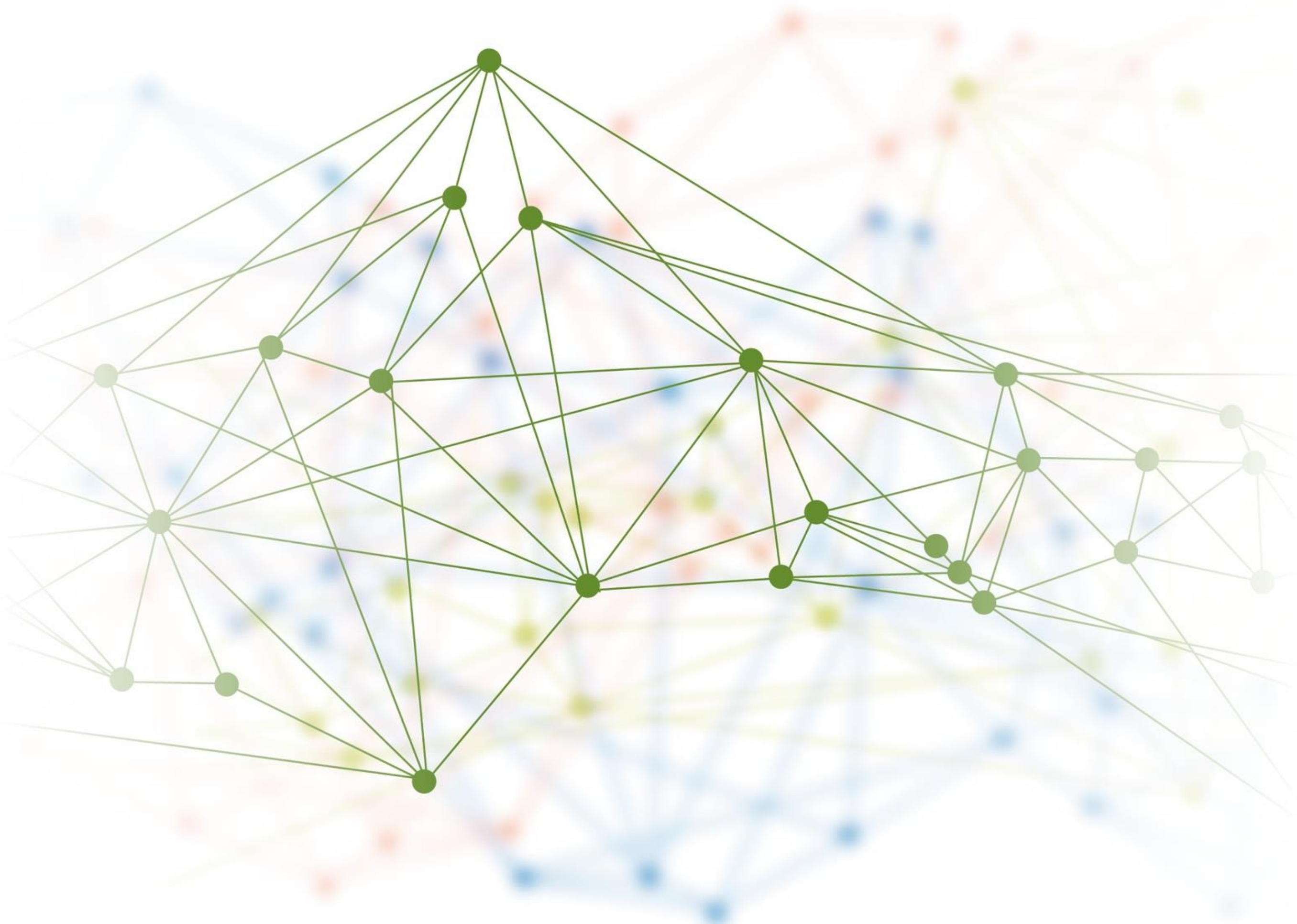
SP ENERGY NETWORKS

RIIO NIC NETWORK INNOVATION COMPETITION

PHOENIX

Project Progress Report 2019



University of Strathclyde Engineering

ABB

nationalgridESO

DTU

About Report

Report Title	:	Project Progress Report - December 2019
Report Status	:	Final (External)
Project Reference	:	SPTEN03 / Phoenix

Report Progress

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Recommendations by	:	Project Partners	06/01/2020
Reviewed by	:	Michael Walsh	21/01/2020
Approved by	:	James Yu	05/02/2020
Signed-off by	:	James Yu	05/02/2020

Report History

Date	Issue	Status
20/12/2019	Rev 0	First Draft
17/01/2020	Rev 1	Second Draft
23/01/2020	Rev 2	For Review
05/02/2020	Final	Final Issue

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 with duration to 31st May 2021.

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 focus has been on work package 1 where the H-SC in in the final installation phase, looking ahead to the Live Trial next year. From the commercial work package, study results from the H-SC at Neilston has been fed into the CBA model and there is an increase in boundary transfer a net cost benefit value. Looking ahead to the next reporting period, the H-SC will be energised to the network where the live trial will begin. The data from the live trial will be validated against the system studies, as well as exploring other geographical locations for the roll out of SC / H-SC technology.

Project Highlights

This is the third annual progress report for the Phoenix project, covering the project delivery period January 2019 – December 2019, referred to within as *"the reporting period".*

The project delivery is in line with the original proposal; however there has been updates to the project programme. The design of the H-SC and it's innovative control system has suffered delays which has resulted in a knock-on to the start of the civils work on site. This delay to the start of site works has been carefully managed throughout the reporting period between both SPEN and ABB. The programme has been proactively reviewed monthly to ensure different areas of site works happen in parallel to minimise the risks and delays. Ultimately the knock-on effect means Commissioning of the H-SC will begin early 2020 where the Live Trial will start thereafter. This has been discussed in line and agreement with all project partners to ensure the start date of the Live Trial will not cause effect to the studies and reports which will be delivered in parallel of the Live Trial.

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 engineering and design feasibility studies (SDRC1.1)
- Report on environmental studies (SDRC 1.2)
- Report on detailed installation diagrams and site layouts (SDRC 1.3)
- Report on routine and type testing procedures (SDRC 1.4)
- Report on Site Installation Process, Details and Recommendations for Future – Electrical (SDRC 6.2)
- Report on electrical layout of H-SC design with protection and control architecture (SDRC 6.4)

Work Package 2 – Live Trial

- Functional specifications for H-SC output monitoring- Methods and User Interface (SDRC 7.3)
- Functional specification for H-SC wider system operational performance monitoring (SDRC 7.4)

Work Package 3 – Commercial & Regulatory

- Report on cost benefit analysis of SCs and H-SCs based on system studies and FES (SDRC 2.2)
- Report on international application of SCs and benefit analysis (SDRC 2.3)

Work Package 4 - Technology (H-SC Control System and Methodology)

- Report on output of SCAPP project on protection and control of synchronous condenser and simulation results of new control methods (SDRC 3.2)
- Report on methods and functional specifications of innovative control schemes for future roll-out (SDRC 3.4)
- Report on FAT test procedure and results of pilot hybrid co-ordinated control system (SDRC 3.5)

Work Package 5 - Research

- Report on co-simulation for faster prototyping for new designs and controls (SDRC 4.3)
- Report on system studies and quantification of overall benefits from application of SCs / H-SCs in GB System (SDRC 5.1)

Work Package 6 – Knowledge Dissemination

- Innovation and Demonstration Workshops (SDRC 8.3)
- 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

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.

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 for Commissioning Scheme checks
- Collaboration with SPEN Projects Site Works
- Pre-Construction CDM Requirements
- Specs/Standards and associated info for review and implementation
- 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 works in order to minimise delays and escalate site works.

Project Managers Report

This section highlights the projects' key activities, milestones, risks and learning over the second reporting period (January 2018 - December 2018).

Project Progress Summary

The significant achievements during the reporting period are as follows:

- Welfare Cabins were set up on site, taking into consideration office space for both SPEN and ABB Site Teams. The Welfare Cabins also include a meeting room and Knowledge Dissemination Room.
- The noise survey was concluded with the final decision made for the Noise Enclosure for the Synchronous Condenser. This was an additional cost to the agreed scope and will be included within project learnings

- In February, we held a successful Technical Stakeholder Event in Edinburgh. This involved several presentations from ABB, NGESO, UoS and DTU where the technical design of the H-SC was discussed, as well as proposed studies
- We presented Phoenix to a SPEN-Led Community Stakeholder Engagement Event for retirees, held in Paisley which is close to the Neilston installation
- The civil works formally kicked off on site in March 2019
- FATs for all main components were carried out throughout the reporting period with both SPEN and ABB in attendance to witness, including representatives from NGESO where required
- The Control System FAT was held in June in ABB Office, Vasteras, Sweden. SPEN and NGESO attended to witness the Control System Simulations with further follow up workshops planned to close out the design
- The SPEN Project Management Team has held monthly Knowledge Dissemination Events at Neilston Substation, with both internal and external stakeholders. The events normally last half a day and include a presentation on the project, before an escorted site tour explaining the different components.
- Monthly Commissioning meetings started half way through the current reporting period. These meetings are chaired by the SPEN Commissioning Manager, with attendance from SPEN and ABB to ensure all commissioning documentation and procedures are in place prior to start. These meetings are held monthly and will continue until the H-SC is energised during the next reporting period.
- The 275kV Bay, which is the SPT project running in parallel in which Phoenix will connect into, has been successfully commissioned with outages booked for the full scheme commissioning during the next reporting period.
- There have been three Commercial Work Group meetings during the current reporting period, with the focus on reviewing the two main Commercial SDRCs which were delivered earlier this year. The group has also been focusing on the Commercial Impacts and Wider Impact Assessment of SCs / H-SCs, which will be concluded near the end of the next reporting period.
- Phoenix was presented at this year’s LCNI conference, where the focus of the presentation was on understanding the design of the H-SC and the early commercial findings from the installation at Neilston. The Phoenix team also then chaired a small breakout session from the SP Energy Networks stand to discuss the benefits of the overall project. Phoenix also presented at two other project partner stands, NGESO and ABB.
- SPEN had a stand at the All Energy 2019 Conference, where Phoenix was discussed
- SPEN and ABB are writing a collaborative paper for CIGRE 2020. During the current reporting period a synopsis and initial draft has been written and submitted to the CIGRE committee for review / acceptance.
- In line with key construction and installation works, there has been a drone capturing footage of works on a regular basis. This footage has been used for the creation of a promotional video for the project. This video was then published via the SP Energy Networks website and Social Media pages.

