Electricity Network Innovation Competition Screening Submission Pro-forma

Notes on completion
Before completing this form, please refer to the Electricity Network Innovation Competition (NIC) Governance Document. **Please use the default font (Verdana size 10) in your submission, the text entry areas are predetermined and should not be changed. The full-completed submission should not exceed 10 pages in total.** **Ofgem will publish all the information contained within the Screening Submission.**
Funding Licensee
SP Transmission Plc (SPT)
Network Licence Project Partners
To be finalised
Funding Licensee area
SP Transmission network
Project title
Phoenix - System Security and Synchronous Compensators
Project Summary
The Licensee must provide an approximate Project start and end date.
Phoenix will demonstrate a sustainable design, deployment and operational control of a Synchronous Compensator at a strategic point on the SPT network. The project will also undertake studies to further develop the commercial mechanisms available to incentivise the use of Synchronous Compensators to enhance system stability and security. The future generation mix in Scotland will mainly consist of intermittent, asynchronous renewable energy sources. The successful demonstration of Synchronous Compensator technology through this innovative arrangement for the first time on the GB network will enable subsequent applications to: 1. Boost system inertia; 2. Provide dynamic voltage regulation; 3. Deliver reactive power injection support to alleviate voltage dip conditions; 4. Increase the system fault level and system total strength; 5. Enhance the oscillation damping capability; and 6. Aid in maintaining power quality of the network in the event of harmonics and power system imbalances. Aligned with the SPT's RIIO T1 Transmission Innovation Strategy Review (2014) and NETS SQSS, Phoenix will help transition to a future GB transmission network that can make full use of clean energy resources without compromising the security and quality of supply to the GB customers. The project is expected to commence in January 2017 and planned to come to successful conclusion by March 2021.
Estimated Project funding
The Licensee must provide an approximate figure of the total cost of the project and the NIC funding it is applying for.

Total cost of Project	£15.3m	**NIC funding requested**	£13.7m
Cross Sector Projects only: requested funding from Gas NIC, NIA or second tier LCN Fund?	*If yes, please specify* N/A		

Problem

The Licensee must provide a narrative which explains the Problem(s) which the Project is seeking to address.

"As the volume of asynchronous generation on the GB system grows there is an increasing need for new services and products that can be economically deployed to manage the resulting changes in system characteristics. As highlighted in the 2015 System Operability Framework synchronous compensators should be effective in addressing several of the most significant system changes. Exploring the technical performance of synchronous compensators and how commercial services can be developed is timely given the future requirements highlighted in SOF." – Statement of support, NGET SO

- The change in generation mix creates system issues that risk the security of supply to the GB customers including;
    - **Reduced inertia** compromising the network stability and security in event of a large infeed loss and resulting in a large rate of change in system frequency.
    - **Low fault level** results in poor power quality with higher risks of harmonics and power system imbalances. It can also result in certain protection schemes failing to operate.
    - **Limited voltage control** in absence of immediate dynamic response as obtained from synchronous generators can result in voltages outside the statutory limits.
- The lower system inertia also requires the SO to procure higher system spinning reserve to compensate the fast frequency drop; increasing the balancing costs that make up around 1% of the GB customer's bill.

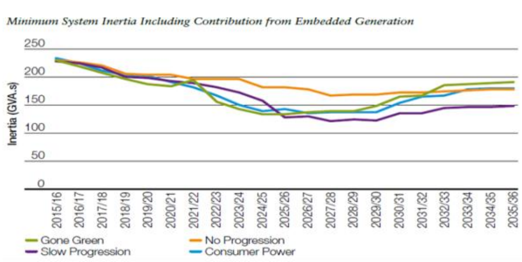

Figure 1 displays the future minimum system inertia including the contribution of embedded generation for National Grid's four future energy scenarios [National Grid. System Operability Framework 2015].

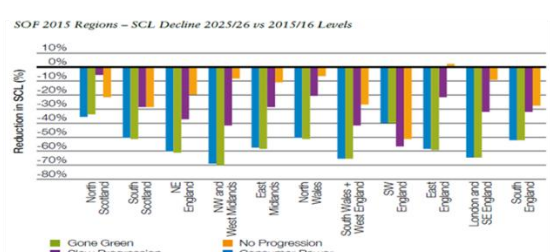

Figure 2 illustrates the future decline in short circuit level expected from 2015/16 to 2025/26 and states the level in South Scotland could fall 50% under two of National Grid's four future energy scenarios [National Grid. System Operability Framework 2015].

