D-Suite - Beta Phase

Annual 1 Report

December 2025

6/3/26

Future Networks

ABOUT REPORT

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REPORT PROGRESS

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Index

Abbreviations and Definitions

Abbreviation	Definition
API	Application Programming Interface
BaU	Business as Usual
CI/CML	Customer Interruptions/Customer Minutes Lost
CIGRE	Conseil International des Grands Réseaux Électriques
CIRED	Congrès International des Réseaux Electriques de Distribution
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
D-SOP	Distribution Soft Open Point
D-ST	Distribution Smart Transformer
D-STATCOM	Distribution Static Synchronous Compensator
ECCE	Energy Conversion Congress and Exposition
ENA	Energy Network Association
EoI	Expression of Interest
EV	Electric Vehicle
HiL	Hardware-in-the-Loop
I/O	Input - Output
iDNO	independent Distribution Network Operators
IPR	Intellectual Property Rights
IPT	Integrated PowerTech
LCT	Low Carbon Technologies
LV	Low Voltage
NLCS	Network Level Control System
NPV	Net Present Value
Ofgem	Office of Gas and Electricity Markets
OpenDSS	Open Distribution System Simulator
PED	Power Electronic Device
PNDC	Power Networks Demonstration Centre
PV	Photovoltaic
QRM	Quarterly Review Meeting
SG	Stage Gate
SIF	Strategic Innovation Fund
SPEN	Scottish Power Energy Networks
SPM	Scottish Power Manweb
UI	User Interface
UKRI	United Kingdom Research and Innovation
UPFC	Unified Power Flow Controller
WP	Work Package

1. Executive Summary

The D-Suite Beta Phase project[1], started on 2024 and planned to finish on 2029, funded under Ofgem's Strategic Innovation Fund (SIF), is a collaborative initiative led by SPEN in partnership with UK Power Networks, Newcastle University and Integrated PowerTech. It addresses the growing challenges in low voltage (LV) electricity distribution networks caused by the rapid uptake of low carbon technologies (LCTs) such as electric vehicles (EVs), heat pumps and distributed generation. The project aims to develop and trial a suite of partially rated LV Power Electronic Devices (PEDs), namely the D-ST D-STATCOM and D-SOP, alongside a production grade LV Design Tool to enable smarter, cost-effective reinforcement planning.

In 2025, the project transitioned from planning to execution, with significant progress across relevant work packages with the following key achievements:

- The LV Design Tool matured into a technically validated platform, incorporating a five-step siting and sizing algorithm, integration with NAVI for real-time data access and robust modelling capabilities using OpenDSS and PowerFactory.
- PED specifications were developed and shared with manufacturers and trial sites were shortlisted based on technical benefit and installation feasibility.
- Stakeholder engagement was a standout feature, with structured governance, Steering Board meetings and dissemination activities including webinars, workshops and contributions to CIRED, CIGRE and the ENA Innovation Forum.

No significant delays or problems were encountered during this reporting period. However, risks such as potential supplier withdrawal and backend data integration challenges were proactively managed. The project demonstrated agility in adapting to user needs, refining its tools and specifications through iterative feedback and validation.

Key learnings include the value of partial PED rating for cost reduction, the importance of feeder diversity in trial planning, and the effectiveness of modular control architectures. The project also highlighted the need for intuitive UI design and backend optimisation to support Business as Usual (BaU) integration. Metrics developed include lifetime benefit assessments, technical benefit scores, and cost-effectiveness rankings for PED deployment which will inform future investment decisions.

Dissemination activities were extensive and impactful, nurturing industry-wide learning and positioning D-Suite as a reference point for LV network innovation. The project's transparent and collaborative approach has laid a strong foundation for future trials, commercialisation and integration into standard operational practices across UK distribution networks.

[1] Please see relevant registration documents: D-Suite Project - SP Energy Networks , 10117774 | ENA Innovation Portal

2. Project Summary

The D-Suite beta phase meets three of Ofgem's SIF Round Two Innovation Challenges: Preparing for a net zero power system; Improving energy system resilience and robustness; and Accelerating decarbonisation of major energy demands. It will be achieved by developing partially rated power-electronic devices (D-STATCOM, D-SOP, D-ST) integrated with a production-grade LV Design Tool and Network Level Control System (NLCS) that together aims to address the growing challenges in low voltage (LV) electricity distribution networks caused by the rapid uptake of decarbonisation technologies such as EVs, heat pumps and distributed generation.

LV networks are increasingly experiencing voltage excursions, high transformer utilisation and severe phase imbalances. Traditional reinforcement approaches are often costly and disruptive. D-Suite seeks to develop and trial partially rated LV PEDs that offer a flexible, cost-effective alternative to conventional reinforcement.

The project is developing three core PED technologies as follows:

- Distribution Smart Transformer (D-ST) which is based on Unified Power Flow Controller (UPFC) architecture. The target Core Services of this device includes Voltage control per phase at the outgoing terminal, imbalanced load cancellation to reduce phase current imbalance seen upstream and controlled power flow to share capacity between neighbouring substations.
- Distribution STATCOM (D-STATCOM) which is a shunt-connected device for reactive power compensation and phase voltage balancing. The expected Core Services include voltage control per phase at the point of connection, power factor correction by regulating reactive power to reduce upstream flows/losses, imbalanced load cancellation to improve asset utilisation and phase voltage profiles.
- Distribution Soft Open Point (D-SOP) which is a back-to-back AC/DC/AC converter for dynamic feeder interconnection and bidirectional power flow control. The expected Core Services include controlled active/reactive power flow between two LV networks via back-to-back conversion, voltage control per phase through reactive power injection/absorption, imbalanced load cancellation ensuring no imbalance is transferred between the two interconnected substations.

These devices are supported by an operational LV Design Tool, developed by Newcastle University, which enables optimal siting and sizing of PEDs based on network constraints, technical benefits and cost effectiveness.

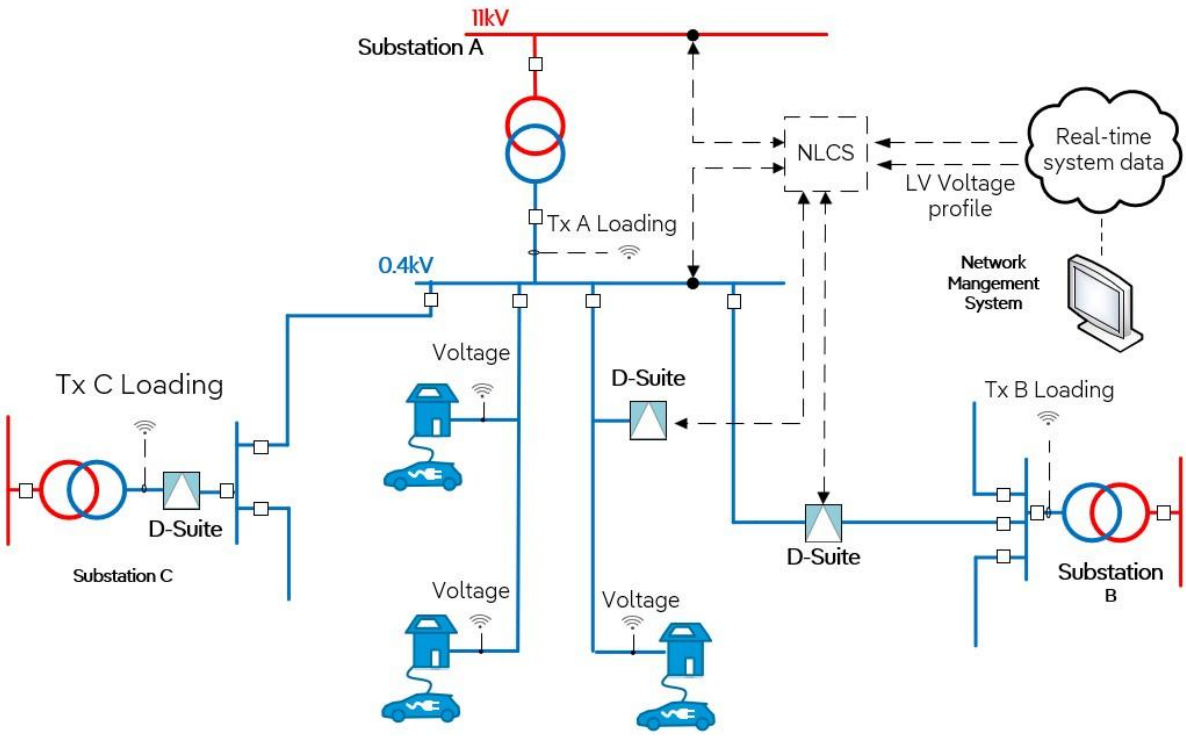

Figure 1. High Level Concept of D-Suite Solution demonstrating how the PEDs are placed within the LV network and how they integrate with NLCS

1.1. Project Structure

The project was initially formed in collaboration among academics and DNO partners as follows:

- SP Energy Networks: The project lead and responsible for overall project governance, delivery, and commercialisation strategy. Leading the technical activities, procurement, trial site installations, safety/compliance and NAVI back-end integration; ensures BaU adoption and customers value.
- Newcastle University: Responsible for designing the algorithms and backend developments of the D-Suite LV Design Tool and coordinating integration into the SP Energy Networks NAVI platform. .
- Integrated PowerTech: Responsible for developing modular PED reference designs, simulation models and lab prototypes to inform the hardware design and manufacturing activities.
- UK Power Networks: Provides cross-DNO user requirements and independent validation on technology and adoption of LV Design Tool.

SPEN will appoint a number of manufacturing partners in 2026, through competitive tendering. These partners will be responsible for designing, manufacturing, and testing the PEDs.