Work Package Overview

Currently we are coming to the end of the Implementation phase with the focus of the next reporting period pushing towards the Validation stage. This will be both on site at Neilston working through Commissioning and the Live Trial / Output Monitoring and through further development of the Commercial work package as we receive results from studies from further studies looking at capacity of H-SC and locations within the GB Network.

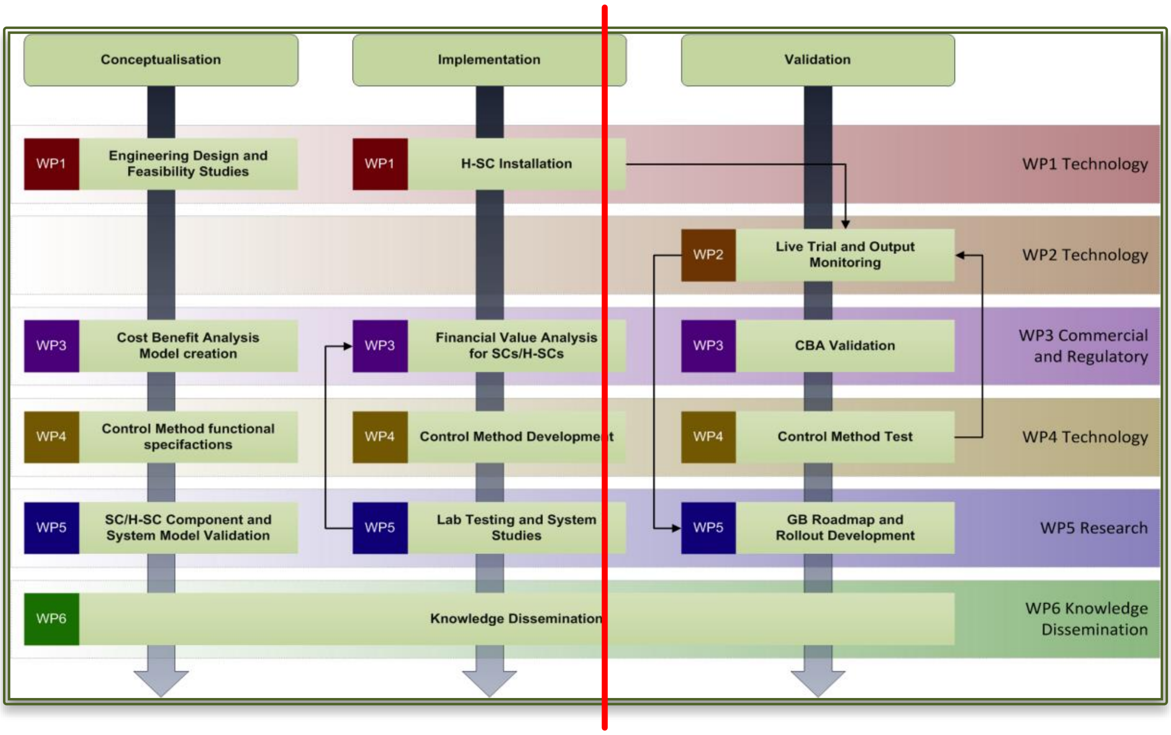

Figure 1 – Phoenix Work Packages

Work Package 1 – H-SC Design, Install & Build

- The final design phase was concluded, however due to design and standards issues this delayed the start of the civils works on site
- Both SP Energy Networks and ABB have been proactively reviewing the construction programme to mitigate risk and delays as much as possible, and as a result the Commissioning phase has been rescheduled for early 2020

Work Package 2 – Live Trial

- The H-SC is now scheduled to be energised in early/mid 2020, where the twelve-month Live Trial will begin
- Pre-Commissioning meetings between SP Energy Networks, Transmission Ops, ABB and NGESO are taking place to ensure plans are in place between all required parties to ensure Grid compliance in advance of Energisation.

Work Package 3 – Commercial & Regulatory

- NGESO have completed the CBA Model using the BID3 Economic Tool which will explore the following network backgrounds –
    - 2019 network
    - 2023 network
    - 2027 network
- Studies from the current installation at Neilston have been carried out with results showing the H-SC device increases the B6 boundary transfer between Scotland and England & Wales from 2023 onwards by 45 MW to 90 MW (Winter & Summer)
- This increase results in the net cost benefit that can be achieved is £53m to £66m over the asset's life period of 40 years (based on the FES 2018 Community Renewable scenario)
- There have been three Commercial Work Group meetings during the current reporting period with input to the CBA Model, Report on Cost Benefit Analysis and International Assessment of SCs

Work Package 4 – H-SC Control System and Methodology

- Control System Philosophy has been completed by ABB, implementing operational modes decided by SPEN and NGESO
- The FAT for the Control System was carried out in August, witnessed by with both SPEN and NGESO with design discussions still ongoing with the view to close these out prior to the SATs during Commissioning in the next reporting period

Work Package 5 – Research

- System Studies have started during the current reporting period looking at –
    - To determine the benefits of a single H-SC installed at Neilston to analyse the B6 Boundary transfer
    - Analyse Dynamic Reactive Power
    - Short Circuit Level and Peak Current Assessments
    - System Inertia and effects to RoCoF

Work Package 6 – Knowledge Dissemination

- A well-attended Technical Stakeholder Engagement event was held in Edinburgh during the first quarter of the current reporting period.
- SP Energy Networks and ABB have submitted a synopsis to CIGRE, and currently working on a paper
- Phoenix was presented at this year's LCNI Conference. (Day 1 - Wider Impact: Commercial Evolution and New Services session) and a high-level progress presentation from the stand
- Onsite, within the welfare cabins, there is a Knowledge Dissemination Room where we have hosted monthly presentations and site tours to both internal and external stakeholders.

- SP Energy Networks has been working closely with a design studio who have been capturing drone footage of the installation. This has been used to create a high level promotional video for the project which was published on SP Energy Networks social media accounts

Construction and Installation Works

During the current reporting period, the focus for Work Package 1 has moved from the office / design phase to site works at Neilston Substation. The Detailed Engineering in office was finalised in the beginning of the year, overlapping with the start of the Civil Works which ran in parallel with the site works during Q1.

Both SPEN and ABB site teams mobilised early 2019 with Civil Works formally starting March 2019 with the first foundations. At the time of writing, the main civil works are now complete with minor works to be closed out during the next reporting period.

Figure 2 – STATCOM Base being poured

In September, the installation works commenced starting with the installation of the outdoor primary equipment. During the current reporting period all outdoor equipment has now been installed, including the two large components, the Main Transformer and the Synchronous Condenser.

Indoor installation works started in October inside the STATCOM Building. During the current reporting period, we took delivery of the AC-DC panels, Control & Protection Panels which were installed within the STATCOM Building's Control Room. The IGBT Valves modules then arrived on site and were safely installed within the Valve Room within the STATCOM Building. Throughout the last month, cable pulling and termination has started and will be continuing throughout the first months of 2020.

Figure 3 - Ongoing Installation Works

Figure 4 - Ongoing Installation Works

During the start of the upcoming reporting period, rough alignment of the Synchronous Condenser and Pony Motor will be finalised before the final alignment during the Commissioning phase. The next steps will be taking delivery and installation of the Noise Enclosure around the Synchronous Condenser.

Prior to Commissioning starting on site, the Auxiliary and Earthing Transformers will be delivered and installed early next year and the cable pulling, and termination will be finalised. From the civils works, there are minor cosmetic works to conclude such as chippings and interlocked fencing to be installed.

Commercial Work Package

Introduction

Through the Phoenix project, the commercial work aims to assess and bring forward opportunities for Hybrid-Synchronous Compensators (H-SCs) and similar assets. 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, commercial service development and other approaches.

The commercial work package is led by the Market Specialist with input from NGESO, informed by wider international experience of similar assets / services and by a Commercial Working Group representing a range of GB stakeholders.

The main elements of the work and associated SDRCs to assess and access value are illustrated in below in Figure 5.

