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 Manweb plc.
Network Licence Project Partners
UK Power Networks plc (Additional partners TBC during preparation of FSP)
Funding Licensee area
SP Manweb plc. and SP Distribution plc.
Project title
LV Engine
Project Summary
The Licensee must provide an approximate Project start and end date.
The integration of low carbon technologies (LCTs) is creating a strain on LV networks. Consequently, there is a need to make a significant change in the way LV networks are planned and operated. **Passive LV networks with limited flexibility may not deliver value for money for our customers in a low carbon energy system.** **Project LV Engine aims to add flexibility to LV networks by informing the design and selection of intelligent secondary transformers to enable the cost effective uptake of LCTs.** It will achieve this objective by carrying out a live network trial of two innovative technologies; 1) Solid State Transformers (SSTs) as a direct replacement and; 2) Vacuum Tap Changers as a retrofit option to the conventional secondary transformer (11kV/415V). This trial will provide the LV network with the flexibility it requires to accommodate future uncertainties in the uptake of LCTs and customer behaviours. **LV Engine will demonstrate the first grid trial of SSTs** within the UK electricity network and provide valuable learning to other UK DNOs. **The project will also make an LV DC supply available to customers to satisfy the increasing demand for Direct Current.** The project will commence in February 2018 and be completed by December 2022.
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	£6.9m	**NIC funding requested**	£6.2m
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.

Passive distribution networks no longer represent value for money for customers, particularly in areas which are experiencing a growth in LCTs. The electricity network in the UK is experiencing a significant change in the way energy is generated and consumed creating a strain on the LV network. The level and time horizon of these changes are difficult to predict. As the industry continues to mature it is expected that the penetration of LCTs will continue to increase in the form of renewable generation, energy storage, electric vehicles, and electrified heat. Learning from previous network innovation projects (e.g. FUN-LV, NTVV) has shown that the LV network in many areas will be unable to meet the demands of increased LCT adoption.

Smart techniques to increase the flexibility of LV network need to be developed as a priority if the aspirations of a low carbon energy system are to be achieved whilst delivering value for money to UK electricity customers. More specifically, a higher penetration of LCTs is leading to the following:

- Increased peak loading, with the potential to cause thermal overloads
- Increased variation (magnitude and rate of change) with the potential for voltages to be outside statutory limits
- Provision of a DC supply to customers thus enabling a DC grid for the future.
- Increased uncertainties in daily demand/generation profile

LV networks within SPD & SPM licensee areas are already experiencing a strain due to unexpected load growth and the increasing penetration of LCTs, particularly photovoltaics (PV). Since LV networks are conventionally passive, significant network upgrades will be required to facilitate additional LCTs and avoid the associated voltage regulation challenges.

However, the traditional approach to LV network reinforcement may no longer represents a techno-economical option and an alternative approach must be found to deliver the LV network of the future. In short, LV networks need to be scalable, flexible and adaptable to be able to accommodate the uncertainty in demand and generation. **Secondary substations, as the bridge between LV and the rest of grid, can be intelligent hubs providing smart functionalities and the flexibility required for the operation of our future LV networks**. Consequently, there is a need to develop a more informed secondary substation selection process to assess the levels of smart functions required by the specific LV network based upon its characteristics, thus ensuring the network is prepared for future uses and provides value for money for UK electricity customers.

Method(s)

The Licensee must describe the Method(s) which are being demonstrated or developed. It must also outline how the Method(s) could solve the Problem. The type of Method should be identified where possible eg technical, commercial etc.

In order to develop a novel and informed approach to the selection of secondary transformers, **we propose trialling smart Solid State Transformer (SSTs) within secondary substations and comparing their effectiveness in supporting the LV network with that of conventional MV/LV transformers retrofitted with vacuum tap changers.** The trial will lead to policy documents, design tools, technical specifications and a methodology which will inform the optimal selection of the secondary transformers given the specific characteristics of the local LV networks.

This project will trial intelligent transformers for three distinctive applications where potential trial areas have already been investigated.

Application 1 – SST for Voltage Regulation & Power Quality: We have identified potential trial areas where the uptake of PV has been severely limited due to the capacity of the LV network to accommodate further generation without significant network reinforcement. Some of these LV networks supply tower social houses with PV fitted to address fuel poverty.