1.2.Project Manager's Update

The D-Suite project is structured around five work packages (WPs), each designed to ensure the development of fit-for-purpose D-Suite solutions suitable for deployment within LV networks. The project also aims to generate all the necessary knowledge to support the BaU adoption of the technology after the project concludes. Project progressed in its first year, as planned, with the following key achievements:

- Significant progress in D-Suite LV Design Tool which will be used by design engineers to assess and justify the installation of a D-Suite PED as an alternative or supplemental solution to meet network reinforcement needs. Newcastle University, the project lead for developing this tool, worked closely with various stakeholders to develop the algorithms, user requirements and integration to existing SPEN design platform (NAVI).
- SPEN carried out a fresh extensive market engagement to identify potential suppliers for D-Suite power electronic hardware. This activity increased the number of manufacturers which initially identified in Alpha phase.
- SPEN developed D-Suite technical specifications and prepared materials required for initiating the procurement of D-Suite Manufacturing Partners.
- SPEN carried out several dissemination events to raise awareness about the project and share the learnings gathered to date.
- Strong collaboration between SPEN and UK Power Networks were carried out especially for LV Design Tool developments.

The following sections summarises specific progress made in each work package along with their aims and objectives.

1.2.1. Work Package 1 - Detailed Design & D-Suite LV Design Tool

This work package focuses on development and trial of the LV Design Tool for D-Suite power electronic technologies. Design engineers can use the tool to identify the optimum locations on which D-Suite solutions can be deployed. Newcastle University leads this work package with inputs from all Project Partners. The following key activities were carried out:

- Significantly progressed in development of LV Design tool functional requirements, designs, algorithms, software implementation and user interface.
- Addressed process gaps for the LV Design tool identified from D-Suite Alpha.
- Conducted various stakeholder engagement activities to collate feedback on user experience and raise awareness about the LV Design Tool.

D-Suite LV Design Tool Development

High-Level Architecture and Development Approach

The LV Design Tool is designed to be replicable for use by both SPEN and other DNOs. To achieve this accessibility for other DNOs, the tool has a three-part architecture, as shown in Figure 2 The architecture has core algorithms and data, which can then be called by either SPEN's NAVI code (used for the Production tool version within SPEN) or by a Reference version of the tool developed by Newcastle University. By providing the Reference tool source code under a permissive open licence to other DNOs, this will ensure the integration of the tool by other DNOs can be made as efficient as possible. On the other hand, by partnering with SPEN's NAVI ecosystem, the tool can leverage substantial previous and ongoing LV digitalisation efforts.

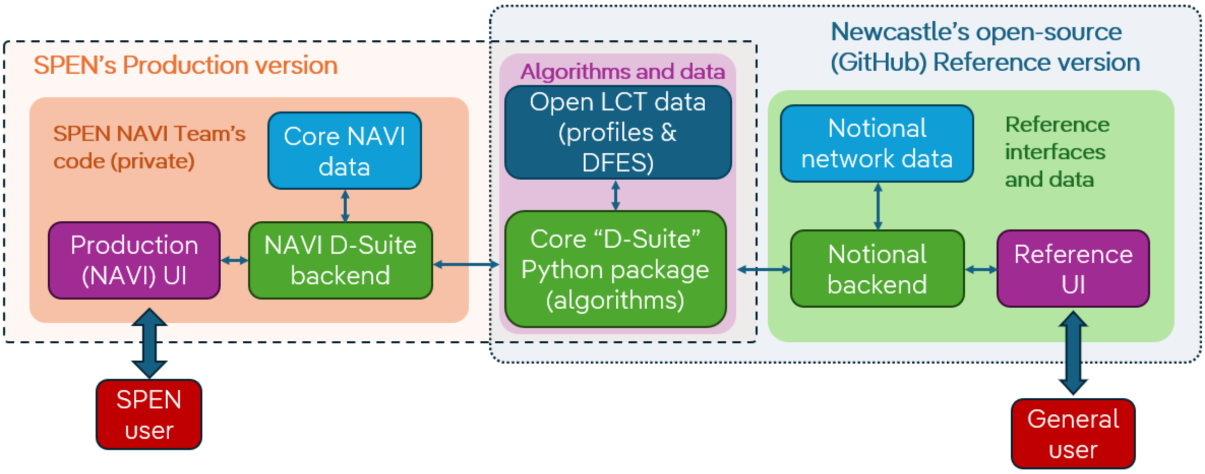

Figure 2. LV Design Tool Architecture, the architecture comprises three main components: core algorithms and data, SPEN's NAVI-based production implementation and a reference version developed by Newcastle University

The main tool development started through a requirement gathering exercise. The functional and non-functional requirements of the tool were collected through a "User Stories" workshop led by Newcastle University, resulting in 60 unique requirements. Development priorities were determined by ranking by impact against complexity. It was found that the core functionality of the tool could be achieved effectively building on the NAVI platform with the proposed architecture.

Algorithm Development

Having developed the requirements for the tool, the siting and sizing algorithm was developed. This has been defined as a five-step process that:

1. Identifies the potential locations and types of D-Suite devices in the network
2. Calculates the Specific Technical Benefit (the 'volts and amps' difference) for those locations
3. Draws scenarios of LCT uptake based on DFES scenarios
4. Calculate the violations and constraints across scenarios and profiles with and without the D-Suite devices then
5. Ranks those devices according to their benefits and costs in the network.

These steps are summarised in Figure 3.

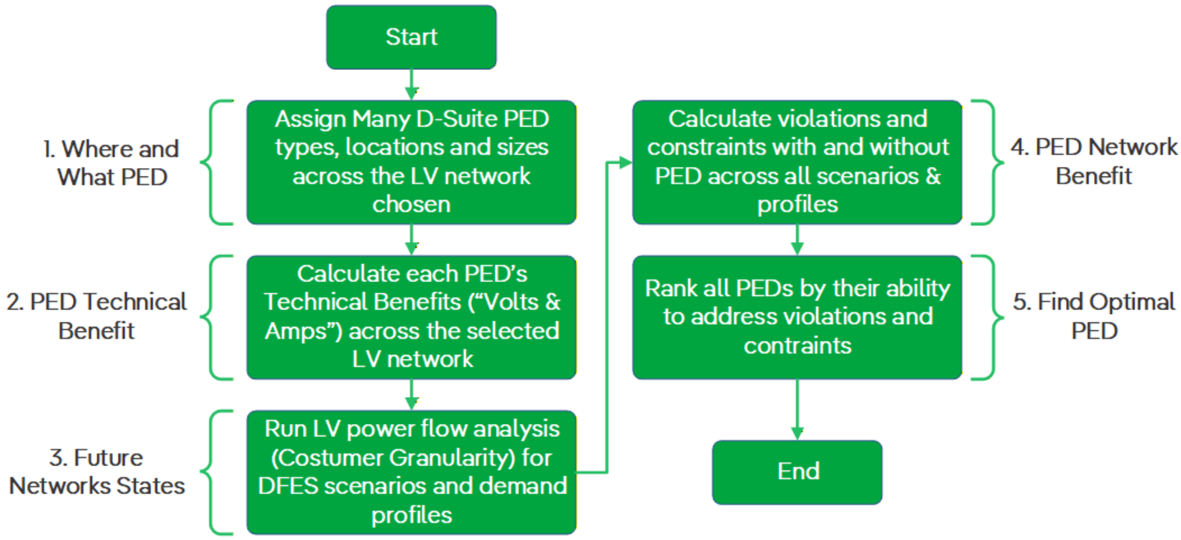

Figure 3. Siting and Sizing Algorithm Flow Chart, the 5 steps are indicated in this diagram from top left, starting with 1. Where and what PEDs, 2. PED Technical Benefits, 3. Future Network States, 4. PED Network Benefits and 5. Final optimal PED

This algorithm has been implemented for multiple D-Suite devices, multiple control schemes, and across multiple networks. It successfully builds on the D-Suite Alpha profile sampler for load flows. Example outputs from the algorithm, in terms of network technical issues and optimal PED siting and sizing, are shown in Figure 4 for a rural network. In the coming year, this will be extended to all devices, controls, and benefit types and tested across a wide range of networks.

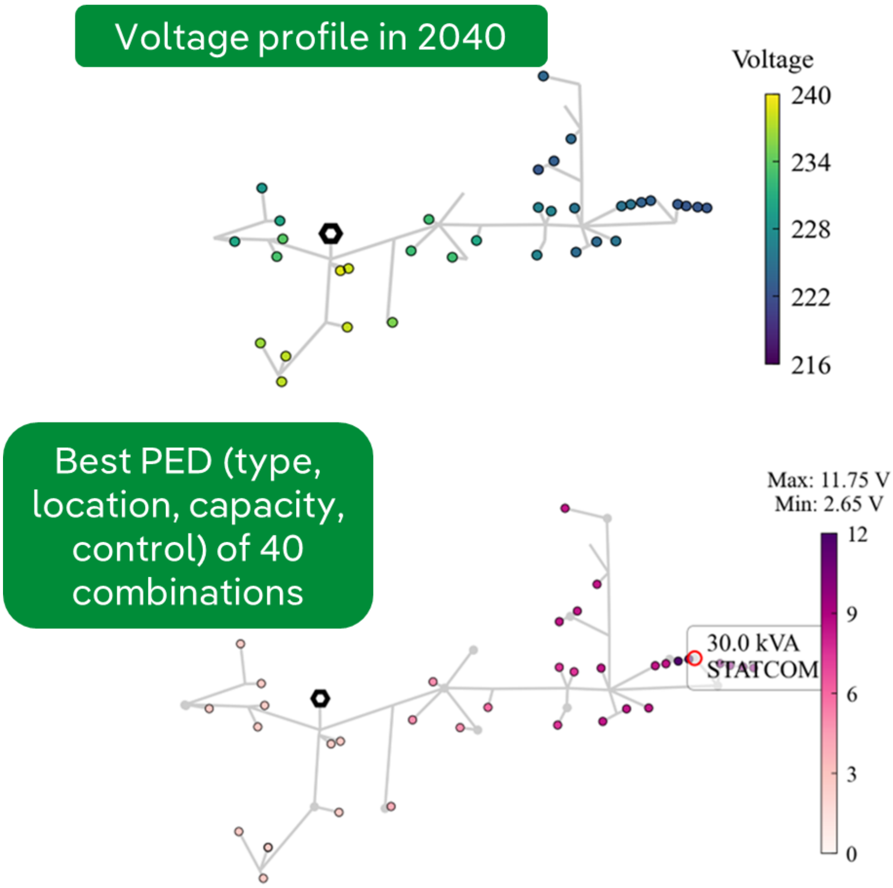

Figure 4. Siting and Sizing Algorithm Example Outputs in terms of network technical issues and optimal PED siting and sizing, are shown in Figure 4 for a rural network. This will be extended to all devices, controls, and benefit types

Quality Assurance

To ensure the validity of the results of the Tool, Newcastle University's calculated PED network technical benefits (using OpenDSS solver) were compared against calculations conducted by the SPEN innovation team (using Powerfactory DIGSILENT solver). The specific technical benefits were identical to within numerical tolerance across multiple PED types. This independent validation gives users confidence in the accuracy of the LV Design Tool and provides project assurance that the specifical technical benefit approach agrees to the standards of SPEN engineers using their own familiar tools.