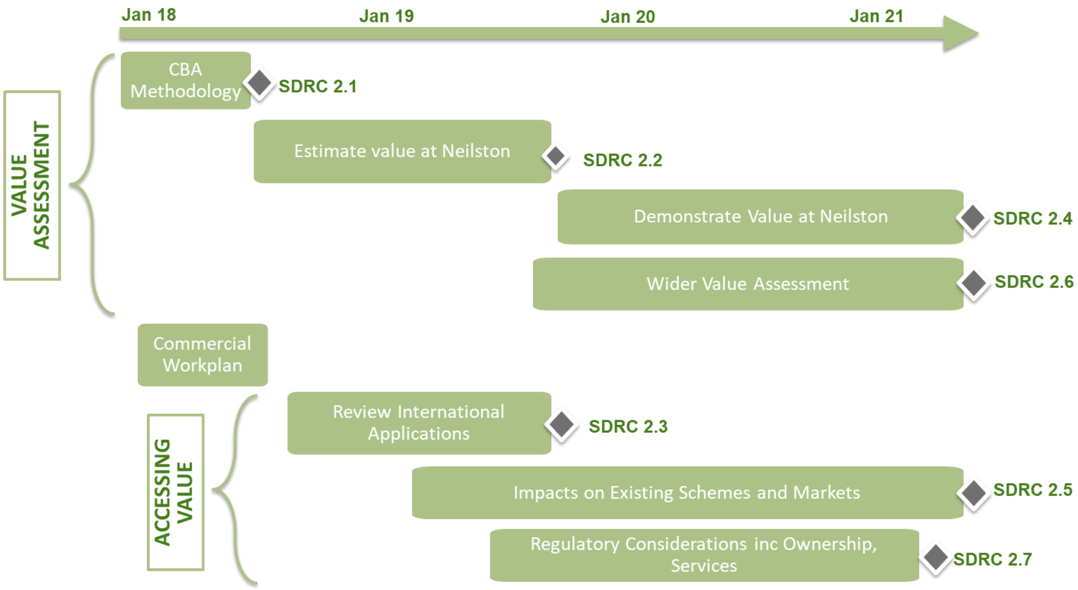

Figure 5 – Main Phases of Commercial Work Package

Progress Update

During the current reporting period the following work has been carried out:

- Completion of the CBA studies for Neilston and issue of report (SDRC 2.2)
- Completion of the International Review and issue of report (SDRC 2.3)
- Initial work started on commercial impacts (SDRC's 2.5 & 2.7)
- Initial work started on wider value assessment (SDRC 2.6)

CBA Studies for Neilston (SDRC 2.2)

Work to complete CBA studies for different cases at Neilston was carried out in the period up to September 2019, with the final report being published in October 2019.

Four different options were modelled at Neilston as follows:

i) 140MVA rated STATCOM only
ii) 140MVA rated Synchronous Condenser only
iii) 70MVA rated STATCOM + 70MVA rated Synchronous Condenser (without a single optimised hybrid control scheme)
iv) 140MVA rated H-SC (70MVA Synchronous Condenser and 70MVA STATCOM with hybrid control system, as is being currently installed at Neilston).

The impact of the above options has been analysed on the Anglo-Scottish B6 Boundary transfer limit between England & Wales and Scotland, and based on the following network backgrounds:

- 2019 Network
- 2023 Network – Assumed the closure of Hunterston Nuclear Station
- 2027 Network – Assumed the closure of Torness Nuclear Station

The analysis showed that dynamic reactive support from H-SC improves the boundary transfer capability, after the closure of nuclear plant in the region (post 2023). The increase in B6 boundary transfer with the Phoenix Neilston H-SC device could be 45 MW to 98 MW based on the Community Renewables (CR) Future Energy Scenario (FES) 2018 scenario, as illustrated in Figure 6 below.

Network	Season Background	Increase in B6 Boundary Transfer
2019 Network	Summer	0 MW
2019 Network	Winter	0 MW
2023 Network	Summer	45 MW
2023 Network	Winter	90 MW
2027 Network	Summer	65 MW
2027 Network	Winter	98 MW

Figure 6 - The increase in Boundary Transfer with the Phoenix Neilston H-SC Device

In terms of power system transfers, the H-SC solution provided a higher Net Cost Benefit than the other options as illustrated in Figure 7 below.

FES Scenario	STATCOM	SC	SC and STATCOM	H-SC
CE	60 – 70	58 -70	67 - 83	73 - 86
CR	45 - 55	43 - 55	47 -63	53 - 66
TD	46 - 56	44 - 56	48 - 64	54 - 67
SP	37 - 47	34 - 46	34 - 50	40 - 53

Figure 7 - Net Cost Benefit (£m) for Different Future Energy Scenarios

The addition of H-SC also improves the residual voltage, Transient Over Voltage (ToV) and voltage angle of the system. However. the increase in Short Circuit Level (SCL) and inertia, with a single 140MVA H-SC is not enough to influence the operation of the system. The initial analysis on improvement in SCL and inertia of the system with multiple SC/ H-SC has been carried out with will be reported within the next reporting period.

International Review (SDRC 2.3)

System characteristics, system challenges, recent synchronous condenser applications and market arrangements have been reviewed for several other international transmission systems. This work drew on inputs from published reports, inputs from project partners, Commercial Working Group members and wider contacts, with the final report being published in October 2019.

Seven of the international areas that were reviewed were chosen on the basis that information was available on recently installed, or proposed, synchronous condensers. These areas are Denmark, Germany, Italy, California, Ohio, Texas and Australia. The other two areas, Iceland and Ireland, were included on the basis that they have smaller island based synchronous systems with increasing levels of renewable generation. Characteristics for the different areas are summarised below within Figure 8.

The report demonstrates that synchronous condensers have been successfully used internationally over the last five to six years to support transmission systems with reducing levels of synchronous generation. Several new synchronous condensers have been installed and a smaller number of existing generators have been converted for use as synchronous condensers.

The local context, system requirements and commercial arrangements were diverse across the areas that were reviewed, and whilst they don't indicate a clear direction for commercial and regulatory arrangements in GB, the examples have provided valuable insight into potential synchronous condenser use and commercial approaches. The commercial arrangements have included TSO ownership, the installation and remuneration of synchronous condensers through a wider industry process to review available options, and the installation of synchronous condensers by transmission companies or generation project developers to meet a local compliance requirement or to deliver a target short circuit or inertia level.

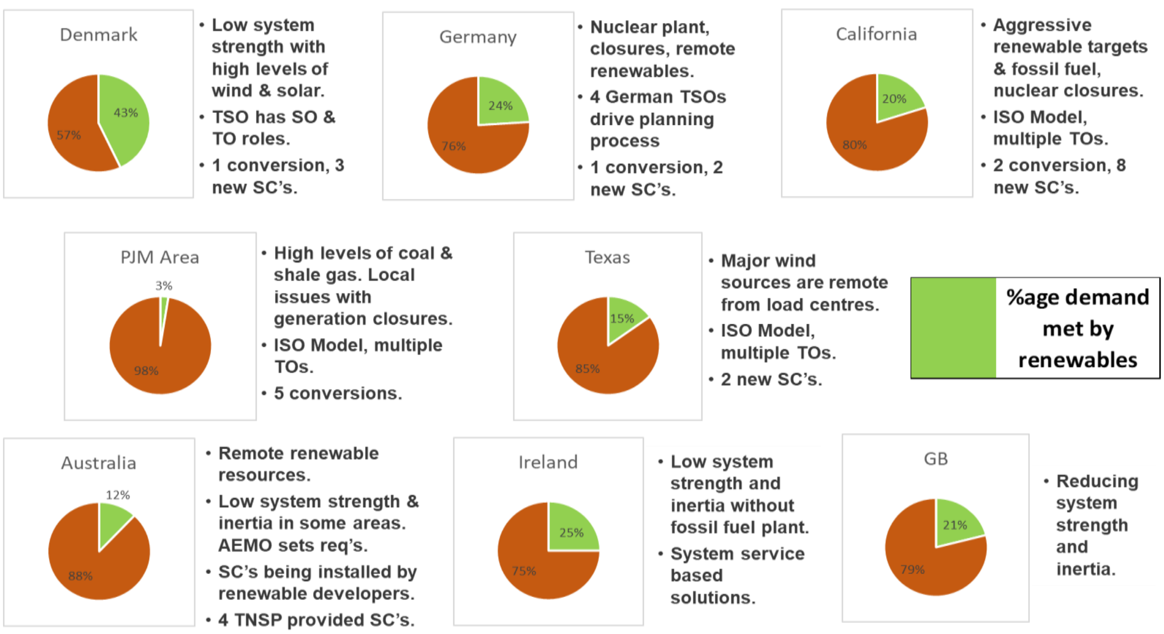

Figure 8 - Characteristics of Review Areas and Synchronous Condensers Installed

Initial work started on Commercial Impacts (SDRC's 2.5 & 2.7)

During the current reporting period, work has started to consider how the wider introduction of H-SCs (or synchronous condensers) would impact existing GB markets. To provide a framework for this assessment, the model shown within Figure 9 below is being used to assess several approaches including:

i) a compliance / standards-based approach
ii) an approach based on identifying needs, reviewing options and select a preferred option
iii) an approach based on establishing a broader system services framework.

This work is being supported by the wider Commercial Working Group and will continue into the next reporting period to inform the deliverables for SDRC 2.5 and SDRC 2.7.