Method(s) continued

Application 2 – Vacuum Tap Changer for Voltage Regulation: It is expected that under certain network conditions SSTs may not be the most cost effective solution to reinforce the LV network where the penetration of LCTs is less severe. For this reason, the project will also trial vacuum tap changers as an alternative method of voltage regulation.

Application 3 – SST for LV DC: SSTs are capable of providing a LV DC supply to satisfy the increasing DC requirements of our customers and reduce network losses. We intend to inform the future DC micro grid by trailing a DC supply for the connection of LCTs, EV charging stations, and large commercial customers.

LV DC can also provide a DC link between two secondary substations to add power flow control functionality. This allows load balancing between secondary substations, additional network flexibility, and better utilisation of network assets.

We will use the learning from the aforementioned applications to **inform the future selection of the most techno-economical technology given the characteristics of local LV network**, reducing costly network reinforcement and delivering value for money to our customers.

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.

Following our informal discussions with research centres, major suppliers and manufacturers we have identified some of the challenges and effort required to deliver this project. Our estimation of the project cost and breakdown of the funding required at this stage, is based on our initial manufacturer engagement, SPEN's unit costs and our experience in delivering innovation projects. Nonetheless, project cost may be refined and detailed during the full submission process. The project is planned within five main work packages (WP):

WP 1 - Design: Includes developing the technical specifications for procurement of the SST and vacuum tap changers, design of grid integration requirements e.g. protection, monitoring and control etc, £0.8m.

WP 2 - Manufacturing of SSTs: Includes procurement, manufacturing, and testing of a fit-for-purpose SST, £3.9m.

WP 3 – Trail at PNDC: The functions of the designed SSTs will be demonstrated at the PNDC prior to a live network trial to alleviate risk and boost confidence, £0.5m.

WP 4 – Live Network Trial: Trail and performance assessment of the intelligent transformer options within the network under the different applications described in the Method section, £1.2m.

WP 5 – Development of novel approach for transformer selection: This includes tools, policy documents, design methodology, £0.2m.

WP 6 – Dissemination and knowledge sharing, £0.3m.

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.

LV Engine aims to facilitate the integration of LCTs by providing flexibility and controllability in LV and MV networks. Passive distribution networks are no longer cost effective solutions to accommodate the uncertainty in the generation and the demand profile of our customers. LV Engine will trial cutting-edge technologies to provide a novel approach for selecting fit-for-purpose secondary transformers. The outcomes of this project can be a model for operation and planning of our future distribution networks.

Impact on low carbon energy sector and environmental benefits:
The outcomes of LV Engine can contribute to our low carbon energy by:

1) Expediting the connection of renewables e.g. PV uptake may be limited due to voltage issues without considerable LV network reinforcement;
2) Reducing the curtailment of the renewables connected to the MV and LV network due to temporarily voltage issues;
3) Providing local reactive power compensation and reducing the overall network losses which will ultimately reduce carbon emissions;
4) Expediting the connection of electric vehicles and other LCTs which may benefit from a LV DC connection;
5) Avoiding or deferring network reinforcement which will eliminate associated environmental adverse impact and any associated carbon emission;
6) Reducing the fire risk due to use of dry type transformers which will allow the use of secondary substations within large buildings and within environmentally sensitive areas.

Financial Benefits to customers:

Conventionally, distribution networks are passive and they are designed for the worst demand and generation conditions. This approach can be prohibitively expensive for investment in our future network whose cost will be paid by our customers. LV Engine will demonstrate fit-for-purpose flexible secondary substations and a methodology to select the economic design for our future LV networks. It is expected LV Engine will provide the following benefits to our customers:

1) Reducing network charging costs by avoiding or discarding network investments both in LV and MV networks.
2) Addressing fuel poverty by facilitating access to cheaper energy by facilitating additional PV connections.
3) Providing scalability to secondary substations for capacity increase by adding additional "capacity blocks" to an SST. This will allow capacity upgrade close to actual requirement rather than replacing a overloaded transformer with a higher rated and under-utilised one (conventional approach).
4) Providing cost competitive and fit-for-purpose SST design for distribution networks.

