SP ENERGY NETWORKS

RIIO NIC NETWORK INNOVATION COMPETITION

LV ENGINE

Manufacturer Engagement Plan (2018)

University of Strathclyde Engineering

C A U Christian-Albrechts-Universität zu Kiel

UK Power Networks

WSP

About Report

Report Title	:	LV Engine Manufacturer Engagement Plan (2018)
Produced By	:	SP Energy Networks
Report Status	:	Live
Project Reference	:	SPMEN02
Date	:	19/06/2018

Report Progress

Created by	:	Anthony Donoghue	19/06/2018
Reviewed by	:	Ali Kazerooni	09/04/2018
Approved by	:	Anthony Donoghue	19/06/2018
Signed-off by	:	Anthony Donoghue	19/06/2018

Report History

Date	Issue	Status
05/04/2018	Version 1	Draft
11/04/2018	Version 2	Closed
21/05/2018	Version 3	Closed
19/06/2018	**Version 4**	**Live**

Contents

1. Introduction

LV Engine is a flagship innovation and Smart Grid project lead by SP Energy Networks which will bring Smart Transformers (ST) to the Distribution network for the first time. The project is funded by Ofgem through the Network Innovation Competition (NIC) funding mechanism.

The purpose of this document is to set out SP Energy Networks 2018 engagement plan for potential manufacturing partners who are interested in partnering with us on this globally innovative project to provide the Smart Transformers that will be used within the live network trial.

It is critical to the success of the project that potential manufacturing partners are aware of the progress of the project prior to a competitive tendering exercise that will be carried out in November 2018. This document will provide details on what information will be made available throughout 2018, the tendering process which will follow and how to formally express interest in the project.

2. LV Engine Overview

Historically, distribution networks were not designed to accommodate the large number of Low Carbon Technologies (LCTs) that are now becoming a critical part of our fight against climate change. The uptake of LCTs such Photovoltaics and Electric Vehicles is expected to create a sizeable strain on the low voltage distribution network and lead to costly network reinforcement.

LV Engine is a 5 year innovation project which is designed to address this growing challenge. The project will take place across both of SP Energy Networks distribution licenced areas; SP Manweb & SP Distribution. The project will carry out a globally innovation network trial of Smart Transformers within the distribution network at secondary substations. As a minimum, LV Engine will deploy a total of 6 Smart Transformers as part of a live network trial after Network Integration Testing of 2 further prototypes.

Our conservative estimation shows that there is an opportunity to deploy ST in 7,819 and 36,270 ground mounted substations within the UK by 2030 and 2050, respectively. It should be noted that the 36,270 figure is only 16% of the exiting substations in the UK and the uptake of ST technology can potentially be higher than the estimated figures.

If deployed across Great Britain the use of Smart Transformers has been estimated to **lead to savings of up to £528m by 2050** for GB electricity consumers as described within the NIC Full Submission (FSP). The ST technology can be also deployed within the industrial applications, renewable power plants and private network owners, creating a larger size market for ST.

For more information on LV Engine and its objectives please see the NIC Full Submission using the link below:

https://www.ofgem.gov.uk/publications-and-updates/electricity-nic-submission-sp-energy-networks-lv-engine

2.1 LV Engine Network Functionalities

The deployment of this innovative technology will bring several valuable functionalities to the distribution network for the first time. The following key functionalities will facilitate the growth of Low Carbon Technologies (LCTs) by releasing additional capacity within our existing network infrastructure without the need for costly network reinforcement:

- **Phase Voltage Regulation** – The power electronic design of STs allows for smooth voltage regulation of individual phases at the LV busbar of a secondary substation in real-time. The overall voltage profile of an LV feeder can be optimised by intelligently adjusting the phase

voltage in real-time at the secondary substation in response to monitored voltage data points along the length of each LV feeder.

- **Reactive Power Control** – An ST can offer independent voltage regulations at the LV and MV sides of STs. Reactive power support and local voltage regulation at MV can be deployed to improve the voltage profile along the MV network. This function can be complementary to the conventional Automatic Voltage Control (AVC) scheme at the upstream primary substations.
- **Power Flow Control** – STs have the capability to control power flow due to the inclusion of power electronics. This allows an ST to load share with nearby traditional transformers in real time for the purposes of reducing the thermal strain at peak times and maximising network capacity.
- **Low Voltage DC Supply** – Conversion of voltage from MV to LV by use of power electronics provides access to a DC voltage at the secondary substation. A DC connection can be made available to satisfy any local DC demand, renewable energy sources (RES), or energy storage without repeated rectification from AC to DC and the resulting network and customer losses. Running the LV network at DC can also increase the transfer capacity of the network allowing more EV load to connect to the network before costly reinforcement is required
- **Active Harmonic Filtering** – A ST can be deployed as an active harmonic filter to improve the total harmonic distortion within LV and MV networks. An ST can also function as a resonance damper in LV networks.