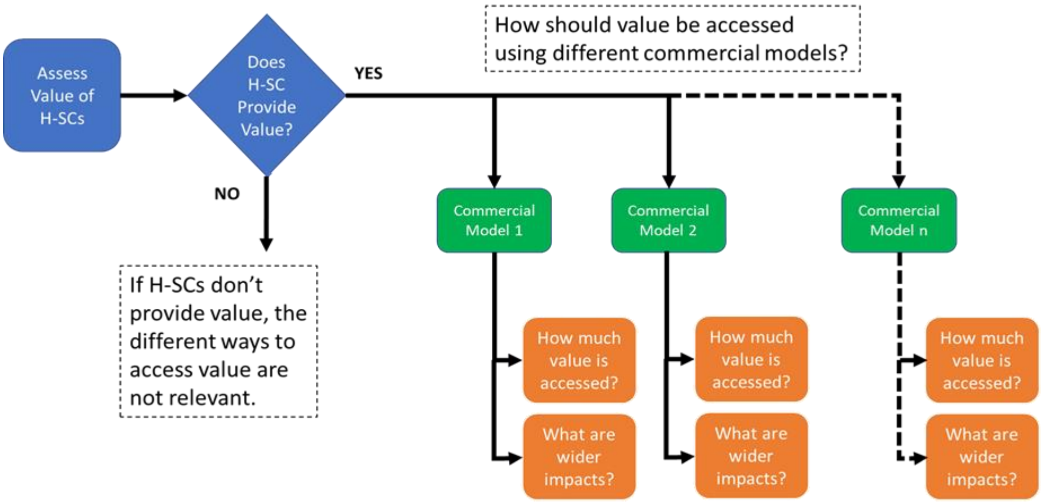

Figure 9 – Framework for Commercial Impacts Discussion

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 the Market Specialist and, as well as NGESO, the group currently includes representatives of several organisations outside of the Phoenix project including project developers, industry trade bodies, networks and policy makers.

The Commercial Working Group met face on three occasions during 2019. These workshops were held at the IET Building in London on March, August and November 2019 to review ongoing and completed commercial work and to consider the interactions with other industry initiatives including the NGESO's "Stability Pathfinder" initiative.

In addition, several WebEx meetings have been held with members of the Commercial Working group to help develop a "Commercial Impacts" assessment. For the two commercial SDRCs delivered during the current reporting period, the Commercial Working Group has provided valuable input and will continue to do so throughout the next reporting period.

Research and Studies

System Studies

Earlier during the current reporting period, the generic H-SC model was delivered by ABB and validated by NGESO within PowerFactory. The generic H-SC model has a Master Control, which has the following functions activated:

- Coordinated voltage control between Synchronous Condenser (SC) and Static Compensator (STATCOM) and
- Fast Transient Compensation (FTC)

NGESO also validated the actual Neilston H-SC model provided by ABB. The Neislton H-SC model has a Master Control with the following functions:

- Coordinated voltage control between SC and STATCOM
- Power Loss Minimisation (PLM)
- Fast Transient Compensation (FTC)
- Slow Q Control mode
- Inertia Support Maximisation (ISM)

The validated model report and model has been submitted to NGESO planning team as well as SP Energy Networks System Analysis Team.

The aim of the system studies during the current reporting period was to assess and quantify the contribution of Synchronous Condenser, STATCOM and H-SC units for the following:

- Dynamic reactive power provision
- System inertia
- Changes in primary frequency response from closure of conventional plants
- Short circuit level

The studies have been based on a model of the GB transmission system which is represented by a 36-bus equivalent network (refer to Figure 10 below). This model has been developed by NGESO in DIgSILENT PowerFactory, with each numbered zone in the model representing a part of the system and consists of a mix of different energy sources and loads. Generators within each zone are represented by static generators and synchronous machines including relevant dynamic controllers. In each zone, generation, loads, HVDC interconnectors and transmission lines are connected to 400-kV busbars. The GB model has been dispatched to represent years 2019, 2023 and 2027 for both winter peak and summer minimum periods. The generic H-SC model described above has been used by the University of Strathclyde to analyse the benefits of Neilston H-SC in the GB transmission system.

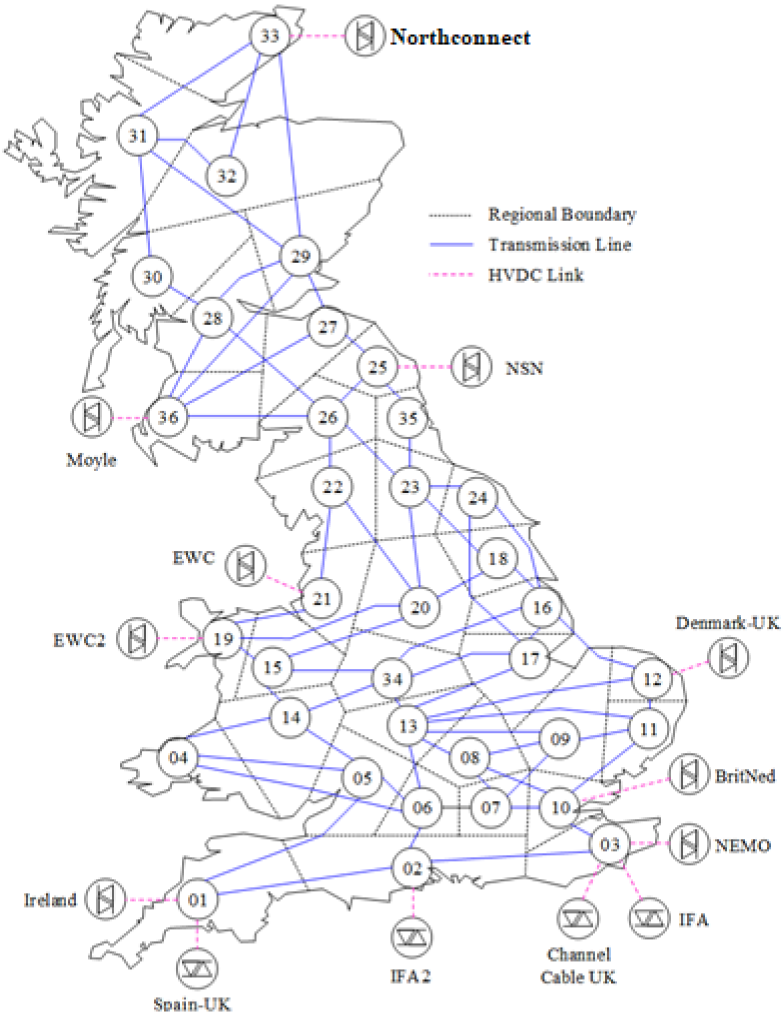

Figure 10 - 36-bus equivalent network GB transmission network

System Studies have demonstrated that the deployment and operational control of Synchronous Condenser, STATOM and H-SC units in the GB transmission system can bring significant advantages to the system. During the current reporting period, the main focus of the Dynamic reactive power provision studies has been on Zone 28 (i.e. Neilston location) considering different mixes of Synchronous Condenser, STATCOM and H-SC technologies. Simulation results have revealed the following (refer to Figure 11 for a representative case of transmission line fault):

- Synchronous Condenser, STATCOM and H-SC units can provide reactive power support in steady state conditions. In the case of H-SC, reactive power delivery is equally shared between Synchronous Condenser and STATCOM
- Synchronous Condenser, STATCOM and H-SC units can provide dynamic reactive power capabilities during transmission line faults. Synchronous Condenser units are characterised by great overload capability and additionally can export increased amounts of reactive power, even when the voltage is significantly depressed. STATCOM units have limited reactive power capability when the voltage is severely depressed. Relevant sensitivity analysis demonstrated that that STATCOM units can utilise their full capacity when faults have fault resistance approximately 12 Ω.
- At the instance of fault clearance both the Synchronous Condenser and STATCOM units generate large negative and positive reactive power spikes respectively. However, when Synchronous Condenser and STATCOM units are combined (either as standalone units or via

the H-SC design), reactive power spikes at the instant of fault clearance is significantly compensated due to the complementarity of resources

- After the fault clearance Synchronous Condenser and STATCOM units revert to a steady state condition. STATCOM seems to recover faster while Synchronous Condenser takes more time due to its slower dynamics.

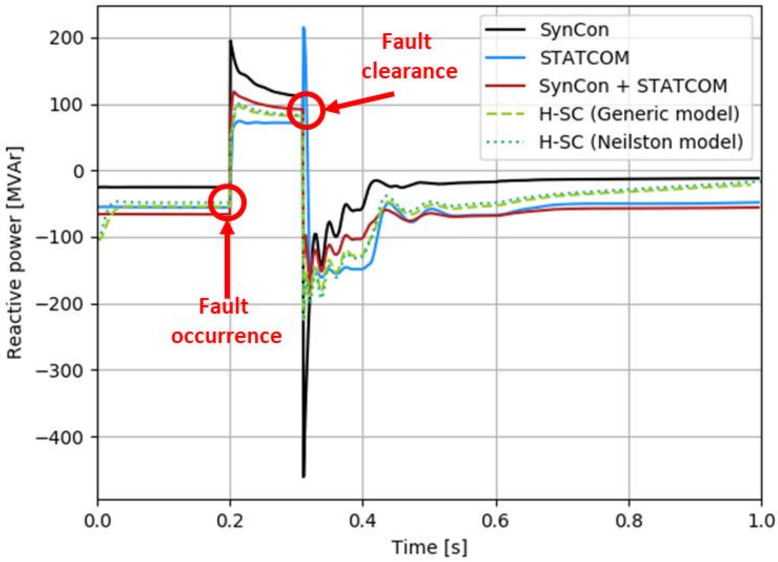

Figure 11 - Reactive power response during transmission line fault

Studies on system inertia have been also conducted considering that the system is characterised by a 82 GVAs inertia. A loss of non-synchronous generation event (i.e. 1005 MA) was triggered to drive frequency to reach a nadir of 49.2 Hz with Synchronous Condenser units of different capacities put forward to investigate their contribution.

