

SIF Alpha Round 2 Project Registration

Date of Submission

Jan 2024

Project Reference Number

10086622

Initial Project Details

Project Title

D-Suite

Project Contact

Andrew Moon

Challenge Area

Improving energy system resilience and robustness

Strategy Theme

Net zero and the energy system transition

Lead Sector

Electricity Distribution

Other Related Sectors

Electricity Distribution

Project Start Date

01/01/2024

Project Duration (Months)

6

Lead Funding Licensee

SPEN - SP Manweb Plc

Funding Mechanism

Collaborating Networks

UK Power Networks

Technology Areas

Heat Pumps

LV & 11kV Networks

Control Systems

Modelling

Network Automation

Substation Monitoring

Substations

Project Summary

Compared with conventional solutions, we will better address both thermal and voltage issues that we increasingly experience in LV networks. The TRL of this project is approximately 4-5, and will benefit from dedicated innovation support to uplift the readiness of the following technologies:

LV Distributed STATCOM (D-STATCOM). This technology has never been deployed in UK network;

Distributed Soft Open Point (D-SOP) -- We aim to build up on the technology developed by UKPN to trial a more flexible and controllable solution;

Distributed Smart Transformer (D-ST) -- We build up on learnings from LV Engine project to fit a partially rated power electronics within slim design distribution transformer; and

Distributed Harmonic Filter (D-HF) -- There are number of solutions in the market that need further development for LV applications.

In addition to those well-established ENA and IEC standards for network interfaces, insulation requirements etc. we will particularly ensure the compliance with safety requirements in power electronics specified in IEC 62477 and for monitoring equipment in BS EN 61010. IT and OT cyber security of the control system is also need adequately implemented based on those specified in IEC 62433, recommendations by ENA OT/IT taskforce and our updated ED2 internally developed cybersecurity requirements.

Add Preceding Project(s)

10060423 - D-Suite

Project Budget

£550,224.00

SIF Funding

Project Approaches and Desired Outcomes

Problem statement

Due to government incentives, such as the planned rollout of 600,000 heat pumps a year from 2028, the ban on new ICE vehicles by 2030 and, ultimately, the net zero target for 2050, the LV network is expecting a large uptake of heat pumps, EV chargers and distributed generation. As record numbers of electric vehicles, renewable energy sources and heat pumps are introduced to our energy system, the coming 5 years will be crucial in repurposing the existing infrastructure, recognising the scale of transformation required and the leading role networks will play in enabling that vision for decarbonisation.

The problems LV networks will experience will mainly be voltage rise and high circuit and transformer utilisation due to LCTs, which will be compounded by large phase imbalance due to single phase connections of most customers. D-SOPs, D-STATCOMs and D-STs can mitigate these issues, at the point of connection, on the LV network.

SP Energy Networks has undertaken analysis of 6 LV networks, across its two license areas, for Urban, Suburban and Rural areas and modelled the present level of LCT rollout, as well as those in 2028, 2036 and 2040. This analysis has shown increasing utilisation of LV circuits and transformers, which will require intervention to facilitate the levels of LCTs required. Active Power Electronic Devices can adapt to a changing network and defer passive reinforcement solutions, as the network changes.

The potential users of D-Suite technology are LV network design engineers, LV control room staff and, ultimately, LV connected customers, who will benefit from reduced disruption and high LCT penetration. The LV design engineers will need the control philosophies of each D-Suite device to model them in planning tools/software for customer LCT connection agreements. Control engineers will require visibility of the D-Suite devices to audit their behaviour to ensure they are operating as designed.

Three completed projects, that are relevant and are contributing to this Project are: LV Engine (SPEN), FUN-LV (UKPN) and Active Response (UKPN), which

have trialled Soft Open Points and Smart Transformers respectively. The learning from these three projects has fed into the development of the D-Suite technical specification during the Discovery stage.

Innovation justification

D-Suite is applying against the Improving Energy System Resilience and Robustness challenge Theme 2. SP Energy Networks partnered with Newcastle University who have expertise in Power Electronic supply chains. Newcastle University will continue to partner with SP Energy Networks in the Alpha stage.