Front-End Development

To design the UI, Newcastle University led a front-end workshop between the NAVI team and Newcastle University to discuss the PED siting and sizing algorithm. Discussions from the workshop were used to develop an initial wireframe, integrating example outputs from Newcastle University. This built on the existing NAVI front-end with the basic 'landing page' for the user shown in Figure 5 (with D-Suite features integrated). This wireframe was then shared with the SPEN Innovation team at a wireframe workshop.

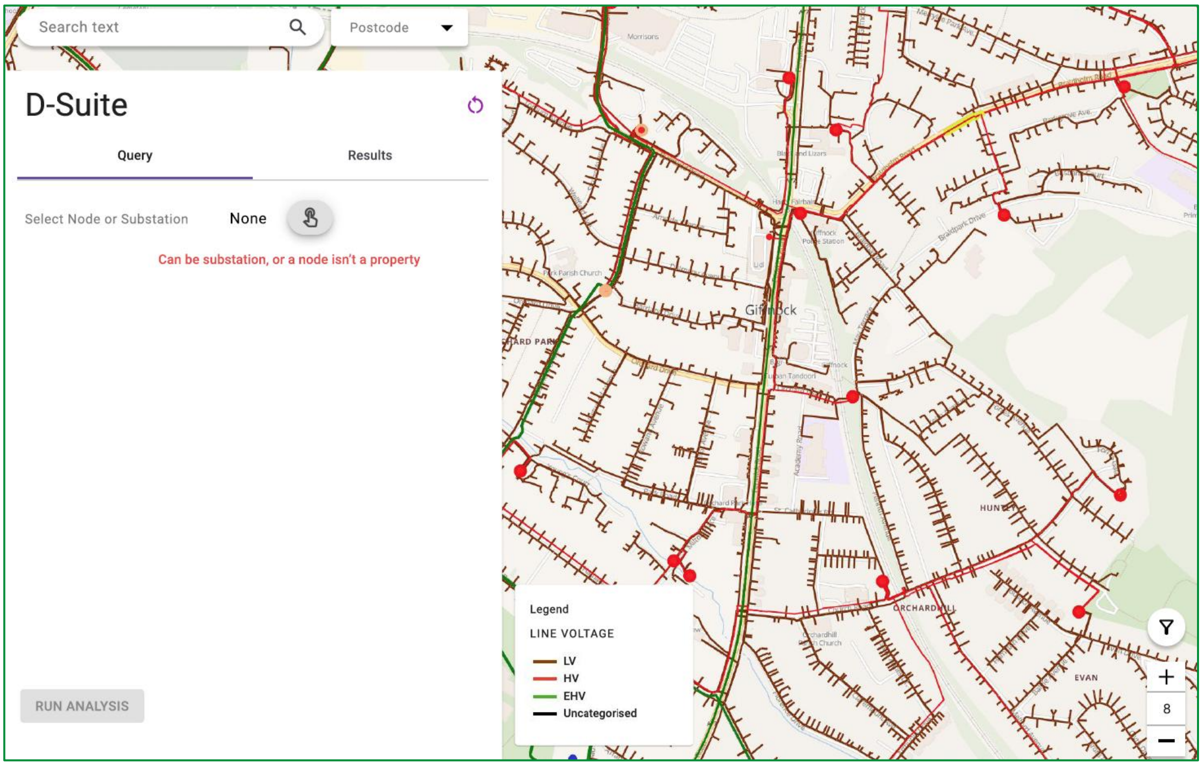

Figure 5. Initial Wireframes presented during the UI workshop

To ensure the user journey will maximise the LV Design Tool uptake and integrate end-user feedback at the design stage, the SPEN innovation team then extended the wireframe into a fully detailed User Journey. This end to end journey was presented to end-users, within SPEN, with feedback highlighting the need for tool outputs to be clearly understandable when showing the benefits. The complexity of the D-Suite devices was noted by the attendees in this context, given the purpose of the tool is to support the easy uptake of devices by design engineers, this aligns with expectations. The SPEN innovation team used this accepted User Journey to confirm the final proposed user interface design.

Back-end Integration

There have been two main back-end integration tasks. The first was for Newcastle University to address a number of minor process gaps identified in the Alpha phase of the project. The following areas were addressed.

1. A new open-source set of solar and electric heating profiles for simulation have been developed with an appropriate licence for commercial use.
2. The mapping from customer meters to properties has been confirmed, enabling the use of granular sociodemographic data in modelling.
3. A route for integrating commercial profiles has been agreed.
4. LV Monitoring data has been made available through new SPEN systems for all networks to confirm understanding of the existing networks.
5. Link box data has been made available to the LV Design Tool through NAVI.
6. Measurement types and latencies have been confirmed for the control system, enabling development of control simulations to proceed.

Validation activities have been carried out for these activities. For example, LCT profiles and modelling approach was shared with UK Power Network's 'Network Insights' team to ensure these satisfied their requirements, with link box data validity confirmed through on-site visits.

The second substantial integration task has been for Newcastle University to provide a software interface for the core 'D-Suite' Python package. To achieve this, Newcastle first developed a set of anonymised 35 'notional networks' from SPEN data, capturing a range of system archetypes and created to be available for testing and development (and support the open-source reference version of the tool).

Once the main siting and sizing algorithm was implemented, Newcastle's 'D-Suite' package interface was then defined. SPEN's NAVI team have installed this package successfully into their software ecosystem and have been able to call the function to run the siting and sizing algorithm on networks. This is a strong collaborative success between Newcastle and SPEN's NAVI Team and we go into the next year confident that this solid basis provides the underpinning for implementing the Tool's User Interface.

Hardware in Loop Testing

Form Factor and Modular Design Technical Review

IPT has completed a comprehensive technical review to determine the final ideal form factor for modular D-Suite PEDs. The review aimed to draw extensive learnings from established industry applications of modular power electronics, particularly within photovoltaics (PV) systems and high-power EV charging infrastructure (Figure 6). These sectors demonstrate proven advantages of modular architectures, including improved fault tolerance, flexible power scaling, reduced downtime and streamlined manufacturing. Case studies such as micro-inverter PV systems and modular fast chargers (e.g. ABB Terra, Porsche Modular Fast Chargers and Tesla Superchargers) were analysed to extract transferable design principles relevant to D-Suite devices.

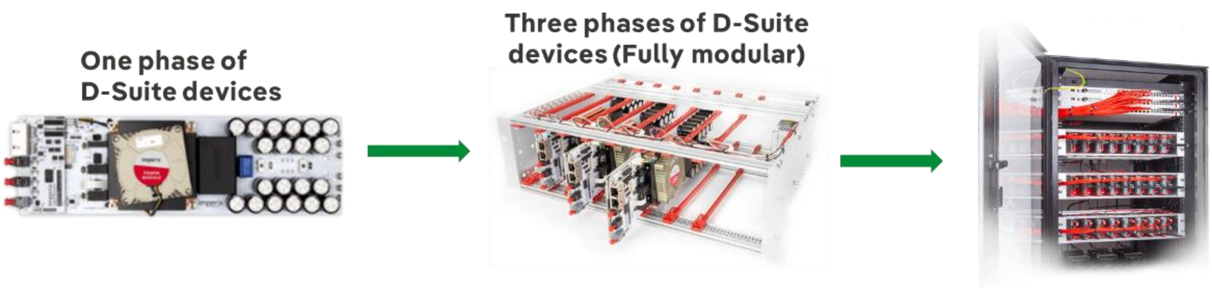

Figure 6. Integration and Control of Modular D-Suite Devices. Left shows modular D-Suite devices, Middle shows on module of D-Suite devices and right shows multiple D-Suite devices connected in parallel/series

Building on this analysis, IPT evaluated the applicability of modular three-phase four-wire power electronic converter building blocks across the full D-Suite device portfolio, including D-ST, D-STATCOM and D-SOP configurations. The assessment confirmed that a common modular power electronic converter platform can be configured in series and/or parallel arrangements to meet a wide range of voltage and power requirements, while preserving a consistent control and protection philosophy across device types.

IPT produced learnings from the proposed form factor that can be used by manufacturers and also lab-based prototyping to inform:

- Scalability, enabling device ratings to be adapted to local networks' needs through module replication.
- Maintainability, with swappable modules allowing rapid replacement and reduced outage durations.
- Future-proofing, facilitating incremental upgrades as network demands evolve.

- Manufacturing efficiency, through standardised modules compatible with multiple device variants.

Hardware prototyping of D-suite Modules focused on de-risking the development and future deployment of PEDs, by establishing representative simulation models and laboratory hardware platforms in advance of supplier-built equipment. The work undertaken by IPT enables early validation of control approaches, protection behaviour and system integration, ensuring that key technical risks are addressed ahead of on-network trials.

Reference Models and Interim Hardware

IPT developed reference D-Suite PED models and representative hardware platforms to act as interim substitutes for supplier-built D-ST, D-SOP and D-STATCOM units, please see Figure 6. This approach allows testing, control validation and protection studies to progress without reliance on supplier delivery timelines, reducing programme risk and supporting parallel progress across work packages. The activity started with the development of detailed simulation models for the D-STATCOM, reflecting its role in power management among three phases. The modelling framework was subsequently extended to cover the full D-Suite device portfolio.

Modular Simulation Models

IPT developed modular control and thermal simulation models aligned with the agreed D-Suite architecture. While initially implemented for the D-STATCOM, the models have been structured to enable straightforward adaptation to other PED topologies, including the D-SOP and D-ST. This ensures consistency of control philosophy and scalability across device types. The models support assessment of normal operation, unbalanced and distorted network conditions and credible fault scenarios. This capability is essential for informing device ratings, control strategies and protection requirements before field deployment.

