installation process, details and recommendations for future – Civil

On-site installation and commissioning of pilot H-SC demonstration. Civil work and electrical connection of H-SC to the transmission network.	3. Report on SAT procedure and test results
8) Knowledge Dissemination Stakeholder engagement and dissemination of learnings and outcomes of the pilot H-SC demonstration through project.	4. Project Phoenix regular project progress reports

Business Case Update

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Intellectual Property Rights [Confidential]

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Other

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Accuracy Assurance Statement

I therefore confirm that processes in place and steps taken to prepare the PPR are sufficiently robust and that the information provided is accurate and complete.

Signature:

Name (Print): Craig Hume

Title: Project Manager

Date: 18/12/2020

Signature:

Name (Print): James Yu

Title: Future Networks Manager

Date: 05/02/2021

Appendices

Appendix 1 – Phoenix Successful Delivery Reward Criteria

Successful Delivery Reward criterion	Evidence
1) Architecture, Design and Engineering feasibility Engineering design and feasibility analysis for pilot H-SC deployment and demonstration. Site selection and planning consent for H-SC installation. Detailed layout, civil designs and approval through system review group for finalising tender for site works and ordering equipment.	1. Report on engineering and design feasibility analysis. WP1 2. Report on environmental studies and life cycle analysis. WP1 3. Report on detailed installation diagrams and site layouts. WP1 4. Report on routine and type testing procedure and results. WP1
2) Financial Value Evaluation and Regulatory Recommendations Develop and demonstrate a commercial framework to financially incentivise services provided by synchronous condenser. Enable service providers to participate in a new market for inertia and other ancillary services provided by SCs. Create recommendations for regulatory considerations for future roll-out of SCs/H-SCs.	1. Cost benefit analysis model for SCs and H-SCs. WP3 2. Report on cost benefit analysis of SCs and H-SCs based on system studies and FES. WP3 3. Report on international application of SCs and benefit analysis. WP3 4. Report on value evaluation of SCs/H-SCs based on pilot installation and performance. WP3 5. Report on impact of SCs/H-SCs on existing balancing schemes and markets. WP3 6. Report on value analysis from roll out of SCs/H-SCs in GB in future potential sites. WP3 7. Report on regulatory considerations and recommendations for future roll-out of SCs and H-SCs. WP3
3) Control Methods Development and Testing Innovative control methods to maximize benefits of SC/H-SC installations in different network conditions and different locations across GB. Simulation of co-ordinated control schemes with other network components such as SVCs, STATCOMS and battery storage. Development and on-site testing of hybrid control scheme for H-SC.	1. Report on methods and functional specifications of hybrid control mechanisms developed and trialled in pilot demonstration. WP4 2. Report on output of SCAPP project on protection and control of synchronous condenser and simulation results of new control methods. WP4 3. Report on performance of pilot hybrid co-ordinated control system. WP4 4. Report on methods and functional specifications of innovative control schemes for future roll-out. WP4 5. Report on FAT test procedure and results of pilot hybrid co-ordinated control system. WP4 6. Report on SAT test procedure and results of pilot hybrid co-ordinated control system. WP4
4) Lab Functionality and Component Model Testing Testing of different operational scenarios in laboratory environment to generate results to better understand performance of SC/H-SCs under various limits and constraint conditions. Lab testing will test different operational parameters of SC/H-SCs. Use of RTDS to facilitate simulation of technical models and control algorithms.	1. Component model adapted to pilot demonstration and for further system studies. WP5 2. Report on component level studies from SCAPP project and relevance to pilot demonstration and future installations. WP5 3. Report on co-simulation for faster prototyping for new designs and controls. WP5
5) Application of synchronous condenser: GB system studies System studies using SC/H-SC component model and GB system model developed through EFCC project and SOF studies to critically analyse impact of future roll-out of SC/H-SCs in GB network. Case studies for specific system cases on GB network.	1. Report on System Studies and Quantification of overall benefits from application of SCs/H-SCs in GB system. WP5 2. Report on case studies on system characteristics of SCs/H-SCs in conjunction with other innovative solutions proposed through EFCC and HVDC converters. WP5 3. Report on optimal placement and capacity evaluation of SCs/H-SCs in GB. WP5 4. GB roadmap for roll-out of SCs/H-SCs. WP5

6) Pilot Installation and Operational Trial On-site installation and commissioning of pilot H-SC demonstration. Civil work and electrical connection of H-SC to the transmission network.	1. Report on site installation process, details and recommendations for future - Civil. WP1 2. Report on site installation process, details and recommendations for future - Electrical. WP1 3. Report on SAT procedure and test results. WP1 4. Report on electrical layout of H-SC design with protection and control architecture. WP1 5. Report on extended live trial and recommendations for future installations
7) Performance Monitoring Monitoring of equipment performance such as losses, vibrations and maintenance requirements of rotating parts of the pilot H-SC. Condition monitoring of the H-SC output and impact on the regional and wider power system.	1. Report on pilot H-SC installation component level SC, STATCOM condition monitoring. WP2 2. Process documentation for SC type testing requirements for future installations. WP2 3. Functional specifications for H-SC output monitoring - Methods and User Interface. WP2 4. Functional specification for H-SC wider system operational performance monitoring WP2 5. Report on pilot H-SC installation output data logging and monitoring WP2 6. Report on H-SC system impact in local and wider system context - Usage, Control methods and Interactions. WP2
8) Knowledge Dissemination Stakeholder engagement and dissemination of learnings and outcomes of the pilot H-SC demonstration through project.	1. Report summarising findings of TO SO working groups. WP6 2. Report on emerging technical standards for synchronous condenser. WP6 3. Innovation testing and Demonstration Workshop WP6 4. Project Phoenix regular project progress reports. WP6. 5. Project Phoenix Close down report. WP6