SP Energy Networks have led two Network Innovation Competition (NIC) Funded projects, Angle-DC and LV-Engine, which have involved design, procurement, testing and deployment of novel Power Electronic (PE) systems at medium and low voltage levels respectively. Lessons learned from these projects include how to reduce the required functionality and ratings to an optimal level, to reduce unit costs as far as possible. Other lessons include operation and control, visibility in the network Energy Management System, carrying out fault and protection studies and mitigating cooling and noise issues that come with active PE technologies. UKPN is a project partner who has led two Projects, FUN-LV and Active response, funded by the Low Carbon Networks Fund and NIC respectively. UKPN gained valuable learning procuring and deploying Soft Open Point (SOP) power electronic devices.

The learning from the above projects, is informing our Project plan, which is structured to develop the D-Suite technology technical scope, seek feedback from the supplier base, identified in the discovery stage, and select appropriate trial sites to test the technology. SP Energy Networks will continue to work with the end users (network design, planning and control engineers), PED suppliers, PE consultancies, network design and standards teams, local authorities, and academic partners to ensure the D-Suite technologies are fit for purpose at the deployment stage. A deployment of a D-STATCOM, at the LV voltage level, would be a first for UK DNOs and would represent a leap forward in active LV network control using PEDs.

D-Suite alpha is scoped to progress the Project aims as far as possible within 6-months and under the allowable budget. There is no Work Package element that is not required to begin tenders with suppliers in the Beta Stage. D-Suite requires innovation funding to:

- Kickstart the LV PED market to produce innovative low-cost D-Suite designs based on modular DC- components.
- Develop D-Suite control and protection strategies to maximise benefits and equipment safety.
- Develop D-Suite design and planning tools.
- Develop operation and safety documents for novel D-Suite technologies.

The TRL levels of the D-Suite Technologies will rise from 4-5 to 6-8 based on the work undertaken in the Alpha and Beta stages of this project, should it be successful in achieving its aims.

Counterfactual alternatives to D-Suite technologies include 1) increasing the capacity of LV feeders and secondary transformers, 2) installation of three phase supplies to customers connecting high capacity LCTs (e.g., heat pumps, EVs and DER) and 3)

installing passive harmonic filters. The first two options are very disruptive to customers and require a large engineering resource to deploy nationwide. The passive filter option, to mitigate harmonic emissions on LV networks, requires the same connection arrangements as a D-HF, but will require period tuning and possible reinstallation, as the background harmonic spectrum changes over time.

Impact and benefits (not scored)

Financial - future reductions in the cost of operating the network

Environmental - carbon reduction – indirect CO₂ savings per annum

Impacts and benefits description

From initial studies for the Discovery Proposal and as part of the Discovery workpackage, we can realise the following benefits:

- 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
- Environmental - carbon reduction -- direct CO₂ savings per annum
- Environmental carbon reduction - indirect CO₂ savings per annum against a business-as-usual counterfactual

The above benefit categories have not changed, since the Discovery proposal, since the discovery has not changed the benefits case. Detailed D-Suite network level control modelling will provide network specific technical benefits based on a year's worth of simulation of D-Suite technology performance.

Teams and resources

There are no changes to the project partners, but there will be additional experts within Newcastle University brought onto the Project. No new equipment or facilities will be required, as part of the Alpha stage, though additional expertise is being applied as extra resource. There will be extra parties included within the departments of Network Operators, who will be consulted on the D-Suite technical specification and design and planning tool proposals. Local authorities will be engaged early.

UK Power Networks

UK Power Networks is the Electricity distribution network owner and operator for London, the Southeast and East of England. They will also ensure that the project development is scalable and can be applied to other regions of the UK as it transitions to BaU.

Robert Davies, the UKPN project manager will be responsible for the day-to-day management of the UKPN project work package, ensuring it delivers in line with the stated objectives. Robert will be supported throughout project delivery by a team of subject matter experts in areas such as expertise in electricity networks, network planning and asset management.