Laboratory Hardware Prototyping

To complement simulation activities, IPT commissioned a modular half-bridge hardware platform based on the Imperix real-time control system. This platform replicates the core modular building blocks of D-Suite devices and enables device-level testing under controlled laboratory conditions. IPT constructed a working laboratory test version of a D-Suite module, (Figure 7) using modular components and closed-loop testing was successfully completed. This step provides confidence in the underlying hardware and control structure and represents an important progression towards testing at Test Centre (the project's dedicated laboratory testing facility, formerly PNDC) and subsequent field deployment.

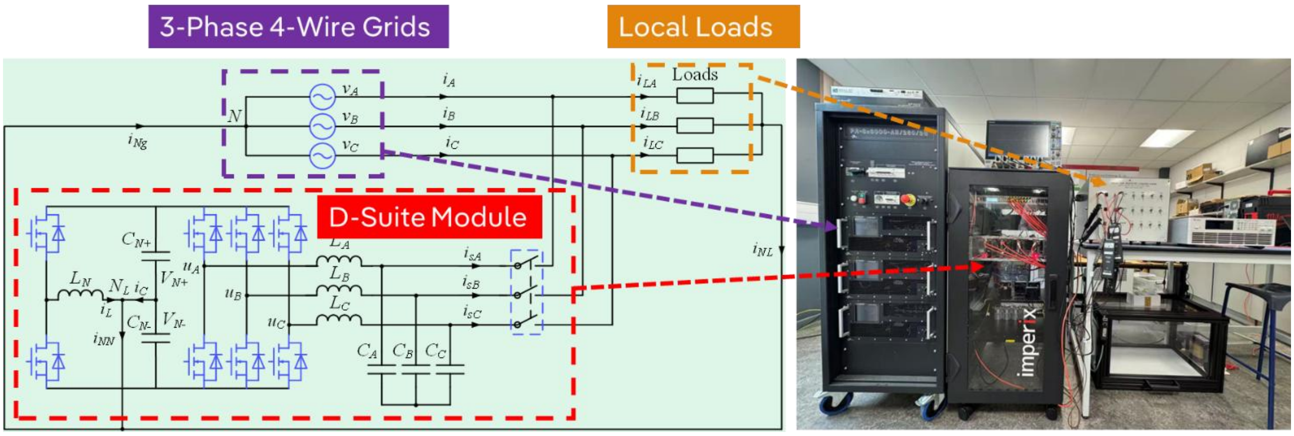

Figure 7. Hardware Prototyping of D-suite Modules. Left shows D-Suite Schematics and right shows D-Suite Hardware

Hardware Testing Progress

To inform Test Centre testing, IPT advanced the hardware testing programme from initial functional validation to closed-loop laboratory operations, providing increased confidence in device-level performance and significantly de-risking the next phase of full-system validation, including Hardware-in-the-Loop and full power testing at Test Centre. As part of this work, IPT successfully completed closed-loop laboratory testing of a modular D-suite STATCOM, building on earlier open-loop testing activities and confirming that the control system operates effectively in standalone inverter mode and behaves as expected under controlled operating conditions. In parallel, a dedicated software tool was developed to calculate realistic power ratings for the D-STATCOM under unbalanced distorted grid conditions, directly supporting technical specification development, robust device sizing for the tendering process and more efficient engagement with suppliers.

Network Level Control System (NLCS)

Moving from the hardware level control to network level control, in the control hierarchy, Newcastle University has made progress in the development of a document on NLCS which includes the initial notional network level control philosophy. The document currently includes the general philosophy for three separate control modes with different levels of complexity that will be considered for implementation within D-Suite Project. Figure 8 shows the notional control philosophy hierarchy that is currently under development. The notional control philosophy will be provided to suppliers to design against and will ensure synergy between the LV design technical benefit calculations and real the world control response of the D-Suite PED.

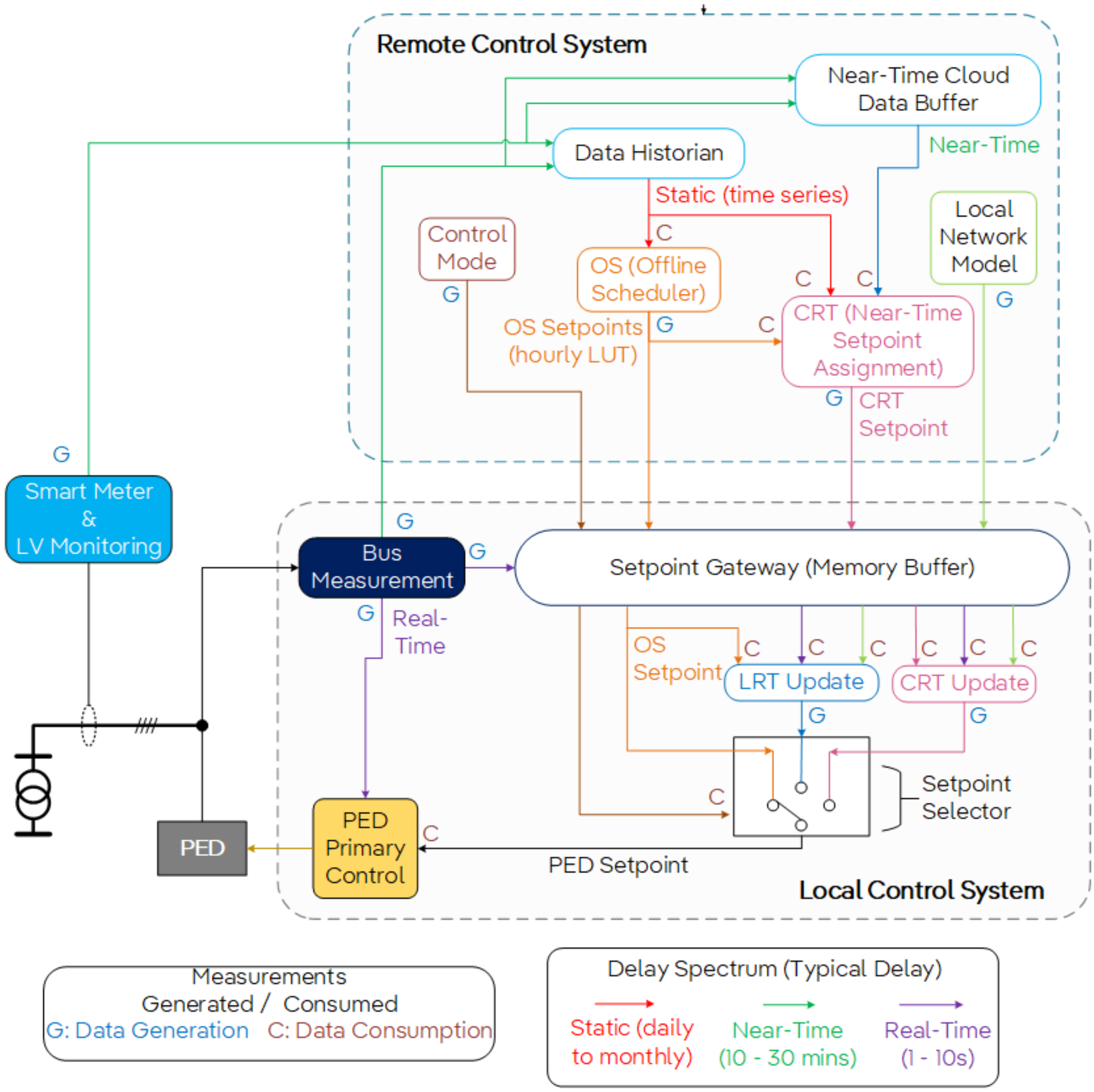

Figure 8. Control Architecture Representing D-suite Control Philosophy and Data Flows

To move towards simulations of the NLCS, Newcastle University have developed an I/O Schedule for the control architecture. This I/O Schedule captures how data is passed between the different components of the Control System Architecture, from measurements devices (e.g., smart meters) through to the point at which the D-Suite Local Control System assigns the setpoint. This I/O schedule captures:

- The measurands (i.e., the physical or system parameter being measured) and their location within the control system's architecture.
- The frequency of communication of those measurands between components of that control architecture.
- The data types being transmitted (e.g., integer, floating point number, look-up-table).
- The control function or system component that consumes the data to determine control setpoints.

The NLCS I/O schedule is more restrictive than the D-Suite Alpha phase project's assumptions on I/O. For example, the schedule has been developed assuming secure local communications between LV Monitoring and the D-Suite device does not exist, as it is anticipated such a function could exist as standard or soon after the D-Suite Project's lifetime. Therefore, to enable those more complex control objectives (e.g., phase current balancing), a more complex communications route will be required, sending data through a 'near-real-time' channel; this is a new and ambitious approach within the project.

SPEN will be reviewing this I/O Schedule, with internal stakeholders, to map out when it can be anticipated that different functions could become available.

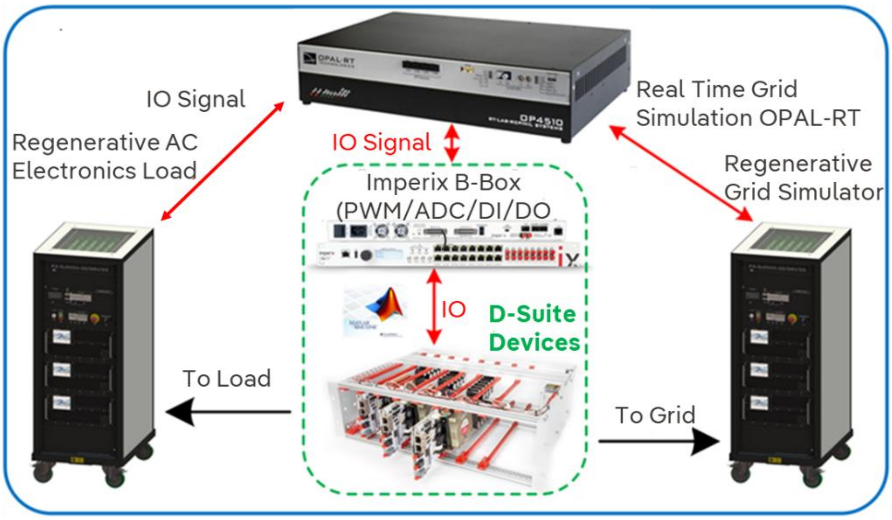

Figure 9. Regenerative AC Electronic Load, this is design send the data through a near real time channel

Preparation of D-Suite Hardware Technical Specifications

In 2025, SPEN has carried out extensive market research and stakeholder engagement to identify potential capable D-Suite manufacturing partners. To begin, an Expression of Interest (EoI) was issued to collect the market status, capabilities and formalise the engagement process to develop the detailed technical specification. Following issuing the expression of interest to manufacturers, SPEN assessed the responses and arranged interviews with key manufacturing teams. That resulted in manufacturers being shortlisted for engagement during technical specifications development.

