SIF Round 3 Project Registration

Date of Submission

Jun 2024

Project Reference Number

SPEN_SIF_10106405

Initial Project Details

Project Title

LV Optimiser - LVOE

Project Contact

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Challenge Area

Novel technical, process and market approaches to deliver an equitable and secure net zero power system

Strategy Theme

Net zero and the energy system transition

Lead Sector

Electricity Distribution

Project Start Date

01/03/2024

Project Duration (Months)

3

Lead Funding Licensee

SPEN - SP Manweb Plc

Funding Mechanism

SIF Discovery - Round 3

Collaborating Networks

SP Energy Networks Distribution

Technology Areas

Active Network Management

Protection

Resilience

Fault Current

Fault Management

Voltage Control

Project Summary

Public description
The LVOE project focuses on an innovative LV (Low Voltage) power electronic device (LV Optimiser) with its novel control algorithm designed to address LV voltage quality and imbalance, enabling the vast adoption of Low Carbon Technology (LCT) connections within the LV network.

The Low Voltage network is currently undergoing substantial changes due to the increased integration of LCTs such as solar panels, heat pumps and electric vehicle chargers. Traditional strategies are no longer effective at mitigating the strain from LCTs.

The LV Optimiser will provide a technical solution to dynamically operate the network, allowing for the widespread introduction of LCTs.

Add Preceding Project(s)

SPMWEN02 - LV Engine

UKPNEN02a - Active Response to Distribution Network Constraints

Add Third Party Collaborator(s)

University of Glasgow

Project Budget

£162,094.00

SIF Funding

£142,136.00

Project Approaches and Desired Outcomes

Problem statement

Problem statement
This project focuses on an innovative LV power electronic device (LV Optimiser) and its novel control algorithm designed to address LV voltage quality and imbalance, enabling the accelerated and cheaper adoption of LCT connections within the LV network. This project builds on the learning from Active Response, LV-Engine and FUN-LV.

Problems To Be Resolved

The UK's electricity network is currently undergoing substantial changes due to the increased integration of low carbon technologies (LCTs). This situation has put increased strain on the network, presenting several challenges:

(1) Uncertainty in LCT Growth: This stems from factors such as changing consumer behaviour, the maturity of technology, cost fluctuations in LCTs, and evolving government policies.

(2) Rise in Demand and LV Connections: The growing popularity of PV connections, Electric Vehicles (EVs) and heat pumps, can lead to imbalances in three-phase voltage, particularly during peak and off-peak periods.

EV chargers, SolarPanels and households are connected at 1-phase as part of the 3-phase feeder; which means any issue with the voltage/power on one phase will require reinforcement of the whole feeder. Traditional strategies for LV feeders are not adequately equipped to address these emerging challenges in an economically efficient manner.

Innovation Challenge Aims

This project will contribute to Challenge 2 by introducing a new device to the market.

Focus Areas

*Customised LV Optimiser: A new power electronic device, LV-Optimiser, as the technical solution for dynamically operating unbalanced LV networks. Its implementation facilitates the widespread adoption of LCTs, while optimising network operations.

*Advanced Control for Three-Phase Voltage Imbalance: A new control algorithm, allowing the separate control of three-phase output current/power of LV Optimisers, will be designed, developed, and tested.

*System & Device Protection Strategy: A protection strategy and hardware inbuilt into the Optimiser so that faults from either the DC or AC side should not interfere with the AC or DC side.

*Location Planning of Installation: different device installation locations, including substations, middle of the feeder, close-to customers, planned through digital simulation and advanced modelling techniques.

Potential Users Enabled by Solving the Problem

This project aims to understand the benefits for distribution network operators (DNOs) and electricity consumers. We strive to offer a design all DNOs can adopt, with benefits including:

(1) Active operation of LV networks for better voltage quality and imbalance management

(2) Better visibility/utilisation of network assets

(3) Unlocking energy system flexibility to accelerate integration of LCTs

Video Description

https://www.youtube.com/watch?v=2hdTjzCBZz0

Innovation justification

In direct relation to most customers, the challenges presented in low-voltage (LV) networks necessitate both innovative thinking and technological advancement in LV network dynamic management. Responding to this need, Project LVOE has been formulated, underpinned by four foundational innovations:

(1) A refined approach that directly targets LV voltage quality and systematically mitigates imbalances.