Following a loss of generation event, the frequency nadir and RoCoF values have been analysed with and without synchronous condenser. These simulation results demonstrated that Synchronous Condenser have the potential to contribute to system inertia. Each SC has been assumed to have an inertia constant of 1.34s and hence their contribution on improvement on frequency nadir and RoCoF is low. This analysis has been carried out by assuming all SCs are located at the same location. Further analysis will be required, assuming multiple SCs at different locations, to establish the benefit of SC on inertia and their impact on frequency nadir and RoCoF on the GB Transmission network. Further analysis will also be carried out in the upcoming reporting period to determine their impact on improvement on the maximum infeed loss that could be achieved with the addition of SCs.

Relevant sensitivity analysis on short circuit level (SCL) demonstrated that i) GB system will be subject to great SCL decline between years 2019 and 2023 and ii) Zones 10, 12 and 19 will experience the largest SCL decline (refer to Figure 12 and Figure 13 below). These outcomes can be a significant input regarding the design, control and operation of power system protection schemes and devices driven by phase locked loops. By conducting a large set of simulations, it was concluded that by deploying Synchronous Condenser units the SCL can be significantly elevated (refer to Figure 14, Figure 15 and Figure 16 below). However, the selection of a precise rated capacity of those units is anticipated to be based upon other features, including power system protection performance and commutation failure of HVDC links.

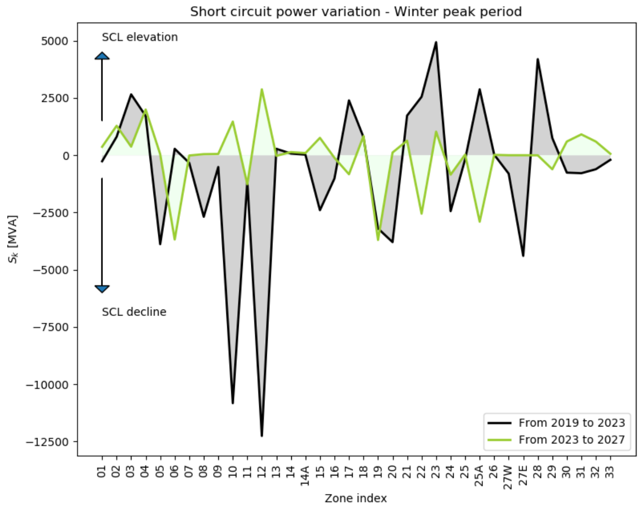

Figure 12 - Short circuit level change from 2019 to 2023 and 2023 to 2017 for winter peak period

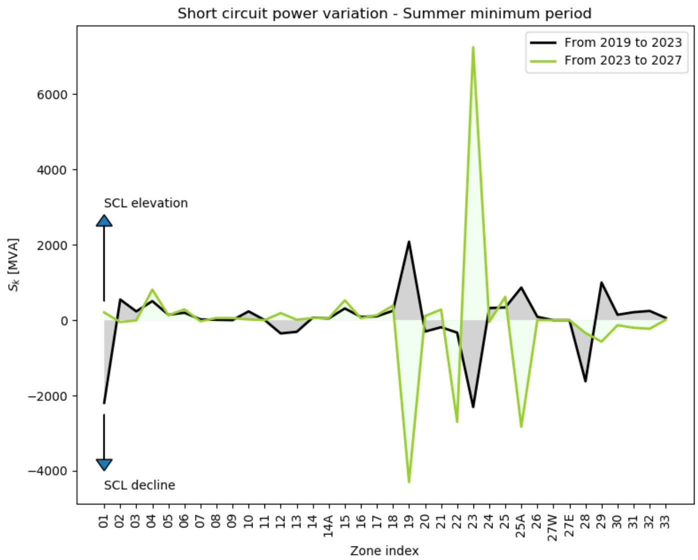

Figure 13 - Short circuit level change from 2019 to 2023 and 2023 to 2017 for summer minimum period

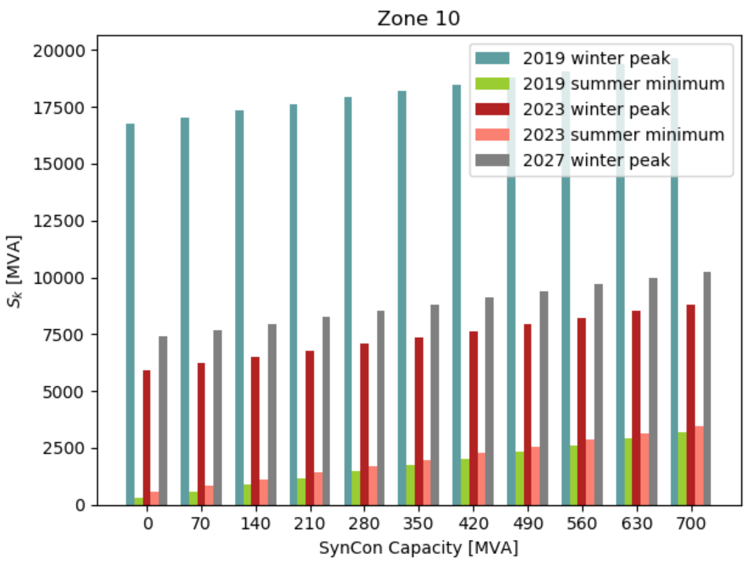

Figure 14 - Short circuit power at Zone 10 for different SynCon capacities and different dispatch scenarios

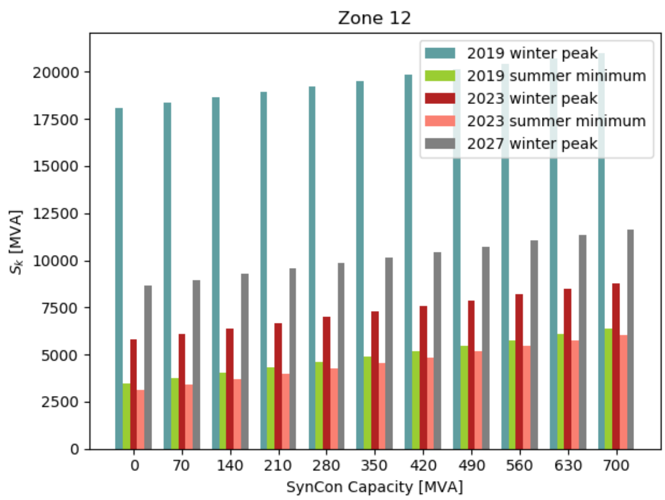

Figure 15 - Short circuit power at Zone 12 for different SynCon capacities and different dispatch scenarios

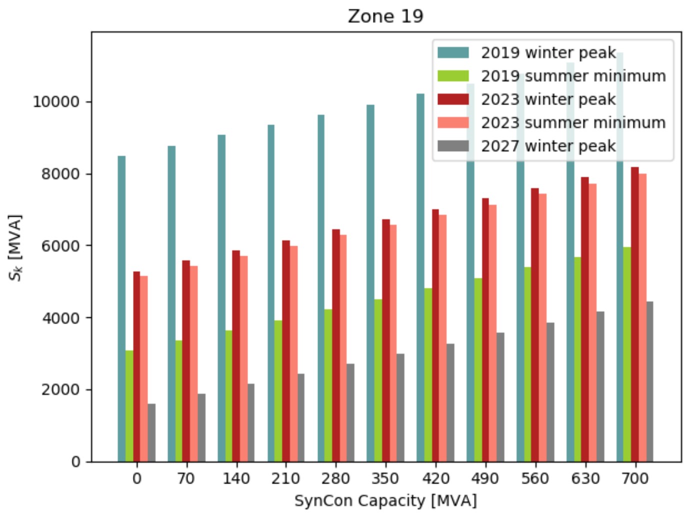

Figure 16 - Short circuit power at Zone 19 for different SynCon capacities and different dispatch scenarios

Component Studies

Modelling of H-SC with BESS Progress

The battery model for the H-SC has been developed in PSCAD, which is based on the previously delivered PowerFactory model. The parameter of both models are identical with the exception of an LC filter, which introduces an acceptable error of 1-5% in injected reactive power flow. The models were compared in identical operation scenarios, where we have shown that the models respond in the same way to different disturbances.

Figure 17 below shows the battery response to a frequency drop to 47 Hz with a rate of change of 1 Hz/s. The battery system has a frequency droop control (droop 0.03), which means that it will inject full rated power for this frequency deviation. The battery starts to discharge, and we, as expected, can notice a voltage drop at the terminal. The plots captured in PSCAD and PowerFactory are matching to a very low margin of error.