Integrated PowerTech

Dr Wenlong Ming, by leveraging the EPSRC, NIA and UKRI investment and the research resources in the same research group, will lead the delivery of Workpackage 2: WP 2 - Hardware Design and Control of D-Suite Modules. Dr Ming's track record on hardware design will factor in the device protection and operational health & safety requirements. This work package will focus on the modular hardware design and hardware switching control. The D-Suite modular nature, as well as reducing the functionality and equipment ratings are the key focus to reduce costs for LV applications.

Newcastle University

Newcastle University has a track record in working with the energy sector. Power System Group is the UK's largest academic research group in Electrical Power.

Newcastle has state-of-the-art research laboratory facilities, with academic activities that are highly cross-disciplinary and multi-disciplinary. Newcastle University provides effective solutions in three areas of expertise:

1. Power Electronics, Drives and Control.
2. Machines.
3. Power Systems and Energy Storage.

Newcastle University's team is led by Dr Matt Deakin. His team will leverage the research investment and resources at Newcastle University to lead Work package 1: Control Detailed Design and Algorithm Performance Analysis. The workpackage will provide detailed network control results, which will provide the D-Suite technical benefits and fully quantified revenue streams on SP

EnergyNetworks' networks. Newcastle University will add Dr David Greenwood and Dr Mohamed Daida to their Team.

Dr David Greenwood is a Research Fellow, at Senior Lecturer level, and has been involved in developing control schemes, e.g., for the Smarter Network Storage project with UKPN back around 2015. Dr Greenwood will contribute formally as WP Co-investigator.

Dr Mohamed Dahidah is Senior Lecturer in Power Electronics and is just starting a three-year EPSRC funded research project on Smart / Hybrid Transformers. He will lead a researcher to support the Cost Benefit Analysis of the project in the second half of the work package delivery.

Matt Deakin is a Royal Academy of Engineering Research Fellow at Newcastle University. To date, Dr Deakin has published more than 23 peer-reviewed articles, with recent outputs exploring low-cost reconfigurable AC/DC converter designs, placement of power electronics within distribution grids, and cost-benefit analysis of distribution-connected power electronics. He holds a PhD from the University of Oxford on the topic of benefits from reactive power control from distribution-connected power electronics.

The formal governance is in place: The project partnership agreement sets out clear responsibilities of each partner and the scope of delivery. The payment milestone is linked with the success criteria.

Project Plans and Milestones

Project management and delivery

1.

WP1: Control Detailed Design and Algorithm Performance Analysis* --Newcastle University --
(M1.1-M1.3) (£105,600)

1.1

Network Models

1.2

Network Level Control Development and Evaluation

1.3

CBA Analysis -- The results from the algorithm performance studies will provide the technical benefits for each D-Suite Technology.

2.

WP2: Hardware Design and Control of D-Suite Modules -- Integrated PowerTech-
(M2.1-M2.4) (£150,100)

2.1

Modelling of D-Suite Modules for Simulations - D-STATCOM, D-ST, D-SOP, D-HF -- The electrical and thermal modelling of active switches and passive elements of the D-Suite modules, which make up the D-Suite technologies.

2.2

Optimal Design of D-Suite Modules for Cost, Size and Efficiency -- This task will involve multi objective optimisation at the hardware level.

2.3

Intelligent Hardware Control of D-Suite Modules -- In contrast to Work Package 1, the control studies at the hardware level.

2.4

Integration of D-Suite Modules with MV/LV Transformers --* This work package task will include the optimisation of hardware connections between D-Suite Modules and network interface transformers.

3.

WP 3: -Techno-economic Framework and Standards Review -- UKPN
(M3.1-M3.2) (£36,540)

3.1

D-Suite

Techno-economic Framework Review

. UKPN will review the use cases and benefits for D-Suite devices on their network, including size, location and capacity requirements.