- The increased amount of power electronics on the system (power converters and controllers) have also increased the risks of sub-synchronous resonance, torsional interactions and control interactions in power networks (Project VISOR 2014). Studies and demonstrations are required to prove the concept of closed loop damping control and if required supplementary control to be made available in case sub-synchronous interactions are detected on the system using enhanced monitoring units deployed in project VISOR.

Method(s)

Project Phoenix will demonstrate methods for design and deployment of Synchronous Compensators (SC). The project will also research and help develop the future commercial and roll-out mechanisms to incentivise and build a roadmap for SC deployment in GB.

Method 1: Conversion/Deployment of Synchronous Compensator

- Design and deliver Synchronous Compensator infrastructure including communications and excitation technology.
    - Option 1: Convert an existing large synchronous generator or motor nearing end of life to substantially benefit SPT and the SO by proving the concept and assessing the risks and benefits of such a conversion.
    - Option 2: Deploy a new Synchronous Compensator in the optimum location for SPT and the GB System Operator.

Method 2: Live Trial

- Run the Synchronous Compensator ensuring the sending/receiving of instructions from the control centre operator, correct financial flows and real-time control functionality to provide network services in dynamic circumstances.

Method 3: Commercial Arrangements and Ownership

- Liaise with the GB System Operator to develop commercial arrangements to incentivise and reward the Synchronous Compensator operator for the ancillary services provided.

Method 4: Feasibility and Comparative Studies

- Review of future applications of the Synchronous Compensators and feasibility studies.
- Develop model(s) for desktop system studies for optimal placement and GB roadmap.
- Produce technical and functional specifications taking into account future applications of Synchronous Compensators across GB.

Method 5: Integration and Control Methods Investigation

- Develop software and algorithms to allow compensator technologies to monitor and control operation of SCs on TO’s network whilst providing ancillary services to the GB SO.
- Research and develop mechanism for closed loop control if and when supplementary damping is required (Level of interactions and damping requirements to be monitored and analysed using enhanced monitoring techniques demonstrated in Project VISOR).

Method 6. Knowledge Capture and Dissemination

- Capture key industry findings and share recommendations to facilitate the GB wide roll out of Synchronous Compensators.

Funding commentary

The Licensee must provide a commentary on the accuracy of its funding estimate. If the Project has phases, the Licensee must identify the approximate cost of each phase. OFTOs should indicate potential bid costs expenses.

The funding estimates are based on SPT's experience of delivering major projects, substation work and managing innovation projects such as NIC VISOR and FITNESS. The accuracy of the funding estimate will be further improved during detailed design in support of the full submission. The approximate project cost of £15.3m can be divided between the proposed work packages (WP) tentatively as follows:

WP 1: Conversion/Deployment of Synchronous Compensator £9m

WP 2: Live Trial £1.9m

WP 3: Commercial Arrangements and Ownership £0.8m

WP 4: Feasibility and Comparative Studies £1.5m

WP 5: Integration and Control Methods Investigation £1.3m

WP 6: Knowledge Capture and Dissemination £0.8m

Specific Requirements (please tick which of the specific requirements this project fulfils)

A specific piece of new (ie unproven in GB) equipment (including control and/or communications systems and/or software)	
A specific novel arrangement or application of existing electricity transmission equipment (including control and communications systems software)	✓
A specific novel operational practice directly related to the operation of the electricity transmission system	✓
A specific novel commercial arrangement	✓

Accelerates the development of a low carbon energy sector & has the potential to deliver net financial benefits to existing and/or future customers

The Licensee must demonstrate that the Solution has the potential to accelerate the development of the low carbon energy sector in GB and/or deliver wider environmental benefits to GB customers. The Licensee must demonstrate the potential to deliver net financial benefits to existing and/or future customers.

- The utilisation of Synchronous Compensators facilities the Carbon Plan by enhancing the network strength and stability which can securely accommodate renewable energy sources. Synchronous Compensators are a perfect partner for distributed and intermittent renewable generation offering essential network services such as inertia, fault level and dynamic voltage control that renewable energy resources cannot provide as an immediate and dynamic response to fast changes in the network.

- SP Transmission will actively engage and inform GB TOs, the SO as well as Offshore Transmission Owners (OFTOs) and Distribution Network Operators (DNOs) regarding the design, deployment and outcomes of the project and consequently all customers will benefit from a more secure and stable system.