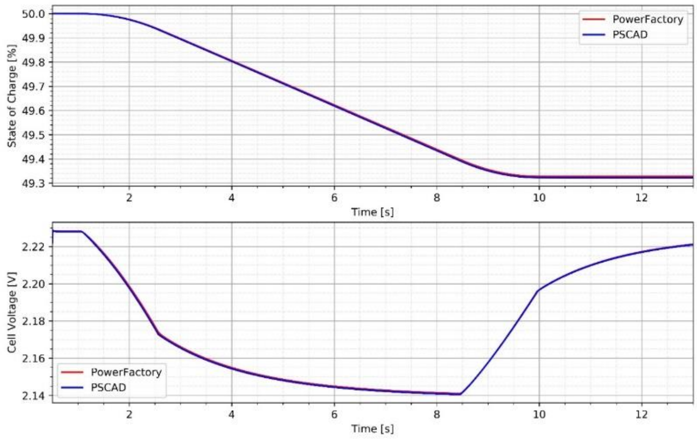

Figure 17 - Battery Model - PowerFactory and PSCAD Comparison

The parameters of the battery system are fully adjustable (droop coefficient, control parameters, PLL parameters, reference voltage and power, etc.), and the whole system can be scaled to the desirable size. The default rating of the system is 10 MW, ±4.5 MVar, 690 Vac, 1.3 Vdc. A preliminary test of the hybrid system was simulated in PowerFactory to demonstrate some of the capabilities and behavior of the components. The test is basically a comparison of the responses from the hybrid system, synchronous condenser, and BESS to a frequency event.

The battery model was updated recently with the fault-ride-through strategy being changed to match the requirements of the UK grid code. If the measured voltage at PCC drops below 0.9 pu, the fault-ride-through function will be activated, and the resulting reactive power injection will be equal to the sum of the pre-fault value of the reactive current and the current estimated based on an I-V fault characteristic modelled as per the grid code. Full rated reactive power will be injected if the voltage at PCC drops to 0.5 pu. An additional frequency support function was implemented, namely the RoCoF function, which generates an active power reference proportional to the rate of change of frequency. The block diagram of the control structure is shown in Figure 18 below.

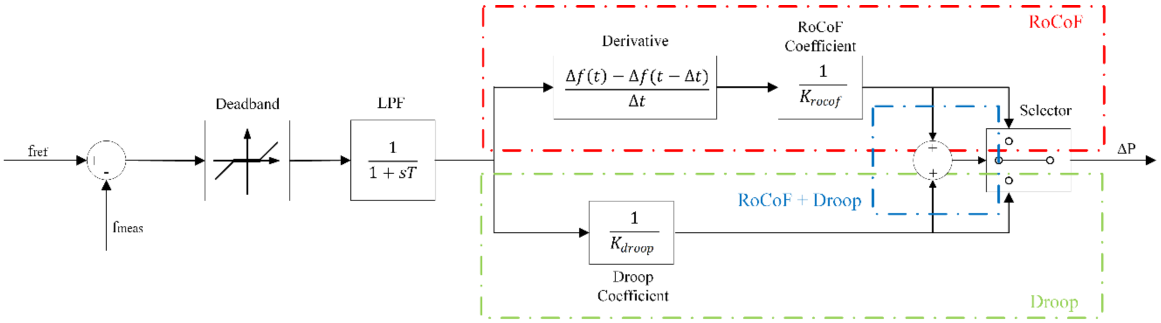

Figure 18 - Frequency Droop/RoCoF Controller

The user can change between the preferable control strategy by choosing droop, RoCoF, or sum of both functions. The droop control is slower to react, and it affects the frequency nadir, and the steady state frequency, while the RoCoF should be faster and more sensitive function. The RoCoF functions is not active if the frequency is constant (output is 0 because it is directly proportional to the derivative of frequency).

The focus during the next reporting period will be on evaluating the stability of the hybrid system based on the impedance scan measurements and developing more elaborate and detailed control design for the hybrid system.

Experimental Platform Development Progress (Power Hardware-In-the-Loop (PHiL) testing)

The objective of hardware in the loop-testing platform is to serve as a high-fidelity validation platform for the analytical methods of converter characteristics and the developed control strategies for the hybrid system composed of BESS and SC. The overall test system comprises of a simplified model of power system derived from the network model supplied. This power system model along with the SC and its control is simulated in Real-Time Digital Simulator (RTDS). The real-time power system simulation is interfaced with an actual two-level BESS integrated voltage source converter (VSC) and its control system emulated on NI GPIC board.

Due to delays involved in establishing a long optical fiber signal interface between the RTDS and high power electrical lab and procurement of equipment and cabinet assembly to satisfy the lab safety measures, the full PHiL Dynamic performance study to assess the impact of BESS+SC on Nielston area power system will be carried out within the next reporting period. Despite of the delay on the PHiL test, controller hardware-in-the-loop (CHiL) study of the hybrid system consisting of a synchronous condenser and BESS connected to a simplified power system was carried out during the current reporting period. For this study, an ideal battery connected VSC and Synchronous condenser (both rated 70 MVA) along with the IEEE AC8B excitation system was implemented in RTDS. A generic active and reactive power droop-based controller for the BESS-VSC, along with the PWM and inner current controller is implemented in the National Instruments-sbRIO hardware platform, the programming for the controller is done using LabVIEW. The Thevenin equivalent for the test power system is chosen such that the Hybrid system affects the PCC voltage by 5%. The droop setting for the active power loop of BESS was chosen as 2%, which implies a full rated active power injection from the BESS for a 1 Hz drop in system frequency. Whereas the slope for reactive power loop was chosen as 5% for both BESS and SC. The sizing of the hybrid system is not optimized in the study, as this aspect will be investigated later within the project. The runtime (control panel) snapshot of the RSCAD hybrid system model is shown in Figure 19 below.

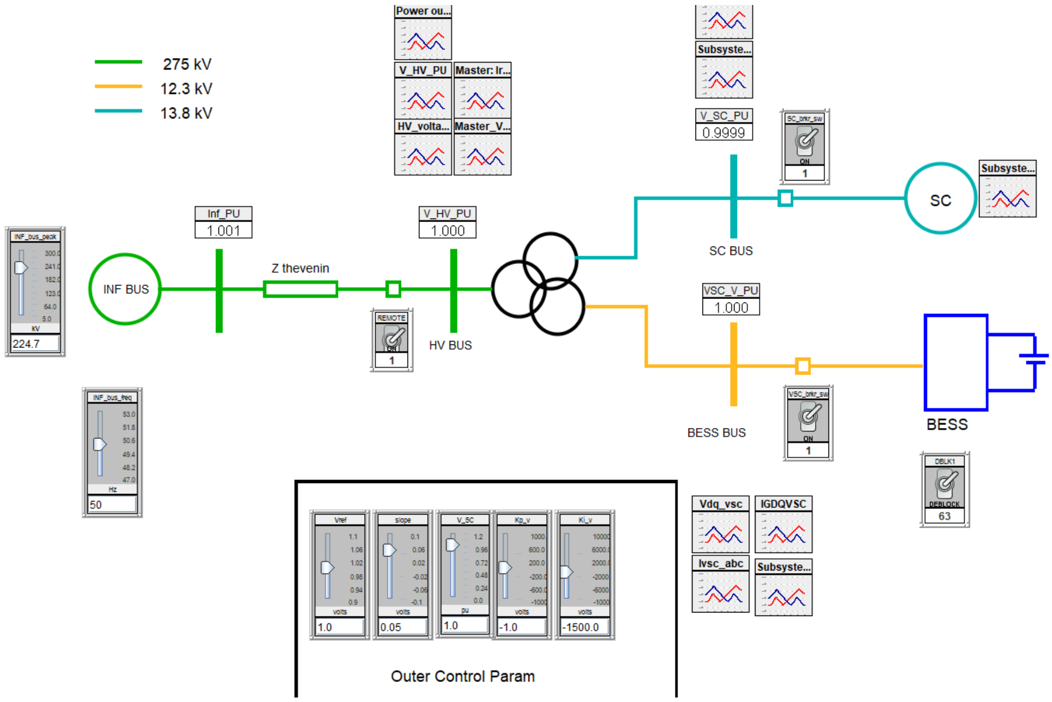

Figure 19 - Runtime snapshot of RSCAD hybrid system model

In parallel, a linear small-signal model of the hybrid system was derived in MATLAB. The control parameters for AVR and the VSC were tuned utilizing the MATLAB control system toolbox and the derived linear model. Overall, the same control parameters tuned using the small-signal model were found to meet the design objectives in the real controller of VSC, with minor changes. An additional slower phase-locked loop (PLL) was used in estimating the system frequency for power-frequency droop control of BESS. The responses for the hybrid system for a 5% change reference voltages and a system frequency drop to 49 Hz at a rate of -1 Hz/s. These results are displayed within in Figure 20 and Figure 21 below.