In addition to the functionalities described above, the Smart Transformer may also improve flicker and voltage fluctuations, fault isolation between the 11kV and LV networks, and phase balancing.

2.2. Project Work Packages (WP)

The project will be delivered within 7 Work Packages (WP) as described within Table 1 below. The project is designed to ensure fit-for-purpose Smart Transformers are developed which are appropriate for deployment within secondary substations, whilst providing all knowledge necessary for the BaU adoption of the technology after the project is completed.

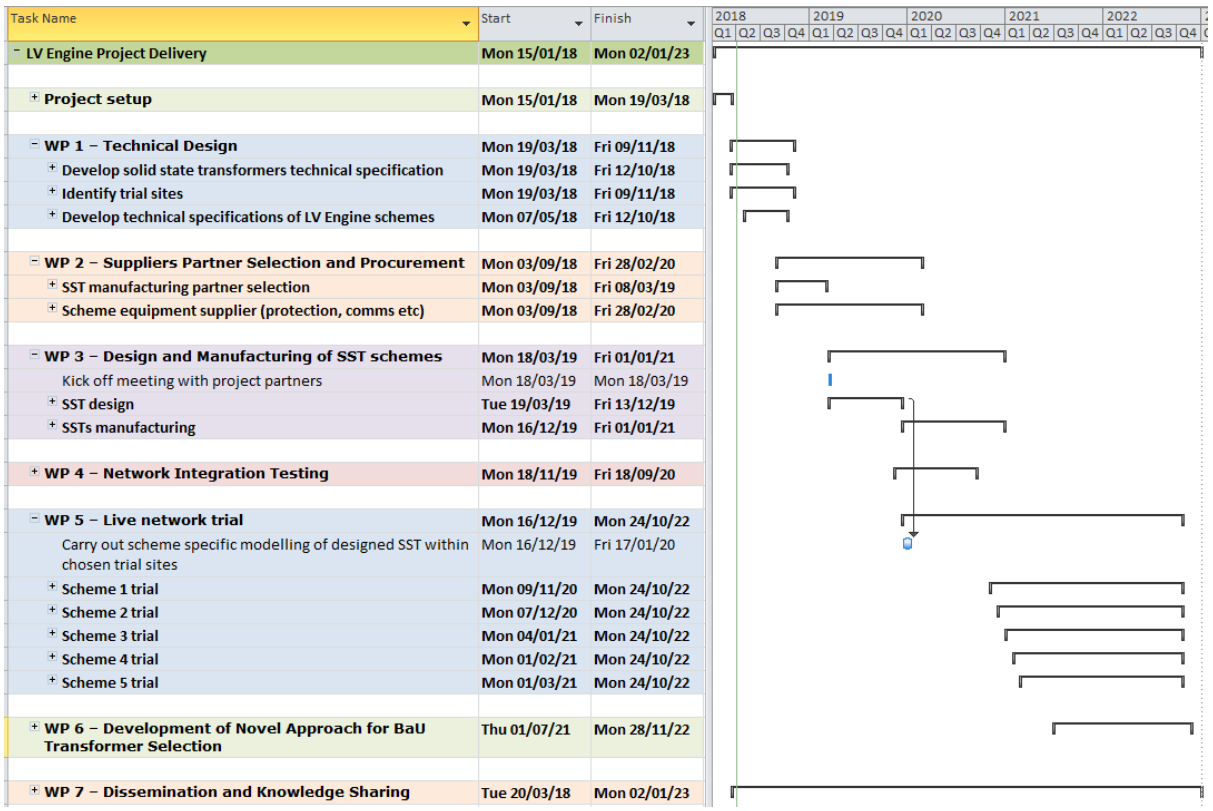
Table 1: LV Engine Work Package Description

Work Package (WP)	Description of Work Package
WP 1: Technical Design	Development of the detailed technical specifications which will be required for manufacturing and implementation of the LV Engine solution and identify trial sites.
WP 2: Partner Selection & Procurement	Selection of the manufacturing partner(s) through a competitive tendering process. Includes the procurement of the equipment required for each LV Engine schemes.
WP 3: Design & Manufacturing	Design and manufacture a fit-for-purpose ST based on the technical requirements and functionalities developed in WP 1.
WP 4: Network Integration Testing	Testing the functionalities and reliability of the manufactured ST's in a network integration facility and obtain network integration certificate.
WP 5: Live Network Trial	Installation and commissioning of the LV Engine schemes and monitoring of their performance.
WP 6: Development of BaU Adoption Strategy	Development of documentation for the BaU adoption of ST and comparison with current conventional solutions and design policies
WP 7: Dissemination & Knowledge Sharing	Dissemination of lessons learnt and the techniques implemented in LV Engine to interested parties in particular UK

DNOs, academics and UK Power Electronic industry.