(2) A rigorous evaluation of dedicated LV power electronic devices (PEDs) - LV Network Optimiser (LVOE) to ensure the network's adaptive responsiveness beyond substations.

(3) The incorporation of cost-conscious and practice-oriented designs, prominently featuring standard converters.

(4) The inception of adaptable, control and protection strategies allowing seamless shifts between varied operational parameters.

Drawing insights from its distinguished forerunners -- namely LV Engine (SPEN), FUN-LV (UKPN), and the concluding Active Response (UKPN), LVOE is more than an incremental step forward. It signifies a paradigm shift where traditional substation located PEDs have been the norm, LVOE investigates PEDs specifically located and designed for LV feeders to improve operational flexibility. With analytical views across diverse Distribution Network Operator (DNO) regions, the Project's ambition is to formulate findings with nationwide applicability, shaping the future of the UK's vast LV networks.

Further distinguishing LVOE is its commitment to practicality. The PEDs in power networks have seen custom models excel in the realms of high/medium-voltage applications. However, these bespoke solutions, while effective, present barriers to widespread LV adoption. Recognising this limitation, Project LVOE explores innovative use of existing topologies but advocating new control solutions, the project is not merely proposing an alternative but is laying the foundation for the next industry standard in LV PED oriented protection schemes. Leveraging new research on phase-exchanging PEDs, with manufacturer and academic partners on board, the aim is to elevate the technology readiness level (TRL) and set new benchmarks.

Impacts and benefits selection (not scored)

Financial - future reductions in the cost of operating the network

Financial - cost savings per annum on energy bills for consumers

Financial - cost savings per annum for users of network services

New to market – products

Impacts and benefits description

Electric networks play a critical role in the transition to a low-carbon future by enabling the integration of renewable energy sources, electric vehicles, charging infrastructure, and heat pumps into the grid. However, the effectivity is heavily dependent on the Low Voltage (LV) networks, which are the direct interface with households and communities. They must evolve to keep pace with changing energy consumption patterns. Phase voltage imbalance is highly significant in LV networks, with current passive infrastructure there is a substantial cost-saving potential.

Passive Low Voltage Networks: The electricity networks were planned, developed, and operated over the past century focussing on current issues, as a result the visibility and controllability of the LV network is less developed than possible.

As more households adopt technologies like photovoltaics, EV chargers, and heat pumps, they exert a direct impact on single-phase voltage levels within the LV network. This impact results in an imbalance in phase voltage, requiring significant reinforcement, resulting in extended delays and increased costs.

A Smart Technology Solution: In 2022, the UK government commissioned national studies[1] that found Phase Balancing as one of the most significant challenges for LV networks. This has the potential to save up to 38% of the costs associated with LV network enhancements, a saving of over £6 billion before 2035 at national level. These results have brought to light a solution that has far-reaching implications for the future of low carbon energy distribution. Based on current SP Energy Networks electricity customers such a smart technology can benefit at least 150,000 households within the franchised area and 1.5 million at the GB level.[2]

Application Scope: While our application will verify the benefits of Phase Voltage Balancing, considering the intricacies of various networks, it is crucial to acknowledge the substantial potential savings that this technology offers. Our efforts align with the broader national imperative to drive cost-effective, sustainable, and efficient low carbon energy distribution in the United Kingdom.

LV Optimiser will inform and contribute to smart technology development required in our energy transition, as in Challenge 2, SIF Round 3. By carrying out the thorough feasibility study, we can confirm our specifications required, de-risking the innovation, enabling a focused and fit-for-purpose design in the Alpha phase.

[1] Low Voltage Network Capacity Study, Department for Business, Energy and Industry Strategy: July 2022

[2] Based on 5% circa 30 million UK electricity customers

Teams and resources

SP Energy Networks (SPEN) operates three registered licensees, SPT, SPD and **SP MANWEB PLC**, the electricity distribution licensee for the Merseyside and North Wales network, in which this project will be completed. SPEN's Innovation Team is devoted to driving innovation into the heart of the organisation. Led by James Yu, the team has secured funding for a multitude of major flagship national innovation projects with over £100million funding total. These include Predict4Resilience, LV-Engine and ENSIGN. SPEN will act as the lead network operator and project manager for LVOE. Sophie Sudworth, Head of Connection, will sponsor this project on behalf of the organisation. The SPEN team are responsible for Cost-Benefit-Analysis and Project Management and Dissemination (Workpackages 2 & 5)

The University of Glasgow has a high reputation for quality research. Dr Jin Yang has 15 years of experience in the field of electric power systems with research practices combining computer modelling and simulation, advanced analytics, experimental validation for modern electricity networks. He led multiple industrial-led and academic research projects including 'Active Response', 'Street2Grid' and 'Electricity Satnav', feeding-in directly the learnings from previous innovation endeavours. UoG will lead Workpackage 1 on Innovation Landscape.