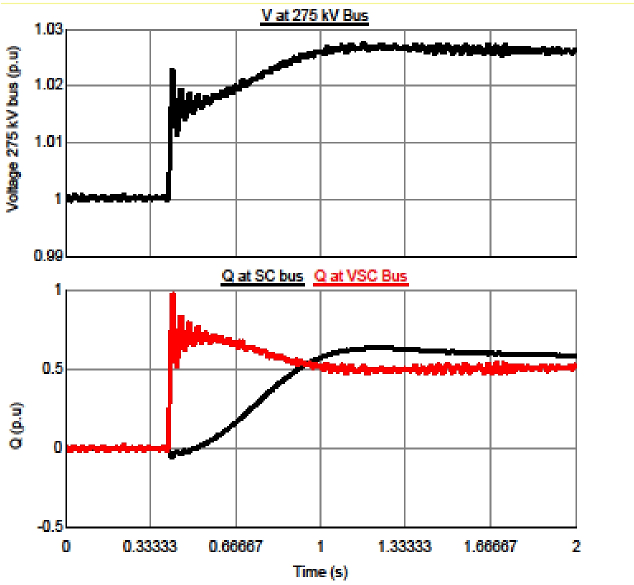

Figure 20 - Hybrid system Vref increase by 5%

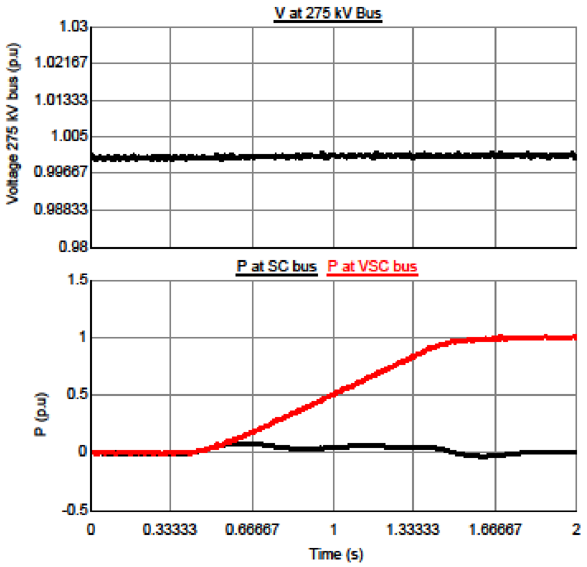

Figure 21 - System Frequency drop to 49 Hz at -1Hz/s

In addition to the CHIL study, a theoretical assessment of the dynamic performance of VSC control system and its potential impact on the small signal stability of the power system was carried out.. Two major studies were carried out, firstly, a frequency-domain passivity theory was used to compare the dynamic input impedances of a grid connected Voltage Source Converter (VSC) with two different design alternatives for the current controller; a decoupled current controller and Proportional Resonant controller. Secondly, the impact of dynamics of instrument transformers and signal processing filters on PLL performance during power system faults. DTU is in the process of publishing the results of this work in a Journal.

Knowledge Dissemination & Stakeholder Engagement

Stakeholder Engagement Event

In February, we held a Technical Stakeholder Engagement Event in Edinburgh. Based on the feedback from an event held during the previous reporting period, it was evident that many of our project stakeholders were interested in the technical design of the H-SC and the design / understanding of the innovative control system.

This well attended event included a project progress update from SPEN before ABB presented on the design of an H-SC and the innovative Control System. After lunch, both universities presented on their studies using the H-SC model and a look ahead to what studies will be carried out in collaboration with each other and ABB. The event then finished with a Q&A panel where interesting discussions were had regarding how the H-SC would work on the network and how the Control System would react to events when in Live Trial. These learnings were taken back, and the basis of studies have been edited to reflect key questions from our stakeholders.

Figure 22 - Stakeholder Engagement Event

Figure 23 - Stakeholder Engagement Event 2

Neilston Substation Site Visits

During the set up and design of the on-site welfare facilities at Neilston Substation, it was agreed that there would sufficient space for a knowledge dissemination room. In line with Scottish Power's in-house design studio, there were wall canvases designed and a touch screen set up for presentations.

On a monthly basis, the SPEN Project Management Team has held monthly Knowledge Dissemination Events with both internal and external stakeholders. The events normally last half a day and include a presentation on the project where there is a need for H-SC technology and the benefits and learnings from the project, before an escorted site tour explaining where we explain and discuss different components as well as various learnings from the construction and installation works.

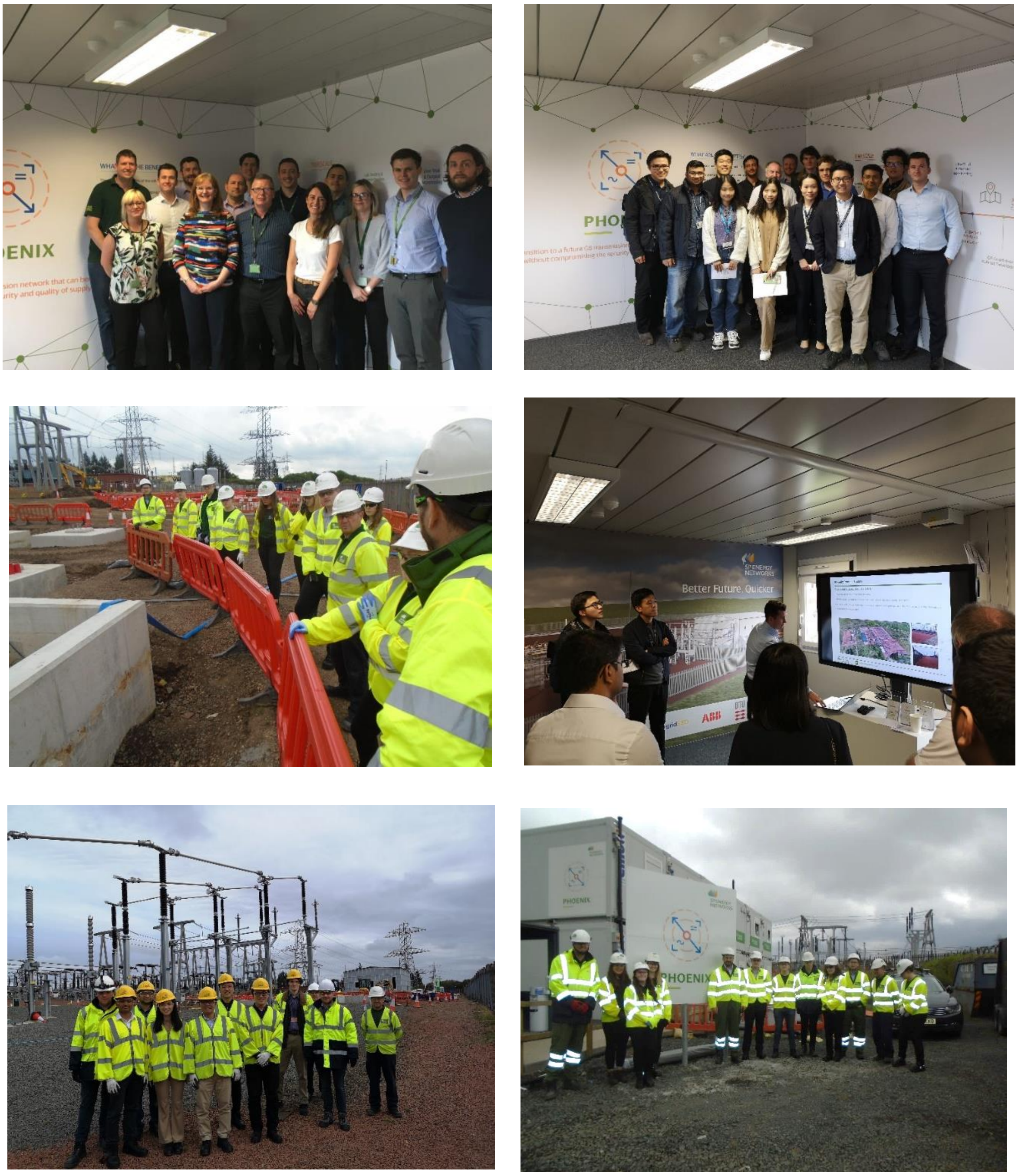

Figure 24 – Neilston Site Visits

LCNI 2019

At this year's Low Carbon Network & Innovation conference, Phoenix was presented during one of the breakout sessions. On Day 1 of the conference, during the Commercial Evolution and New Services breakout, SPEN and ABB collaborated on a joint presentation.

This presentation started with explaining how the network is changing and the requirement for the Phoenix project, before then moving into the benefits it can deliver. ABB then followed on by presenting on H-SC technology and how the innovative control system works. The presentation then moved onto the results from the system studies of the Neilston area which have fed into the early CBA results. This proved to be good timing to start presenting on these results, as the CBA Studies for Neilston (SDRC 2.2) was formally published the same week as LCNI.

Figure 25 – LCNI 2019

Video and Drone Footage

Through the current reporting period, in agreement with the SP Energy Networks Transmission SAP, there has been a drone capturing ongoing construction and installation works. This footage has been collated with the view to create a progress video of the H-SC Installation.

However, prior to this, SP Energy Networks project team has been working closely with a design studio to create a high-level overview video to explain what Phoenix is and the benefits of the project. The main aim of this video was to be an ice breaker and to ensure all viewers will understand from stakeholders, academics to our customers and the public. This video was released via social media as part of an agreed communication plan.

Look Ahead to the Next Reporting Period

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

Commissioning and Live Trial

As highlighted earlier, the primary focus, once the final installation works conclude, is the commissioning of the H-SC. Commissioning Panel Meetings (CPM) chaired by SPEN commissioning manager started during the current reporting period and will continue throughout the commissioning phase. The CPM includes representatives from SP Energy Networks Project Team, SP Energy Networks Transmission Ops and ABB.

With regards to the live trial, there is ongoing communication to both SPEN and NGESO Control Room about how the H-SC will be tested and operated. This communication will continue through the commissioning phase to ensure all the requirements of each operational modes is understood for the testing of the H-SC throughout the live trial and evaluation period.