Accelerates the development of a low carbon energy sector & has the potential to deliver net financial benefits to existing and/or future customers (continued)

TABLE I
CONVENTIONAL AND DER REACTIVE POWER SOURCE CHARACTERISTICS

Reactive power source		Response speed	Voltage support	Investment cost ($/ kVAr)[3]
Capacitor/ reactors		Slow	Poor	10 - 30
Generators		Fast	Very good	-
Synchronous condenser		Fast	Very good	10 - 40
FACTS		Fast	Poor - Good	40 - 100
DER	Inverter	Fast	Good	40 - 90
	Synch. Generator	Fast	Good	25 - 40

The investment cost of the technologies currently available for voltage support are summarised in Table 1 [Assessment of the Economic Potential of Microgrids for Reactive Power Supply, Asia Conference on Power Electronics, 2011, 8th International] showing a competitive cost for Synchronous Compensators compared to other advanced solutions such as FACTS.

- The rollout of Synchronous Compensators will create a platform where clean renewable energy can supply the demand and Synchronous Compensators can contribute to keeping the GB system stable and secure. This model has already been successfully rolled out across the USA, Denmark and New Zealand.

- A competent method for providing voltage support in GB areas with high penetrations of renewable generation is the deployment of SVCs and STATCOMs. SCs provide **faster dynamic response** upon the loss of infeed and also additionally contribute to **fault level and inertia** in the network improving **power quality and network stability**.

ii. The utilisation of Synchronous Compensators will have substantial environmental benefits for GB customers as they offer a like for like replacement for the stability and security offered by large conventional synchronous generators without the carbon footprint associated with fossil fuels, enabling the deployment of renewable sources of generation which do not have these characteristics. Synchronous Compensators can facilitate increased penetration of clean energy resources like wind and solar as successfully demonstrated in other countries. There are additional environmental benefits if conventional synchronous generators or motors are converted to Synchronous Compensators as this will limit the environmental impact associated with manufacturing, installation, infrastructure and delivery.

iii. Financial Benefits

The following financial benefits can be achieved by deployment of Synchronous Compensator, we will quantify the benefits as part of full submission:

- Delay or avoid network reinforcements which are triggered by voltage and network stability
- Avoid the cost and complexity of developing new protection techniques to operate with heavily loaded circuits but low fault level
- Avoid or reduce the investment for reactive power compensators
- Reduce network losses due to capability for voltage control
- Potentially increase B6 and B4 boundary transfer limits which contributes to more export of renewables to England
- Potentially improve power quality issues and reduce the investment required for harmonic filters.
- Potentially reduce the reliance on spinning reserve for the SO

Delivers value for money for electricity customers

The Licensee must demonstrate that the Method(s) being trialled can derive benefits and resulting learning that can be attributed to or are applicable to the electricity transmission system.

i. The scope and deliverables of Phoenix are aligned with SPEN's Transmission Innovation Strategy Review (2014) to establish SPT as innovation leaders in localised inertia system management, voltage management, additional damping resources and dealing with low short circuit levels. The project will demonstrate the deployment of a Synchronous Compensator to offer essential system services. The technical capability generated will positively impact other TO's, SO and DNOs.

ii. The total cost estimated for this project is £15.3m. This includes the cost of deploying a Synchronous Compensator for the duration of the project with development contributions of £1.6m expected from SPT and the partners. The nature of the project, which will utilise a Synchronous Compensator to provide ancillary services including fault level and dynamic voltage control as well as aiding the development of new commercial mechanisms and markets

The deployment of SCs in this novel arrangement will be demonstrated for the 1st time in GB. The aim of the demonstration is to compare and assess performance and benefits of SCs against business accepted solutions such as SVCs and STATCOMs. The successful demonstration of SCs at the end of this project along with a developed commercial mechanism to incentivise service providers, will provide engineers, planners, service owners and operators with confidence in the new system allowing Synchronous Compensators to be more quickly deployed into 'BaU'.

iii. SP Transmission will adhere to SPT procurement obligations and follow competitive selection criteria during procurement to ensure best value for customers.

iv. The successful integration with BaU and knowledge captured will reflect cost benefits in the RIIO T2 period for all TOs and SO. A detailed cost benefit analysis based on dynamic system studies and feasibility studies will be a part of the full submission. Early indicators of financial benefits can be assessed by benchmarking against similar deployment and studies undertaken in other countries as follows:

