SP ENERGY NETWORKS

LV Engine

Project Progress Report

January 2020

RIIO NIC NETWORK INNOVATION COMPETITION

Version History

Author	Revision	Date	Status	Comments
Michael Eves	V0.3	09/10/2019	Draft	Issued for review and comment.
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Approval

Name	Position	Date	Signature
James Yu	Future Networks Manger	20/01/2020	

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1 Executive Summary

1.1 Background

SP Energy Networks, in collaboration with UKPN, submitted the proposal for LV Engine under the Network Innovation Competition (NIC) mechanism in 2017. WSP, University of Strathclyde, and University of Kiel have also provided technical support for the proposal preparation. Ofgem approved the proposal and issued the Project Direction on the 16th of January 2018.The project commenced in January 2018 and is due to conclude in December 2022.

The LV Engine innovation project intends to trial Smart Transformers (ST) within secondary substations as the central point of an active and intelligent 11kV and LV distribution network. The Smart Transformers (ST) trialled during the project will bring together sophisticated power electronic hardware with intelligent network monitoring and control to maximise the performance and efficiency of the distribution network.

This is the second in the series of annual progress reports for the LV ENGINE project, covering the project reporting period January 2019 to January 2020, the "reporting period".

1.2 Project Highlights

The project highlights in this reporting period are as follows:

- **SST Project Partner** – One of the major milestones achieved in this reporting period was appointing ERMCO- Grid Bridge (EGB), who will design and manufacture the Solid State Transformer (SST). This partnership was the result of a thorough and robust competitive procurement process, in which we assessed competence and ability to represent the highest value to the customer across the market. EGB have proven track record in power electronic based solutions for grid applications. EGB is also one of the transformer manufacturers in the US. Further information can be found at Grid-bridge.com and ermco.com.

- **Trial sites for LVAC schemes progressed –** Since 2018, we have moved ahead with our priority locations within Wrexham and Dumfries. Both areas have been fitted with monitoring devices, with the data being used to create detailed system models to evaluate the impact of different network arrangements and LV Engine schemes; this will allow better understanding of network performance prior to installation of SSTs and de-risking network trial failure.

    - **Wrexham –**Four substations and their associated LV networks have been considered for implementations of LV Engine Scheme 1, 2 and 3. The trial sites provide the opportunity to demonstrate capacity sharing between substations with complementary load profiles. The monitoring equipment have been installed on all the LV feeders within the trial area and the network model has been developed. In order to provide adequate loading for the LV Engine scheme demonstration, further load has been moved to trial area by conducting LV network rearrangement.

  - **Dumfries –** Three substations within Dumfries have been considered for LV Engine schemes. In a similar manner to Wrexham, monitoring has been installed, and data applied in load models to assess network capability.

- **Trial sites for LVDC schemes identified –** We have been focusing on two sites which we are confident in realising our DC schemes.

  - **Scheme 4: Falkirk Stadium –** Since 2018, we have worked with Falkirk Council to ensure the site has suitable dimensions and capability to account for an SST installation. We have in place a connection agreement in principle. The trial site is around Falkirk stadium where extensive development is currently taking place for providing an EV charging facilities. We have the initial connection plan, land layout. Further design and implementation planning will take place during next reporting period.

  - **Scheme 5: EV Taxi Rank within Glasgow City Centre –** We have also an agreement in place with Glasgow City Council (GCC) to use LV Engine scheme with LVDC to supply an Electric Taxi Hub planned to be commissioned in a car park in Glasgow.

- **LV Automation –** LV Automation will be part of LV Engine schemes, especially, Scheme 1, 2 and 3. In order to understand the latest status of market on controllable LV Circuit Breakers and Linkbox switches, a market research report was prepared. The report summaries the technical capability of the products which are commercially ready or have technology readiness level greater than 7. In addition, we prepared a document specifying the technical requirements of the LV automation devices and interfaces which will be used in LV Engine. This document will be used for the procurement of LV Automation products in 2020.

- **DC Metering -** LV Engine team have investigated several options to facilitate the metering of a DC supply. There is currently no approved DC metering product or arrangement in the UK. Instead enquiries have been made into unmetered supplies, HV metering, manufacturer developments and metering dispensations to try and find a solution. Some of the explored options were found to be unsuitable or unfavourable. It is hoped a metering dispensation can be sought from ELEXON to facilitate the connection of DC meter pulsing to an approved AC meter to be utilised for billing.

- **Smart Meter Uptake –** We have investigated the viability of supporting Smart Meter uptake in the Wrexham area, as the existing low uptake of SMETS2 meters limits the current learning capability of the project. The team explored a range of approaches to instigating increased Smart Meter uptake; but many were not pursued as customer contact is not a viable option for SPEN due to confusion may create on liability on Smart Meter performance from customers point of view. We have developed an action plan for deployment in 2020, focussing on utilising the network and contact methodologies available through local suppliers, and have provided a report on the lessons learned in conducting this exercise.

- **Dissemination (LCNI, Webinars, Tutorials, CSA and materials) –** The learnings of the project and its objectives were widely disseminated through LCNI, international conferences, and a joint event with Compound Semi-conductor Application (CSA) Catapult and Power Electronics UK.

- **Learning from collaboration with Active Response project –** As set in the final proposal submission to Ofgem, Active Response (by UKPN) and LV Engine, have been collaborating to share knowledge, finding solutions for common challenges, and deliver joint disseminations.

- **LV DC Infrastructure** – Initial steps have been taken to identify manufacturers with existing LV DC expertise in Electric Vehicle (EV) charging or LED street lighting, as identified in the final submitted proposal. Utilising LV DC infrastructure components as part of the DC trial sites will allow for further evaluation of the SST capabilities. Following the market engagement in 2018, we continued to engage with EV charger manufacturers who potentially can provide products with DC input supply. There are number of suppliers who have shown interest for collaboration in LV Engine as they already have development programme to manufacture EV chargers with input DC supply. We are in continued discussions with them to specify the requirements of the LVDC network which can be suitable for their products and have a better chance of roll out.

1.3 Project Issues

The project continues to progress well and is expected to be completed as specified in Project Direction (December 2022).

The key current project issue of note is a non-material change delay (approx. 20 weeks) associated with the SST manufacturing partner procurement exercise. The team has worked with the SST supplier to set an aggressive project programme to avoid any material change in the project. In addition, non-dependant work in the trial site development has been accelerated to improve the progress. The success of this strategy will be reported in the next reporting period. The primary causes for the delay are:

- **Market Engagement** – We engaged with a total of nine manufacturers prior to the release of the ITT. While the engagement delivered high value (seen in the technical specification and tender outcome), the engagement took a significant amount of time and effort to hold multiple bi-lateral conversations.
- **Manufacturer Responses** – Due to the tender being for a product yet to be designed, there were a number of queries which arose during the tendering process, which were answered through the procurement governance process. Furthermore, we allowed an extension of two weeks beyond the original deadline for initial proposal submission to accommodate a request made from tenderers.
- **Technical Evaluation** – During the technical evaluation of submissions, there was a number of queries raised by the LV Engine team which required a series of conversations with each tenderer, in line with Iberdrola procurement policy. In addition, following interview sessions there was a second series of conversations to close out technical queries before providing final indications of technically compliant bids.
- **Terms & Conditions negotiation** – As the terms were dealt with on a competitive basis with all technically compliant tenderers, there was a significant amount of effort expended to deal with all term changes and clarifications.

The delay allowed SPEN to ensure the tender process was completed as per competitive tendering company policy and extract the best value for the customers from the tender. In particular negotiations over terms and conditions with short listed project partners were time-consuming.

To reduce the impact on the long-term project objectives and avoidance of any Material Change, we will be incorporating the following measures in the next reporting period:

- Accelerate the work unaffected by the delay, primarily the trial sites preparation. We have set ourselves an accelerated target to conduct all site preparation works and commissioning of LV Automation system concluded by the end of 2020 ensuring no delay will be seen in this process.
- Pursuing an aggressive delivery schedule (agreed with our SST partner) to optimise our time during the detailed design and manufacturing phase of the SST.
- Preparation of the test plans for network integration testing (work package 4) and placing the contract with the capable facility in 2020. That will allow all the logistics and preparation take place in 2020.

At this moment, there is no concern that the above reported issue will impact the ability for the LV Engine project to be successfully delivered by December 2022 or that a Material Change has been realised as a result. The only additional impact we foresee at this stage is an impact on the delivery of Deliverable 3 in September 2020 which will be reported on in further detail in the next reporting period.