Research and Studies

The studies carried out so far assumed a 140 MVA SC/ STATCOM / H-SC at Neilston location. Currently, the benefit of H-SC with higher ratings (280 MVA, 420 MVA) is being analysed by NGESO and will continue throughout the upcoming reporting period. These works are expected to complete with results written up within the first six months of the upcoming reporting period.

As the results from the Neilston installation are analysed, the system studies will begin to analyse the optimal geographical placement of H-SCs within the GB Transmission network considering both the loss of short circuit level and the progressive decline of synchronous generation.

There will also be additional system studies running in parallel taking into consideration the BESS model from The Technical University of Denmark, and exploring system intertia alongside the findings of the NGESO NIC Project EFCC.

From a component studies perspective, the full PHiL Dynamic performance study to assess the impact of BESS+SC on Neilston area power system will be concluded. Further studies with the BESS+SC system will look into the factors influencing potential small signal instability. These studies will aim to derive some control design guidelines for BESS+SC control systems and will be concluded near the end of the upcoming reporting period.

Commercial Work Package

In parallel to the system studies listed above, the further opportunities for H-SC in GB system will be analysed by carrying out analysis in different part of the GB system. The studies will consider the different part of the GB system as shown in Figure 26 below. Further analysis will then be carried out to quantify the power loss incurred by the H-SC device, the improvement of short circuit level and inertia of the system with the multiple units of SC / H-SC installed. These works are expected to conclude and analysed within the first six months of the upcoming reporting period.

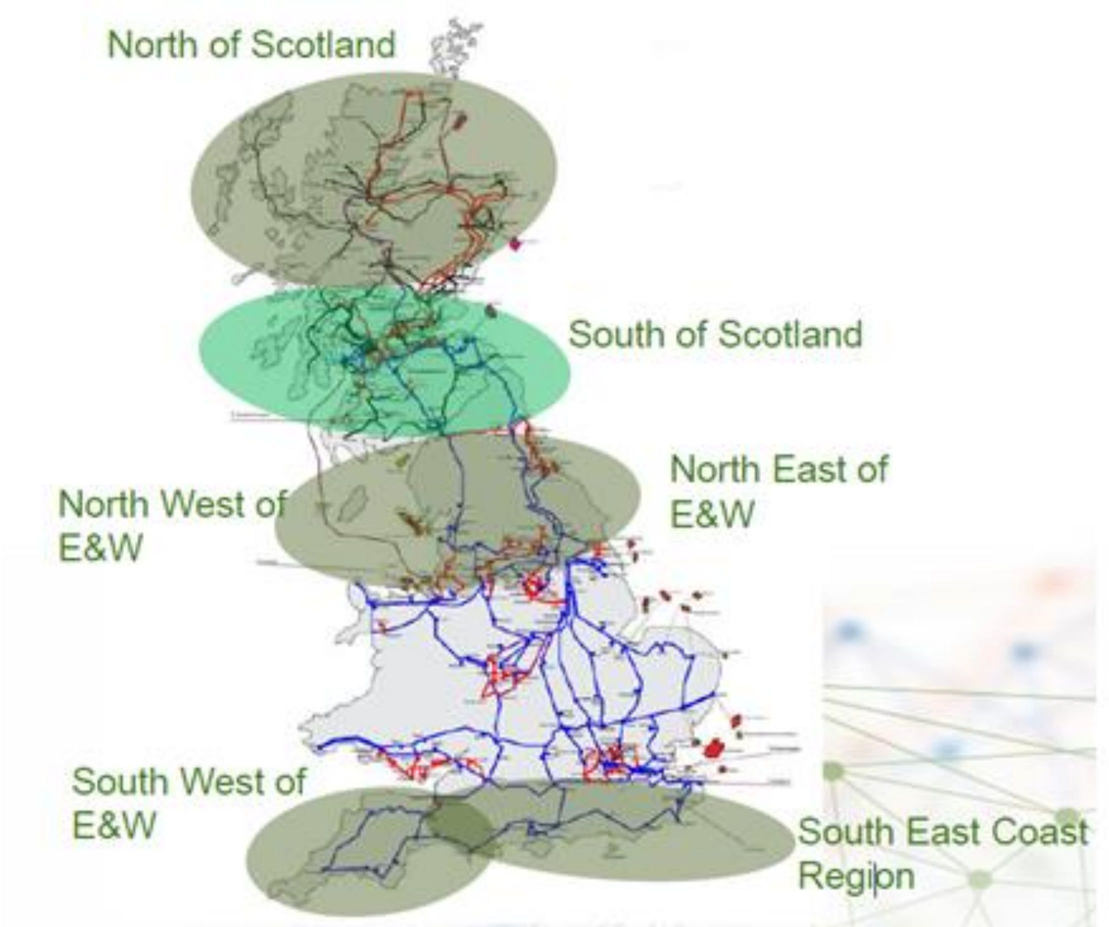

Figure 26– Wider H-SC Opportunities on the GB Network

There are plans for three Commercial Work Group meetings throughout the upcoming reporting period. The focus of these meetings will be a chance for the group to review results from the pilot installation at Neilston once the system is energised, to contribute to the Report on value evaluation of SCs/H-SCs. Additionally, the group will add value to the delivery of both the Balancing & Markets Impacts work and the review of Regulatory Considerations for the roll out of H-SC technology.

Knowledge Dissemination

Where possible, around a busy commissioning programme in the first half of 2020, 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 how busy site will be at certain stages through commissioning and being conscious of Health and Safety when escorting Stakeholders around site.

Looking ahead to post energisation, SPEN will be organising a Stakeholder Engagement event to summarise all the learnings from the first installation of an H-SC and how this was commissioned and tested on site. The focus of this event will be to disseminate the plans for the Live Trial and to discuss findings and results from the various system studies which will be completed throughout the next reporting period.

Consistency with Full Submission

At this early stage of the project deliver, Phoenix remains consistent with the original Full Project Submission with regards to budget, however as previously mentioned the project programme has suffered some delays. Site works starting later than planned has had subsequent knock-on effects to Commissioning start date and ultimately the beginning of the Live Trial.

This delay has been communicated with all resource and relevant parties, to ensure the full project programme is on track to be delivered within the originally NIC project end date tolerances. Additionally, SPEN and all project partners will continue to proactively review the programme and deliverables to understand what works can run in parallel.

Successful Delivery Reward Criteria (Current and Next reporting period)

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 2019:

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 2. Report on environmental studies and life cycle analysis 3. Report on detailed installation diagrams and site layouts 4. Report on routine and type testing procedure and results
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.	2. Report on cost benefit analysis of SCs and H-SCs based on system studies and FES 3. Report on international application of SCs and benefit analysis
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.	2. Report on output of SCAPP project on protection and control of synchronous condenser and simulation results of new control methods 4. Report on methods and functional specifications of innovative control schemes for future roll-out 5. Report on FAT test procedure and results of pilot hybrid co-ordinated control system
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.	3. Report on co-simulation for faster prototyping for new designs and controls
5) Application of synchronous condenser: GB system studies System studies using SC/H-SC component model and GB system model	1. Report on System Studies and Quantification of overall benefits from application of SCs/H-SCs in GB system. WP5

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.	
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.	2. Report on Site Installation Process, Details and Recommendations for Future – Electrical 4. Report on electrical layout of H-SC design with protection and control architecture
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.	3. Functional specifications for H-SC output monitoring- Methods and User Interface 4. Functional specification for H-SC wider system operational performance monitoring
8) Knowledge Dissemination Stakeholder engagement and dissemination of learnings and outcomes of the pilot H-SC demonstration through project.	3. Innovation Testing and Demonstration Workshop 4. Project Phoenix regular project progress reports

The following SDRC are due for completion in the upcoming reporting period:

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.	3. Report on performance of pilot hybrid co-ordinated control system 6. Report on SAT test procedure and results of pilot hybrid co-ordinated control system
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	3. Report on optimal placement and capacity evaluation of SCs/H-SCs in GB 4. GB roadmap for roll-out of SCs/H-SCs

network. Case studies for specific system cases on GB network	
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 2. Report on Site Installation Process, Details and Recommendations for Future – Electrical 3. Report on SAT procedure and test results
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 2. Process documentation for SC type testing requirements for future installations
8) Knowledge Dissemination Stakeholder engagement and dissemination of learnings and outcomes of the pilot H-SC demonstration through project.	2. Report on emerging technical standards for synchronous condenser 3. Innovation Testing and Demonstration Workshop. WP6 4. Project Phoenix regular project progress reports. WP6.

Learning Outcomes

During the current reporting period the construction and installation has not yet concluded, with a knock-on effect to commissioning. The main learnings from an installation and commissioning perspective will come during the upcoming reporting period.

However, from a system studies point of view, we can already see results from the installation at Neilston. During the upcoming reporting period, these findings can be analysed and validated in line with data from the Live Trial and evaluation period. Furthermore, the studies exploring different the benefits of different ratings of H-SC will be concluded as well as the geographical location of H-SC installations and the benefits that will be delivered to the GB Transmission Network.

Business Case Update

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Bank Account [Confidential]

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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: 05/02/2020

Signature:

Name (Print): James Yu

Title: Future Networks Manager

Date: 05/02/2020

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

SP ENERGY NETWORKS

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