- SCs in Denmark have help reduce the must-run costs of thermal generation (separate from active power market) by ~20m(€) per year.[*Synchronous Condensers for reliable HVDC operation and bulk power transfer, IEEE PES General Meeting, 2015, 15PESGM3046*]
- Studies conducted by Department of Energy, US, presents a Cost Benefit Comparison between Capacitors and Synchronous Condensers highlighting a NPV of ~4k($)/MVAR for small generator retrofit to act as synchronous condensers [*A Preliminary Analysis of the Economics of Using Distributed Energy as a Source of Reactive Power Supply, the US DOE, 2006*]
- The use of Synchronous Compensators in New Zealand deferred investment in a new transmission line in an area of their network which was prone to voltage stability issues.

Demonstrates the Project generates knowledge that can be shared amongst all Network Licensees

i. Phoenix will generate the following generic learning outcomes through comparative analysis in a live transmission environment:
   - For GB TOs and GB SO and the Offshore Transmission Owner (OFTO), the project will give a comparison of how Synchronous Compensators compare to other technologies available on the market, giving the TOs, SO and OFTOs confidence in the Synchronous Compensators. This future proofs the transmission network for high renewables penetration. It will also generate knowledge in
     - Future applications of synchronous Compensator in GB to improve system stability and security.
     - GB Roadmap for deployment of SCs at optimal locations.
     - Recommendations for potential new commercial mechanisms and markets.
   - For the Distribution Network Owner (DNO), establish infrastructure to increase the penetration and utilisation of renewable and local energy sources without compromising system stability and security.
   - For generation companies and other ancillary service providers, Phoenix will provide confidence in the financial incentives available to invest in, operate, and maintain Synchronous Compensators.

ii. SPEN will endeavour to include GB TOs, OFTOs, Generation Owners, Service Providers, DNOs and SO in the project advisory board and/or as potential partners to influence the development of the Synchronous Compensator concept and applications. Involvement of vendors as project partners will allow learning generated through this project to influence the R&D portfolio of various vendors and accelerate future innovation in this area. Future products and applications from vendors for Synchronous Compensator solutions should be in line with network operators' interoperability and scalability needs.

Additionally, SPEN will use established arrangements for knowledge capture from previous NIA and NIC projects to support knowledge dissemination during the execution of the project. SPEN has successfully demonstrated such methods through its ongoing NIC project VISOR and FITNESS. Key learning outcomes and reports will be published in a project dedicated website and SPEN's innovation webpage http://www.spenergynetworks.co.uk/pages/investment_innovation.asp
A detailed knowledge dissemination approach will be a part of the full submission.

iii. SPEN conforms to the default IPR arrangements set out in NIC governance document.

Please tick if the project conforms to the default IPR arrangements set out in the NIC Governance Document?	✓

If the Licensee wishes to deviate from the default requirement for IPR then it must demonstrate how the learning will be disseminated to other Licensees and how value for money will be ensured. The Licensee must also outline the proposed alternative arrangements and justify why the arrangements are more suitable than the default arrangements.

N/A

How is the project innovative and with an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness?

i. The overall objective of Phoenix is to provide confidence in the perceived benefits of Synchronous Compensators demonstrated for the 1st time in the novel arrangement as proposed in this project on GB transmission network. Future applications of SCs for improving network security and stability requires technical confidence in the technology, practical assessment of the business case and establishing commercial mechanisms to be developed throughout the course of this project.

Synchronous Compensators are a well known, proven technology. Large synchronous machines have been widely used in GB, however the utilisation of synchronous machines as Compensators has significantly declined in the last two decades.

There has been renewed interest in Synchronous Compensators to maintain security and stability in **weak AC grid systems with high penetration of renewable asynchronous intermittent generation** in countries like Denmark and New Zealand where the levels of renewable generation are comparable to GB and in particular Scotland. The novel arrangement proposed in this project under the two deployment options are as follows:

Option 1
The technique of converting an end of life synchronous generator into a Synchronous Compensator making use of most of its existing parts and infrastructure has never been demonstrated in GB before.

Option 2
The vendors have redesigned and introduced new improved Synchronous Compensators into the market which claim to have fewer mechanical issues, losses and better design requiring less maintenance. These Synchronous Compensators have never been demonstrated in GB before.