1.4 Key lessons learnt

- The existing technology readiness level (TRL) of SST Topology 1 is around 6 and Topology 2 is around 5. It is feasible that LV Engine increases TRL for Topology 1 to 9 and Topology 2 to 8. Significant academic work and prototype developments have been undertaken.
- SST development is in strategy of several power electronic technology suppliers; this is not only driven by same solution as LV Engine, but also for provision of DC supply to production lines (in manufacturing) or renewable connections to the grid. It is expected competitive market grow within LV Engine project lifetime.
- The increasing experience in use of SiC (Silicon Carbide) products provides good confidence that it could be a right time to develop a fit for purpose SST for grid application (better size, better efficiency compared to Si power electronic products).
- The ongoing engagement with EV charger manufacturers suggested that 800-900VDC unipolar can be ideal LVDC supply voltage. The 900V LVDC can potentially offer 30% thermal uplift compare to a 3 phase 400V AC network. We have considered the 900VDC as our LVDC output in the SST design.
- Capacity sharing capability between neighbouring substations is limited to the thermal rating of the LV interconnection. This should be investigated prior to site selection, cable tapering and use of random small size cable sections may have significant impact on overall LV interconnection thermal rating.

- For the purpose of LV voltage control, we are focusing on use of voltage alarms generated by Smart Meters. This can significantly reduce the data traffic compared to the approach which considers full voltage profile generated by a Smart Meter. In addition, this approach offer a better latency as voltage alarms are transmitted immediately as they occur, whereas the voltage values are averaged and transmitted after a waiting period.

1.5 Summary of key activity in next reporting period

- To conduct and conclude the procurement process for selection of Intelligent Control System partner
- To finalise the detailed design of Solid-State Transformer in collaboration with SST manufacturing partner
- To develop the first prototype of SST for both topologies which will be mainly used by EGB to test the performance and inform the final product development
- Conduct market research to identify suitable network integration facility to deliver Work Package 4
- Install and commission and operate the LV Automation in Wrexham trial site;
- Liaise with councils to implement the LV Engine scheme 4 and 5 for EV charging in the car parks located near the trial sites;
- Confirm availability of LV DC infrastructure technologies and further investigate use within the DC scheme sites.
- Deliver strong disseminations in various forms (UKDNO workshops, technical papers, LCNI, webinars etc)

2 Project Manager's Report

This section provides an overview on the project progress made in this reporting period (16th January 2019 – 16th January 2020)

2.1 Project Progress

The project successfully progressed in different Work Packages during this reporting period.

The key highlight of the period was the appointment of the SST Manufacturing Partner as part of Work Package 2 activities. The SST Manufacturing Partner, ERMCO-Grid Bridge (EGB), will design and manufacture Solid State Transformers (SST) as planned in Work Package 3. This appointment was through conducting a competitive tendering process evaluating the technical solutions and commercial offers submitted by multiple tenderers.

In summary following progress made in each work package:

Work package 2:

- Appointment of EGB, our SST Manufacturing partner, through competitive tendering process with participation of international and national tenderers.
- Procurement preparation for the Intelligent Control System partner appointment
- Market research and procurement preparation for purchasing the LV automation and protection equipment
- Commence the procurement process for the SCS partner
- Update the smart control system technical specifications to account for the requirements gathered for system integration

Work package 3:

- Following the appointment of EGB in November, the SST design stage has started and the initial discussions between project partners are taking place. We are in a better position to report on design and manufacturing in next reporting period.
- The scope for Life Cycle Assessment (LCA) of the SST has been developed through internal and external engagement. We will appoint capable consultant to deliver the LCA studies in the next reporting period.

Work package 4:

- Power Network Demonstration Centre (PNDC) was commissioned to develop the technical specifications of the tests required for the ST to ensure the safe operation and functionalities of ST prior to any live trial.

Work Package 5:

- Following the trial site selection activity conducted in previous reporting period, we have now focused on trial sites in Wrexham and Dumfries for Schemes 1, 2 and 3.

- Trial sites were fitted with monitoring equipment to understand the load profiles and voltage variations which will enhance our understanding about trial sites and inform our control and planning strategies.

- Trial sites information reports have been prepared to provide all the drawings of the sites, switching points, loading conditions, the issues identified, the plant and equipment required, the connectivity of LV network etc.

- Unbalanced network model detailing the HV and LV connections of trial sites in Wrexham and Dumfries were developed and initial load flows studies demonstrated the network performance during Scheme 1,2 and 3.

- We have started collecting the data from Smart Meters (SMs) connected to our trial sites to have a better understanding on availability and quality of SM data, the uptake level and mechanism to use them for control purposes.

- We have agreement in principle with two councils, Glasgow City Council (GCC) and Falkirk Council, to collaborate for trial of our LVDC schemes (Scheme 4 and Scheme 5).

- Market engagement with potential suppliers of DC input EV chargers or street lighting has been taking place. We will be in a position to report the supplier (collaborator) for DC input EV charger and street lighting in the next report period.

- Explored the options for DC metering in the absence of approved DC meter

Work Package 7:

- The project has gone beyond its obligation for dissemination and knowledge sharing by sharing the project learning through a series of external presentations and published articles, material development and conference attendance. That includes project website, international conferences (CIRED and PowerTech), LCNI 2019, joint dissemination with CSA catapult and power electronics UK and submission of webinar proposal to IEEE for annual presentation of LV Engine achievements during project time.

The following sub-sections provide more details on the work carried out in each key activity with the learning and issues summarised in following sections.

2.1.1 Work Package 2 - Partner Selection

2.1.1.1 SST Manufacturing Partner Selection

Invitation to Tender & Submissions

The project team worked to develop a standardised submission template for tenderers (available upon request) using the technical specification (Deliverable 1) as the main technical criteria for evaluation, using the essential criteria set out by the business as the measure of a technically compliant offer and potential for business as usual adoption.

The procurement includes selecting a SST manufacturing partner who will design, manufacture, support commissioning and live trial of two SST topologies (Topology 1 and Topology 2) shown in Figure 1:

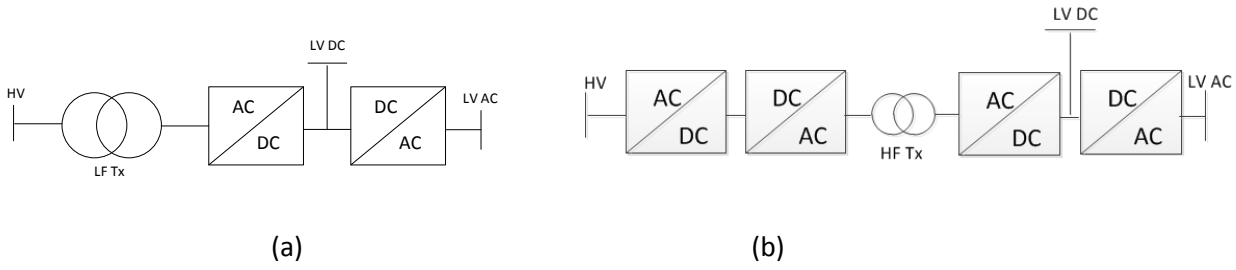


Figure 1: SST Topologies will be trialled in LV Engine

(a) Topology 1, a bolt-on solution added to the existing transformers
(b) Topology 2, a complete SST using high frequency transformer

In addition, tenderers had to provide a bid covering three specific responses:

- **Technical Response 01 - Proposed SST Solution and BaU adoption**: This response provides technical description of the proposed SST in terms of dimensions, topology, cooling system etc. Also, tenderers were requested to provide their view on how SST can be adopted into business as usual by SPEN after LV Engine project completion.
- **Technical Response 02 - Implementation Plan & technical capability:** This response provides the project programme and tasks breakdown of the activities required to fulfil the scope of services and deliverables. Also the proposed team and man-hour estimate for individuals.
- **Technical Response 03 – Project Management**: This response provides the project management strategy/capability, communication strategy and risks identified for delivery of this project.

Technical Evaluation

The technical evaluation was carried out by a team consist of direct project team and end users within the SPEN with standards and operation background. Given the broad spectrum of requirements, the team ensured that input was taken from the Standards, Communications, as well as colleagues who are operational working within the district. Technical responses were evaluated based on the criteria shown in Table 1. The technical evaluation process has also been outlined below in Figure 2.