3.2

Review the Technical Standards for D-Suite Technologies. UKPN will review the technical specification for the D-Suite devices for use on their network and report on the technical applicability differences between SP Energy Networks and UKPN.

4.

WP 4

Development of Supplier PQQ and Tender Pack

-- SP Energy Networks

(M4.1-M4.2) (£120,800)

4.1

Draft of PQQ - with Technical Specification for all D-Suite Technologies, Standards and Scope for Stakeholder Review

4.2

PQQ Process -- held with suppliers identified in the Alpha stage.

4.3

Tender Pack Final Draft -- Ready to be issued to supplier base in the Beta stage.

5.

WP4: Identification of Sites for between 2 -4 D-Suite Technologies --
(M5.1-M5.4) (£51,820)

5.1

Identification of 6 circuits.

5.2

Site Visit and Site Assessment of 6 Original Circuits for Feasibility.

5.3

Selection and Network analysis of New Sites if Needed.

5.4

Site Visit and Site Assessment of New Circuits.

6.

WP5: Project Management – SP Energy Networks –

(M6.1) (£30,150)

6.1

Dissemination

6.1.1

Webinars

6.1.2

Steering Group Meetings

6.1.3

Reports

Key outputs and dissemination

Work packages 1-5 will have between 1-3 reports as deliverables, and these will be shared on the smarter Networks Portal following final review. SP Energy Networks will host a D-Suite Webinar at the end of the delivery period in March 2024, which will be recorded and hosted on the Smarter Networks Portal and SP Energy Networks innovation webpage.

Commercials

Intellectual property rights, procurement and contracting (not scored)

All partners will comply with the requirements set out in Chapter 9 of the SIF Governance Document. Where applicable, we will list background IP in our collaboration agreements with each partner. SP Energy Networks is using the default arrangement for the Alpha stage.

SP Energy Networks will subcontract part of its work to a Power Electronic Consultancy to develop the tender pack. None of the Project partners have stated they are intending to use subcontractors to complete their work packages.

Commercialisation, route to market and business as usual

The general innovation commercialisation strategy can be broken down into two constituent parts, by technology push and end-user pull:

1.

Technology Push is being managed by public and private partners Newcastle University and Integrated PowerTech LTD, who will optimise the design of hardware and network control philosophy, taking onboard the latest engineering developments and operational needs from DNOs SP Energy Networks and UKPN.

2.

End-user Pull, is being managed by SPEN and supported by UKPN, to challenge the technology boundary with a clear purpose to improve its competitiveness and facilitate its application at LV. Network licensees, owners and operators will be the primary customer segment for this innovation, and they could own, operate, and purchase D-Suite type products following a successful beta phase delivery.

The Alpha stage D-Suite Project plan, Work Packages content and milestones are set up to:

1.

Improve the TRL, so the D-Suite technologies are more readily available.

2.

Encourage the D-Suite supplier market's participation in a tender Pre-Qualification Questionnaire, so DNOs can understand the indicative costs before full tender in the Beta stage.

3.

Select several D-Suite technology trial sites within at least one UK DNO LV network.

4.

Develop and verify a fully evidenced Cost Benefit Analysis through desktop study D-Suite simulation results for technical benefits and use PQQ returns for provision of indicative costs.

5.

Develop training pack inputs for LV design engineers, so they can easily design LV networks with D-Suite Technologies at the network planning and investment approval stage.

6.

Develop draft operational and safety policy documents inputs, within at least one DNO for each D-Suite technology, to remove licensee barriers to deployment.

Completion of the above tasks will ensure a mature tender pack to go to market and that planning engineers have sufficient confidence, training, and experience to select a D-Suite technology, when it's the optimum solution, compared with traditional design options for incorporation into the DNO investment plan.

The D-Suite Project Partners have the following strategies to support D-Suite Commercialisation:

Newcastle University: Will demonstrate the use case of the D-STATCOM, D-SOP and D-ST through network level control modelling, using real modelled networks and realistic LCT deployments, across the LV Phases, using 1-minute sampling for 1-year. Newcastle will model synthetic LCT levels, based on the SP Energy Networks Distribution Future Energy Scenarios (DFES) in 3-6 LV networks for today, in 2028, 2036 and 2040. The results from these studies will inform the business case for BaU commercialisation.

