SIF Alpha Round 2 Project Registration

Date of Submission

Jan 2024

Project Reference Number

10060423-A (1)

Initial Project Details

Project Title

D-Suite

Project Contact

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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

SIF Alpha - Round 2

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.

Preceding Projects

10060423 - D-Suite

Project Budget

£550,224.00

SIF Funding

£495,010.00

Project Approaches and Desired Outcomes

Problem statement

Due to government incentives, such as the planned rollout of 600,000 heat pumpsa year from 2028, the ban on new ICE vehicles by 2030 and, ultimately, the netzero 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 willplay in enabling that vision for decarbonisation.
The problems LV networks will experience will mainly be voltage rise and highcircuit and transformer utilisation due to LCTs, which will be compounded by largephase 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, onthe LV network.
SP Energy Networks has undertaken analysis of 6 LV networks, across its twolicense areas, for Urban, Suburban and Rural areas and modelled the presentlevel of LCT rollout, as well those in 2028, 2036 and 2040. This analysis hasshown increasing utilisation of LV circuits and transformers, which will requireintervention to facilitate the levels of LCTs required. Active Power ElectronicDevices can adapt to a changing networks and defer passive reinforcementsolutions, as the network changes.
The potential users of D-Suite technology are LV network design engineers, LVcontrol room staff and, ultimately, LV connected customers, who will benefit fromreduced disruption and high LCT penetration. The LV design engineers will needthe control philosophies of each D-Suite device to model them in planningtools/software for customer LCT connection agreements. Control engineers willrequire visibility of the D-suite devices to audit their behaviour to ensure they areoperating as designed.
Three completed projects, that are relevant and are contributing to this Projectare: LV Engine (SPEN), FUN-LV (UKPN) and Active Response (UKPN), which
have trialled Soft Open Points and Smart Transformers respectively. The learningfrom these three projects have fed into the development of the D-Suite technicalspecification during the Discovery stage.

Innovation justification

D-Suite is applying against the Improving Energy System Resilience andRobustness challenge Theme 2. SP Energy Networks partnered with NewcastleUniversity who have expertise in Power Electronic supply chains. NewcastleUniversity will continue to partner with SP Energy Networks in the Alpha stage.
SP Energy Networks have led two Network Innovation Competition (NIC) Fundedprojects, Angle-DC and LV-Engine, which have involved design, procurement,testing and deployment of novel Power Electronic (PE) systems at medium andlow voltage levels respectively. Lessons learned from these projects include howto reduce the required functionality and ratings to an optimal level, to reduce unitcosts as far as possible. Other lessons include operation and control, visibility inthe network Energy Management System, carrying out fault and protection studiesand 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 gainedvaluable learning procuring and deploying Soft Open Point (SOP) power electronicdevices.
The learning from the above projects, is informing our Project plan, which isstructured to develop the D-Suite technology technical scope, seek feedback fromthe supplier base, identified in the discovery stage, and select appropriate trialsites to test the technology. SP Energy Networks will continue to work with the endusers (network design, planning and control engineers), PED suppliers, PEconsultancies, network design and standards teams, local authorities, andacademic partners to ensure the D-Suite technologies are fit for purpose at thedeployment stage. A deployment of a D-STATCOM, at the LV voltage level, wouldbe a first for UK DNOs and would represent a leap forward in active LV networkcontrol 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 thatis not required to begin tenders with suppliers in the Beta Stage. D-Suite requiresinnovation funding to:
-Kickstart the LV PED market to produce innovative low-cost D-Suite designsbased on modular DC- components.
-Develop D-Suite control and protection strategies to maximise benefits andequipment 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 thework undertaken in the Alpha and Beta stages of this project, should it besuccessful in achieving its aims.
Counterfactual alternatives to D-Suite technologies include 1) increasing thecapacity of LV feeders and secondary transformers, 2) installation of three phasesupplies to customers connecting high capacity LCTS (e.g., heat pumps, EVs andDER) and 3)

installing passive harmonic filters. The first two options are verydisruptive to customers and require a large engineering resource to deploynationwide. The passive filter option, to mitigate harmonic emissions on LVnetworks, require the same connection arrangements as a D-HF, but will requireperiod tuning and possible reinstallation, as the background harmonic spectrumchanges 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 abusiness-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 networklevel control modelling will provide network specific technical benefits based on ayear'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 expertswithin Newcastle University brought onto the Project. No new equipment orfacilities will be required, as part of the Alpha stage, though additional expertise isbeing applied as extra resource. There will be extra parties included within thedepartments of Network Operators, who will be consulted on the D-Suite technicalspecification and design and planning tool proposals. Local authorities will beengaged early.
UK Power Networks
UK Power Networks is the Electricity distribution network owner and operator forLondon, the Southeast and East of England. They will also ensure that the projectdevelopment is scalable and can be applied to other regions of the UK as ittransitions to BaU.
Robert Davies, the UKPN project manager will be responsible for the day-to-daymanagement of the UKPN project work package, ensuring it delivers in line withthe stated objectives. Robert will be supported throughout project delivery by ateam 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 theresearch 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'strack record on hardware design will factor in the device protection andoperational health & safety requirements. This work package will focus on themodular hardware design and hardware switching control. The D-Suite modularnature, as well as reducing the functionality and equipment ratings are the keyfocus to reduce costs for LV applications.
Newcastle University
Newcastle University has a track record in working with the energy sector. PowerSystem Group is the UK's largest academic research group in Electrical Power.
Newcastle has state-of-the-art research laboratory facilities, with academicactivities that are highly cross-disciplinary and multi-disciplinary. NewcastleUniversity 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 theresearch investment and resources at Newcastle University to lead Work package1: 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 DrMohamed Daida to their Team.
Dr David Greenwood is a Research Fellow, at Senior Lecturer level, and has beeninvolved in developing control schemes, e.g., for the Smarter Network Storageproject with UKPN back around 2015. Dr Greenwood will contribute formally asWP Co-investigator.
Dr Mohamed Dahidah is Senior Lecturer in Power Electronics and is just starting athree-year EPSRC funded research project on Smart / Hybrid Transformers. Hewill lead a researcher to support the Cost Benefit Analysis of the project in thesecond half of the work package delivery.
Matt Deakin is a Royal Academy of Engineering Research Fellow at NewcastleUniversity. 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 analysisof distribution-connected power electronics. He holds a PhD from the University ofOxford 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 outclear responsibilities of each partner and the scope of delivery. The paymentmilestone 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 providethe 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 - DSTATCOM, D-ST, D-SOP, D-HF -- The electrical and thermal modelling of active switches and passiveelements 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 taskwill involve multi objective optimisation at the hardware level.
2.3
Intelligent Hardware Control of D-Suite Modules -- In contrast to Work Package1, the control studies at the hardware level.
2.4
Integration of D-Suite Modules with MV/LV Transformers --* This work packagetask will include the optimisation of hardware connections between D-SuiteModules 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 usecases and benefits for D-Suite devices on their network, including size, locationand capacity requirements.