Table 1 – Technical Evaluation Criteria

Score	Evidence
Fail entire tender	• Answer is incomplete and does not provide enough evidence to conclude how the requirements will be fulfilled • The requirements have been only partly understood • There is a high risk that the proposed approach fails or being successful • Limited capabilities are demonstrated and requirements can be fulfilled only partly • Technical mistakes or significant editorial errors have been identified
Fail entire tender	• Some aspects of requirements are answered and evidences have been provided • Technical capabilities are demonstrated to some extend however there are still some lack of capabilities • There are limited risks that proposed approach fails or being unsuccessful • The proposed methodology needs further details to match the requirements
Conditional Pass	• Answer provides enough evidence that majority of requirements can be fulfilled • Evidence of technical capabilities are demonstrated in most aspects in line with the requirements however minor technical gaps were identified • The proposed approach is likely to be successful and only limited low probability risks of failure were identified • A good understanding of the requirements is demonstrated however some minor clarification may be required • Minor improvement in the proposed approach have been identified
Unconditional Pass	• The requirements can be fully fulfilled • Strong and robust approach has been proposed • Answer is clear, coherent and well written • Proposed approach and evidence provides strong confidence in successful delivery of the requirements • Strong technical capabilities have been demonstrated

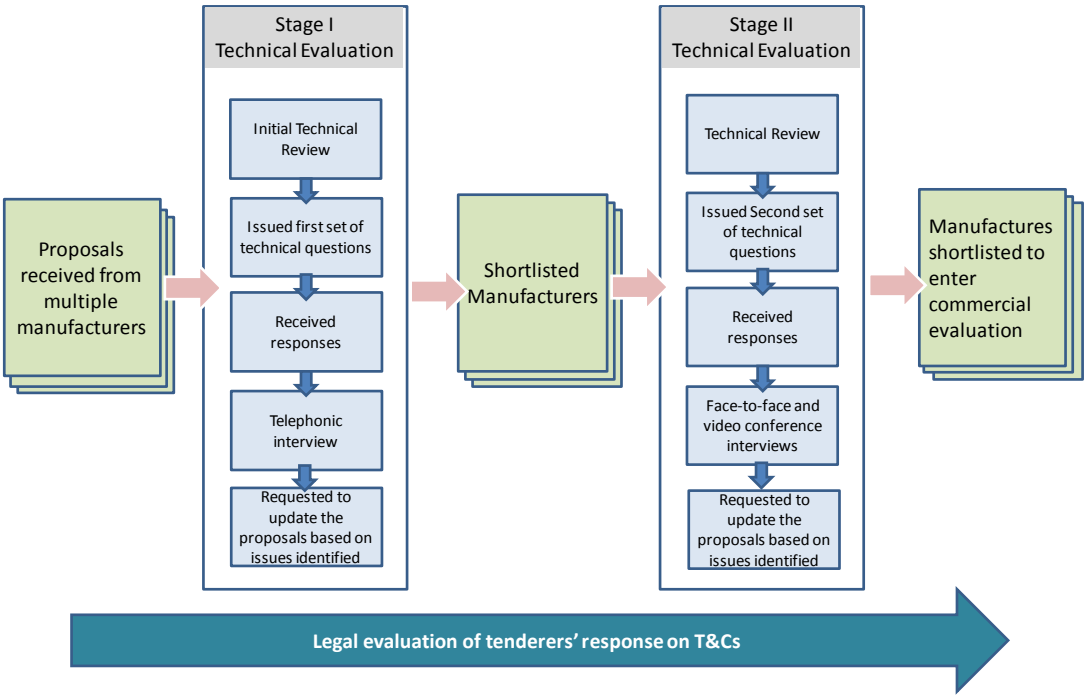


Figure 2: Technical Evaluation Process

Contractual & Commercial Evaluation

The project team worked with the legal and procurement teams to settle terms and conditions with each supplier. This decision was taking by applying learning from previous projects where terms had been negotiated aggressively following contract award and the process was lengthy to ensure agreeable terms were met for both parties. This was done within the procurement process and before commercial evaluation with the view that favourable terms would be counted as value within the best and final offer.

Following the settlement of terms across all suppliers, the tender was then submitted to our procurement team for a final commercial settlement in a Best and Final offer submission. Once this was concluded, the best value technically compliant tender was chosen for the contract award.

2.1.1.2 SCS Partner Procurement

- Within the previous reporting period the team took the decision to postpone the SCS selection process as some dependencies based upon the SST tender were identified. Upon selection of the SST partner, the SCS process has been unfrozen.
- Evaluating the tender process by comparing the success of the outcome versus the delay causations can be used as a commercial learning exercise to assist in streamlining further examples in LV Engine.

The next actions to finalise the partner selection and procurement include:

- Completing the PQQ assessment and inviting successful suppliers to submit a tender via an Invitation to Tender (ITT)
- Concluding the technical evaluation of submissions and place a contract award.

This work is expected to be concluded by June 2019.

2.1.1.3 LV Automation & Protection Procurement

In addition to the procurement of the SST and SCS project partner, the project will also procure LV automation and protection equipment. This exercise shall be able to provide remote and automatic control and monitoring of the LV network, supporting the enhanced functionality that the Smart Transformer proposes.

LV Engine proposes to use intelligent LV switching devices that can be remotely controlled, sense feeder flows and offer dynamic reconfiguration of the LV network. This shall allow for a centralised LV network management and automation platform.

To deliver this, the existing LV fuses at the distribution substations shall be replaced with LV Circuit Breakers – Controllable (c-LVCB) and the LV link box switches shall be replaced with LV Switches – Controllable (c-LVS) that will be used to interconnect the distribution network.

The c-LVCB's and c-LVS's will communicate locally with a compatible communication protocol which will in turn transmit status to the Energy Management System (EMS) to improve the utilisation of the LV network.

The progress in 2019 in this area has been the fully developed technical specification for LV Automation equipment and which has been consulted by the wider business. In 2020, the project team will commence the tendering process for LV Automation products (LVCB and LVS), award the contract, and install the equipment on site within WP5.

As the LV Automation may not specific to LV Engine project and may be used for other purposes, in order to facilitate full integration of technology into BaU, the team has developed the Technical Specifications for general LV automation application but with LV Engine project specific requirements added as separate parts in the document.

2.1.2 Work Package 4 – Network Integration Testing

Work Package 4 is to test the functionalities and reliability of the manufactured SST in a network integration facility and obtain network integration certificate. In this activity, network integration tests for the ST have been specified by the University of Strathclyde to bridge the gap between factory acceptance tests and network trials, while increasing the ST system readiness level. The tests specified cover functional and performance tests that encompass the ST, SCS and LV protection and automation schemes.

One of the key challenges associated with this is the alignment of the specified core ST functions with an industry that is still being matured and standards that are under development.

To address this challenge, the specified network integration testing adopts holistic testing methods that build on years of experience of the smart grid testing and validation academic and industry communities. Such methods rely on power hardware in the loop (P-HIL) test platforms and systematic design of experiments (DoE).

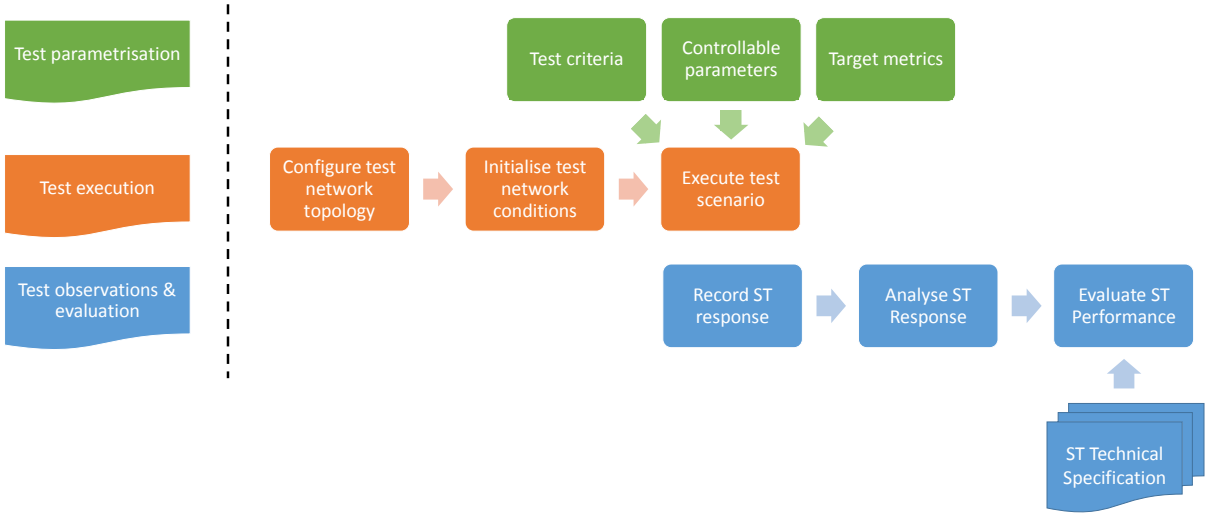


Figure 2: System integration test flow for the LV Engine ST focusing on de-risking the system functionality in a controlled test environment prior to field trials

Network integration testing specifications documents were developed to outline the following:

- The technical capability of the network integration testing facility which may conduct the required tests for LV Engine solution as planned in Work Package 4
- The test scenarios which should be considered for demonstration of Solid State Transformer core functionalities and performance of Smart Control System.
- The standards and engineering recommendations shall be considered during the tests
- The expected results with a cross reference to technical specification of smart transformer developed in Work Package 1.