SPEN developed three separate technical specifications, for the three D-Suite solutions, (D-ST, D-STATCOM and D-SOP) as defined in the original scope of project. The technical specifications documents were built, based on SPEN experience from similar power electronic projects and the technical requirements for apparatus deployed in LV networks. These documents specify a wide range of requirements including: the Core Services to be delivered, by each PED type, the connection arrangements, the operating conditions, the electrical rating parameters and the protection requirements.

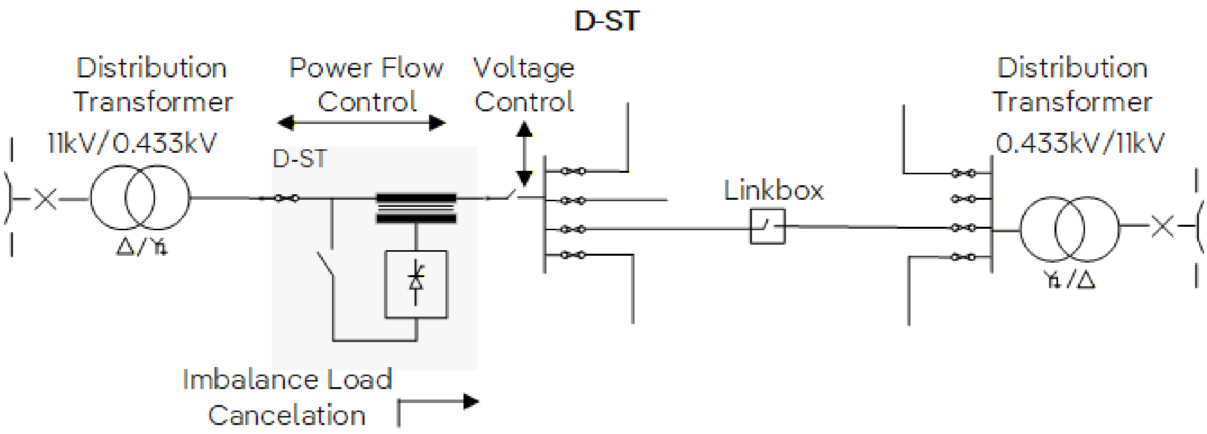

Figure 10. D-Suite D-ST Schematics. D-ST is deployed in a secondary substations where it can regulate the voltage delivered by the distribution transformer and cancelled imbalanced load otherwise would be passed to the distribution transformer. Also, D-ST can control the power flow exchanged between the two substation if the linkbox is close and the two substations are interconnected through LV network

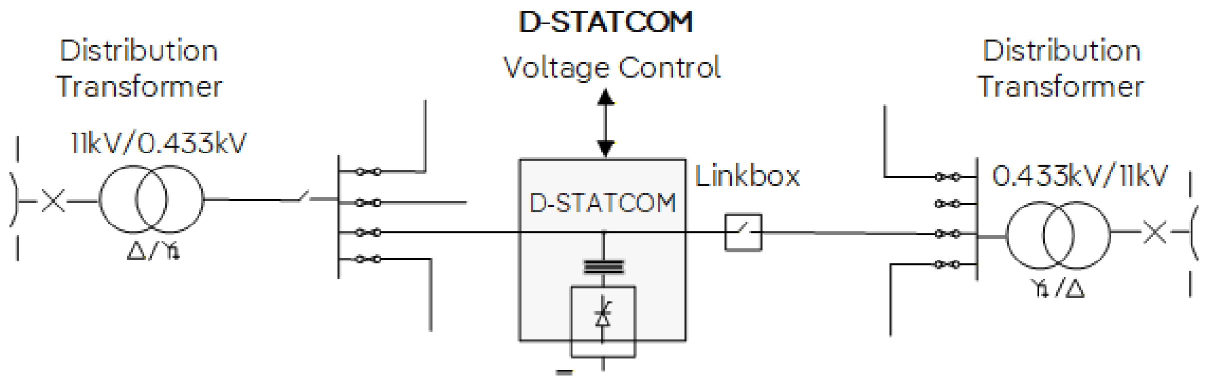

Figure 11. D-Suite D-STATCOM Schematics. D-STATCOM is deployed in a LV cable circuit, where D-STATCOM regulate the voltage at the point of connection by injecting or absorbing reactive power

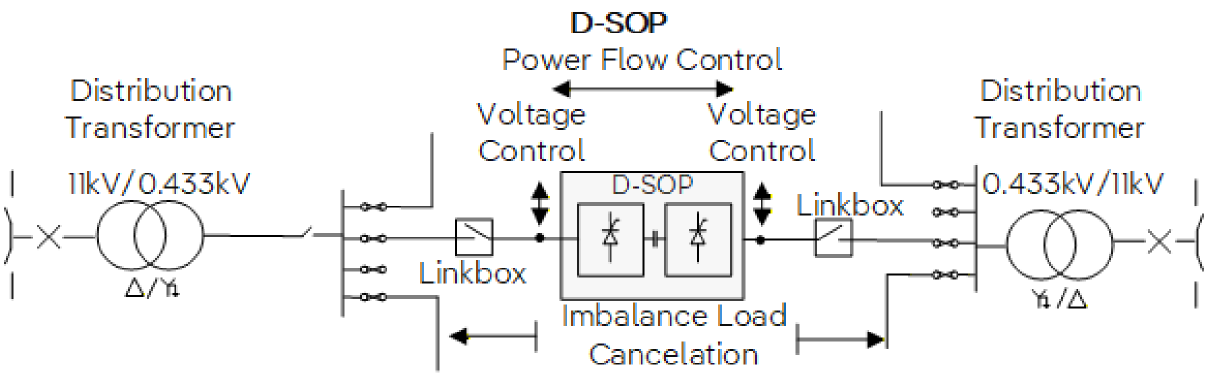

Figure 12. D-Suite D-SOP Schematics. D-SOP is deployed between two ends of circuits connecting two neighburing substations. D-SOP can control power flow exchange between the two distribution transformers, and also regulate the voltage at the point of connection. LV network fault level is not increased as a result of interconnecting the two substations as D-SOP limits the fault currents exchange between the two substations

Fresh Market Engagement

After shortlisting the potential manufacturers, preliminary D-Suite specification documents were shared by SPEN to solicit feedback and assess feasibility from a market perspective. This critical engagement shaped the final procurement scope and ensured alignment with the commercialisation strategy, which prioritises a competitive and ready supply chain.

In parallel, SPEN initiated the formation of an external approval committee to provide an additional layer of expert technical review for D-Suite hardware product development. This committee will offer independent technical recommendations to SPEN regarding the suitability of hardware design, manufacturing and testing. The appointment stemmed from the recognition that SPEN internal staff may not possess in-depth technical knowledge of some of the emerging power electronic products, for LV network applications. The approval committee is intended to mitigate this gap and provide an opportunity for SPEN's internal team to enhance their technical expertise in the LV power electronics domain.