3.2
Review the Technical Standards for D-Suite Technologies. UKPN will reviewthe technical specification for the D-Suite devices for use on their network andreport on the technical applicability differences between SP Energy Networks andUKPN.
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 Betastage.
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 willbe shared on the smarter Networks Portal following final review. SP EnergyNetworks will host a D-Suite Webinar at the end of the delivery period in March2024, which will be recorded and hosted on the Smarter Networks Portal and SPEnergy 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 SIFGovernance Document. Where applicable, we will list background IP in ourcollaboration agreements with each partner. SP Energy Networks is using thedefault arrangement for the Alpha stage.
SP Energy Networks will subcontract part of its work to a Power ElectronicConsultancy to develop the tender pack. None of the Project partners have statedthey are intending to use subcontractors to complete their work packages.

Commercialisation, route to market and business as usual

The general innovation commercialisation strategy can broken down into twoconstituent parts, by technology push and end-user pull:
1.
Technology Push is being managed by public and private partners NewcastleUniversity and Integrated Powertech LTD, who will optimise the design ofhardware and network control philosophy, taking onboard the latest engineeringdevelopments and operational needs from DNOs SP Energy Networks and UKPN.
2.
End-user Pull, is being managed by SPEN and supported by UKPN, tochallenge the technology boundary with a clear purpose to improve itscompetitiveness and facilitate its application at LV. Network licensees, owners andoperators will be the primary customer segment for this innovation, and they couldown, operate, and purchase D-Suite type products following a successful betaphase delivery.

The Alpha stage D-Suite Project plan, Work Packages content and milestones aresetup 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 beforefull tender in the Beta stage.
3.
Select several D-Suite technology trial sites within at least one UK DNO LVnetwork.
4.
Develop and verify a fully evidenced Cost Benefit Analysis through desktopstudy D-Suite simulation results for technical benefits and use PQQ returns forprovision of indicative costs.
5.
Develop training pack inputs for LV design engineers, so they can easily designLV networks with D-Suite Technologies at the network planning and investmentapproval stage.
6.
Develop draft operational and safety policy documents inputs, within at least oneDNO 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 marketand that planning engineers have sufficient confidence, training, and experience toselect a D-Suite technology, when it's the optimum solution, compared withtraditional design options for incorporation into the DNO investment plan.
The D-Suite Project Partners have the following strategies to support D-SuiteCommercialisation:
Newcastle University: Will demonstrate the use case of the D-STATCOM, D-SOPand D-ST through network level control modelling, using real modelled networksand realistic LCT deployments, across the LV Phases, using 1-minute sampling for1-year. Newcastle will model synthetic LCT levels, based on the SP EnergyNetworks Distribution Future Energy Scenarios (DFES) in 3- 6 LV networks fortoday, in 2028, 2036 and 2040. The results from these studies will inform thebusiness case for BaU commercialisation.
Integrated PowerTech will model the hardware control algorithms for the D-SuiteTechnologies, tol show the tender technical specification for the D-Suite hardwarecan achieve the desired functions of each D-Suite technology. In the Beta stage,detailed models, will be simplified to be used with industry power systemmodelling platforms such as IPSA Power and DigSilent Power Factory , allowingLV design engineers to understand the behaviour of each D-Suite Technology forLV network planning.

Integrated PowerTech will also develop the modular design of D-Suitetechnologies, 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 therequired equipment ratings and amount of hardware, to reduce costs as far aspossible. This specification will reduce the commercial and technical riskspresented by deploying novel PEDs onto LV distribution networks.
UKPN leads a work package readying a techno-economic framework to enablefuture investment decisions, tailored to UKPN networks, policy, and processes forthe Beta stage.
D-Suite PED suppliers will not be brought on as partners, since there are currentlya significant number of suppliers with Power Electronic fabrication expertise readyto 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 requiredchanges 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 NETWORKSHOLDINGS LIMITED, £36,540 for UK POWER NETWORKS (OPERATIONS)LTD, £150,100 for INTEGRATED POWERTECH LIMITED and £105,600 forNewcastle 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 agrant, which has been factored into the Benefit in Kind contribution. The remainingpartner BiK figures are derived through addition contributions through Projectlabour provision from the general overhead of their teams,
Due to the accelerated delivery requirements of SIF projects in Alpha stage, themost efficient and cost-effective method of providing 6 -- months resource isthrough 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 noimmediate requirement for these skill sets 'in house', when the Alpha stage hasclosed. 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

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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