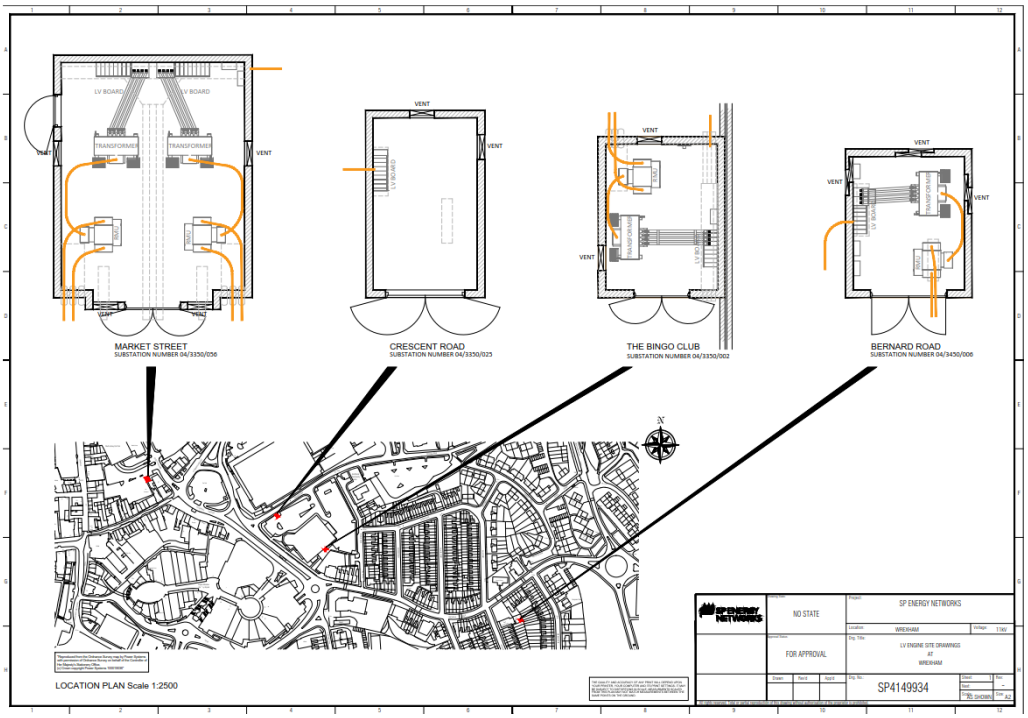
2.1.3 Work Package 5 – Live Trial

This chapter covers the work carried out for the key sites identified. These are in Wrexham and Dumfries for the Schemes1, 2 and 3 which are demonstrating AC functionalities and Falkirk which is for the DC schemes demonstration.

Wrexham and Dumfries trial sites:

Trial site assessment for LV Engine Schemes 1-3 was conducted through desktop analysis and from the input from local district engineers in SPM region. Four substations in Wrexham and four substations in Dumfries were selected as trial sites through the analysis of the gathered data and more detailed assessment through the site attendance:

- Complementary Load Profile
- Available NOP
- LV only substation
- Network Connection
- Available space alongside existing conventional transformers
- Substation location and access
- Imbalanced load across the phases



Falkirk trial site:

Falkirk Council is developing a low carbon transport hub at the site of Falkirk Community Stadium.

The development at Falkirk Stadium will capitalise on local renewable generation and integrate it with local demand, including building and transport loads facilitating the use of electric vehicles with charging infrastructure. Falkirk Council's engagement with LV Engine stems from an interest to provide a more efficient supply for the DC profile and trial of new technology which potentially can facilitate integration of further low carbon technologies.

LV Engine proposes to offer the installation of a 500kVA Smart Transformer adjacent to the site of the Energy Storage unit. The ST would offer the use of either an exclusive LV DC supply or a hybrid LV AC & DC supply, satisfying the requirements of trial Schemes 4 or 5. Through agreement with Falkirk Council a piece of land with adequate footprint has been considered for installation of Smart Transformer in the developments around Falkirk stadium.

2.1.3.1 Network Monitoring

Monitoring Equipment

The identified trial sites have had monitoring installed across multiple feeders and circuits to understand the voltage and load profile across the sub-station. 8 substations are now being monitored with data remotely collected for at least a full year analysis before commissioning LV Engine schemes.

Figure 3: Monitoring installation works in Dumfries and Wrexham

The trial sites consist of areas with commercial and residential customers providing the opportunity to demonstrate the capacity sharing functionality of ST between two neighbouring substations with complementary load profiles. Figure 4**Error! Reference source not found.** shows the load profile captured at two substations in Wrexham.

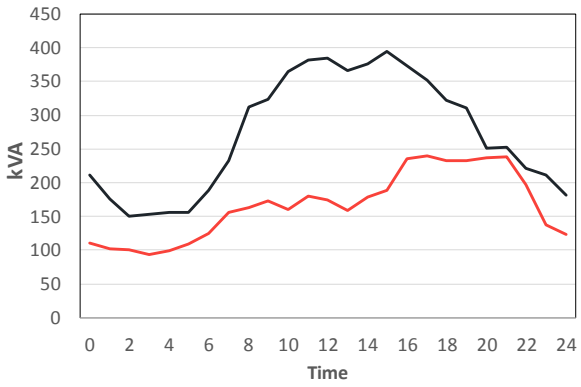


Figure 4: The loading of two neighbouring substations selected in Wrexham trial site [CONFIDENTIAL]

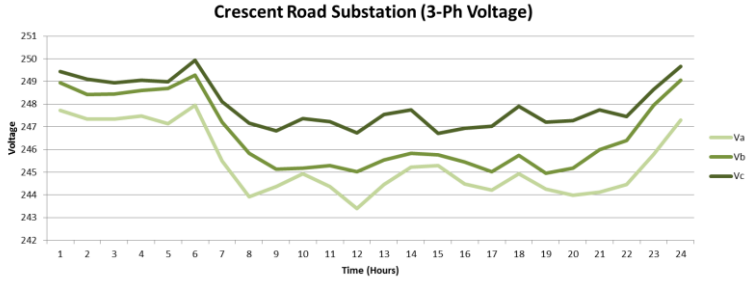


Figure 5: The voltage monitored at a LV only substation in Wrexham trial site [CONFIDENTIAL]

Monitored data is collected on a regular basis from the trial sites and imported to data analysis tools we have been developing for LV Engine. We will report on the data analysis and tools developed in the next reporting period.

2.1.3.2 Network Modelling

One of the key activities was the modelling the trial sites in Dumfries and Wrexham. In order to develop an offline load flow HV/LV distribution network model of an LV Engine trial site(s) that represents schemes 1, 2, and 3. The model demonstrated the functionalities of the LV Engine schemes in different load/generation scenarios. The model was developed using DIgSILENT and was benchmarked against real load flow data of the selected sites provided by SPEN with agreement on the appropriate simulation tools, network(s) layout, data required (e.g. network capacity, GSP fault levels, SST suitable model(s), cable parameters, load/generation profiles, and etc.), and operational scenarios.

Wrexham Network Modelling

The Wrexham network was selected as a trial site on the basis that there would be complementary load profiles on adjacent transformers, which would allow for greater load sharing cooperation potential with the introduction of a Smart Transformer (ST). This potential has been confirmed verified with detailed load data that has been, and continues to be, collected from the network. A

representative network model has been developed in DIgSILENT and tuned and validated by utilisation of selected monitoring. Validation to within 2% error between the model and reality at strategic points on the network has been achieved.

All three LV Engine AC schemes have been implemented within the DIgSILENT model and several studies conducted to understand the impact that the introduction of STs will have on improving the network performance.

Dumfries Network Modelling

A second trial network has also been modelled in DIgSILENT for a section of network in Dumfries. Lessons learned during the development of the Wrexham model were applied to the Dumfries modelling exercise, with further enhancements being made to the GIS data extract tool to facilitate the improved realisation of network models within DIgSILENT.

This methodology and developed tool will be of wider benefit to innovation projects. A similar validation approach was pursued for Dumfries and the three LV Engine AC schemes have been established within the network model, although the observability on the network was more challenging for this network.

The models of the two test networks studied: (a) Dumfries network and (b
Wrexham network: during the course of the project the process of developing validated network models from SPEN's GIS data has improved.