The project will also include commercial innovation as Synchronous Compensators will require a well designed commercial market and mechanism to ensure the future deployment of Synchronous Compensators is financially viable. Finally, there will be substantial innovation in system operation and control including innovative software to introduce closed loop wide area control for damping mechanisms making better use of enhanced monitoring systems installed on GB network.

ii. Synchronous Compensators largely address emerging issues rather than immediate concerns. Although the benefits have been demonstrated in countries with similar levels of renewable generation, the technology in this novel arrangement is still unproven in GB. As BaU aims to deploy low cost, low risk, proven technologies, Synchronous Compensators due to their unproven nature in GB coupled with the high capital investment required means they cannot be classified as BaU.

iii. The risks associated with SCs preventing business as usual deployment can be classified into following categories
Technical - Although large synchronous machines are a proven technology, the new Synchronous Compensators or converting a conventional synchronous generator or motor to a Synchronous Compensator has never been connected to the GB system so the operational risks are unknown. Also control interactions with other power electronics and generators in the network have not been studied or evaluated before.

How is the project innovative and with an unproven business case where the innovation risk warrants a limited Development or Demonstration Project to demonstrate its effectiveness? (continued)

Commercial - There are only limited established commercial mechanisms to incentivise ownership and operation of Synchronous Compensators in GB. There is also a reluctance to invest in and implement this technology without a thorough demonstration and establishment of financial incentives.

Regulatory – Electricity code NETS SQSS requires GB TOs to maintain security and stability of supply. The proposed new arrangement of SCs may be able to extend life of retired generator units (Option 1) and provide dynamic voltage support and inertia (Option 1 and 2). This however unless proven does pose a risk to the obligations under NETS SQSS and thus requires a proof of concept.

Project Partners and external resourcing/funding

The Licensee must provide evidence of how Project Partners have been identified and selected, including details of the process that has been followed and the rationale for selecting participants and ideas for the project.

The Licensee should provide details of any Project Partners who will be actively involved in the Project and are prepared to devote time, resources and/or funding to the Project. If the Licensee has not identified any specific Project Partners, it should provide details of the type of Project Partners it wishes to attract to the Project.

SPT has engaged with NGET SO, in early stages of this proposal to inform about Project Phoenix. We have received positive feedback and support from GB SO and we will work closely with them during the full proposal development to develop mechanisms to financially incentivise SCs deployment in GB.

SPT has also commenced extensive internal and external stakeholder engagement with other TOs (UK and worldwide), generator owners, service providers and with multiple vendors and has received extremely positive response and generated industry-wide interest in its potential learning outcomes.

The project was selected based on its merit through internal stakeholder engagement, its compliance with business innovation strategy and its aim to demonstrate learning outcomes building upon the following NIA and NIC projects:

1. Enhanced Frequency Control Capability (NGET)
2. VISOR (SPEN, NGET, SSE)
3. Dynamic Assessment of Wind Generation Synthetic Inertia Contribution to the GB Power System (SPEN)
4. Assessment of Distributed Generation Behaviour during Frequency Disturbances (NGET)
5. Reactive Power Exchange Application Capability Transfer, REACT (SPEN, NGET, ENW, NPG, SSE, UKPN, WPD)

Vendors are being assessed through various stages of partner selection based on their compliance to project scope and requirements, costs, responsiveness and resource availability. A detailed partner selection procedure will be a part of the full submission.

Derogations or exemptions

The Licensee should outline if it considers that the Project will require any derogations, exemptions or changes to the regulatory arrangements.

No derogations or exemptions identified.

Customer impact

The Licensee should outline any planned interaction with customers or customers' premises as part of the Project, and any other direct customer impact (such as amended contractual or charging arrangements, or supply interruptions).

Phoenix does not require any direct interaction with customers as no work is carried out on customer sites and no outages are required. The live trial will only be carried out after building sufficient level of confidence through the demonstration project and should not result in any supply interruptions due to failure of equipment and/or design concept.

Details of cross sector aspects

The Licensee should complete this box only if this Project forms part of a larger cross sector Project that is seeking funding from multiple competitions (Electricity NIC, Gas NIC or LCN Fund). The Licensee must explain about the Project it will be collaborating with, how it all fits together, and must also add a justification for the funding split.

N/A

Any further detail the Licensee feels may support its submission

N/A

Contact name

Priyanka Mohapatra

Contact Address

SP Energy Networks
Ochil House
10 Technology Avenue
Hamilton International Technology Park
G72 0HT
Scotland

E-mail

pmohapatra@spenergynetworks.co.uk

Direct telephone line

+44 (0)1416142789

Job title

Senior Project Manager