BCARE was founded in 2018. It is based in the Basque Country, Spain. Javier Olarte, one of the founders and the key resources for this project is a visionary leader bringing over 30 years of experience in design, development, production, marketing and after-sales service of power electronic systems, energy storage systems and battery connections. BCARE has established a trusting working partnership with SPEN. BCARE will act as an expert in hardware/software design and development, and will provide the knowledge, technical means and team to guarantee success of the project. The BCARE team are responsible for the hardware and software specifications (Workpackages 3 & 4)

Francisco Pazos has over 30 years experience in distribution network operation, power quality and power electronic devices. He will serve as an industrial adviser, as part of the in-kind support from ScottishPower Corporate, to review and safeguard the project delivery, quality and supplier engagement.

Project Plans and Milestones

Project management and delivery

At SPEN, we pride ourselves on our proven track record and a robust process designed to ensure the successful delivery of innovation projects across various phases. The following key elements exemplify our commitment:

1. Established Structure for LVOE Project:

Senior support via the direct **Sponsorship** from **Head of Customer Connection** at SP Manweb: This ensures high-level support and alignment with organisational goals.

Setup of Delivery Team with a strong leadership: We have established a dedicated delivery team equipped with the necessary skills and resources for the successful execution of the LVOE project.

2. Regular and Urgent Meetings:

Regular Meetings: A structured schedule of regular (weekly) meetings has been implemented to facilitate ongoing communication and progress updates. These meetings serve as a platform for team collaboration and issue resolution.

Opportunities for Urgent Meetings: Recognising the dynamic nature of projects, we have incorporated provisions for urgent meetings: prompting identification and mitigation of risks during project delivery, ensuring adaptability and responsiveness.

3. Clear Communication of Milestones and Contributions:

Milestone Communication: Each project partner's milestones and contributions have been clearly communicated to all stakeholders. This transparency ensures a shared understanding of project expectations and fosters a collaborative environment.

Pre-commitment Acceptance: Prior to project commitment, all partners have formally accepted the communicated milestones and contributions. This alignment minimizes potential misunderstandings and enhances project commitment.

Key Deliverables are:

3.1. The report from the University of Glasgow regarding innovation landscape, latest technology development (WP1)

3.2. The specifications of the software and hardware from BCAREMB (WP3&4)

3.3. The high-level Cost Benefit Analysis (CBA) for the LVOE proposed solution at SPM, SPEN and UK level (WP2)

4. Risk Mitigation and Efficient Contracting Process:

The most significant risk is the demanding timescale for formal legal process while deliver. To expedite the project initiation process, we have proactively circulated contract templates in advance. This ensures that partners are familiar with the terms and conditions, streamlining the contracting phase.

Principle Acceptance: Partners have already accepted the contract templates in principle, facilitating a smoother and faster contracting process.

By incorporating these measures, we aim to not only ensure the success of the LVOE project but also to set a precedent for effective project management within SPEN. Our focus on clear communication, proactive risk management, and streamlined processes reflects our dedication to delivering innovative projects on time and within scope.

Key outputs and dissemination

Overall, the aim of **LV Optimiser** is to enable the inclusion of Low Carbon Technologies for households without hindering their voltage quality or causing imbalance. The Discovery phase will allow the consortium to explore innovative, existing technology while seeking to implement novel control solutions.

Regarding the Discovery Phase in particular, the key outputs are:

WP1 - To carry out prior research review with wider business engagement to reconfirm the latest developments of power electronics materials and devices, identifying and recommending the most economical semiconductor products for the specific products proposed, at an international level.

Deliverable: WP final report
Responsible: University of Glasgow

WP2 - To confirm the potential need case from SP MANWEB and at the UK level. This WP will include network modelling, criteria for site specifications (working with WP 3 closely).