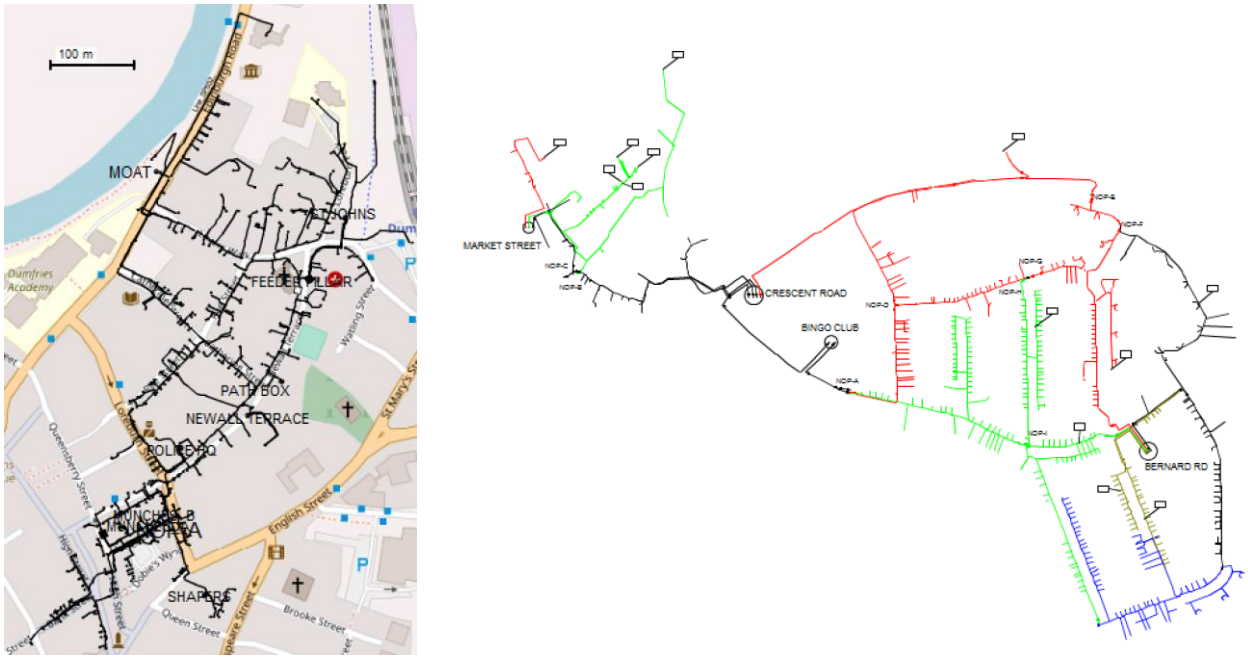


Figure 6: The models of the two test networks studied: (a) Dumfries network and (b) Wrexham network.

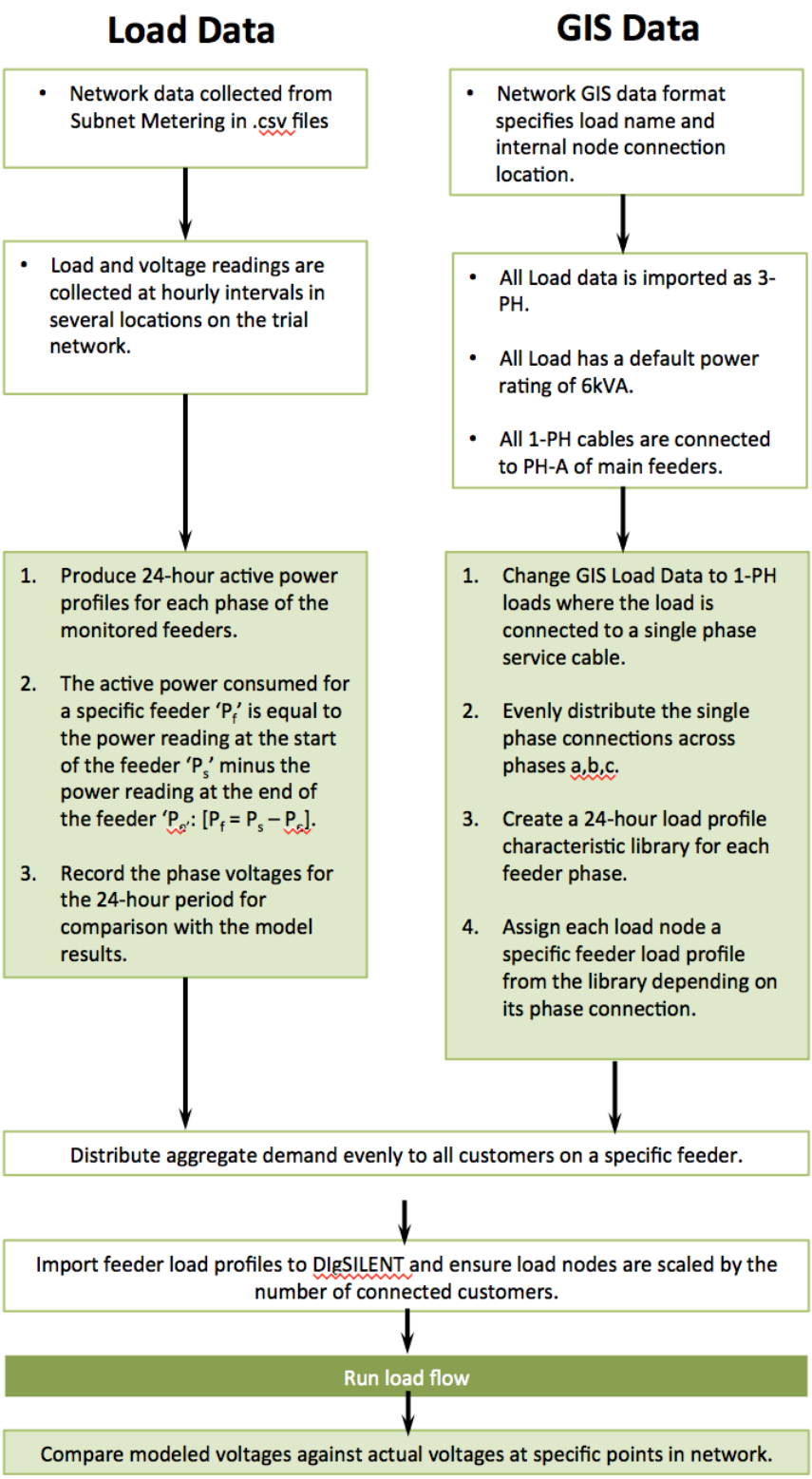


Figure 7: Network validation methodology

As a result of the work in the reporting period, this project has realised a functional model of STs (with two configurations, conventional line transformer; and dual active bridge configuration) together with their control schemes suited to LV network load flow studies and related fault studies for assessing protection implications.

2.1.3.3 Site Preparation

Across both sites (Wrexham and Dumfries), the team have developed the site information packs and plan for the trial sites detailing out all the equipment, site works at each substation and reconfiguration / upgrade on the LV Network required to implement the schemes. These site packs also provide a detailed description of the electrical network configuration before and after the implementation of the LV Engine schemes.

Working with the site delivery teams, the possible AC scheme arrangements have been identified across key feeders through a series of detailed discussions and workshops took place with the site delivery teams. This site specific information will be used for the site preparation and also site introduction to SST manufacture to design the transformers.

The following is a summary of the work carried out in 2019:

- The existing running arrangement of LV network and agreed on potential changes in the network to adequately transfer load to trial sites was developed;
- The details of the network arrangement for running LV Engine schemes were developed;
- The team then used the necessary data (SLD, cable & transformer data) to model the HV/LV network in DIgSILENT for both Wrexham and Dumfries regions to identify how the SST would operate in this arrangement;
- Initial CAD drawings of the substation with the existing plant layouts were prepared and shared with the site delivery team for approval
- Opened dialogue with LVDC EV charging and LED street lighting manufacturers to ascertain availability of the technology and potential installation on schemes 4 & 5
- Monitoring equipment were installed at the substations to monitor the load profile for trial sites, which have been fed into the DIgSILENT models
- The plan for site preparation, the switchgear required and the installation arrangement were planned and documented
- Working with manufacturers to establish the LVDC network installation requirements. Outstanding issues such as voltage step down and control methods for LED street lighting are to be resolved as ongoing development work.

In addition to the work across these two sites, the Baltic Triangle in Liverpool is considered as another option to implement the LV Engine Schemes. Monitoring equipment have been installed by SPEN (as part of Business as Usual activity) for enhancing the visibility across the LV network. LV Engine team plan to use the monitored data in the next reporting period to establish any sites can be suitable for LV Engine implementation.

2.1.3.4 Smart Meter Uptake

During 2018, the trial sites were investigated based on specific criteria of the substation (such as footprint and capacity). Uptake of second generation Smart Meters (SMETS2) were not considered as an essential criterion; as it was expected that there will be significant uptake of SMETS2 by 2021 across UK. Also there was an alternative plan to use voltage monitoring equipment in strategic locations if SMETS2 uptake is low. However, the project team recognised that part of the roadmap to a Net Zero electricity network is SMETS2 models and therefore wanted to fully explore the viability of SMETS2 models as part of the project delivery, and therefore to explore how the team could locally support the uptake of smart meters specifically in the AC Scheme trial site areas.

An initial review in Wrexham trial area showed a significant number of meters installed in the trial site areas are SMETS1 models. The LV Engine team identified and explored different methods to actively encourage increased uptake of smart meters, working in co-ordination with the business including the stakeholder management, communication, telecommunications and wider customer service group.

After initial contact with local suppliers regarding increasing uptake, it was communicated to the project team that work to incentivise in the Wrexham trial site was underway. This was not a targeted approach but formed part of a wider campaign within the UK by energy suppliers. Subsequently, it was decided to cease the SM uptake pursuit to evaluate the supplier campaign results when available in January 2020.