2.3 Project Timeline

The seven Work Packages described in section 2.2 will be delivered in 5 years commencing in January 2018 until December 2022. Figure 1 shows the planned timescale for each Work Package.



Task Name	Start	Finish
LV Engine Project Delivery	Mon 15/01/18	Mon 02/01/23
Project setup	Mon 15/01/18	Mon 19/03/18
WP 1 – Technical Design	Mon 19/03/18	Fri 09/11/18
Develop solid state transformers technical specification	Mon 19/03/18	Fri 12/10/18
Identify trial sites	Mon 19/03/18	Fri 09/11/18
Develop technical specifications of LV Engine schemes	Mon 07/05/18	Fri 12/10/18
WP 2 – Suppliers Partner Selection and Procurement	Mon 03/09/18	Fri 28/02/20
SST manufacturing partner selection	Mon 03/09/18	Fri 08/03/19
Scheme equipment supplier (protection, comms etc)	Mon 03/09/18	Fri 28/02/20
WP 3 – Design and Manufacturing of SST schemes	Mon 18/03/19	Fri 01/01/21
Kick off meeting with project partners	Mon 18/03/19	Mon 18/03/19
SST design	Tue 19/03/19	Fri 13/12/19
SSTs manufacturing	Mon 16/12/19	Fri 01/01/21
WP 4 – Network Integration Testing	Mon 18/11/19	Fri 18/09/20
WP 5 – Live network trial	Mon 16/12/19	Mon 24/10/22
Carry out scheme specific modelling of designed SST within chosen trial sites	Mon 16/12/19	Fri 17/01/20
Scheme 1 trial	Mon 09/11/20	Mon 24/10/22
Scheme 2 trial	Mon 07/12/20	Mon 24/10/22
Scheme 3 trial	Mon 04/01/21	Mon 24/10/22
Scheme 4 trial	Mon 01/02/21	Mon 24/10/22
Scheme 5 trial	Mon 01/03/21	Mon 24/10/22
WP 6 – Development of Novel Approach for BaU Transformer Selection	Thu 01/07/21	Mon 28/11/22
WP 7 – Dissemination and Knowledge Sharing	Tue 20/03/18	Mon 02/01/23

Figure 1: LV Engine Timeline

3. The Smart Transformer

This section will briefly describe the high level principles of a Smart Transformer. However, it is important to note that the **project is open to innovative approaches to the Smart Transformer design which provide the functionalities described above.**

A Smart Transformer (ST), as also known as a Solid State Transformer (SST) due to use of power electronic switches, can be described as a digitally controlled power electronics converter which provides multiple functionalities over and above the standard voltage conversion of a conventional transformer.

These functionalities are valued as they allow the Distribution System Operator (DSO) to operate the distribution network more efficiently by improving power quality and maximising the utilisation of existing assets. There is a variety of potential topologies for a Smart Transformers and an example topology is shown below is Figure 2.