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 existing distribution operational practices can be prohibitively expensive for accommodating existing and upcoming LCTs. The outcomes of LV Engine can improve our network planning and operational approach by considering flexibility, scalability and controllability. This can reduce network investments in the LV network and provide better utilisation of network assets which results in lower network charges paid by customers.

ii) The total cost estimate of this project is £6.9m which is constructed based on our initial manufacturer and internal stakeholder engagement and number of trial sites considered. Within the UK, a significant investment is spent annually to upgrade and develop secondary substations and the LV network. This investment is driven by the conventional approach and passive network operation. The outcomes of LV Engine can target this investment made by DNOs, and if proven successful facilitate a large scale roll-out of the approach to minimise the LV network reinforcement cost.

iii) It is planned to carry out a competitive procurement to identify project partners which are capable of delivering of project at the lowest cost and also willing to provide resource and monetary contributions towards development of the SST. We are also planning to collaborate with other parties to build upon on the learning provided by relevant projects.

iv) The outcomes of this project will largely enhance the operation and planning of distribution networks. However, the project also benefits the transmission network by enabling more embedded generation connections reducing transmission network losses and constraints.

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

The Licensee must explain the learning which it expects the Method(s) it is trialling to deliver. The Licensee must demonstrate that it has a robust methodology in place to capture the learning from the Trial(s).

i) The following learning is expected to be generated by LV Engine:

- A novel methodology for selecting secondary transformer based on the high level load/generation characteristics of the local LV network.
- Technical specifications for a fit-for-purpose SST and retrofitted vacuum tap changer for BaU application.
- Control algorithms required for LV and MV voltage regulation, power flow with a DC link and other functionalities of SSTs.
- Modular based design of the MV AC/DC converters for a scalable SST.
- Technical requirements for provision of LV DC distribution network for industrial and commercial customers.

ii) The results of the project will be captured and shared through our internal and external dissemination activities. A dissemination strategy will be submitted within the full submission. It will include webinars, industry workshops, and continuous engagement via industry working groups, academic, and summary reports to capture the project findings. In particular, the outcomes of design phase for technical specifications of SST will be shared and consulted with other UK DNOs before proceeding with the procurement.

iii) The delivery of LV Engine will meet the default IPR arrangements set out within the NIC governance.

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.

The work undertaken as a part of this NIC project will adhere to default IPR arrangements. Project partners and suppliers will comply with the default IPR arrangements as a part of the selection criteria. Any deviations, if identified, during the proposal development will be highlighted in the full submission.

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?

Demonstrate why the Licensee has not previously used this Solution (including where the Solution involves commercial arrangements) and why NIC funding is required to undertake it. This must include why the Licensee would not run the trial as part of its normal course of business and why the Solution is not Research.

If approved, this project will undertake a **globally innovative distribution network trial of SSTs** for the purpose of supporting and enabling the LV network of the future. Consequently, we believe this project is highly innovative and addresses a significant challenge which is relevant to all UK DNOs and it has the potential to become a major enabler of LCTs. Similarly, the trial and study of vacuum tap changer within secondary substations will inform an **innovative methodology for the selection of the most technically capable and cost effective reinforcement solutions for the secondary substations of the future**.

Trail of SST technology requires Ofgem NIC funding as the technology readiness level (TRL) of this device is not high enough for grid application. The technology has reached a level of maturity in railway traction applications, which use similar voltage levels to distribution networks. The TRL of SSTs for traction applications is considered to be 8, as prototype units have been deployed and tested in field trials. The TRL of SSTs for grid applications is considered to be 6, as prototype devices have been through laboratory trials. However, there are yet challenges to demonstrate the reliability of the device, and a efficient fit-for-purpose design for grid applications and enhance the TRL of SST to 8. In addition, LV Engine aims to trial SSTs with higher rating (~500kVA) than previous prototypes.

There are still several technical and operational challenges for a SST grid application which require to be addressed before BaU adoption. Some of these challenges are modular base design, protection design, improving efficiency, compact design and developing control algorithms. In addition, **the provision of a LV DC network for the direct connection of customers is one of the challenging and innovative aspects of this project.**

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.