2.1.3.5 DC Metering

To demonstrate the DC output functionality of the Smart Transformer an LV DC customer will be connected to the Smart Transformer. In a standard AC supply the energy metering equipment is usually installed at the customer boundary with the DNO equipment. For DC applications, however, in the absence of approved (by Elexon), this is not currently a standard practise provided by energy retailers for billing purposes.

Efforts have been made to identify alternative metering arrangements in this reporting period. The initial investigation was made as to whether we could provide an unmetered supply. This was quickly ruled out as the expected DC load did not meet the requirements specified by Balancing and Settlement Code (BSCP520) for that of an unmetered supply as follows:

- **Predictable –**The load consumption from selected schemes would not be predictable, and would vary upon consumer behaviour. EV chargers are not considered as predictable loads.
- **Less than 500W** – The LV Engine scheme includes DC supply to EV chargers with loading of significantly larger than this criterion.

Therefore, the project team has explored multiple options in order to fulfil the requirements and expectations of the project outcomes:

HV metering

SP Retail was engaged with to determine what solution they would be able to propose. They reiterated that there was no meter approved for UK use. One of the feasible option was to meter on the HV side of the transformer with an approved AC meter. Although this solution is technically viable, the drawback for BaU rollout is that it would see the customer likely paying for the losses or it may introduce complication for any commercial settlement in the connection agreement with a DNO. Nonetheless, we have decided to keep this option feasible for further negotiation with our LVDC customer for the purpose of LVDC trial.

Reconfiguring existing non-UK products

Despite the lack of available standards, engagements with potential DC meter suppliers were carried out. There are number of DC meter manufacturers identified suppliers of DC meter. However due to the lack of an available standard and the timescales required to get a meter through compliance testing, the use of this product within the UK is not feasible within the project lifetime. The progress of the DC meter rollout will be monitored closely during the project lifeline as the closest available product to market.

Early review of IEC Standard for DC Metering

We have identified the development of an IEC standard for DC meters; IEC 62053-41 ED1. This standard is due to be published in January 2021, with access to the draft document only currently available to working group members. We anticipate that the release of this standard will allow better development of DC meter technology and a reference to provision of approved DC meters.

Given the timescales of both the release of the standard and the time needed for technology development and testing, the opportunity to find an approved DC metering product seems to fall beyond LV Engine delivery programme. However, the progress of this standard will be monitored as the project progresses to check for any updates, with learning being reported.

Intended Solution

Given the outlook on a DC metering solution, a potential compromise solution has been identified with previous success in the UK in a windfarm application. Investigation of meter dispensations from Elexon has revealed an applicable case in which a DC meter was used in conjunction with an approved AC meter. Unlike the LV Engine requirements, the arrangement is being utilised in offshore windfarm infrastructure, rather than a billing tool for customers. Nevertheless, it is still a working solution and as such can be utilised as part of the LV DC trial sites to meet the DC meter requirements.

A dispensation will have to be submitted to ELEXON and approved by them for this solution to be suitable. Ongoing work is being carried out to engage with Elexon and energy retailers to establish the solution.[1]

[1] More information on the testing requirement can be found at: https://www.elexon.co.uk/documents/bsc-codes/bscps/bscp601

The full dispensation case is available here: https://www.elexon.co.uk/documents/training-guidance/bsc-guidance-notes/statement-of-generic-metering-dispensations/

2.1.3.6 Communication Network Bandwidth and Architecture Requirements for the LV Engine SCS

The LV Engine scheme relies on an integrated Smart Control System (SCS) that utilises distributed smart metering measurements and optimisation functions to perform its power sharing and voltage regulation functions. The SCS is underpinned by a fit for purpose communication architecture that ensures the reliable and secure of information between the SCS components. Within the reporting period, a set of communication network requirements was developed to ensure reliability; this will feed into a requirements specification for the SCS supplier.

In order to develop the communication requirements a report covering the following topics were prepared:

1- Detailed bandwidth calculation by considering digital and analogue data point to point communication requirements, frequency and latency of data, the security requirements for compliance with IEC 104, firmware update etc.
2- The learning captured from other NIC and NIA projects
3- The comparison between existing communication solutions with their pros and cons for application in LV Engine
4- The recommendation on communication system architecture and consideration for communication implementation

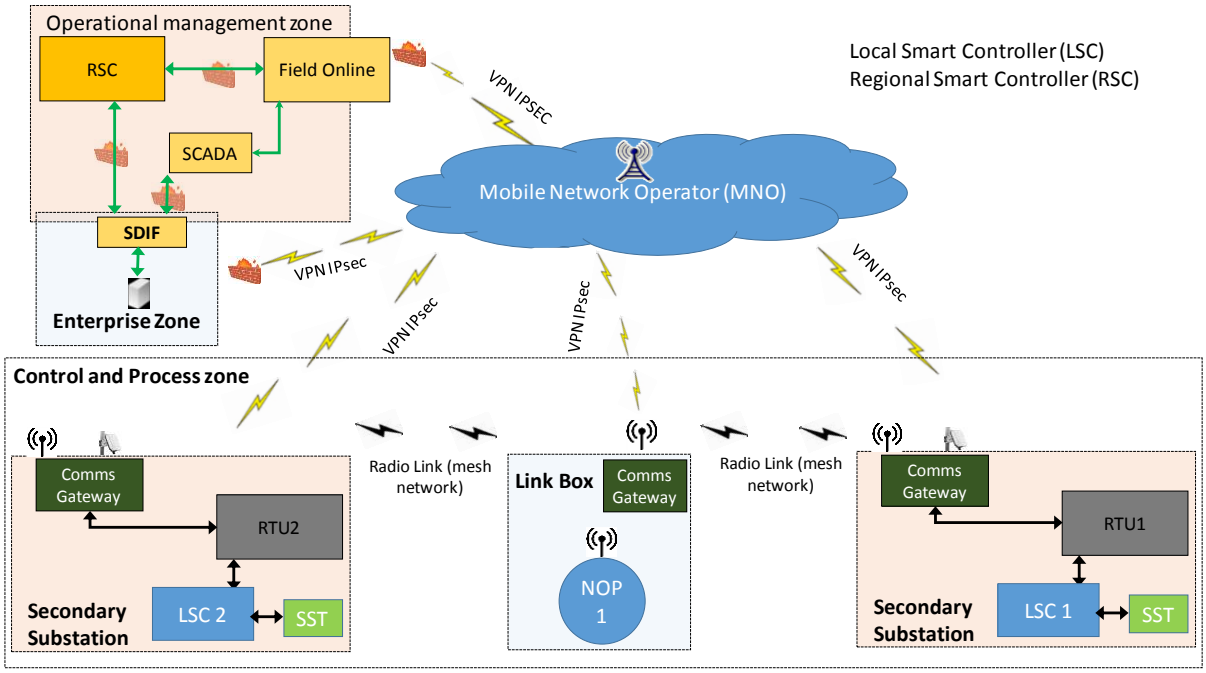


Figure 8: High level communication architecture focusing on secure communication between field components of the system

2.1.4 Work Package 7 – Dissemination and knowledge sharing

Project team has conducted internal and external dissemination activities, a summary of these activities are as follows:

- **Developing dissemination material** such as an external project video, updated fact card and project poster. These materials have been used in multiple events to help tell the story of LV Engine to a wide range of stakeholders.
- **Knowledge sharing at the LCNI** where project was shared with a wider range of interested parties, with the aim of sharing lessons learned in 2019 and identifying new stakeholders.

Figure 9: LCNI Stall Presentation with 30+ attendees

- **Linking into the power electronic forums:** The project team presented LV Engine on the 28th of November as part of an event organised in collaboration with the Compound Semi-Conductor Catapult. LV Engine and Active Response were both presented as utility specific applications of Power Electronics, with the intention of stimulating the Power Electronics manufacturers and suppliers to note the work and developments in UK Electrical networks.

Figure 10: LV Engine presented at CSA Catapult in Newport, Wales

- **Actively collaborating with the Active Response team in UKPN**, where we have held regular call sessions to bi-laterally share learning across both projects and identify opportunities to disseminate together and share learning on relevant topics such as Power Electronics.

Figure 11: LV Engine & Active Response co-presented at the CSA and LCNI

- **IEEE Webinar** – In order to provide wider knowledge sharing opportunities, LV Engine team summited a proposal to IEEE for a series of LV Engine webinar during project lifetime. The first session of the series webinars is now planned for late Feb.
- **PowerTech tutorial** – LV Engine team together with Kiel University (our Project collaborator) delivered a day tutorial on Smart Transformer and their applications.
- **SPEN Utility of the Future conference** - LV Engine was presented at this conference in September 2019 to over 200 senior managers and leaders in Scottish Power, as well as to representatives of Glasgow City Council. It was noted as one of the highlights of the event, ranking top in the Sli.do feedback comments.