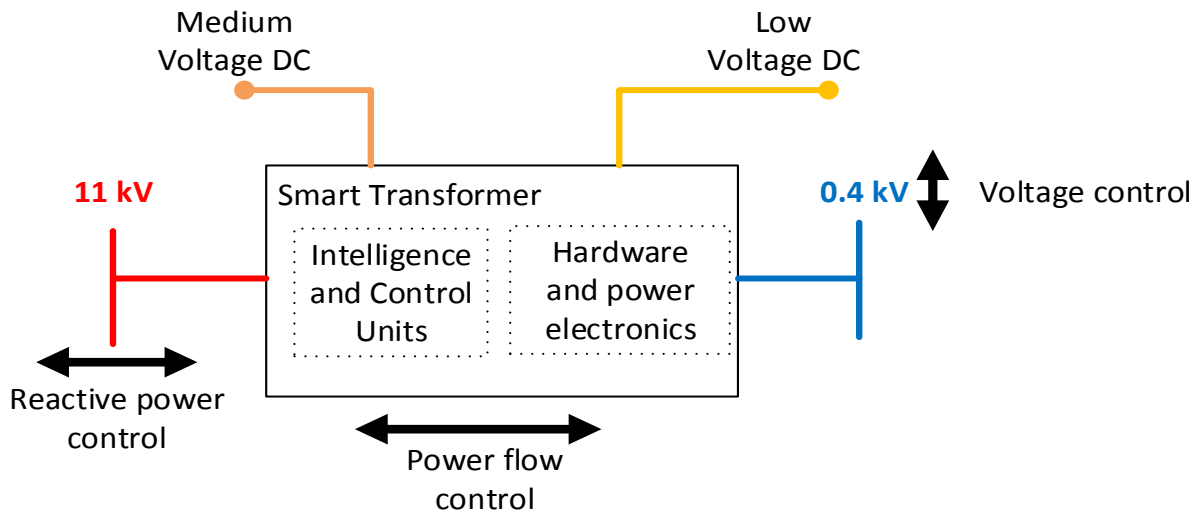


Figure 2: Example Smart Transformer Topology

A Smart Transformer can be broken down into two key elements; the **Solid State Transformer (SST)** and the **Smart Control Unit**. LV Engine will be tendering for both of these elements separately. The SST can be considered as the hardware whilst the Smart Control Unit gathers data from around the local distribution network and processes the data to determine optimal set points for the SST to regulate to. This will require a number of algorithms along with software to be developed to allow value associated the functionalities provided by the SST to be maximised.

The Solid State Transformer can be considered as three separate back to back converters. On the HV side an AC/DC converter (singular or modular) provides reactive power compensation and also access to a HV DC busbar if required. Next a DC/DC converter which includes a High Frequency Transformer (HFTR) steps down the voltage to LV and can be used for Active Power Control. Again, access to a low voltage DC busbar is available prior to the final DC/AC converter. This provides the low voltage AC output and can be used to regulate the phase voltage at the LV busbar.

An *LV Engine Smart Transformer Technical Specification* is currently in development. This document will determine the technical requirements from the Smart Transformers that will be trialled within the project and will be used as part of the project manufacturing tendering.

The intention is to design, manufacturer and trial at least six 0.5-1.0MVA 11kV/0.4kV Smart Transformers during the project. At least one of these is to be designed with 100% DC output on the LV side of the transformer, and the remaining STs with both AC and DC outputs. For more information a high level technical specification was produced as an Appendix within the LV Engine Full Proposal (FSP).

4. Project Partners

This section will describe the roll of current and future LV Engine project partners who will be responsible for important the deliverables throughout the course of the project.

4.1. Current Project Partners

LV Engine will be led by SP Energy Networks in partnership with a variety of organisations that will be responsible for a number of key project deliverables. These partners are described below:

4.1.1. UK Power Networks

UK Power Networks will act as a project partner and member of our design authority board during LV Engine. Collaboration between DNOs is critical to ensure our respective innovation projects are adopted into BaU practices and value is delivered to our customers.

For this reason partnership with UK Power Networks will ensure LV Engine considers the requirements of DNOs across the UK and shares learnings from its complementary NIC proposal "Active Response". The direct involvement of another DNO will maximise the rate at which Smart Transformers are adopted into "Business as Usual" across the UK and increase the potential future market place for the technology.

4.1.2. WSP

WSP are acting as the lead consultancy for LV Engine and will be supporting all aspects of the project. Within 2018 WSP will be responsible for collating all learnings into three important documents. The first is a document of shortlisted trial sites for the project, and the other two documents are the technical specification of the Smart Transformers and the functional specification for each LV Engine scheme. These two documents will be used as part of the tendering exercise.

4.1.3. University of Strathclyde

The University of Strathclyde are an important project partner and will be responsible for producing three reports which will directly inform the functional specification which will be developed within 2018. These three reports will provide recommendations of the fault level impact and protection requirements for AC, DC, and Hybrid systems which incorporate Smart Transformers, review the existing industry standards for the use of such technology within distribution networks, and provide advice on the LV DC requirements of each LV Engine trial scheme.

4.1.4. University of Kiel

University of Kiel in Germany will provide valuable input into the Smart Transformer technical specifications by producing three project reports aimed at informing some of the key aspects in Smart Transformer design. The universities direct experience in Smart Transformer design brings important knowledge to the project team and improves the projects understanding of important design parameters.

4.1.5. PowerelectronicsUK

As the main UK industry association in Power Electronics with over 70 members, we intend to work closely with PowerelectronicsUK to promote the project and share learnings with the industry on the outcome. This will help to ignite a new market place for power electronics within distribution networks in the UK and allow providers of power electronics to develop a strategic partnership with the industry.

4.2. Manufacturing Partner(s)

LV Engine is looking for at least one manufacturing partner who can design and manufacture the Smart Transformers described within the project technical specifications whilst representing value for money to UK electricity consumers. The project is funded using public money provided by the industry regulator Ofgem and strict governance is in place to ensure the money is spent in the best interest of our customers.