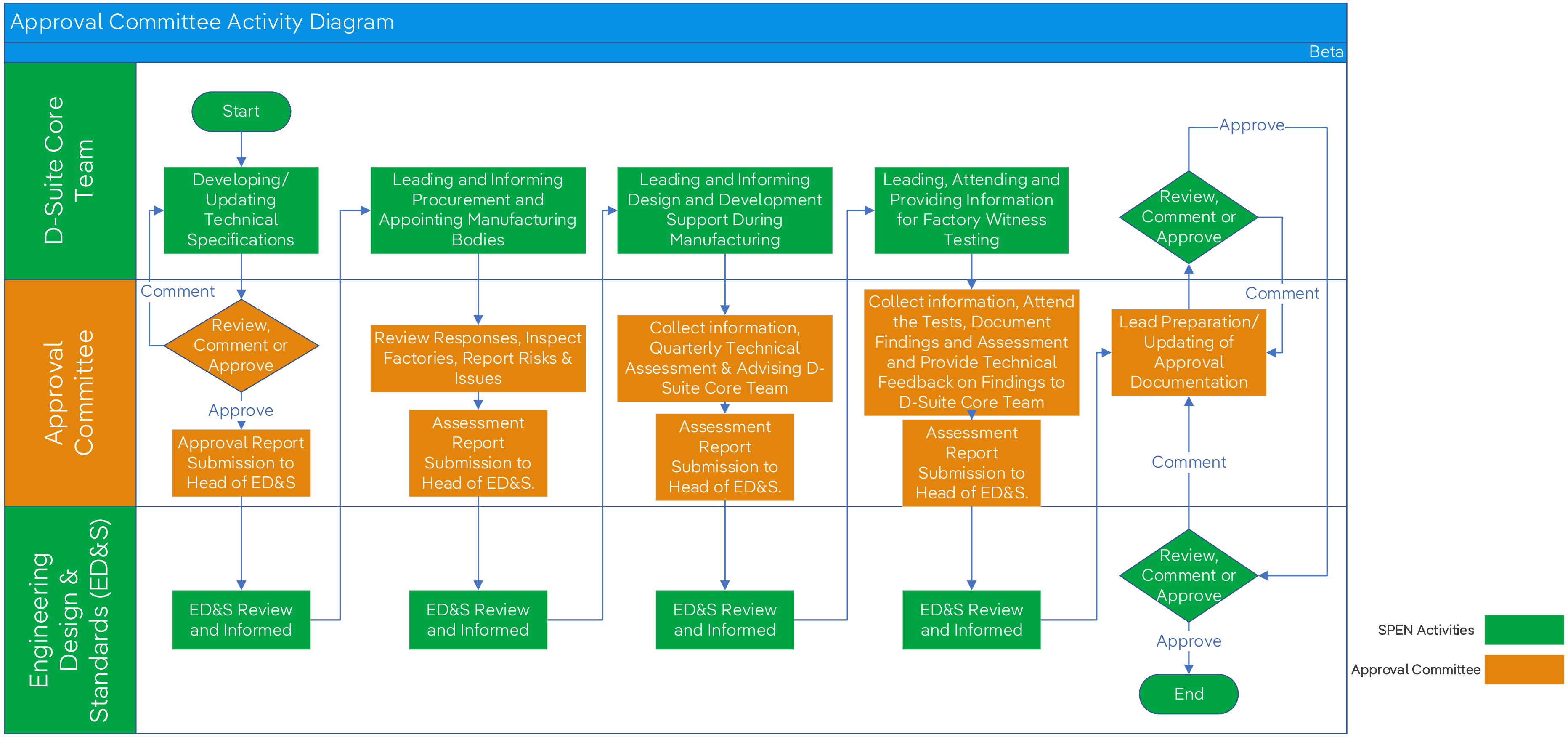

Figure 13. Approval Committee Activity Diagram that demonstrates the activities and their dependencies and sequence for D-Suite core team, Approval Committee and the SPEN ED&S.

1.2.2. Work Package 2 - Procurement, Installation and Commissioning

This work package focuses on the design, development, manufacturing, testing and installation of D-Suite power electronic solutions. The aim is to design and manufacture value-engineered power electronic technologies that can be safely deployed within the network, while delivering the Core Services specified in the relevant D-Suite technical specifications.

Moreover, several sessions were held with the SPEN procurement team to facilitate progress on D-Suite procurement activities which aim to conduct in Q1 2026.

1.2.3. Work Package 3 - Trial and Operational Performance

As part of WP3, SPEN must update the locations of suitable trial sites, for the deployment of D-Suite technologies, due to the changing nature of the LV network, due to design and operational changes needed to meet statutory requirements. During the trial period, various control modes and target settings will be implemented to better understand the operational benefits under different configurations at the selected trial locations.

SPEN D-Suite Project team has made progress in selecting trial sites for D-Suite deployment. Sites identified during the Alpha stage of the project were reassessed and the selection process was further refined. SPEN has now shortlisted sites within the SPM licence area where the D-Suite solution is expected to deliver measurable benefits. These sites are scheduled for further evaluation through site visits SPEN district level engagement and system studies to finalise deployment locations.

During the initial screening, several key criteria were considered:

1. Areas with potential voltage issues due to long feeders or high penetration of PVs.
2. Neighbouring substations with complementary load profiles.
3. Interfaces with large customers, such as iDNOs.
4. Existing substation footprints and accessibility.

Engagement with SPEN District teams is currently underway, to confirm site feasibility and to raise internal awareness of the project. The team is coordinating site visits, with support from district staff, to assess both the physical and operational suitability of each location.

1.2.4. Work Package 4 - Business as Usual (BaU) Integration

The purpose of this work package is to ensure that the D-Suite solutions, both hardware and software, can be adopted into standard design and operational practices across SPEN and other UK distribution network operators. This includes the development of operational policies, maintenance procedures, equipment registration protocols and the integration of the LV Design Tool into BaU planning processes.

SPEN is not yet due to forming the policies and operational documents under the project program, however the BaU practicalities required for the design and operation of the D-Suite solutions have been considered in the D-Suite technical specifications that have been developed in this reporting period.

1.2.5. Work Package 5 - Project Management, Stakeholder Engagement and Dissemination

Work Package 5 covers the day-to-day project management, knowledge sharing activities, internal/external engagement. SPEN led disciplined delivery with structured reporting, milestone tracking and risk oversight, with weekly coordination that kept teams aligned.

In line with progress reporting requirements, SPEN successfully held four Quarterly Reports with UKRI covered project progress compared to original plan, finances and risk register trends.

SPEN also held a D-Suite Steering Board session, consisting of SPEN's senior management, UK Power Networks representatives, Newcastle University's leadership, and IPTs representative, in which we reaffirmed strategy, showcased technical progress, and collected constructive feedback.

Dissemination activities were delivered beyond expectation, including presentations in internal and external conferences, updating the project website, presenting in webinars, and industry workshop related to D-Suite. More details of dissemination activities are provided in 3.

1.3. Project Performance Relative to Its Aims and Objectives

Project Partners have progressed the project against its objectives, contributing to the achievements described in this section, beginning with the PED hardware.

1.3.1. Trial Partially Rated PEDs

The project advanced toward this objective by completing key preparatory activities, essential for successful trials. Technical specifications for all PEDs were developed, through extensive market engagement capable UK manufacturers were identified and shortlisted, reducing supply chain risk and supporting competitive procurement. Modular hardware prototypes and simulation models were built by IPT, enabling early validation of control strategies and protection behaviour ahead of field deployment. The technical benefits, of the PE, control response, has progressed with development of the LV Design Tool.

1.3.2. Develop a Detailed LV Design Tool

Development began with Newcastle University leading LV Design Tool requirement listing via user story workshops, resulting in identification of functional and non-functional requirements. A five-step siting and sizing algorithm was implemented by Newcastle University and validated against SPEN PowerFactory models, to ensure accuracy. Integration with the SPEN NAVI platform was achieved, enabling real-time data access and streamlined workflows. Backend enhancements included anonymisation processes, new LCT profiles and API development for interoperability between the Newcastle back-end calculation engine and the NAVI platform front-end. Front-end design advanced through wireframes and user journey workshops, ensuring usability for planning engineers. These activities collectively position the tool for BaU adoption and future trials.

1.3.3. Conduct Extensive Trials

Trial site selection was refreshed by SPEN and priority locations were shortlisted using technical-benefit scoring, district engagement, and feasibility checks. Control and monitoring readiness advanced through the development of NLCS I/O schedule, confirming measurands, data latencies and routes for near-real-time telemetry. IPT's simulation and laboratory prototypes de-risked control strategies ahead of HiL and Test Centre full-power testing. Manufacturer market engagement, and draft specifications, support timely procurement and commissioning. The measurement plans, along with the impact monitoring and evaluation approach, establish the before-and-after trials baselines and determine how changes can be attributed to the trials. Before the trials begin, the technical specification must be apprised for compliance with standards and safety.

1.3.4. Ensure Compliance and Safety

Compliance and safety were embedded through preparatory activities that ready the project for secure trials and BaU adoption. SPEN drafted device technical specifications, covering Core Services, connection arrangements, ratings, protection and operating conditions and initiated expert external approval to review hardware design and testing. Through several stages of lab testing and expert reviews, as explained in previous sections, we plan to continuously assure the compliance and safety requirements. SPEN has shared learnings on the WP1 development, through extensive collaboration and dissemination.

1.3.5. Collaborate and Share Learnings

Collaboration included Steering Board sessions with SPEN, Newcastle University, IPT and UK Power Networks, ensuring strategic alignment and transparency. Technical progress was disseminated through presentations at CIRED, CIGRE and the ENA Innovation Forum, alongside a public webinar. Internal workshops refined the LV Design Tool’s user journey and interface, Regular bi-weekly technical reviews with IPT and Newcastle University supported joint development of algorithms, hardware prototypes and integration processes.

3. Knowledge Creation and Dissemination

In 2025, the D-Suite Project distinguished itself through a proactive and wide range audience target dissemination strategy.

- The SPEN D-Suite Project team arranged the first steering board meeting to educate and engage the leadership teams of all involved partners.
- The SPEN D-Suite Project team delivered presentations at leading conferences, seminars and forums including CIRED, CIGRE, ENA Innovation Forum, Voltage Matters Forum, ECCE Conference EIS Conference, Enlit Conference, Durham University Engineering Seminars, University of Oxford Control Engineering Seminars, Risk and Resilience day oral presentation (Birmingham University) and Hochschule Darmstadt (h-DA) power systems seminars, showcasing early findings on PED design, LV network modelling and control philosophies.
- To ensure the LV Design Tool was fit for purpose, a user interface story board was created. To ensure this suggested user journey was feasible, feedback and suggestions were taken from Newcastle University and SPEN's NAVI team, on the workings and outputs of their algorithm, to ensure the suggested features were feasible within the established project timeline.
- A paper on the project was published by the Project Partners: 'D-Suite: A Suite of Partially Rated Modular Power Electronics to Increase Low Voltage Network Capacity, published as a CIRED Conference paper.
- A UI Refinement workshop was organised to present the user journey concept, with LV design engineers from across SPM. As good as an engagement meeting with the reinforcement teams.
- Finally, as part of the D-Suite Project's stakeholder engagement strategy, SPEN held its first public webinar.

4.Intellectual Property Rights Generation

The D-Suite Project has begun generating foreground Intellectual Property (IP), primarily through the development of the LV Design Tool and the technical specifications for the D-ST, D-STATCOM and D-SOP devices. The LV Design Tool incorporates proprietary algorithms for, LCT uptake scenario models, PED siting and sizing, technical benefit calculation and policy flag integration. These components represent novel contributions to network planning and control optimisation. The code is version controlled to ensure traceability and future licensing potential.

While the tool and specifications are being developed under open collaboration principles, the Project Partners have agreed to share relevant IP across networks to support wider adoption. The commercialisation strategy includes licensing arrangements for PED designs and modular control architectures, with provisions for multi-supplier engagement and BaU integration.

No IPR exclusions have been specified, at this stage, and the project remains committed to ensuring that all outputs, where appropriate, are accessible to other DNOs and stakeholders through structured dissemination and knowledge transfer mechanisms.