- A **DSO-focused workshop** was held in February 2019 to share the learning found so far and hold focused conversations on how related projects from other DNOs, and the challenges in maximising roll out opportunities.
- **CIRED** - 2 technical papers on LV Engine were presented as posters at the 2019 CIRED Conference in Madrid in June 2019.
- **Internal staff awareness** – The project team have had several bi-lateral conversations with internal staff members in order to raise awareness and prepare them for the Smart Transformer. This is viewed as a critical aspect of ensuring business as usual adoption.

2.2 Lessons learnt

In addition to the detailed analysis and technical knowledge presented in the reports produced during this reporting period (see section 2.3), the following summarises some of the learning made during the reporting period from each of the active work packages.

2.2.1 Work Package 2

- The existing technology readiness level (TRL) of SST Topology 1 is around 6 and Topology 2 is around 5. It is feasible that LV Engine increases TRL for Topology 1 to 9 and Topology 2 to 8. Significant academic work and prototype developments have been undertaking.
- SST development is in strategy of several power electronic technology suppliers; this is not only driven by same solution as LV Engine, but also for provision of DC supply to production lines (in manufacturing) or renewable connections to the grid. It is expected competitive market grow within LV Engine project lifetime.
- The increasing experience in use of SiC (Silicon Carbide) products provides good confidence that it could be a right time to develop a fit for purpose SST for grid application (better size, better efficiency compared to Si power electronic products).
- Terms and conditions, especially the IPR arrangement and compliance with NIC governance should be settled with the tenderers prior to receiving their best and final commercial offer.

2.2.2 Work Package 3

This work package has recently started in Nov and we intend to report the learnings in next reporting period. Nonetheless, the following lessons can be shared at this stage:

- The ongoing engagement with EV charger manufacturers suggested that 800-900VDC unipolar can be ideal LVDC supply voltage. The 900LVDC can potentially offer 30% thermal uplift compare to a 3 phase 400V AC network. We have considered the 900VDC as our LVDC output in the SST design.
- The vulnerability of power electronic devices to temporary overvoltage and overloading is one the issues that will impact the ultimate product. Techno-economical design is required to make a trade-off between technical capability and fit-for-purpose functions/specifications of the product to ensure the final product has higher chance to roll out. These trade-off design shall be prepared by a manufacturer at initial phase of project to inform DNO/customer.

2.2.3 Work Package 4

- While developing the network integration test specification, it became clear that the LVDC community needs a concerted effort to mature the standards related to the integration of STs to public grids, their instrumentation and advanced functionality (e.g. load balancing). GB DNOs need to play an active role facilitated by the ENA to ensure that ST related international standards and technical guidelines are applicable to GB distribution networks. This active engagement with the international standardisation working groups is required not only to ensure requirements are captured but also to shape the future innovations in this application area.

2.2.4 Work Package 5

- Capacity sharing capability between neighbouring substations is limited to the thermal rating of the LV interconnection. This should be investigated prior to site selection, cable tapering and use of random small size cable sections may have significant impact on overall LV interconnection thermal rating.
- X/R ratio in LV network is less than one (network is rather resistive) and that means the active power flow within a LV interconnection directly depend on voltage difference at two ending of interconnection. However, the unwanted reactive power circulation can be reduced by adjusting the phase angle difference at two endings.
- In order to compensate the voltage drop in LV networks, traditionally the voltage at LV busbar at a secondary substation is set at a high level by tapping (usually permanently or seasonally) or deploying distribution transformers with higher nominal secondary voltage e.g. 11kV/0.433kV. This may limit the power transfer capability between neighbouring substation as there would be little room for voltage variation which would directly impact the power flow control.
- The voltage regulation impact on HV may not be very noticeable with only one 500kVA ST ,however with multiple connections the impact can be noticeable.
- The control system for HV voltage regulation shall consider the impact of the conservation voltage reduction practices at primary substation to ensure CVR action at primary remains effective
- There are a number of challenges that need to be addressed to enable the required communications. One of the main challenges that needs to be addressed is the reliable, non-intrusive and cost effective communication between the ST and subterranean LV link boxes. LV Engine team will be focusing on this issue in next reporting period.
- It is recommended for the sake of saving bandwidth to use batching polling messages (for IEC 104) and class reporting (for DNP3). However, some legacy RTUs, which use IEC 101, may not support batch reporting. It is also recommended to optimise the frequency of the analogue polling and to consider whether all the analogues should be sent to field online.
- There are two promising communication technologies that warrant further investigation so that their suitability for the SCS application can be appraised. These are Narrow Band IoT (NB-IoT) and Broadband over Powerline (BPL) communication technologies.
- Smart meter uptake is slower than expected (especially in the areas selected for LV Engine trials), however energy suppliers have started stronger campaign including offering financial incentives to residential customers to expedite the smart meter installation. It seems the smart meter uptake among small business and commercial customers is still very little. One the issue is the temporary supply cut required for installation smart meter that may interrupt the business so that a customer may incur financial losses.
- For the purpose of LV voltage control, we are focusing on use of voltage alarms generated by Smart Meters. This can significantly reduce the data traffic compared to the approach which considers full voltage profile generated by a Smart Meter. In addition, this approach offers a

better latency as voltage alarms are transmitted immediately as they occur, whereas the voltage values are averaged and transmitted after a waiting period.

- The loading of LV distribution network can be significantly imbalance and that may cause transformers reaching their thermal limit before reaching full power (kVA) rating.
- Integration with legacy communication systems, particularly at the secondary substation and the enterprise network, requires careful consideration of the communication interfaces as well as the format of the data being transmitted – for example, bandwidth savings can be achieved by batch transmission of measurement data points.
- Potential issues may arise in terms interoperability with legacy communication equipment and protocols that do not support batched data transmission.
- Establishing secure communications between different components of the SCS can result in significant bandwidth overhead. As such careful consideration should be taken to determine the appropriate level of security required for each link without overburdening the limited available bandwidth.

2.2.5 Work Package 6

- The integration of LV Automation and reclosing practices in LV networks requires development of new policies, operational guidance and technical specifications in compliance with existing safety design and operation standards. We have considered developing these documents within our 2020/2021 plan.

2.2.6 Work Package 7

- Team endeavoured to set up a series webinar with IET to disseminate the knowledge and projects lessons learnt to wider audiences, however, we learnt that IET does not host any webinar except those developed internally by IET. For that reason, we've pursued this opportunity through IEEE services.

2.3 Project reports and materials

During the reporting period the following reports have been generated to document the learning made within the project to date:

- **Trial site Network Modelling and initial desktop study demonstration** - this was the provision of an unbalanced LV network model together with appropriate reduced HV (11kV) network model for the two proposed trial sites and a technical report on the HV and LV network model development with associated load flow studies for these sites.
- **Technical specifications of network integration testing for Smart Transformer** – Essential tests for Network Integration Testing of ST. This included the list of tests, methodology of tests, the equipment required for the test.
- **Communication solutions for LV Engine** – Calculation of communication bandwidth by considering all the analogue and digital data point to point communications under standard security of 104 or DNP3, comparison between available communication solutions and suitability for LV Engine and capturing lessons learnt from other UK innovation projects.
- **LV Automation market research** – summarising the technical specifications of the LV automation products currently available in the market and evaluating them in terms of suitability to be deployed in LV Engine project.
- **LV Automation technical specifications** - Technical requirements of the controllable circuit breakers, linkbox switches and interfaces required for integration within SPEN IT/OT system.
- **Trial site information packs** – The information gathered from each trial sites, including the CAD drawing, location specific information, existing connection arrangement, loading conditions, equipment/plant required etc have been reported under dedicated report for each trial site.

These documents can be made available to interested parties upon request, in line with SP Energy Networks Data Sharing Policy.

2.4 Project Issues

The project continues to progress well and is expected to be completed as specified in Project Direction (December 2022).

The key current project issue of note is a non-material delay (approx. 20 weeks) associated with the SST manufacturing partner procurement exercise. The team has worked with the SST supplier to set an aggressive project programme to avoid any material change in the project. In addition, non-dependant work in the trial site development has been accelerated to improve the progress. The success of this strategy will be reported in the next reporting period.

The delay allowed SPEN to ensure the tender process was completed as per competitive tendering company policy and extract the best value for the customers from the tender. In particular negotiations over terms and conditions with short listed project partners were time-consuming.

We believe the value of accepting the delay to ensure the quality of the process and its outcome will be recognised as the project progresses. As a result, the project team is satisfied that the procurement process was carried out in a manner which resulted in a successful, highly competitive tender which has delivered value for the customer.

In addition, unsuccessful candidates have stated that they will use the learning from the exercise to pursue developing a Smart Transformer through alternative sources of funding, due to the alignment with their strategy. The LV Engine team welcomed this development, and have looked to keep these manufacturers involved as project stakeholders to ensure that the project learning will maximise the development of the technology.