Appendix 2 – Project Risk Register [Confidential]

Technical Risks

Risk	Potential Impact	Control & Mitigation Measures
Interface Management	Project Delays Health & Safety	SPEN to assist ABB with all requirements at an early stage
Failure with collaboration	Project Delays	SPEN to assist with and maintain regular collaborative meetings with all relevant partners and Operations. Correct NDAs and Document Management Systems in place to ease with sharing of information
Modelling Accuracy	Project Delays	Continual engagement with Academia SPEN to be considered in all review stages Allow time for review stage, before actual deliverable date
Clarity of Models & Studies requirements	Project Delays Standard of model is compromised	Plans in place for a Model & Studies workshop to ensure all partners understand programme and respective requirements SPEN to be involved with all review stages
H-SC does not work	Project Delays	FAT to take place prior to installation on site Design Testing at manufacturing stages Academia to provide studies with assistance from SPEN and ABB based on the actual parameters and data from Synchronous Condenser and STATCOM
SPEN Engagement	Project Delays	Advance involvement with SPEN Projects at an early stage SPEN Projects to attend project meetings
Despatch Who? How?	Project Delays	SPEN to work closely with NG to determine requirements for despatch NG to decide on how Phoenix will be despatched based on different scenarios
Data Gathering	Evaluation of Data Project Delays Configuration of records/data	SPEN to further discuss Data Exchange (TBD)
New technology within the Network	Project Delays Health & Safety	Training plan will be in place, including factory and manufacturing visits Knowledge Dissemination - both internal and external Stakeholder engagement events will be planned throughout project
Continuation Plan / Post Project O&M concerns	Risk of stranded asset post-project	Currently a 12 month operation window in place with ABB There will be a possibility of making ownership decision at the last phase of this project if the owner of the asset is not a TO/SO the service provider could potentially return some investment to the NIC mechanism
Impact on the EDF Nuclear Safety Case at Hunterston	Project Delays Changes to design and operation at a late stage Project Termination	SSTI requirement report to be completed and presented to EDF to eliminate any safety concerns

Equipment / Components fail FAT	Project Delays	Intensive QA/QC during the build and manufacture phases SPEN and NG to be involved at testing
Plant and Equipment Compliance	Project Delays	Timely submittal of equipment specifications from suppliers to SPEN Engineering Standards

Project Management Risks

Risk	Potential Impact	Control & Mitigation Measures
Stakeholder Engagement	Knowledge is not effectively shared Impact of project is lower than expected (internal & external)	Regular stakeholder engagement meetings planned throughout the project SPEN, NG and Market Specialist to lead on creating a working group SPEN working closely with Comms to ensure knowledge is regularly disseminated throughout the company
Contractual agreements	Project Delays	Continual communication with Legal and project partners legal representatives to ensure contracts are concluded within a timely manner
Resource Planning	Project Delays	Continual communication with project team through email and monthly SPEN project team meetings Steering board meetings planned every 3 months Quarterly meetings with Phoenix Project Delivery team to be planned in advance
Academic Involvement	Academic partners do not have enough resources Contribution to project is limited	Academic partners have been chosen based on their experience in related projects Regular communication & meetings with Academia Academia to be involved at quarterly project team meetings and stakeholder engagement events
Review of Deliverables	Project Delays	Deliverables to be submitted with a 2 week review window to allow for feedback and re-drafts (if required) SPEN to continue to chase internally when reviews are causing delays Feedback teleconferences to be planned in advance to discuss re-draft of deliverables Document Management System now in place, managed by project manager
Commercial mechanisms required for post project roll-out	Delayed roll-out of technology post project	Market specialist to lead development of CBA model Work closely with NG to ensure suitable commercial frameworks are in place to facilitate deployment with regulatory recommendations
Programme	Project Delays	Preparation of detailed site plan from ABB SPEN Projects to review SPEN to collate ABB plan with SPEN Projects plan to ensure no clashes / obstructions

Construction Risks

Risk	Potential Impact	Control & Mitigation Measures
Health & Safety on Site	Health & Safety	Early involvement with SPEN Projects - meetings, reviewing of ABB site documents SPEN Projects to review H&S plan, with this being agreed and in place Training plan will be in place, including factory and manufacturing visits
Ground risk	Project Delays	Ground Reports to be conducted in advance of site work starting ABB and SPEN Projects to review
Outage Window	Project Delays	Preparation in advance with SPT Planning and NG Early communication with NG to ensure outage window is agreed Submit Site Plan for review
Weather	Project Delays	Winter weather precautions (Winterisation plan) in place Winter Weather training to take place
Access / Authorisation	Project Delays Health & Safety	Site Surveys to be conducted in advance from ABB and SPEN ABB to provide personnel details for site staff and subcontractors at an early stage SPEN to plan for authorisation and inductions for ABB and subcontractors
SPEN Handover	Project Delays	Advance involvement with SPEN Projects at an early stage SPEN Projects to attend project meetings Collaboration meetings with SPEN Projects and ABB
Sub-Contractors	Project Delays Health & Safety	SPEN to be involved with ABB subcontractor tender process ABB to provide subcontractor details in advance SPEN to plan for authorisation and inductions for subcontractors in advance
Working Time	Project Delays Health & Safety	Work closely with Legal regarding legislation currently in place - Working Time Directive / Working Time regulations Preparation of site plan in advance to understand work / shift patterns
Plant Protection	Project Delays Health & Safety	Advance involvement with SPEN Projects at an early stage ABB to liaise with SPEN projects regarding current works happening during Outage Window
Transport of equipment to site	Project Delays	Access surveys and plan in place Liaise with SPEN Projects and 275kV Bay Delivery

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