Table 1. D-Suite Intellectual Property

IP NAME	DESCRIPTION	WP	TYPE OF IP	OWNER
LV Design Tool	The algorithm for forecasting the demand. Generation and identifying the location and D-Suite devices	WP1	Joint foreground IPR	University of Newcastle and SP Energy Networks
Technical specifications of D-Suite technology	Technical specification of D-SOP, D-ST and D-STATCOM which has been prepared for procurement of devices	WP1	Joint foreground IPR	SP Energy Networks
Trial site criteria selection	Criteria developed and methodology to assess the sites for selection of trial sires to demonstrate the performance of D-Suite	WP3	Joint foreground IPR	SP Energy Networks
D-Suite devices control strategy	The overall hierarchy of control strategy	WP1	Joint foreground IPR	SP Energy Networks

5.Data Access Details

To access and download material generated through the project, please visit the D-Suite website using below link:

D-Suite Project - SP Energy Networks

Access to the project data must be requested by contacting SPInnovation@spenergynetworks.com.

Please provide the following information in your request:

1. Affiliation
2. Position
3. Contact details of requesting party
4. Relevant project and type of data required
5. Reasons for requesting this data and evidence that this data will be used in the interest of the UK network electricity customers

Full details on the SPEN data sharing policy is described on the link below: https://www.spenergynetworks.co.uk/pages/data_sharing_policy.asp

6. Route to Market / Business as Usual

SPEN have drafted a 'Commercialisation and BaU Adoption' strategy document, to provide key actions required for creating a market for D-Suite solution and ensure BaU integration. This plan is based on learnings from previous innovation projects and internal consultations. SPEN recognises that BaU adoption and commercialisation of the innovations are highly interdependent. The BaU integration and commercialisation strategy have been built on three pillars which are key enablers to the BaU goal, which is deploying the D-Suite solution at scale, with a strong techno-economic drive justification.

- Pillar 1 - Techno-economic demonstration – D-Suite products have been successfully designed, value engineered and demonstrated in the field supporting business case against competitive solutions.
- Pillar 2 - End user readiness – End users (mainly SPEN and UK Power Networks) have developed and deployed tools and processes with inclusion of D-Suite solution in their investment plan for regulatory periods.
- Pillar 3 - Competitive and ready supply chain – Manufacturing and technical support capabilities (ideally UK based) are in place after D-Suite Project completion to meet DNOs' investment plan for D-Suite solution.

Once further information from manufacturing partners on D-Suite unit prices becomes available, the business case model will be updated to confirm expected benefits to electricity customers and also viability of revenue streams for manufacturers and DNOs. Extensive plan have been made for various activities in the project programme that enhance the chance of strategy success.

SPEN, as the project lead and D-Suite solution end user, plan to maximise its influence on the market, key stakeholders and solution readiness. However, as an innovative solution, the project inherently involves a degree of risk and uncertainty. The overall BaU and commercialisation road map is presented in Figure 14 below.

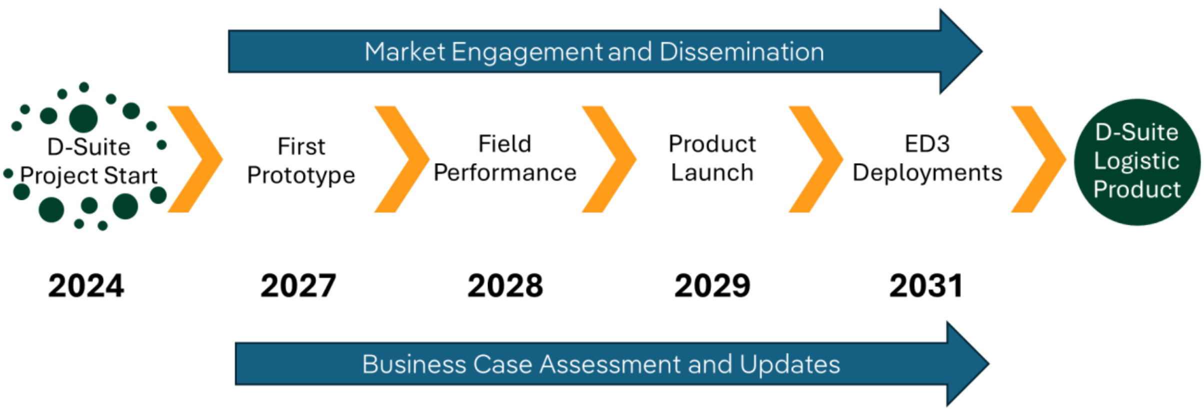

Figure 14. D-Suite Commercialisation Strategy

7. Policy, Regulatory and Standard Barriers

As of the end of 2025, the D-Suite Project has not encountered any active regulatory or standards-related barriers that would impede progress. However, the team has proactively identified potential challenges that may arise during the deployment and commercialisation phases. These include the need for creating new policies for use of power electronic technologies and informing ENA on technical specifications for LV PEDs based on our learnings.

The project's technical specifications and safety documentation are being developed with reference to existing standards, ensuring that any future derogation requests or policy updates are well-founded and supported by trial evidence.

8.User Needs

The D-Suite Project has defined a clear user journey centred around the LV Design Tool and the deployment of PEDs.

Users, primarily LV planning engineers, interact with a frontend interface to visualise technical benefits, policy flags, and cost-effectiveness. This journey culminates in actionable outputs for reinforcement planning, site selection, and procurement scoping. The use of NAVI, for backend and front-end integration, avoids duplication of effort and ensures consistency across NAVI based planning tools. The LV Design Tool scalability and version control features, further support extensive adoption potential across UK distribution networks, ensuring that future users benefit from a streamlined, validated and user-informed process.

User needs have been translated into functional requirements through iterative engagement with SPEN engineers and UK Power Networks representatives. Workshops and feedback sessions informed the development of wireframes, backend integration protocols and technical benefit metrics. The tool's modular architecture, anonymisation features and compatibility with existing planning workflows reflect direct responses to user priorities around usability, data security and operational relevance.

The technical and functional requirements, of the D-Suite power electronic technologies, have been developed, based on insights from previous related projects, as well as existing ENA and SPEN specifications. A value engineering exercise will be also undertaken during the design phase, to ensure that the D-Suite product, manufactured for the D-Suite trial, closely aligns with the version intended for future volume production. SPEN continue to engage with various internal stakeholders, from design team to operation staff, to ensure the final product will be given the greatest chance of adoption at scale.

9. Impacts and Benefits

In 2025, D-Suite progressed towards the consumer benefits set out for the Beta phase. The planning Tool's analysis approach was validated technically by comparing its outputs with those obtained by an independent expert team within SPEN, using an alternative calculation approach with a different power flow solver (Digsilent Powerfactory). This validation ensures the tool's method (Section 1.2.1) can be used with confidence, enabling users to pinpoint where PEDs can improve local electricity networks by raising voltage quality, reducing imbalance and releasing capacity for electric vehicles, heat pumps and solar. This work represents a core innovation, for the D-Suite project and can be extended to include any actively controlled device, operating in a distribution network. The LV Design Tool will predict the technical benefits at the trial sites selected for the D-Suite project.

Priority trial sites in North Wales and Merseyside were refreshed to ensure meaningful, real-world learning, while device specifications and reference hardware/control models help de-risk testing before installation.

To contextualise the tool validation, the project's best-estimate CBA (best-case scenario) indicates that a GB-wide rollout of D-Suite could deliver a whole-life NPV of £5.84bn, comprising of £3.05bn net financial, £1.06bn environmental and £1.73bn societal benefits, with payback within the first year. These figures will be updated as supplier pricing and trial evidence mature during the coming WPs.

At licence-area scale, the best-estimate CBA for SPEN indicates a whole-life NPV of £718m, reinforcing the case for trials that target measurable benefits. These findings align with the refreshed sites in North Wales and Merseyside and the planned measurement approach, guiding baseline setting and post-installation benefit attribution.

10. Risks, Issues and Constraints

Among the most prominent is the potential withdrawal of key manufacturers, due to international resourcing constraints. This could reduce supplier diversity and compromise the robustness of PED trials.

Another significant constraint relates to data integration and backend interoperability between Newcastle University and the NAVI team. Delays in automating smart meter data access and synchronising simulation environments (e.g. MATLAB/Simulink with DIgSILENT) have introduced inefficiencies in tool development.

Additionally, cybersecurity requirements for control system integration pose a long-term challenge to BaU adoption.

For mitigating the risk of withdrawal of key manufacturers, SPEN has responded by initiating licensing discussions with UK-based manufacturers and expanding its supplier engagement strategy to ensure continuity and competitiveness.

Data integration and backend interoperability are being mitigated through early interface testing, Python-based data pipelines and manual fallback procedures.

Overall, the project has shown agility in adapting its outcomes to user needs while operating within technical and organisational constraints.

Many other risks are also identified, such as data timestamp gaps, backend inefficiencies and supply chain volatility and are expected to be resolved through continued collaboration, staged procurement and iterative validation. Table 2 demonstrates top four risks and their mitigation plans.

Table 2. Highest-Scoring Risks and Mitigations

Risk Description	Risk	Impact	Mitigation Actions
ERMCO, a strong US-based manufacturer who previously cooperated with us on the LV Engine Project, may not participate in the D-Suite project, as they are struggling for project resourcing outside US. If ERMCO withdraws, fewer manufacturers will be involved, increasing project risk.	Potential Withdrawal of Key Manufacturer	Reduced number of participating manufacturers, potentially compromising project success and diversity of solutions.	1- Attempting transfer ERMCO's Know-Hows to a UK manufacturer through licensing agreement with a UK based party 2-Reaching out to additional manufacturers to ensure sufficient project participation.
New competing technology outperforms PED on cost for the same or greater technical benefit.	Hardware Risk	WP2 & WP4 cancellation.	Stage gate project at key procurement points. Use LV Design Tool with new technology to this output still retain efficacy.
Data input requirements from SPEN and 3rd parties is not made available in time or requires too many interfaces to be managed effectively.	LV Design Tool - Input Data	Project delays	Model uses open-source databases already available and used in Alpha prototype. Network extract methods already established in Alpha LCT connection predictions already available through Alpha work Substation monitoring and Smart Meter data self-service access is being developed.
Some data requirements for the LV Design Tool are being integrated into the NAVI tool to draw from an API, however not all of this is presently automated	LV Design tool data inputs from NAVI delayed or unavailable	Project delays	Ensure that all data requirements not presently already within NAVI can be made available from a second source

11. Working in the Open

Throughout the Beta Phase, D-Suite worked openly, keeping stakeholders informed and involved. The following method was used to allow open information exchange and collaboration:

- The project holds regular dedicated weekly progress meetings with key project partners to discuss the progress, issues and risks. The cross-work package collaboration is facilitated by the core SPEN D-suite team by sharing the knowledge from various parties on a regular basis and monthly meetings between work package leads.
- Our dissemination plan is also allowing information to be available to other experts in the field, opening opportunities to hear comments, open new contacts and identify interested parties. Updates were shared via a public webinar, regular workshops and contributions to leading industry forums, creating space for challenge, critique and co-creation.
- There is ongoing communication with the Investment Planning and District teams, allowing insight into the growing network issues these teams face and maintaining engagement and project awareness with the D-Suite end users.
- Engineers and operational teams helped refine specifications, user interfaces and siting/sizing approaches, while Steering Board session provided constructive oversight on inclusion of the D-Suite solution in overall business strategy.
- UK Power Networks, our DNO Project Partner, attends all the weekly meetings to understand the progress and SPEN had also opportunities to reach out other functions within UK Power Networks which can be end user of the D-Suite LV Design tool to understand their methods and end user requirements.