Deliverable: Final CBA report
Responsible: SP MANWEB

WP3 - To provide guidelines and recommendations to ensure the hardware design adheres to stringent safety standards.

Deliverable: WP final report
Responsible: BCAREMB

WP4 - Develop the new control of active power exchanges between the unbalanced three phases. The WP will also explore the recent findings on phase-changing/shifting by the project academic partner to leverage the benefits of elevated TRL.

Deliverable: WP final report
Responsible: BCAREMB

WP5 - To coordinate and manage the project's outputs, meetings, and timescales. This will ensure that the project runs to schedule with key outputs achieved and disseminations recorded.

Deliverable: End of Phase report/Alpha application
Responsible: SP MANWEB

Regarding dissemination, the consortium already contains experts in the field of power electronics, experienced leaders, and drivers of innovation. This will allow for **clarity of delivery and key expertise input**. In the project plan, as part of WP5, **a dissemination strategy will be developed** to share the relevant outcomes more widely than the consortium. This will involve knowledge sharing, including.

- a comprehensive video,
- webinars,
- workshops,
- and stakeholder engagements.

We will also publish our Innovation Landscape on the Smarter Networks Portal. Our clear and ultimate objective, however, is to produce a **strong, successful application** for the **Alpha Phase.**

Commercials

Intellectual Property Rights (IPR) (not scored)

The proposal will comply with the default SIF governance regarding IPR. i.e., any relevant foreground IPR will be owned and shared by electricity licensees.

Value for money

As highlighted in the previous sections, the technology proposed under LVOE will contribute to the potential benefits over £6billion, along with other smart technologies for the LV network. Hence it is a **proportional** and **derisked** investment for the UK electricity cutomers.

At **SPEN**, our commitment to delivering value for money is integral to our project management approach. The **LVOE** consortium, exemplifying this commitment, demonstrates value across various dimensions:

1. Strategic Partnerships for Comprehensive Knowledge:

Led by **SPEN**, Partnered with **BCARE** and **University of Glasgow**: The LVOE consortium strategically brings together SPEN's industry leadership with BCARE's expertise in power electronic devices and the University of Glasgow's 15 years of focused research on smart LV grids. This partnership represents a fusion of cutting-edge knowledge in network operations, research, and development at the European level, ensuring a holistic and informed approach.

2. Optimal Resource Allocation for Maximum Innovation Value:

Right Resources for Purposeful Delivery: Recognising the critical importance of resources in driving innovation, the LVOE consortium ensures that **the right resources** are committed to safeguard project delivery. Each partner, amidst competing priorities, has pledged resources with the appropriate skills necessary for the successful realisation of the project's objectives. This commitment ensures that the innovation achieves its maximum value and purpose.

3. Leveraging Expertise and Investments:

Specialised Expertise of Consortium Members: The University of Glasgow dedicated research on smart LV grids, and BCARE, an independent developer of power electronic devices and control software, bring **invaluable expertise to the consortium**. Both partners contribute not only their previous research findings but also their extensive knowledge, know-how, and state-of-the-art modelling/testing facilities, **collectively valued at over £25m**. **This synergy ensures that the LVOE project is built upon a foundation of accumulated knowledge and cutting-edge facilities.**

4. Demonstrated Financial Commitment:

Over 10% Matching Funding: To underscore the consortium's commitment to the success of the LVOE project, all partners have collectively committed 13% matching funding. This financial dedication demonstrates the seriousness and confidence of the consortium in the project's objectives, ensuring a shared responsibility for its success.

By meticulously aligning partnerships, resources, expertise, and financial commitment, the **LVOE consortium** is poised to deliver not only innovative solutions but also exceptional value for money. This approach reflects our dedication to efficient resource utilization, strategic collaboration, and the optimisation of investments to **achieve the highest possible impact** in the realm of **smart LV grids.**

Supporting documents

File Upload

LV Optimiser - Discovery Phase Show and Tell.pdf - 1.4 MB
LV Optimiser - Work Package 3 & 4 Hardware and Software Review Report.pdf - 2.1 MB
LV Optimiser - Work Package 1 Literature Review Report.pdf - 3.0 MB
SIF Round 3 Project Registration 2024-06-07 9_26 - 64.0 KB
Q3_Innovation Justification (Attachment) - LVOE v0.pdf - 207.2 KB

Documents uploaded where applicable?

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