The primary causes for the delay are:

- **Market Engagement** – We engaged with a total of nine manufacturers prior to the release of the ITT. While the engagement delivered high value (seen in the technical specification and tender outcome), the engagement took a significant amount of time and effort to hold multiple bi-lateral conversations.
- **Manufacturer Responses** – Due to the tender being for a product yet to be designed, there were a number of queries which arose during the tendering process, which were answered through the procurement governance process. Furthermore, we allowed an extension of two weeks beyond the original deadline for initial proposal submission to accommodate a request made from tenderers.
- **Technical Evaluation** – During the technical evaluation of submissions, there was a number of queries raised by the LV Engine team which required a series of conversations with each tenderer, in line with Iberdrola procurement policy. In addition, following interview sessions there was a second series of conversations to close out technical queries before providing final indications of technically compliant bids.
- **Terms & Conditions negotiation** – As the terms were dealt with on a competitive basis with all technically compliant tenderers, there was a significant amount of effort expended to deal with all term changes and clarifications.

To reduce the impact on the long-term project objectives and avoidance of any Material Change, we will be incorporating the following measures in the next reporting period:

- Accelerate the work unaffected by the delay, primarily the trial sites preparation. We have set ourselves an accelerated target to conduct all site preparation works and commissioning of LV Automation system concluded by the end of 2020 Ensuring no delay will be seen in this process.
- Pursuing an aggressive delivery schedule (agreed with our SST partner) to optimise our time during the detailed design and manufacturing phase of the SST.
- Preparation of the test plans for network integration testing (work package 4) and placing the contract with the capable facility in 2020. That will allow all the logistics and preparation take place in 2020.

At this moment, there is no concern that the above reported issue will impact the ability for the LV Engine project to be successfully delivered by December 2022 or that a Material Change has been realised as a result. The only additional impact we foresee at this stage is an impact on the delivery of Deliverable 3 in September 2020 which will be reported on in further detail in the next reporting period.

2.5 Outlook to the next reporting period

In the next reporting period, the project critical path will be:

- To progress the detailed design of the Solid State Transformer and begin the manufacturing of the designs (WP3)
- To significantly progress in site preparation works (WP5)

Furthermore, the following progress is planned in the next reporting period under different work packages:

Work Package 2 – Partner Selection Procurement

- To conduct and conclude the procurement process for selection of Intelligent Control System partner
- To conduct and conclude the procurement process for selection of LV Automation equipment

Work Package 3 – Design and Manufacturing of SST

- To review and update the SST technical specification with the SST manufacturing partner where required
- To finalise the detailed design of Solid-State Transformer in collaboration with SST manufacturing partner
- To develop the first prototype of SST for both topologies which will be mainly used by EGB to test the performance and inform the final product development
- To conduct the life cycle assessment of the Solid-State Transformer

Work Package 4 – Network Integration testing

- Finalise the network integration testing specifications and test procedure
- Conduct market research to identify suitable network integration facility to deliver Work Package 4

Work Package 5 – Live Trials

- Complete the data analysis of the sites, load flow and protection grading studies;
- Install and commission and operate the LV Automation in Wrexham trial site;
- Liaise with councils to implement the LV Engine scheme 4 and 5 for EV charging in the car parks located near the trial sites;
- Confirm availability of LV DC infrastructure technologies and further investigate use within the DC scheme sites.

Work Package 7 – Dissemination

- Organise and hold a UK DNO workshop to share the lessons learnt and obtain feedback on design of solid state transformer and LVDC technology
- Organise and hold a seminar for wider audiences (Academic, industry etc) to raise awareness about LV Engine progress and technology development
- Prepare technical papers for relevant conferences and articles
- Share lessons learnt in LCNI conference or any other relevant event
- Continue to share the project progress and lessons learnt with stakeholders within SPEN

3 Business Case Update

There has been no reported change to the Business Case submitted in the Full Submission Proposal (FSP) during the reporting period.

4 Progress against plan

4.1 Key achievements and project highlights

4.1.1 Trial site developments

As referenced in section 2.2.4, after a thorough site selection process we have focused on three specific sites for AC schemes and two sites for DC schemes. We have applied monitoring at multiple key trial sites and developed load flow models to assess any required works to enable the site to be ready for installation.

4.1.2 DC Customer Connections

As referenced in section 2.1.3, we have secured a DC customer at Falkirk Stadium which is currently under development. A connection agreement has been made with Falkirk City Council and the preparatory electrical and civil works will commence in 2020.

4.1.3 SST Partner

As reference in section 2.1.1, we have successfully procured our project partner, EGB to deliver the detailed design for the solid state transformer, then to build and test both Topology 1 and Topology 2.

4.2 Project Issues

As per the discussion in sections 2.4, 2.1.1, and 2.2 the progress against the project plan is delayed by approximately 20 weeks due to the described delay surround the procurement of the Solid State Transformer partner.

Through an aggressive project programme, we anticipate that we will remedy this delay in the upcoming project period (2020/21). In addition, we have accelerated our SCS procurement, trial site developments and network integration work to provide additional compensation.

4.3 Key activities planned for upcoming reporting period (2020/21)

4.3.1 Trial Site Developments

- **Wrexham:** LV Automation scheme will be implemented together system integration into SPEN real time system. The work will also include purchasing and installation of switchgears, linkboxes and cables to significantly progress in site preparation.
- **Falkirk:** We will progress the enabling works and site preparation works to ensure that the site is fully prepared for installation by the end of 2020.
- In each case, we foresee some dependencies on existing site and enabling works as part of business as usual activities. We will look to mitigate possible delays by assigning key contact points between the project delivery team and local support who will have key responsibilities for monitoring and managing the works.

4.3.2 Solid State Transformer – Detailed Design

With an accelerated project programme, the project delivery team will be continuing to work closely with EGB to maximise successful delivery. Detailed design work and SST prototyping will be the key activities planned in 2020.

4.3.3 Network Integration Testing

Building on the SST network integration test specification developed in 2019, we aim to identify a suitable network integration facility and update the testing specification where necessary in collaboration with our SST manufacturing partner.

4.3.4 Dissemination

The project delivery team has a planned dissemination programme, aligning with UKPN's "Active Response" project, as part of partnership, to co-ordinate the sharing of applied Power Electronics. This includes presentations at the key conferences such as the LCNI, submitting papers within academic forums and holding DNO workshops to specifically target key findings to facilitate the rollout of the project (this will also be done in co-ordination with UKPN).

5 Progress against budget [CONFIDENTIAL]

6 Project Bank Account

A dedicated bank account was made available by SPD and SPM to act as the Project Bank Account in to which NGET, as the GBSO, deposited the appropriate project funds through 12 monthly transfers in the Regulatory Year such that the total amount transferred equals the net amount set out in the Funding Direction. This has been received in full.

7 Project Deliverables

The project deliverables set out in the Project Direction links with the Project Milestones and the identified targets directly. This project deliverables can be used to check the progress of the project delivery and position the progress against the original proposal.

Table 2 shows a summary of the LV Engine deliverables defined in the Project Direction.

Table 2: LV Engine project deliverables

Reference	Project Deliverable	Deadline	Comment
1	Technical specification of SST and functional specification of the LV Engine schemes' including relevant control algorithms	10/12/18	**Completed** - This deliverable is now completed and submitted to Ofgem within deadline
2	Detailed technical design of SST by the manufacturer and life cycle assessment	22/12/19	**In Progress** – This deliverable will be prepared in collaboration with SST manufacturing partner
3	Manufacture SSTs for LV Engine schemes	11/01/21	**Not started** – This deliverable will be prepared in collaboration with SST manufacturing partner
4	Complete network integration tests	28/09/20	**In progress** – This deliverable will be prepared in collaboration with Network Integration Test Facility provider
5	Establish the system architecture of LV Engine schemes	20/06/21	**In Progress** – This deliverable will be prepared in collaboration with Intelligent and control system partner and internal SPEN IT & real-time system team
6	Demonstrate the functionalities of SST	20/06/22	**Not Started**
7	Best operational practices of SSTs	07/11/22	**Not Started**
8	Identify a trial site for replicating LV Engine solution within UK Power Networks	26/09/22	**Not Started**
N/A	Comply with knowledge transfer requirements of the Governance Document.	End of project	**Not Started**

SPEN confirm that adequate resources for project management and project delivery have been planned for upcoming deliverables. Resources are available internally in different parts of SPEN organisation and also additional supports will be provided by our project partners.

8 Data access details

The Publically Available Data Sharing Policy is available via SPEN's website: www.spenergynetworks.co.uk/pages/lvengine.aspx

9 IPR

LV Engine complies with the Ofgem default position regarding the IPR ownership and no further IPR has been generated or is expected to be generated.

10 Risk Management [CONFIDENTIAL]

11 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): _____

Title: _____

Date: _____

Signature: _____

Name (Print): _____

Title: _____

Date: _____

12 Material Change Information

None to report

13 Other

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