Integrated PowerTech will model the hardware control algorithms for the D-Suite Technologies, to show the tender technical specification for the D-Suite hardware can achieve the desired functions of each D-Suite technology. In the Beta stage, detailed models, will be simplified to be used with industry power system modelling platforms such as IPSA Power and DigSilent Power Factory, allowing LV design engineers to understand the behaviour of each D-Suite Technology for LV network planning.

Integrated PowerTech will also develop the modular design of D-Suite technologies, which will be generic building blocks that can be used to make a D-STATCOM, D-SOP, D-ST or D-HF. The modules will be optimised to minimise the required equipment ratings and amount of hardware, to reduce costs as far as possible. This specification will reduce the commercial and technical risks presented by deploying novel PEDs onto LV distribution networks.

UKPN leads a work package readying a techno-economic framework to enable future investment decisions, tailored to UKPN networks, policy, and processes for the Beta stage.

D-Suite PED suppliers will not be brought on as partners, since there are currently a significant number of suppliers with Power Electronic fabrication expertise ready to provide trial ready D-Suite products.

Policy, standards and regulations (not scored)

For D-Suite to progress to trial and into BaU, there are no envisaged required changes to the regulations, such as the:

Health and Safety at Work Act (1974).

The Electricity at Work Regulations (1989).

Electrical Equipment (Safety) Regulations (1994).

Electricity Safety, Quality and Continuity Regulations (2002).

Value for money

The total project costs is £550,224. The total SIF funding requested is £495,010, which comprises of £202,770 for SCOTTISH POWER ENERGY NETWORKS HOLDINGS LIMITED, £36,540 for UK POWER NETWORKS (OPERATIONS) LTD, £150,100 for INTEGRATED POWERTECH LIMITED and £105,600 for Newcastle University.

Each partner is contributing just over 10% of the Benefit in Kind (BiK) contribution, with Newcastle Contributing most of Dr Matt Deakin research time through a grant, which has been factored into the Benefit in Kind contribution. The remaining partner BiK figures are derived through additional contributions through Project labour provision from the general overhead of their teams,

Due to the accelerated delivery requirements of SIF projects in Alpha stage, the most efficient and cost-effective method of providing 6 -- months resource is through consultancy, specialising in the PED technology and PED CBA analysis. These skills will be critical to delivery of the Alpha work packages. There will be no immediate requirement for these skill sets 'in house', when the Alpha stage has closed. There is no innovation funding from other sources supporting this project.

Associated Innovation Projects

☒ Yes (Please remember to upload all required documentation)

☐ No

Supporting documents

File Upload

SIF Alpha Round 2 Project Registration 2024-09-04 10_11 - 65.2 KB
D2.4 Report - Protection and Integration of D-Suite Devices.pdf - 828.6 KB
D1.2 Report - Control Algorithms - Control Architecture and Performance.pdf - 1.2 MB
D1.3 Report - Cost-Benefit Analysis.pdf - 2.2 MB
D2.2 Report - Design Guidance of D-Suite Modules.pdf - 942.5 KB
D2.3 Report - Control Design of D-Suite Devices.pdf - 797.1 KB
D3.1 & D3.2 Report - Techno-Economic Framework & Standards Review.pdf - 392.2 KB
D4.1 Specification - D-Suite PED Functional Specification.pdf - 1.8 MB
D5.1 Report – D-Suite Site Selection.pdf - 2.7 MB
Report - Control Algorithms - Control Architecture and Performance.pdf - 1.2 MB
SIF Alpha Round 2 Project Registration 2024-01-17 10_17 - 64.5 KB
D-Suite Alpha Application.pdf - 0.0 bytes
10086622 - D-Suite - Project Direction.pdf - 215.4 KB

Documents uploaded where applicable?

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