We have been in conversation with a variety of potential project partners through our extensive external stakeholder and suppliers engagements. The methodology we have used to identify potential partners include:

1- Carried out a third party challenge to identify ideas which can enhance the grid performance, facilitate our low carbon energy targets, provide value for money for UK customers and also satisfy the criteria for NIC funding. LV Engine has been proposed by WSP | Parsons Brinckerhoff and was shortlisted among the total 35 ideas received.

2- Through a extensive search within the public domain, Achilles database, and using our contacts from relevant projects we will continue to identify suppliers, universities and research centres which are capable of technically supporting the project and can also potentially provide resources and monetary funding contributions. Some of these include ABB, Siemens, Turbo Power Systems, ETH Zurich, NR Electric, Grid Co Systems.

3- Considering the solutions LV Engine can offer, we have identified potential trial areas and relevant stakeholders. This includes an LV DC supply for a data centre within a private network, PV developers for social housing, city centre car parks for EV charging application amongst others.

4- The project concept was explained to potential partners through teleconference or face-to-face meetings. Challenges and risks were identified, and areas which potential partners can provide contributions were discussed.

5- We will continue to engage with manufacturers during the creation of the full proposal and draw up a shortlist of potential partners that are capable of successfully delivering a fit-for purpose SST. If the project were to gain approval we will carry out a full competitive tendering process once the project commences to identify those parties that can provide best value to the project, and ultimately the customer.

6- We have been collecting learning from other relevant UK NIA and NIC projects to consider potential opportunities and challenges e.g. ANGLE-DC, Sola Bristol, Flexible Urban Networks. We are also planning to build upon other non-UK projects such as SPEED in Europe, Intelligent Universal Transformer by EPRI and experiences from LV DC network applications in China.

7– We have been in regular contact with other DNOs to investigate opportunities to collaborate and to ensure that our submissions compliment each other. From this we have partnered with **UK Power Networks** who will act as a "design authority" during the project to ensure the outcomes of the project are fit for purpose and repeatable throughout the UK.

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).

No direct interaction with customers is required. However, in order to maintain security of supply and reduce the risk of any adverse impact on customers, the SSTs will be deployed alongside conventional transformers during the trial phase. We will also reduce the risk associated with the project by carrying out tests of the SST device at the Power Networks Demonstration Centre (PNDC) at Cumbernauld before a live trial of the technology within our network.

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

Solid State Transformer:

Different topologies and designs for SSTs have been proposed and trialled by different suppliers and research institutes. A high level topology for a SST (only to demonstrate the concept) is shown in Figure 1.

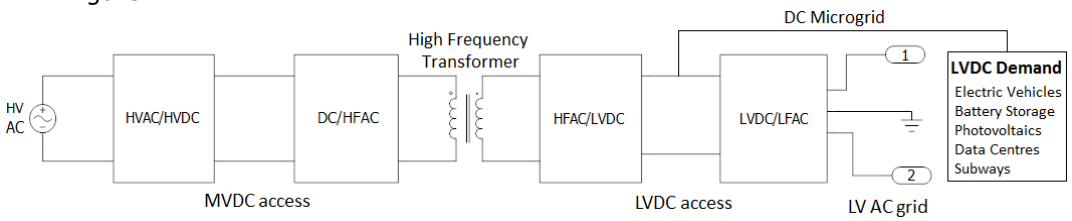

Figure 1. A high level representation of SST (A detailed fit for purpose SST design will be developed in LV Engine project)

SST can play the role of an energy router or an intelligent hub for the LV network by providing various functionalities:

- Control of transferred real power (provides network controllability).
- Allow bi-directional power transfer.
- Independent control of reactive power at each end (decouples the voltage at each end).
- Fine-grained control of voltage and power factor (these can be set to improve voltage profiles and network losses).
- Mitigation of voltage dips/sags and swells (like a STATCOM).
- Mitigation of existing harmonic distortion (improving power quality).
- Balancing of power and voltage between phases, depending on SST topology and controls.
- Fault current management.
- Potential to use SSTs as "circuit breakers" to interrupt fault currents.
- A DC link to allow the direct connection of DC-based LCTs such as solar PV panels and energy storage units, removing the need for inverters (cost and efficiency saving).
- A connection point for future DC micro grids / distribution systems.

Retrofitted Vacuum Tap Changer: A mechanical device which is retrofitted to conventional transformers for automatic voltage regulation. The device is commercially available but it has not been widely deployed in the UK.

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