12. Costs and Value for Money

The project is tracking to its £8.9m forecast while targeting consumer value through avoided LV reinforcement, reduced disruption, accelerated decarbonisation and improved service quality. The value case is supported by conservative whole-life Net Present Value (NPV) estimates of £98.38m for SPEN (net financial £35m; environmental £24m; societal £40m) and £795.4m GB-wide, with a best-case potential exceeding £5.8bn. Cost analysis includes device, civils and ancillary expenses and the counterfactual (traditional reinforcement) is recognised as costlier, more disruptive and space-constrained.

The counterfactual scenario, where D-Suite is not implemented, would result in significantly higher reinforcement costs, increased workforce requirements and greater exposure to CI/CML penalties. Traditional reinforcement solutions, while low-risk, are costly, disruptive and space-constrained, making them less suitable for the scale of LV decarbonisation anticipated under government targets.

The project's approach to value for money is anchored in its ability to defer or avoid costly LV reinforcement, minimise consumer disruption, and accelerate decarbonisation. By leveraging partially rated PEDs and an advanced LV Design Tool, D-Suite offers a scalable, cost-efficient alternative to traditional reinforcement methods. These benefits will be validated through real-world trials and integrated into BaU planning processes, ensuring that consumers ultimately benefit from lower costs and improved service quality.

There have been no significant cost variances to report at this stage. No unspent SIF funding has been identified for return to consumers and no additional financial contributions beyond those set out in the Project Direction have been introduced. The project has not generated any revenues to date that would be returned to consumers. Figure 15 compares the Original and Revised Forecasts against actual costs incurred to date, while Table 3 summarises expenditure by each project partner.

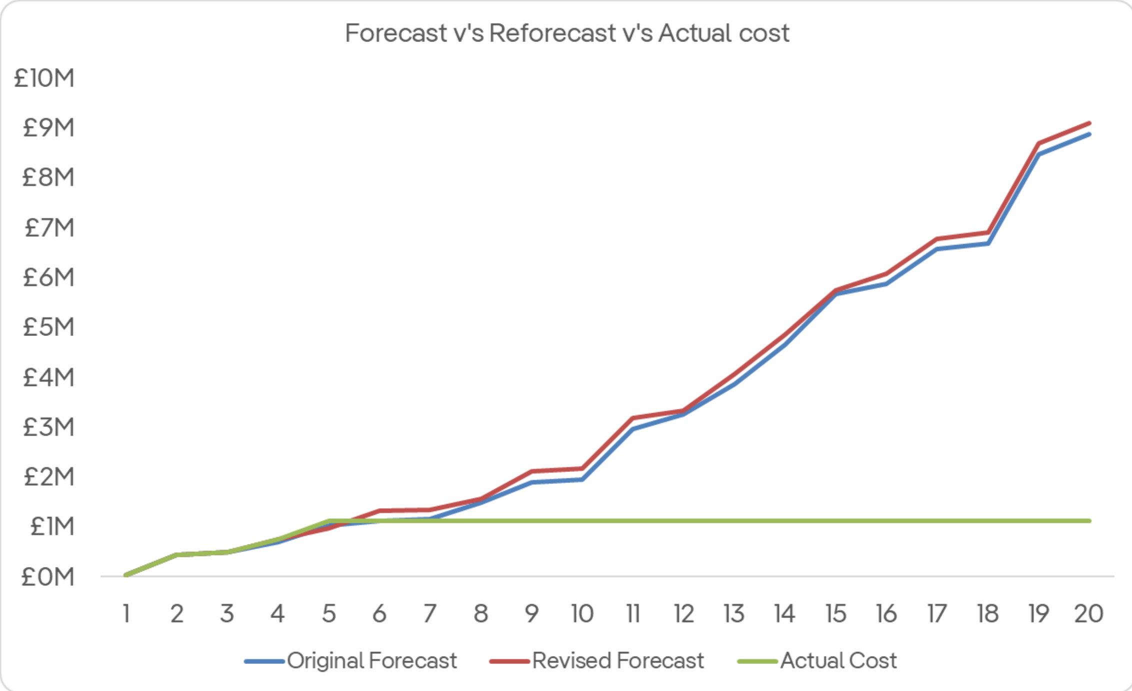

Figure 15. Forecast VS Reforecast VS Actual Cost. Bottom axis is number of quarters since the project start date

Table 3. Summary Table with Final Project Expenditure by Each Project Partner

Project Partner Name	SIF Funding Requested	Total Actual Project Spend	Total Project Contribution made (incl. contributions in kind)
SP Manweb PLC	£6,174,612.00	£294,841	£29,484.10
UK Power Networks	£818,444.00	£0.00	£0.00
Integrated PowerTech	£894,000.00	£142,000	£14,200.00
Newcastle University	£178,690.00	£264,655	£26,465.50

13. Special Conditions

13.1. Condition 1 - Contract Execution Prior to Spend

No SIF funds were expended until contracts with all named Project Partners were fully executed. All purchase orders and claims were raised after contract signature, ensuring compliance with the requirement that spending only commences once partner contracts are in place.

13.2. Condition 2 - Financial Contributions

The Funding Party has reported financial contributions at each QRM during the period, submitting the updated finance report and project costs alongside the monitoring pack. Partner contributions have been tracked against the application baseline. This fulfils the requirement to report finances as set out in the application. Financial Status submitted at QRMs and in the Annual Report.

13.3. Condition 3 - Meeting Arrangements

The Funding Party participated in all invited project meetings during the reporting period. This included:

- Attendance at four QRMs, with report and comprehensive presentation deck prepared and submitted alongside each monitoring pack.
- Participation in Stage Gate 1 held back-to-back with the fourth QRM and attendance at the post-Stage Gate consensus-review session, where actions were agreed and subsequently progressed.
- In addition, SPEN arranged a series of internal meetings to maintain project momentum and ensure effective coordination. These included weekly review sessions with Newcastle University and UK Power Networks, fortnightly meetings with IPT and regular internal core team catch-ups. Furthermore, a Steering Board meeting was convened to promote strategic alignment and raise awareness among SPEN's leadership team regarding the project's objectives and progress.

13.4. Condition 4 - Stage Gate Scoping

The Funding Party worked with UKRI to scope and agree the requirements and success criteria ahead of SG 1. These criteria were proposed, discussed over several meetings, and finalised for adoption within the project management plan and quarterly reporting cycle. The agreed criteria were documented in the Stage Gate Criteria template and used to structure the SG1 evidence pack and panel review. This satisfies Condition 4 by ensuring that SG success criteria were co-developed, clearly recorded and applied ahead of the SG, with additional information (reports/evidence tables) produced as required.

13.5. Condition 5 - Impact Monitoring

This condition shall be satisfied at the end of Beta phase project.

13.6. Condition 6 - SIF Community Forums

The team attended the Community Forum in Edinburgh in 2025 and will continue to participate in future forums to share learning and promote cross-network adoption.

13.7. Condition 7 - Policy, Regulatory and Standards Barriers

During 2025, no policy, regulatory or standards' barriers were identified or raised that would impact Beta Phase delivery. Therefore, there are no derogations or change requirements to report in this Annual 1 submission. Verbal updates at quarterly meetings reflected the same status. The project will continue to monitor and if needed, include any future updates in annual reporting and in the end-of-phase summary, per the SIF requirements.

13.8. Condition 8 - Updated 60-second videos

The Funding Party has produced and shared a 60-second video at the initiation of the project. Given the Project duration exceeds 24 months, a mid-point update video will be provided at the Project's midpoint and a final 60-second video will accompany the end-of-phase report, as required by UKRI guidance.

13.9. Condition 9 - Post-Beta Phase Roadmap

The post-Beta roadmap is set out within D-Suite Commercialisation and BaU Adoption Strategy, defining how the capability transitions from a funded project to business-as-usual after finalisation. This document has been presented to UKRI and Ofgem during Quarterly and SG meetings. It proposes a plan that assigns ownership to SPEN business functions and describes the end-to-end path.

13.10. Condition 10 - Commercialisation Strategy

The project's commercialisation strategy is documented, setting out how partially rated LV PEDs and the LV Design Tool will move from innovation into scalable market offerings and adoption by UK DNOs. A number of pillars within this strategy and the set of actions required to achieve each pillar have been defined.

13.11. Condition 11 - Data Best Practice and Digital Strategy and Action Plan Guidance alignment

D-Suite embedded good data practice in Year 1 by sharing non-sensitive information openly, applying clear metadata and version control and anonymising network data to enable safe re-use. A simple tiered policy, open, controlled-access and internal-only, protects people and systems, supported by documented interfaces and aggregated outputs. The LV Design Tool's results have been independently validated, anonymised examples are used in user workshops and trial-site information is communicated at a high level.

13.12. Condition 12 - Comprehensive Reporting

The project has presented at every QRM as good as SG 1 meeting, clear explanations of project progress to date, material costs, risks and issues and the way forward for the next reporting period.

14. Material Changes

No material changes during 2025.