As part of NIC Governance the project consortium must cover at least 10% of the project costs upfront. This is due to the R&D nature of the innovation competition. The remaining 90% of the funding required by the project will be provided through the NIC funding mechanism should the project be approved by Ofgem. The 10% contribution from each major partner must be in the form of a transfer of cash into the project bank account at the beginning of the project. To this end, SPEN are looking for any major project partner to individually contribute 10% of their associated costs upfront alongside any other additional resources the partner should wish to contribute.

We believe LV Engine represent a major opportunity to any potential manufacturing partners who wish to participate. One of the key objectives of the project is to open up a new market place for Smart Transformers within distribution networks across the United Kingdom. The involvement of both SP Energy Networks and UK Power Networks represents 5 licenced areas within the UK and both companies believe the technology will have a major role to play in future electricity networks. Consequently, any project partners that are capable of contributing towards this project will place themselves at the forefront of this emerging industry by developing a product that has been technically and commercially proven as part of a high profile network trial.

In addition, each project partner must agree to the standard IPR agreement set out in Ofgem's NIC Governance document. A copy of the document can be found using the link below. In brief, all relevant foreground IPR needed to replicate the project must be made available. Any background IPR remains is not required.

https://www.ofgem.gov.uk/network-regulation-riio-model/network-innovation/electricity-network-innovation-competition

5. Manufacturer Engagement Plan

To allow interested manufacturing partners to plan involvement within LV Engine we have produce the following engagement plan shown in Table 2. The intention is to share the following information via email and through the SP Energy Networks website on the dates shown to share project progress and allow manufacturers to prepare for the competitive tendering scheduled for November 2018.

The LV Engine project team will welcome any feedback on any of the reports that are produced and would encourage manufacturers to engage directly with us and challenge any outcomes with any alternative views they may have. The intention is to design Smart Transformers which are fit-for-purpose within a distribution network and the view of manufacturers is extremely important to us.

Table 2: Manufacturer Engagement Plan

Owner	Document Description	Release Date
Uni. of Kiel	Report 1: Technical recommendations on a grid connected ST specification	10/08/2018
Uni. of Kiel	Report 2: Smart Transformer test requirements	16/07/2018
Uni. of Kiel	Report 3: ST function as Active Harmonic Filter and Active Resonance Damping	14/09/2018
Uni. of Strathclyde	Report 1: Fault level impact and protection requirements for LV Engine schemes	24/08/2018
Uni. of Strathclyde	Report 2: Review of existing relevant standards to LV Engine schemes	20/07/2018
Uni. of Strathclyde	Report 3: LV DC requirements for LV Engine schemes	31/08/2018
WSP	Trial Site Selection Report	28/09/2018
WSP	Draft Smart Transformer Technical Specification	01/10/2018
WSP	Draft LV Engine Trail Scheme Functional Specification	01/10/2018
SP Energy Networks	Final Smart Transformer Technical Specification	29/10/2018

SP Energy Networks	Final LV Engine Trail Scheme Functional Specification	29/10/2018
SP Energy Networks	LV Engine Smart Transformer Tender Documents	29/10/2018

SP Energy Networks would welcome any feedback on the Draft Technical specification documents which will be release on the 1st October 2018. Any feedback will be considered prior to the final documents being published and the tendering document release. We are open to either face-to-face meetings or teleconferences depending on the meeting details.

Table 3 shows the key milestones during Work Package 2: Partner Procurement

Table 3: Tendering Milestones

Milestone	Date
Release of LV Engine tendering document	29/10/2018
Deadline for Manufacturer tendering responses	07/12/2018
Initial SPEN tender response evaluation	07/12/2018 – 11/01/2018
Face to face meetings with compliant manufacturers	14/01/2018 – 01/02/2019
Negotiations with shortlisted manufacturers	February – March 2019
Notification of chosen partner(s)	March 2019

6. Contact information

If you have any questions regarding LV Engine or **wish to express your interest in the project** please contact Anthony Donoghue as below. Please also provide details of the best point of contact going forward.

Anthony Donoghue

Senior Innovation Engineer

Future Networks, SP Energy Networks

Ochil House, 10 Technology Avenue, Hamilton International Technology Park, Blantyre, G72 0HT

0141 614 6904 | 07531135379

adonoghue@spenergynetworks.co.uk

SP ENERGY NETWORKS

www.spenergynetworks.co.uk/
facebook.com/SPEnergyNetworks/
twitter.com/SPEnergyNetwork
adonoghue@spenergynetworks.co.uk